GUII

1928

THE
AMERICAN SOCIETY OF
HEATING
AND
VENTILATING
ENGINEERS
GUIDE

1928

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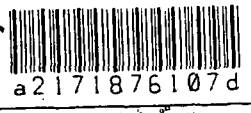

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American Society of Heating and Ventilating Engineers Guide

1928

Containing Design and Specification Data Useful in the Planning and Construction of Modern Heating and Ventilating Installations—Prepared from the Society's Transactions—Investigations of Its Research Laboratory—and the Practice of Its Members

together with a

Manufacturers' Catalog Data Section Containing Essential and Reliable Facts Concerning Modern Equipment

and a

Consulting Service Section for Engineers

also

The Roll of Membership of the Society

with

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PREFACE

THE growth of The Guide in its sixth year of service is impressive as more than 100 pages of additional data are to be found in the edition for 1928 prepared for engineers, architects, contractors and others who are desirous of having a complete knowledge of the heating and ventilating art.

Developments in heating and ventilating engineering during the past year have made many changes in The Guide necessary and these are reflected in both the Technical Data Section, in which new Chapters are to be found, and also in the Catalog Data of Manufacturers which announce many new products. In this sixth edition of The Guide an important contribution has been made in the preparation of Chapter I on "Calculating Heat Losses from Buildings" and comprehensive tables are given for ordinary building constructions which will permit the engineer, architect or contractor to determine the heat losses quickly, not only for the constructions given but for any combination of materials which he may decide upon. Heat loss factors are also given for insulated constructions and it is hoped that the standard tables will be generally adopted by men who figure heating requirements for buildings.

Another notable section is that on "Steam Heating Systems and Piping" which is recommended jointly by the American Society of Heating and Ventilating Engineers and the *Heating and Piping Contractors' National Association* having been based on the research investigations at the A. S. H. & V. E. Research Laboratory at the U. S. Bureau of Mines, Experiment Station, Pittsburgh, Pa. Tables for sizing both large and small, one and two-pipe vapor and vacuum systems have been given with adequate examples to assist the user in laying out his piping in the most effective manner.

Entirely new data are given for Hot Water Heating Systems, Oil and Gas Heating, Automatic Heat Control and Insulation of Pipes and Surfaces.

The Ventilation Section has been completely revised and new data have been given on the Use of the Synthetic Air Chart, Systems of Ventilation, Air Cleaners, Air Conditioning and Motive Power for Fans. Extensive revisions and additions have been made to the other sections of the book and all of this material has been cross-indexed in a comprehensive manner to make it easier for the reader to use.

In every case the various Chapters are the product of one or more specialists and in practically all cases, members of the Society. All data have been drawn from the best available sources and great care has been taken to maintain a logical arrangement of data in order to make the presentation simple, convenient and practical for ready reference.

As in the case of the first edition issued in 1922, the second edition published in 1923 and the third designated 1924-25, the fourth in 1925-26, the fifth edition for 1926-27 and this sixth edition for 1928, has extended

and simplified much of the technical data with the idea of assisting the engineer, architect and contractor in designing and producing the most effective installations for heating and ventilating various types of buildings. This issue of THE GUIDE is designated 1928 to avoid confusion which has been noted with the double numbering system used previously.

Because of the magnitude of producing such a reference volume as THE GUIDE each year, the Council of the Society appointed a Guide Publication Committee consisting of Perry West, Chairman; W. H. Carrier and C. V. Haynes and retained Chairman Perry West as Editor-in-Chief. The Guide Publication Committee then enlisted the service of Sub-Committee Chairmen, W. H. Driscoll, S. R. Lewis and Esten Bolling to take charge of the Heating Section, Ventilation Section and Catalog Data Section respectively. Under their direction the cooperation of a great many Society members was enlisted and their helpful work is gratefully acknowledged as they have made it possible for this volume to appear in its enlarged and comprehensive form for service as the standard reference work in the heating and ventilating field.

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

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

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

THE GUIDE 1928 is issued with the sincere desire that it will perform a worthwhile service in advancing the ideals of modern heating and ventilating and will perform the needed and valuable service in the advancement of this profession.

THE GUIDE PUBLICATION COMMITTEE

PERRY WEST, *Chairman*

W. H. CARRIER C. V. HAYNES

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CODE *of* ETHICS *for* ENGINEERS

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

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

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

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

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

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

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

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

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

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

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

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

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

1928

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PART I

HEATING

HEAT is a prime necessity for human life and is as essential to comfort and health as shelter, food and clothing. Artificial heating has been practiced from the days of the primitive man and the development of heating methods can be traced through the ages. Modern requirements are for the heating of all parts of a room to a comfortable temperature and the principles of systems today are for an even distribution of heat.

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

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

Attention is called in this connection to the following:

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

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

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

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

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

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

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

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

CHAPTER I

CALCULATING THE HEAT LOSSES FROM BUILDINGS

INTRODUCTION

IN the revision of Chapter I for the 1928 Edition of THE GUIDE, the latest available data on the internal conductivities of building materials and insulations have been included in Table 4, greatly extending its scope and usefulness. With these values available, it has been possible to compute an entirely new set of tables of heat transmission coefficients for modern wall, roof and floor constructions, such as are in use today for insulated as well as uninsulated buildings, replacing and greatly extending the old Tables 6 to 12 inclusive.

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

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

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

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

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

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

6. Select unit values and compute the heat equivalent of the infiltration of cold air taking place around outside doors and windows. These unit values depend on kind or width of crack and wind velocity, and when multiplied by the length of crack and

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

The work of compiling and computing Tables 6-12, in accordance with the methods set forth in the text, has been done by P. D. Close, a graduate of the University of Illinois.

the temperature difference between the inside and outside air, the result expresses the heat required to warm up the cold air leaking into the building per hour.

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

INSIDE TEMPERATURE

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

TABLE 1. INSIDE TEMPERATURES USUALLY SPECIFIED

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

In making the actual heat loss computations, however, for the various rooms in a building it is often necessary to modify the temperatures given in Table 1 so that the air temperature at the proper level will be used. By "air temperature at the proper level" is meant, in the case of walls, the air temperature at the mean height between floor and ceiling; in the case of glass, the air temperature at the mean height of the glass, in the case of roof or ceiling, the air temperature at the mean height of the roof or ceiling above the floor of the heated room, and in the case of floors, the air temperature at the floor level. In the case of heated spaces adjacent to unheated (no heat of any kind) spaces, it will usually be sufficient to assume the temperature in such spaces as the mean between the temperature of the inside heated space and the outside air temperature.

The air temperature at the mean height between floor and ceiling is the "breathing line" temperature, Table 1, for rooms not over 10 ft. in height. For rooms above this height, add 2 per cent per foot of height to the breathing-line temperature for each foot or fraction of a foot difference between the mean height of the vertical wall, glass, roof or ceiling surface, and the height of the breathing line.

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

The outside air temperature used in computing the heat loss from a building is seldom taken as the lowest temperature ever recorded in a

given locality. Such temperatures are usually of short duration and are rarely repeated in successive years. It is therefore evident that a temperature somewhat higher than the lowest on record may be properly assumed in making the heat loss computations.

OUTSIDE TEMPERATURE

The outside temperature to be assumed in the design of any heating system must not be more than 15[1] deg. fahr. above the lowest recorded temperature as reported by the U. S. Weather Bureau (Table 2) during the preceding 10 years for the locality in which the heating system is to be installed. The outside temperature assumed and used in the design should always be stated in the heating specifications.

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

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

General Statement on Temperatures and Wind Velocity

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

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

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

3. The average wind velocity in miles per hour for December, January and February, and the direction of the prevailing wind during these same months for the locality in which the heating plant is located—both wind velocity and direction are to be taken from the U. S. Weather Bureau records for the preceding 10 years.

HEAT TRANSMISSION COEFFICIENTS

Definition

The amount of heat expressed in B.t.u. which is transmitted in 1 hr. per square foot of the material as used in the building, for a difference in temperature of 1 deg. fahr. between the air on the inside and outside of the building, is called the coefficient of heat transmission for the material. The heat transmission coefficient for any given building

[1]There seems to be no agreement in this country at present as to the method of arriving at the proper outside temperature to be used in the calculations or design of a heating system. Some offices use the average of the lowest yearly temperatures for the preceding ten years.

Table 2. Climatic Conditions Compiled from U. S. Weather Bureau Records

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

Table 2. Climatic Conditions Compiled from U. S. Weather Bureau Records—(Continued)

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

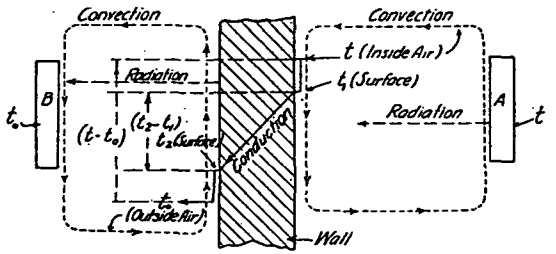
material depends on the structure of the material and its density. Heavy or dense materials, the weight of which per cubic foot is high, usually transmit more heat than light or less dense materials, the weight of which per cubic foot is low.

Transmission Coefficients

By means of suitable tests on an actual wall construction, heat transmission coefficients (Table 6) may be determined directly, or they may be computed if certain physical constants are known. If tests are made to determine heat transmission coefficients, the inside and outside air temperatures should correspond with those actually existing in heating practice, and the amount of air movement, both on the inside and outside of the test wall, should be definitely stated in reporting the coefficients.

Since actual temperature differences vary widely in different parts of the country, it is desirable to adopt some standard basis for testing, such as 70 deg. inside and 0 deg. outside, and in very precise work make a correction for other temperatures. It has been found that the absolute mean temperature of the wall affects the coefficient materially. The coefficient increases with the absolute mean temperature.

Tests are usually run under still air conditions, which means there was no wind movement, during the test, over the surfaces of the wall. In practice, some wind movement over the exterior surface of the wall should always be allowed for; hence *still air* coefficients cannot be used in actual work as they do not provide for the normal wind movement over the outside of the building in the locality in question during the heating season. Moreover, *still air* transmission coefficients cannot be corrected to provide for moving air conditions by multiplying by a single constant factor.[1]



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

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

The coefficient of heat transmission of various building materials and types of construction as given in Table 6, are for still air and for a wind movement of 15 miles and are generally applicable to heat transmission computations using equation (9). Such heat transmission coefficients are always based on the difference between the air temperatures on the inside and the outside of the wall.

Transmission Coefficients by Computation

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

The diagram in Fig. 1 exhibits four important temperatures: *First* the air temperature t inside of the building; *second*, the temperature t_1 of the inside surface of the wall; *third*, the temperature t_2 of the outside surface of the wall, and *fourth*, the air temperature t_0 outside of the building.

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

ing. Heat reaches or enters the inside surface of the wall by radiation and convection, since the air and objects A within the building are *always* warmer than the inside surface of the wall, when the inside air temperature t is greater than the outside air temperature t_0. This heat must then pass through the material of the wall from inside to outside surface by conduction, and is finally given off from the outside surface by radiation and convection, provided, of course, that equilibrium has been established and all four temperatures are constant.

The amount of heat reaching or entering the wall per hour depends on t and t_1 and a coefficient K_1 varying with the character of the wall

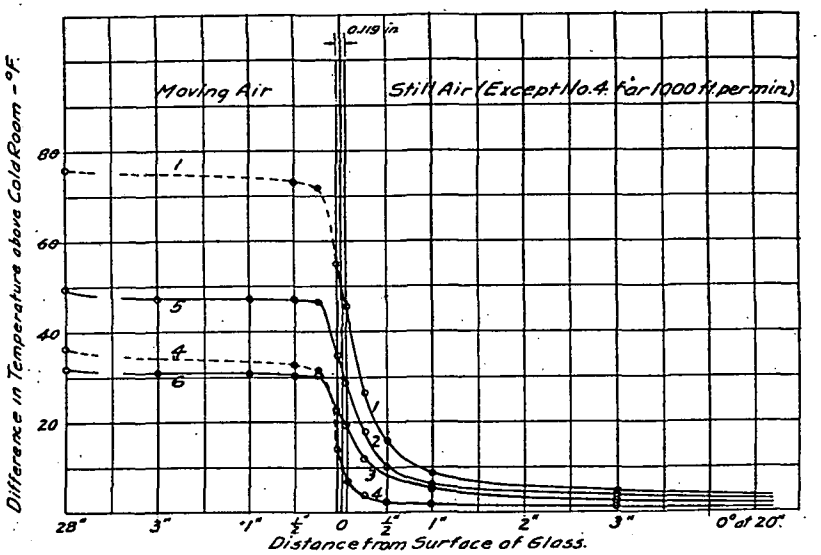


FIG. 2. TEMPERATURE GRADIENT CURVES FOR GLASS (TAKEN FROM BULLETIN NO. 24, ENGRG. EXP. STA., PENNSYLVANIA STATE COLLEGE)

material. K_1 may be defined as the B.t.u. per hour entering each square foot of wall surface per degree difference between the inside air temperature t and the inside surface temperature t_1. Hence the heat received by inner surface of the wall per hour by both radiation and convection is

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

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

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

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

Now K_2 may not equal K_1, in which case $(t_2 - t_0)$ will not equal $(t - t_1)$.

Usually, in an actual wall exposed to wind on the outside, K_2 (Table 5) is greater than K_1 and (t_2-t_0) must be less than $(t-t_1)$. Moreover, the heat H_c passing through the wall by conduction is equal to H_1 and H_2, and if C is the coefficient of conduction = B.t.u. transmitted per hour per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

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

where x = wall thickness in inches.

These equations (1), (2) and (3) are fundamental and are used for determining values for K_1, K_2 and C for actual wall materials by test. They cannot be used for computing heat losses in an actual building, since the surface temperatures t_1 and t_2 are seldom known, although these surface temperatures can be determined in a test by means of thermocouples. Hence, for actual conditions where the only temperatures known are the inside and outside air temperatures t and t_0, it is necessary to use a transmission coefficient U = B.t.u. transmitted per hour per square foot of wall surface per degree difference between the inside and outside air temperatures. Values of U for a limited number of walls are given in Tables 6-12. The heat H transmitted per hour from air inside to air outside is then computed as follows:

$$H = U\,(t - t_0)\,S \tag{4}$$

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

The coefficient U may be determined by test, or it may be computed for any wall provided values for K_1, K_2 and C are known. By proper substitution in the four equations, the unknown temperatures t_1 and t_2 can be eliminated and the value of the transmission coefficient for a simple wall x inches thick is

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

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

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

As in the case of the simple wall, K_1 and K_2 are always the inside and outside surface coefficients for the two materials in contact with air. If the air is still (no wind), then for the same material K_1 and K_2 are the same, and $K_1 = K_2$; but if the outside air is in motion then K_2 is always greater than K_1 and will increase as the wind velocity increases. Values

TABLE 3. SURFACE COEFFICIENTS (K_1) FOR VARIOUS BUILDING MATERIALS UNDER STILL AIR (NO WIND) CONDITIONS

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

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

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

for K_1 in still air as determined by various investigators are given in Table 3. Values for C, the conductivity of building materials, are given in Table 4, and are taken from the published values of various investigators. It should be noted that values of C as well as U are dependent on the temperature range, and it is therefore desirable that the investigator determine conductivity values when the wall is subjected to an air temperature of about 70 deg. fahr. on the inside and about zero on the outside.

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

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

or

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

With certain very special forms of construction which have irregular air spaces, it is necessary to use the conductivity for the unit construction as actually assembled in the wall. This condition exists when hollow tile is used as furring, in which case $\frac{x_1}{C_1}$ is replaced by $\frac{1}{C_u}$, where C_u is the unit conductivity. (*See second footnote of Table 4.*)

TABLE 4. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]

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

A. Building Materials

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (*C* OR *Cu*)	AUTHORITY[14]
Asbestos	Sheet	48.3	110	0.29	Willard, Lichty & Harding
Asbestos Board	Corrugated	20.4	110	0.48	Willard, Lichty & Harding
Asbestos Wood	Asbestos and cement compressed.	123.0	86	2.70	Bureau of Standards
Asbestos Mill Bd.	Pressed Asbestos	60.5	86	0.843	Bureau of Standards
Asbestos Shingles		65.0	75	6.00[2]	Peebles, Armour Institute
Asphalt Shingles		70.0	75	6.50[2]	Peebles, Armour Institute
Brickwork	Mortar Bond and dry conditions.	132.0	100	4.00	Willard, Lichty & Harding
Brickwork	Damp or wet			5.00	Recommended by Harding & Willard[12]
Cement Mortar				8.00[7]	Willard, Lichty & Harding
Concrete	Stone 1-2-4 mix	140.0	110	8.30	Willard, Lichty & Harding
Concrete	Stone	145.0	75	6.30	Peebles, Armour Institute
Concrete	Stone 1-2-5 mix		95[3]	6.27	C.L. Norton, Boston, Mass.
Concrete	Cinder 1-2-4 mix		122	2.35	C.L. Norton, Boston, Mass.
Concrete	Cinder	110.0	75	5.20	Peebles, Armour Institute
Concrete Blocks	Stone Dry	103.6	68	4.84	Hencky
Cornell Wood Board	Ground Wood pulp (3/8" thick).		75	2.50[2]	Peebles, Armour Institute
Gyplap	Gypsum between layers of heavy paper (1/8" thick)	53.5	90	2.60[2]	Bureau of Standards
Gypsum	Building—oven dried 3 weeks.	78.0	68	2.99	Poensgen
Gypsum	Building—mixed with 15 per cent wood fiber.			2.30	Calculated[9]
Gypsum Partition Tile.	Hollow		75	1.00	Peebles, Armour Institute
Gypsum Roof Tile.	Reinforced		75	1.20	Peebles, Armour Institute
2 in. Hollow Clay Tile, 1/2 in. plaster both sides		120.0	110	1.00[3]	Willard, Lichty & Harding
4 in. Hollow Clay Tile, 1/2 in. plaster both sides		127.0	100	0.60[3]	Willard, Lichty & Harding
6 in. Hollow Clay Tile, 1/2 in. plaster both sides		124.3	105	0.47[3]	Willard, Lichty & Harding
2 in. Hollow Clay Tile				1.14[3]	Calculated[4]

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

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

[3]Hot side of plate.

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

[5]Calculated from 2 in. tile tests.

[6]Average of several values.

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

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

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

[10]Not compressed.

[11]The conductivity of plaster varies with the composition. Note range of values from 2.32 to 8.0. The average value for plaster is probably about 5.0. On account of the comparatively high conductivity of plaster and the fact that it is seldom applied more than 3/4 in. thick, this material does not appreciably effect the overall transmission of a construction, excepting in the case of thin uninsulated walls.

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

[13]Thickness of lime plaster and wood lath from back of lath to face of plaster, about 5/8 in.

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

TABLE 4. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]—Continued

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (*C* OR *Cu*)	AUTHORITY[14]
4 in. Hollow Clay Tile				0.65[2]	Calculated[4]
6 in. Hollow Clay Tile				0.50[2]	Calculated[4]
8 in. Hollow Clay Tile				0.43[2]	Estimated
12 in. Hollow Clay Tile				0.26[2]	Estimated
16 in. Hollow Clay Tile				0.185[2]	Estimated
Magnesia Board		13.5	110	0.51	Willard, Lichty & Harding
Magnesia (85 per cent) and Asbestos (15 per cent).	Rigid	19.3	86	0.508	Bureau of Standards
Plaster	Gypsum	46.2	86	2.32[11]	Bureau of Standards
Plaster	Cement			8.00[11]	Willard, Lichty & Harding
Plaster Board			86	3.04	Bureau of Standards
Roofing[8]	Built-up bitumen and felt, gravel or slag surfaced			1.325[5]	Willard, Lichty & Harding
Roofing[8]	Built-up bitumen and felt, gravel or slag surfaced			5.30[2–5]	Willard, Lichty & Harding
Roofing	Composition or prepared		75	6.50[2]	Peebles, Armour Institute
Sawdust	Ordinary		86	1.04	Bureau of Standards
Shavings	Ordinary		86	0.707	Bureau of Standards
Sheetrock	Gypsum mixed with sawdust between layers of heavy paper (0.39 in. thick).	60.7	90	3.60[2]	Bureau of Standards
Slate			201	10.37	Lees & Chorlton
Stone	Limestone or Sandstone.			10.0	Estimated[6]
Stucco				8.00[7]	Willard, Lichty & Harding
Wood lath and plaster[13]	Lime plaster		75	2.0[2]	Peebles, Armour Institute
Woods:					
Cypress	Across grain	28.7	86	0.668	Bureau of Standards
Fir	Across grain	33.4		1.000	Willard, Lichty & Harding
Maple Flooring	Across grain	40.0	75	1.20	Peebles, Armour Institute
Maple	Across grain	44.3	86	1.103	Bureau of Standards
Mahogany	Across grain	34.3	86	0.900	Bureau of Standards
Oak		42.0	75	1.30	Peebles, Armour Institute
Virginia Pine	Across grain	34.3	86	0.958	Bureau of Standards
White Pine	Across grain	31.2	86	0.784	Bureau of Standards
Yellow Pine	Across grain			1.000	Peebles, Armour Institute

B. Insulations (Dry)

Balsa wood	Across grain	20.0	90	0.58	Bureau of Standards
Balsa wood	Across grain	8.8	90	0.38	Bureau of Standards
Balsa wood	Across grain	7.3	90	0.33	Bureau of Standards
Balsam wool[10]	Chemically treated wood fiber.	2.2	90	0.27	Bureau of Standards
Cabots quilt[10]	Eel grass between Kraft paper.	4.6	90	0.26	Bureau of Standards
Cabots quilt[10]	Eel grass between Kraft paper.	3.4	90	0.25	Bureau of Standards
Celotex	Board form insulation made from sugar cane fiber.	13.5	70	0.33	Peebles, Armour Institute
Celotex	Board form insulation made from sugar cane fiber.	13.2	90	0.34	Bureau of Standards
Corkboard	Pure; no added binder.	14.0	90	0.34	Bureau of Standards
Corkboard	Pure; no added binder.	10.6	90	0.30	Bureau of Standards

TABLE 4. INTERNAL CONDUCTIVITIES OF BUILDING MATERIALS AND INSULATIONS[1]—Continued

B. Insulations—(Continued)

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. OF SAMPLE (DEG. FAHR.)	INTERNAL CONDUCTIVITY (*C* OR C_u)	AUTHORITY[14]
Corkboard	Pure; no added binder.	7.0	90	0.27	Bureau of Standards
Corkboard	Pure; no added binder.	9.7		0.32	Willard, Lichty & Harding
Dry zero[10]	Kapok between burlap or paper.	2.0	90	0.25	Bureau of Standards
Fibrofelt[10]	*Flax and rye fiber*	13.6	90	0.32	*Bureau of Standards*
Flaxlinum[10]	Flax fiber	13.0	90	0.31	Bureau of Standards
Flaxlinum[10]	Flax fiber	14.0	70	0.32	Peebles, Armour Institute
Hairinsul[10]	75 per cent hair, 25 per cent jute	6.3	90	0.27	Bureau of Standards
Hairinsul[10]	50 per cent hair, 50 per cent jute	6.1	90	0.26	Bureau of Standards
Hair felt[10]	Felted Cattle Hair	13.0	90	0.26	Bureau of Standards
Hair felt[10]	Felted Cattle Hair	11.0	90	0.26	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	30.0	90	1.00	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	30.0	75	0.92	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	24.0	90	0.77	Bureau of Standards
Insulex or Pyrocell	*Cellular Gypsum*	*24.0*	*75*	0.737	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	18.0	90	0.59	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	18.0	75	0.566	Peebles, Armour Institute
Insulex or Pyrocell	Cellular Gypsum	12.0	90	0.44	Bureau of Standards
Insulex or Pyrocell	Cellular Gypsum	12.0	75	0.400	Peebles, Armour Institute
Insulite	Board form insulation made from wood pulp.	16.9	90	0.34	Bureau of Standards
Insulite	Board form insulation made from wood pulp.	16.5	70	0.34	Peebles, Armour Institute
Keystone Hair[10]		11.0	75	0.25	Peebles, Armour Institute
Linofelt[10]	Flax fibers between paper.	4.9	90	0.28	Bureau of Standards
Lith	Rock wool, flax and straw pulp with binder.	14.3	90	0.40	Bureau of Standards
Lith	Rock wool, flax and straw pulp with binder.	14.5	75	0.38	Peebles, Armour Institute
Masonite	Board form insulation made from exploded wood fiber.	18.0	75	0.33	Peebles, Armour Institute
Maftex	*Board form of insulation made from roots of licorice.*	*16.1*	81	0.337	Peebles, Armour Institute
Regranulated Cork	*About ⅛ in. particles.*	8.1	90	0.31	Bureau of Standards
Rock Wool[10]	Fibrous material, made from rock. Also made in sheet form, felted and confined with netting.	10.0	90	0.27	Bureau of Standards
Ten Test	Board form insulation made from wood pulp.	20.0	75	0.46	Peebles, Armour Institute
Thermofelt[10]	Jute and asbestos fibers, felted.	10.0	90	0.37	Bureau of Standards
Thermofelt[10]	Hair and asbestos fibers, felted.	7.8	90	0.28	Bureau of Standards
Thermofill	Powdered Gypsum.	34.0	90	0.60	Bureau of Standards
Thermofill	Powdered Gypsum.	26.0	90	0.52	Bureau of Standards
Thermofill	Powdered Gypsum.	24.0	75	0.475	Peebles, Armour Institute
Thermofill	Powdered Gypsum.	18.0	75	0.34	Peebles, Armour Institute

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

In each case, the moving air factor is based on still air coefficient (K_1) for *same* material. For conditions where wind velocity is not known use the factor (3) or take K_2 as $3K_1$ for same material.

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

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

**This is usually taken as 3 even.

Heat Transmission Data

Heat transmission coefficients of many common types of building construction are given in Tables 6 to 12, inclusive, each construction being identified by a serial number. For example, in Table 6-A, the coefficient of transmission (U) of a 13-in. brick wall, furring strips, and ¾ in. of gypsum plaster on metal lath, is 0.185, and the number assigned to a wall of this construction is 3-b.

The coefficients in these tables were determined by computations similar to those shown in Fig. 3, using the value of C (or C_u[1]) indicated. The authorities for the conductivities used for computing these coefficients are given in Table 4. As in the case of the examples in Fig. 3, the average value of 1.34 given in Table 3 for K_1 was used for all surfaces in still air. The value of K_2 for outside wall and roof surfaces was taken as $3 \times K_1$, or 4.02, corresponding to a wind velocity of approximately 15 miles per hour.

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

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

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

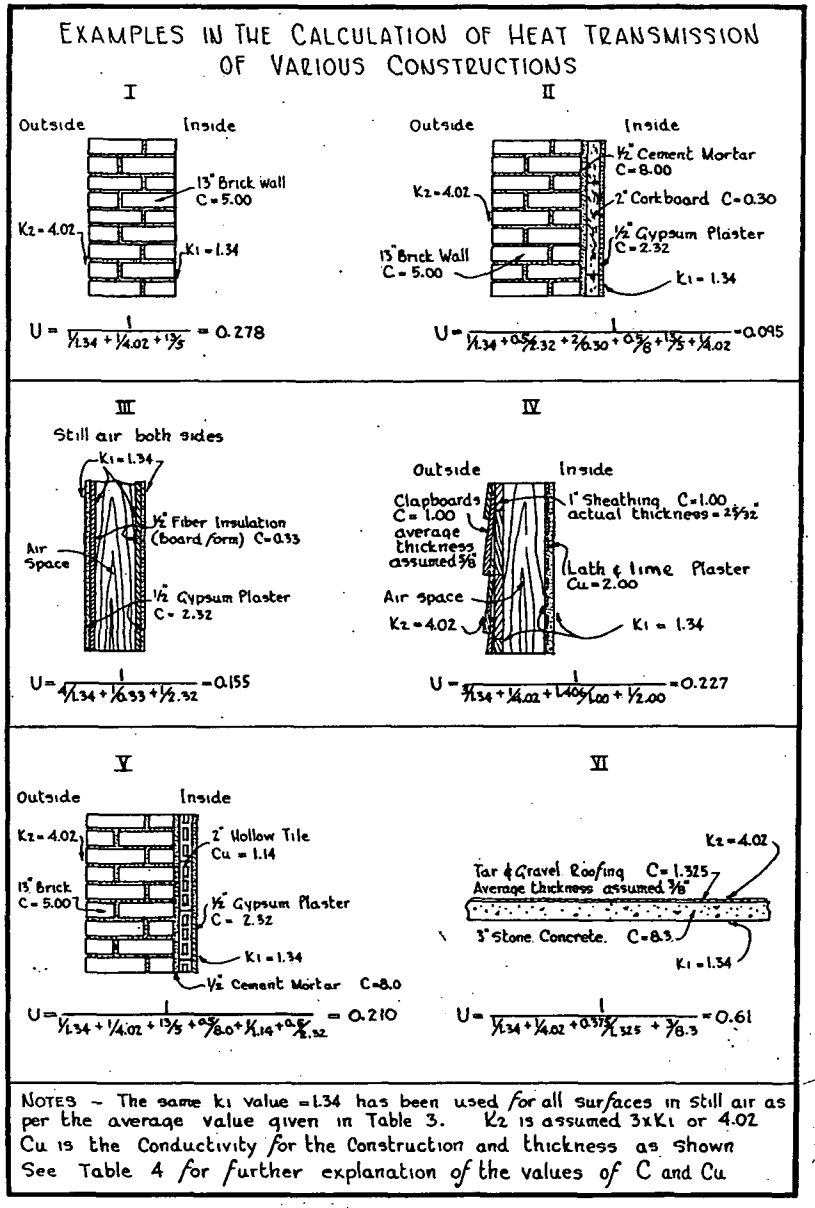


FIG. 3. COMPUTING HEAT TRANSMISSION COEFFICIENTS FOR BUILDING WALLS

mission through the plate. In connection with this plate, it is also necessary to use several other thermocouples to give the temperature of the air within the building temperature of the interior surface of the wall or roof, the temperature of the plate itself, the temperature of the exterior of the wall or roof and the temperature of the exterior air.

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

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

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

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

$$\text{or } U = \frac{1}{\Sigma \left[R_1 + R_s + R_c\right]}$$

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

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

of the internal and surface resistances of the construction. The solution of Example V in Fig. 3, by means of the resistance method is given in the following tabulation:

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

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

The thicknesses upon which the coefficients in Tables 6 to 11, inclusive, are based, are as follows:

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

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

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

The coefficients of transmission of the pitched roofs in Table 11-A apply where the roof is over a heated attic or top floor, such that the heat passes directly through the roof structure including whatever finish,

*Building paper is used because of its value as a wind stop only.

if any, is applied to the underside of the roof rafters. By a heated attic is meant an attic to which heat is supplied directly from the furnace or boiler by means of radiators, hot air registers, or other means.

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

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

where

U_r = Coefficient of transmission of the roof. (From Table 11-A, Pitched Roofs).
U_{ce} = Coefficient of transmission of the ceiling. (From Table 9).
n = The ratio of the area of the roof to the area of the ceiling.

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

$U_r = 0.483$ (Roof No. 238-a, Table 11-A)
$U_{ce} = 0.502$ (Ceiling No. 167-a, Table 9-A)

Substituting these values in the preceding formula:

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

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

Combined coefficients for many common types of pitched roofs and top floor ceilings for unheated attics are given in Table 11-B. If a roof contains two or more dormers and the attic is unheated, it is advisable to disregard the roof structure proper and consider only the top floor ceiling in determining the radiation requirements of the building. In this case it will be necessary to assume the temperature in the attic, which can be taken to be the mean between the temperature under the top floor ceiling (not the attic) and the outside temperature.

AREAS WHERE HEAT LOSSES OCCUR

Heat is lost from a building by transmission through all of those surfaces which separate heated spaces from the outside air or from unheated colder spaces within the building. In general, five kinds of surfaces are involved: (1) outside walls, (2) outside glass, (3) inside walls or parti-

tions next to unheated spaces, (4) ceilings of upper floors, either below a cold attic space or as the underside of a roof slab, and (5) floors of heated rooms above an unheated space. In most cases, only items (1) and (2), outside wall and glass surface, are considered. Failure to take account of the other heat losing surfaces, items (3), (4) and (5), when they exist in a building, has generally resulted in more or less dissatisfaction with the operation of the heating plant, as a result of failure to heat the rooms having such surfaces as indicated by items (3), (4) and (5).

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

CALCULATIONS FOR HEAT TRANSMISSION LOSSES

The calculations for heat transmission losses are made by multiplying the area S in square feet of wall, glass, roof or floor through which the loss takes place, by the proper coefficient U for such construction (Tables 6 to 12, or by computation as described under Transmission Coefficients by Computation) and by the temperature difference between the inside air temperature t at the proper level (in many cases not the "breathing line") and the outside air temperature t_o. Therefore,

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

where

H_t = B.t.u. per hr. transmitted through the material of the wall, glass, roof or floor.

S = area in sq. ft. of wall, glass, roof or floor, taken from building plans or actually measured. (Use the net inside or heated surface dimensions in all cases.)

U = coefficient of heat transmission or B.t.u. per hr. per sq. ft. per 1 deg. fahr. difference between the inside and outside air temperature for air conditions such as exist in the given locality in coldest weather.

$(t - t_o)$ = temperature difference between inside and outside air, in which t must always be taken at the proper level. Note that t may not be the "breathing line" temperature in many cases.

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

TABLE 6-A. COEFFICIENTS OF TRANSMISSION (U) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

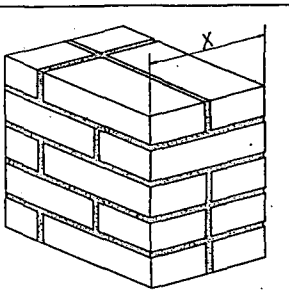
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

SOLID BRICK WALLS †

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

Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Corkboard	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Powdered Gypsum (26#)	0.52	per 1"

Y = Thickness of Insulation where specified



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

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

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

TABLE 6-B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

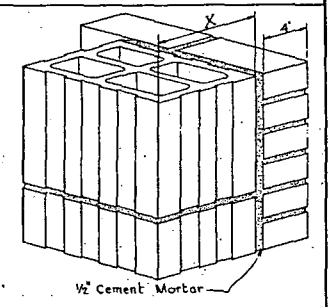
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER ON HOLLOW TILE WALLS

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

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

Y-Thickness of Insulation where specified



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

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

TABLE 6-C. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF MASONRY WALL CONSTRUCTION

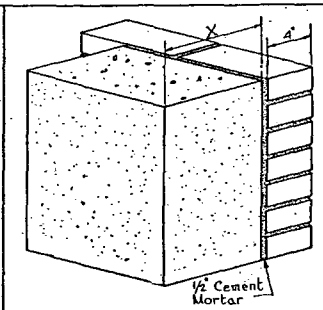
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER ON CONCRETE WALLS

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

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

Y-Thickness of Insulation where specified



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

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

Table 6-D. Coefficients of Transmission (U) of Various Types of Masonry Wall Construction

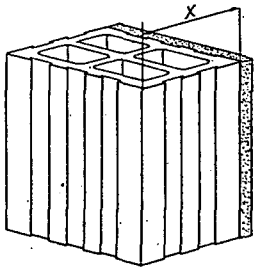
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Hollow Tile Walls with Stucco Exterior Finish †

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

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

Y=Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Hollow Tile - X			
			6"	8"	12"	16"
			a	b	c	d
34	Plain Walls – No Interior Finish		0.320	0.291	0.201	0.153
35	½" Plaster on Hollow Tile		0.299	0.273	0.193	0.149
36	¾" Plaster on Metal Lath – Furred		0.203	0.190	0.147	0.120
37	½" Plaster on Wood Lath – Furred		0.191	0.184	0.144	0.117
38	½" Plaster on ⅜" Plaster Board – Furred		0.202	0.190	0.147	0.120
39	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.157	0.149	0.122	0.102
40	½" Plaster on Wood Lath on 2" Furring Strips – Powdered Gypsum Fill	1⅝"*	0.148	0.142	0.116	0.099
41	½" Plaster on Fiber Insulation – (Board form) Furred	½"	0.158	0.150	0.122	0.103
42		1"	0.127	0.122	0.103	0.089
43	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.119	0.115	0.098	0.085
44		2"	0.099	0.096	0.084	0.074

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

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

Table 6-E. Coefficients of Transmission (U) of Various Types of Masonry Wall Construction

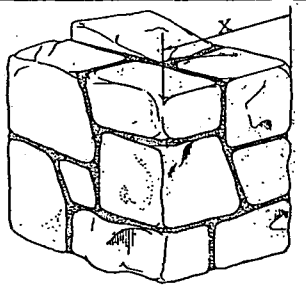
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Limestone or Sandstone Walls

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

Stone	10.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18")	0.59	per 1"
Powdered Gypsum (26")	0.52	per 1"

Y=Thickness of Insulation where specified



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

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

Table 6-F. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

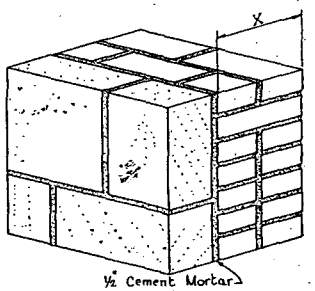
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Brick Walls

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

Stone	10.00	per 1"
Brick	5.00	per 1"
Cement Mortar	8.00	per 1"
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Fiber Insulation (Board/form)	0.33	per 1"
Cellular Gypsum (18")	0.59	per 1"
Powdered Gypsum (26")	0.52	per 1"

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Brick – X			
			9"	13"	18"	24"
			a	b	c	d
56	Plain Walls – No Interior Finish		0.281	0.246	0.198	0.160
57	½" Plaster on Brick		0.280	0.234	0.190	0.155
58	¾" Plaster on Metal Lath – Furred		0.193	0.170	0.146	0.124
59	½" Plaster on Wood Lath – Furred		0.187	0.165	0.142	0.121
60	½" Plaster on ⅜" Plaster Board – Furred		0.193	0.170	0.145	0.164
61	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.151	0.137	0.120	0.105
62	½" Plaster on Wood Lath on 2" Furring Strips – Powdered Gypsum Fill	1⅝"*	0.143	0.130	0.115	0.101
63	½" Plaster on Fiber Insulation – (Board form) Furred	½"	0.152	0.137	0.121	0.105
64		1"	0.124	0.114	0.102	0.091
65	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.116	0.107	0.097	0.087
66		2"	0.097	0.091	0.083	0.076

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

Table 6-G. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

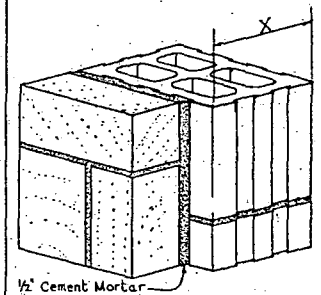
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Hollow Tile Walls

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

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

Y = Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Hollow Tile – X			
			6"	8"	12"	16"
			a	b	c	d
67	Plain Walls – No Interior Finish		0.289	0.265	0.189	0.146
68	½" Plaster on Hollow Tile		0.272	0.250	0.284	0.141
69	¾" Plaster on Metal Lath – Furred		0.190	0.179	0.140	0.115
70	½" Plaster on Wood Lath – Furred		0.183	0.173	0.137	0.113
71	½" Plaster on ⅜" Plaster Board – Furred		0.189	0.178	0.140	0.115
72	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.149	0.142	0.117	0.099
73	½" Plaster on Wood Lath on 2" Furring Strips – Powdered Gypsum Fill	1⅝"*	0.141	0.135	0.112	0.095
74	½" Plaster on Fiber Insulation – (Board form) Furred	½"	0.150	0.143	0.117	0.099
75		1"	0.122	0.117	0.099	0.086
76	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.114	0.110	0.094	0.082
77		2"	0.096	0.093	0.081	0.072

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

Table 6-H. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

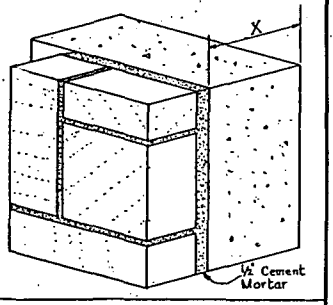
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

4" Cut Stone Veneer on Concrete Walls

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

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

Y-Thickness of Insulation where specified



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

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

Table 6-I. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

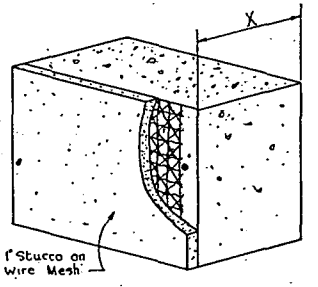
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Concrete Walls with Stucco as Exterior Finish†

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

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

Y-Thickness of Insulation where specified



Wall Number	Interior Construction	Y	Thickness of Concrete - X					
			6"	8"	10"	12"	16"	20"
			a	b	c	d	e	f
89	Plain Walls – No Interior Finish		0.515	0.481	0.431	0.391	0.329	0.284
90	½" Plaster on Concrete		0.465	0.437	0.395	0.361	0.308	0.268
91	¾" Plaster on Metal Lath – Furred		0.267	0.257	0.242	0.229	0.206	0.231
92	½" Plaster on Wood Lath – Furred		0.254	0.246	0.232	0.220	0.199	0.181
93	½" Plaster on ⅜" Plaster Board – Furred		0.265	0.256	0.241	0.228	0.205	0.187
94	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill	1⅝"*	0.193	0.188	0.179	0.172	0.159	0.148
95	½" Plaster on Wood Lath on 2" Furring Strips – Powdered Gypsum Fill	1⅝"*	0.180	0.175	0.168	0.162	0.150	0.140
96	½" Plaster on Fiber Insulation – (Board form) Furred	½"	0.194	0.189	0.180	0.173	0.160	0.148
97		1"	0.150	0.147	0.142	0.137	0.128	0.121
98	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.138	0.136	0.132	0.127	0.120	0.114
99		2"	0.113	0.111	0.108	0.105	0.100	0.096

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.
†The figures on this page may be used with sufficient accuracy for plain concrete walls without stucco.

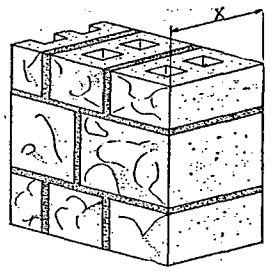
Table 6-J. Coefficients of Transmission (*U*) of Various Types of Masonry Wall Construction

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

Concrete Block Walls †

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

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



Y = Thickness of Insulation where Specified

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

*Based on 1⅝ in., the actual thickness of 2 in. furring strips.
†The figures on this page may be used with sufficient accuracy for concrete block walls with stucco exterior finish.
‡Resistance of hollow concrete blocks = $\left(\frac{1}{c} = \frac{1}{4.84}\right)$ assumed directly proportional to thickness as with solid homogeneous materials.

Table 7-A. Coefficients of Transmission (*U*) of Various Types of Frame Wall Construction

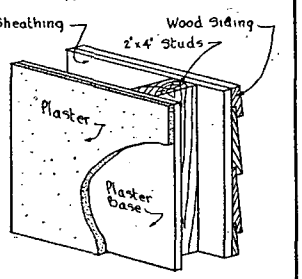
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Wood Siding or Clapboard Walls †

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

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

Typical Construction



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

*Based on ¾ in., the actual thickness of 1 in. or ⅞ in. sheathing.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied on inside of studding with plaster base separated by furring strips.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

Table 7-B. Coefficients of Transmission (*U*) of Various Types of Frame Wall Construction

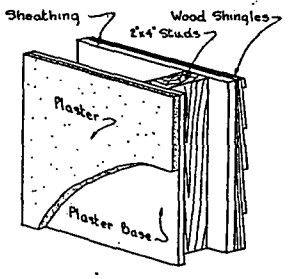
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Wood Shingle Walls **

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

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

Typical Construction



Wall Number	Type of Sheathing	Insulation Between Studding	Plaster Base	Coefficient of Transmission U
122	Wood *	None	Wood Lath	0.228
123	Wood *	½" Felt or Quilt † Insulation	Wood Lath	0.129
124	Wood *	½" Fiber Insulation † (Board form)	Wood Lath	0.135
125	Wood *	Cellular Gypsum Fill ¶	Wood Lath	0.110
126	Wood *	Powdered Gypsum Fill ¶	Wood Lath	0.101
127	Wood *	None	1½" Cork board	0.110
128	Wood *	None	2" Cork board	0.093
129	½" Fiber Insulation † (Board form)	None	½" Fiber Insulation (Board form)	0.127
130	1" Fiber Insulation † (Board form)	None	½" Fiber Insulation (Board form)	0.107
131	½" Fiber Insulation † (Board form)	½" Fiber Insulation † (Board form)	½" Fiber Insulation (Board form)	0.092
132	⅜" Plaster Board ‡	None	⅜" Plaster Board	0.197

*Based on ¾ in., the actual thickness of 1 in. or ⅞ in. sheathing.
**Building paper neglected in computations in accordance with accepted practice.
†Can also be applied on inside of studding with plaster base separated by furring strips.
‡Furring strips between wood shingles and sheathing.
¶Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

Table 7-C. Coefficients of Transmission (*U*) of Various Types of Frame Wall Construction

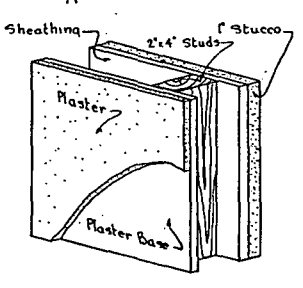
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

Stucco Walls †

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

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

Typical Construction



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

*Based on ¾ in., the actual thickness of 1 in. or ⅞ in. sheathing.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied on inside of studding with plaster base separated by furring strips.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

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

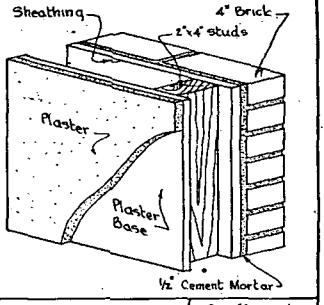
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

BRICK VENEER WALLS

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

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

Typical Construction



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

*Based on ¾ in., the actual thickness of 1 in. or ⅞ in. sheathing.
†Building paper neglected in computations in accordance with accepted practice.
‡Can also be applied to inside of studding with plaster base separated by furring strips.
**Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

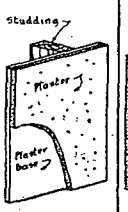
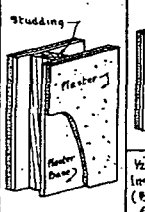
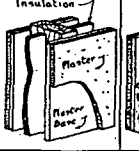
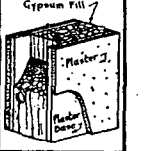
TABLE 8 A AND B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF INTERIOR WALLS AND PARTITIONS

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

PLASTERED FRAME PARTITIONS

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

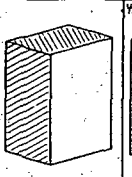
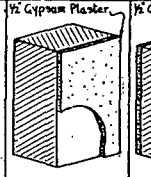
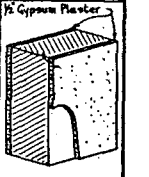
Plaster (Gypsum)	2.32 per 1
Plaster Board	3.04 per 1"
Wood Lath & Plaster	2.00 as appl'd.
Fiber Ins. (Board form)	0.33 per 1"
Felt or Quilt Ins. (Soft)	0.27 per 1"
Cork board	0.30 per 1"
Cellular Gypsum (18*)	0.59 per 1"
Powdered Gypsum (26*)	0.52 per 1"

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

B PLASTERED MASONRY PARTITIONS

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

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

		Plain Walls (No Plaster)	Walls Plastered One Side	Walls Plastered Both Sides
				
Wall No.	Wall Construction	a	b	c
162	4" Hollow Clay Tile	0.33	0.31	0.29
163	4" Brick	0.44	0.40	0.37
164	4" Hollow Gypsum Tile	0.18	0.175	0.17

*The thickness of the Gypsum Fill is approximately 3⅝ in., as this is the approximate 4 in. dimension of 2 in. by 4 in. studding.
†Metal lath and plaster assumed ¾ in. thick.
‡Plaster assumed ½ in. thick.

Table 9-A. Coefficients of Transmission (U) of Various Types of Floors and Ceiling

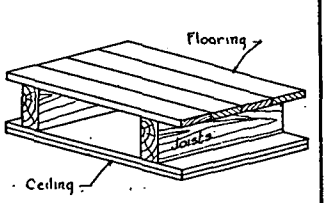
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on still air (no wind) conditions on both sides.

Frame Construction

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

Wood (Yellow Pine or Fir)	1.00	per 1"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Cork board	0.30	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (3oz/ft)	0.27	per 1"
Cellular Gypsum (18")	0.59	per 1"
Powdered Gypsum (26")	0.52	per 1"
Wood (Maple)	1.20	per 1"

Typical Construction



Floor & Ceiling Number	Type of Ceiling	Insulation Between Joists	Type of Flooring: No Flooring	1" Yellow Pine† Flooring on Joists	1" Yellow Pine† Flooring on ½" Fiber Insulation (Board form) on Joists	13/16" Maple or Oak Flooring on 1" Yellow Pine Sub Flooring on Joists
			a	b	c	d
165	No Ceiling	None		0.440	0.264	0.339
166	Metal Lath & Plaster (¾)	None	0.551	0.245	0.179	0.210
167	Wood Lath & Plaster (½)	None	0.502	0.234	0.173	0.202
168	⅜" Plaster Board & Plaster (½")	None	0.546	0.244	0.178	0.209
169	½" Fiber Insulation (Board form) & Plaster (½)	None	0.310	0.181	0.143	0.162
170	Wood Lath & Plaster (½")	½" Felt or Quilt* Insulation (3oz/ft)	0.187	0.131	0.110	0.121
171	Wood Lath & Plaster (½")	½" Fiber Insulation* (Board form)	0.200	0.137	0.114	0.126
172	Wood Lath & Plaster (½")	Cellular Gypsum‡ Fill	0.123	0.112	0.096	0.103
173	Wood Lath & Plaster (1½")	Powdered Gypsum‡ Fill	0.112	0.103	0.089	0.096
174	1½" Cork board & Plaster (½")	None	0.149	0.111	0.095	0.103
175	2" Cork board & Plaster (½")	None	0.119	0.094	0.082	0.088

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

†Based on actual thickness of approximately ¾ in. for 1 in. yellow pine flooring.

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

Table 9-B. Coefficients of Transmission (U) of Various Types of Floors and Ceiling

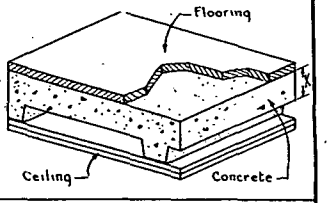
Note.—These coefficients are expressed in B.t.u per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on still air (no wind) conditions on both sides.

Concrete Construction

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

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

Typical Construction



Floor Number	Type of Ceiling	Thickness of X	Type of Flooring: No Flooring (Concrete bare)*	1" Yellow Pine† Flooring on Wood Sleepers embedded in Concrete	13/16" Maple or Oak Flooring on 1" Yellow Pine Sub-Flooring on Wood Sleepers embedded in Concrete	1" Terrazzo or Tile Flooring on Concrete
			a	b	c	d
176	No Ceiling	4"	0.508	0.364	0.292	0.483
177		6"	0.452	0.334	0.273	0.433
178		8"	0.408	0.310	0.256	0.392
179		10"	0.372	0.288	0.241	0.358
180	½" Plaster applied directly to underside of Concrete	4"	0.457	0.337	0.275	0.437
181		6"	0.411	0.311	0.258	0.395
182		8"	0.374	0.290	0.243	0.361
183		10"	0.344	0.271	0.230	0.332
184	Suspended or furred Metal Lath & Plaster Ceiling	4"	0.264	0.219	0.191	0.258
185		6"	0.248	0.208	0.183	0.242
186		8"	0.234	0.198	0.175	0.229
187		10"	0.222	0.189	0.168	0.217
188	Suspended or furred Ceiling of ⅜" Plaster-Board & Plaster	4"	0.263	0.218	0.190	0.256
189		6"	0.247	0.207	0.182	0.241
190		8"	0.234	0.198	0.174	0.228
191		10"	0.221	0.189	0.167	0.216
192	Suspended or furred Ceiling of ½" Fiber Insulation (Board form) & ½" Plaster	4"	0.193	0.167	0.151	0.189
193		6"	0.184	0.161	0.145	0.181
194		8"	0.176	0.155	0.140	0.173
195		10"	0.169	0.149	0.136	0.166
196	½" Plaster on 1½" Cork board set in ½" Cement Mortar on Concrete	4"	0.138	0.124	0.115	0.136
197		6"	0.133	0.121	0.112	0.132
198		8"	0.129	0.117	0.109	0.128
199		10"	0.125	0.114	0.106	0.124
200	½" Plaster on 2" Cork board set in ½" Cement Mortar on Concrete	4"	0.112	0.103	0.097	0.111
201		6"	0.109	0.101	0.094	0.108
202		8"	0.106	0.098	0.092	0.105
203		10"	0.104	0.096	0.090	0.103

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

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

TABLE 9-C. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLOORS AND CEILING

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

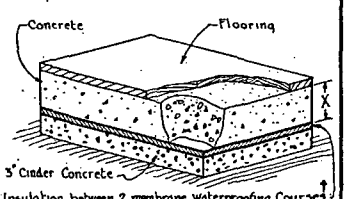
CONCRETE CONSTRUCTION ON GROUND *

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

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

Y = Thickness of Insulation in Inches where specified

Typical Construction



Insulation between 2 membrane Waterproofing Courses †

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

*Assume ground temperature to be 50 deg. fahr.

†Membrane water proofing neglected in calculations.

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

TABLE 10-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING

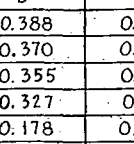
Note.—These coefficients are expressed in B.t.u per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

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

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

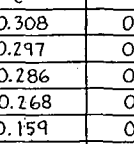
Roofing	1.325 per 1"
Concrete	8.30 per 1"
Gypsum (15% wood fiber)	2.30 per 1"
Wood (Yellow Pine or Fir)	1.00 per 1"
Fiber Insulation (Board form)	0.33 per 1"
Felts & Quilts (Soft)	0.27 per 1"
Cork board	0.30 per 1"
Plaster Board	3.04 per 1"
Cellular Gypsum (24#)	0.77 per 1"

Concrete Roofs



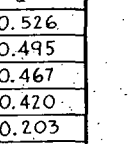
Roof No.	Thickness of Insulation	Kind of Insulation	Thickness - X: 15/8*	2"	3"	4"	5"	6"
			a	b	c	d	e	f
216	0"	No Insulation	0.680	0.658	0.610	0.568	0.532	0.500
217	½"	Fiber Insulation (Board form)	0.334	0.330	0.317	0.306	0.295	0.285
218	1"		0.222	0.220	0.214	0.209	0.203	0.199
219	1½"		0.166	0.165	0.162	0.159	0.156	0.153
220	2"		0.133	0.132	0.130	0.128	0.126	0.124
221	1"	Cork board	0.208	0.206	0.201	0.196	0.192	0.188
222	1½"		0.154	0.153	0.151	0.148	0.145	0.143
223	2"		0.123	0.122	0.120	0.119	0.117	0.115
224	½"	Soft Felt or Quilt (Not Compressed)	0.301	0.297	0.286	0.277	0.268	0.260
225	1"		0.193	0.191	0.187	0.183	0.179	0.175
226	2"	Cellular Gypsum	0.246	0.243	0.236	0.229	0.223	0.217

Wood Roofs



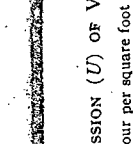
Thickness - X †	1"	1½"	2"	3"	4"
	g	h	i	j	k
	0.485	0.386	0.345	0.256	0.204
	0.280	0.243	0.226	0.184	0.156
	0.196	0.178	0.168	0.144	0.126
	0.151	0.140	0.134	0.118	0.106
	0.123	0.116	0.112	0.100	0.091
	0.185	0.169	0.160	0.138	0.121
	0.142	0.132	0.126	0.124	0.101
	0.114	0.108	0.104	0.095	0.086
	0.256	0.225	0.210	0.174	0.148
	0.174	0.159	0.151	0.131	0.116
	0.214	0.193	0.182	0.154	0.133

Poured Gypsum Containing 15% Wood Fiber



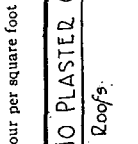
Thickness - X	3"	4"
	m	n
	0.369	0.318
	0.237	0.214
	0.174	0.162
	0.138	0.130
	0.144	0.109
	0.165	0.154
	0.130	0.120
	0.107	0.102
	0.219	0.200
	0.156	0.146

Flat Metal Roofs



o
1.50
0.358
0.232
0.172
0.136
0.217
0.160
0.126
0.319
0.201

Corrugated Iron Roofs



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

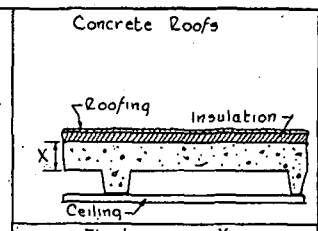
TABLE 10-B. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING

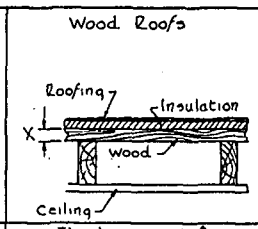
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

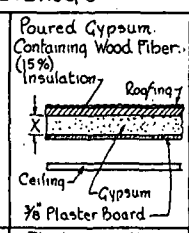
FLAT ROOFS - METAL LATH AND PLASTER CEILINGS.*

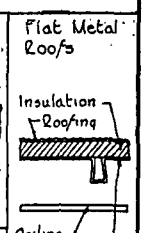
The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Roofing	1.325	per 1"
Concrete	8.30	per 1"
Gypsum (15% Wood fiber)	2.30	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felts & Quilts (Soft)	0.27	per 1"
Cork board	0.30	per 1"
Plaster (Gypsum)	2.32	per 1"
Cellular Gypsum (24#)	0.77	per 1"









Roof No.	Thickness of Insulation	Kind of Insulation	Concrete Roofs — Thickness - X: 1⅜"* a	2" b	3" c	4" d	5" e	6" f	Wood Roofs — Thickness - X†: 1" g	1½" h	2" i	3" j	4" k	Poured Gypsum Containing Wood Fiber (15%) Insulation — Thickness - X: 3" l	4" m	Flat Metal Roofs n
227	0"	No Insulation	0.304	0.300	0.290	0.280	0.271	0.262	0.258	0.227	0.131	0.175	0.149	0.221	0.202	0.324
228	½"	Fiber Insulation (Board form)	0.208	0.215	0.201	0.196	0.192	0.188	0.185	0.169	0.160	0.138	0.121	0.165	0.154	0.217
229	1"		0.158	0.157	0.154	0.145	0.149	0.146	0.145	0.133	0.129	0.114	0.102	0.132	0.125	0.163
230	1½"		0.128	0.127	0.125	0.123	0.121	0.119	0.187	0.112	0.108	0.097	0.089	0.110	0.105	0.131
231	2"		0.107	0.106	0.105	0.104	0.102	0.101	0.101	0.096	0.093	0.085	0.078	0.095	0.091	0.109
232	1"	Cork board	0.151	0.150	0.147	0.145	0.142	0.140	0.138	0.129	0.124	0.110	0.100	0.127	0.120	0.155
233	1½"		0.121	0.120	0.118	0.116	0.115	0.113	0.112	0.106	0.103	0.093	0.085	0.105	0.104	0.123
234	2"		0.100	0.100	0.099	0.098	0.096	0.095	0.095	0.090	0.088	0.081	0.075	0.089	0.086	0.102
235	½"	Soft Felt or Quilt (Not Compressed)	0.194	0.192	0.188	0.184	0.180	0.176	0.174	0.160	0.152	0.132	0.116	0.157	0.147	0.202
236	1"		0.143	0.142	0.139	0.137	0.135	0.133	0.132	0.123	0.118	0.106	0.096	0.121	0.115	0.147
237	2"	Cellular Gypsum	0.170	0.168	0.165	0.162	0.159	0.156	0.154	0.143	0.136	0.120	0.107			

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

TABLE 11-A. COEFFICIENTS OF TRANSMISSION (*U*) OF VARIOUS TYPES OF PITCHED ROOFS

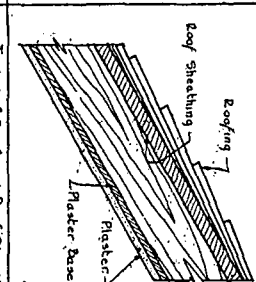
Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

HEATED ATTICS

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

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

Typical Construction



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

*Based on 1 in. by 4 in., spaced 2 in.
†Can also be applied to underside of roof rafters with furring strips between.
‡Assumed 3⅝ in. thick, based on 2 in. by 4 in. rafters.

Table 11-B. Coefficients of Transmission (U) of Various Types of Pitched Roofs

Note.—The figures on this page are the combined coefficients of transmission of pitched roofs, unheated attics, and top floor ceilings, and are expressed in B.t.u. per hour per square foot of roof area per 1 deg. fahr. difference in temperature between the air underneath the ceiling and the outside air. An average exposure of 15 miles has been assumed. These coefficients are based on ⅓ pitched roofs, but are sufficiently accurate for roofs ranging from ¼ pitch to ½ pitch.

Unheated

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

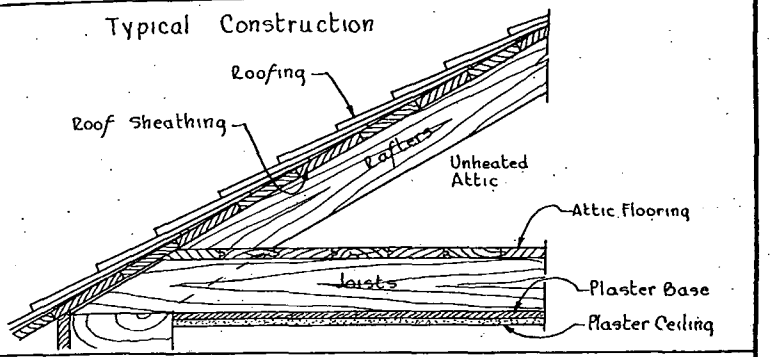
Asphalt or Composition Roofing	6.50	per 1"
Asbestos Shingles	6.00	per 1"
Slate Shingles	10.37	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster Board	3.04	per 1"
Plaster (Gypsum)	2.32	per 1"
Fiber Insulation (Board form)	0.33	per 1"
Felt or Quilt Insulation (Soft)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

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

*Based on 1 in. by 4 in., spaced 2 in.
†Can also be applied to underside of ceiling joists with furring strips between insulation and ceiling.
‡Based on actual thickness of 1 in. lumber of approximately ¾ in.

Attics

Typical Construction



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

*Based on 1 in. by 4 in., spaced 2 in.
†Can also be applied to underside of ceiling joists with furring strips between insulation and ceiling.
‡Based on actual thickness of 1 in. lumber of approximately ¾ in.

TABLE 12. COEFFICIENTS OF TRANSMISSION (U) OF DOORS, WINDOWS AND SKYLIGHTS

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

A. Windows and Skylights

	U
Single	1.13*†
Double	0.45*
Triple	0.281*

*B. Solid Wood Doors***†*

Nominal Thickness Inches	Actual Thickness Inches	U
1	$\frac{21}{32}$	0.563
1¼	$1\frac{1}{16}$	0.485
1½	$1\frac{5}{16}$	0.432
2	$1\frac{5}{8}$	0.382
2½	$2\frac{1}{8}$	0.321
3	$2\frac{5}{8}$	0.277

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

Wind Movement

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

1. Wind movement increases the heat transmission of walls, glass, and roof, affecting poor walls to a much greater extent than good walls.

2. Wind movement materially increases the infiltration (inleakage) of cold air through the cracks around doors and windows, and even through the building materials themselves, if such materials are at all porous.

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

The first condition is readily taken care of as already explained, by using a surface coefficient K_2 for the outside wall surface which is based on the proper wind velocity (Table 5). In case specific data are lacking for any locality, use an average wind velocity of approximately 15 miles per hour. In a similar manner, the heat allowance (Table 14) for infiltration (B.t.u. per hour per foot of crack required to raise the temperature of the air leaking in through one degree) through cracks, must be based on the average wind velocity for a given locality, and is explained in the next subdivision of this chapter.

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

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

INFILTRATION RESULTING FROM WIND MOVEMENT

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

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

where

H_i = B. t.u. per hour required for heating air leaking into building from outside temperature t_0 to breathing line temperature t;
Q = cubic feet of air entering per hour at breathing line temperature, t;
d = density (lb. per cu. ft.) of air at breathing line temperature, t;
t = breathing line temperature;
t_0 = outside air temperature for which heating system is designed;
0.24 = specific heat of air;

The determination of Q, the amount of air leaking in per hour, may be arrived at in either of two ways: (1) by assuming a certain number of air changes per hour for each room, the number of changes assumed (Table 13) being dependent upon the type, use, and location of room, or (2) by computing the infiltration taking place through the cracks around windows and doors in that side of the room which has the greatest number of feet of such crack. In no case should the amount of crack used for computation be less than half of the total crack in the outside walls of the room. Thus, in a room with one exposed wall, take all the crack; with two exposed walls take the wall having the most crack; and with three or four exposed walls take the wall having the most crack, but in no case take less than half the total crack.

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

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

and C. C. Schrader, reported in TRANSACTIONS, A. S. H. AND V. E., Vol. 30, 1924 and Vol. 31, 1925 and others may be conveniently adapted to calculation purposes.

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

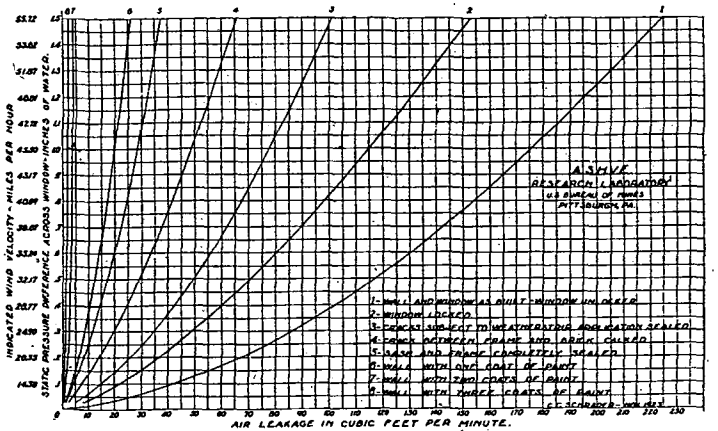


FIG. 4. RESULTS OF TESTS OF LEAKAGE THROUGH VARIOUS PARTS OF WINDOW AND FRAME

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

TABLE 13. AIR CHANGES TAKING PLACE UNDER AVERAGE CONDITIONS EXCLUSIVE OF AIR PROVIDED FOR VENTILATION

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

Table 14 gives the leakage through a 13 in. brick wall, between the frame and the brick, the leakage for a plain window not weather-stripped and the leakage for the same window fitted with a good weather-strip for various wind velocities.

Table 15 gives the leakage in cubic feet per hour per foot of crack per mile wind velocity for a plain frame window and also for a frame window fitted with weather-stripping. The leakage is given for various cracks

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

	Wind Velocity Miles per Hour	Per Sq. Ft. of 13" Brick Wall; Plastered		Per Ft. of Uncalked Crack Around Frame		Per Ft. of Crack Around the Sash Including Meeting Rail					
						Plain Unstripped Wood Window		Weather Stripped Window			
								Average Results		Best Results	
		Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.	Leakage Cu. Ft. per Hour	B.t.u.
PART I	5.0	0.666	0.845	1.76	2.22	49.1	62.5	3.75	4.76	3.27	4.15
	7.5	1.73	2.20	7.95	10.1	78.6	100.0	8.52	10.8	7.20	9.14
	10.0	3.07	3.90	14.1	17.9	106.0	134.0	14.7	18.7	13.1	16.6
	15.0	6.66	8.45	28.3	35.9	155.0	197.0	28.6	36.4	25.6	32.5
	20.0	10.7	13.5	38.8	49.3	201.0	256.0	43.6	55.4	38.6	49.0
	30.0	19.9	25.1	67.1	85.3	291.0	370.0	74.5	94.6	65.5	83.1
	40.0	31.5	40.0	95.0	121.0	386.0	491.0	110.0	139.0	98.2	125.0
Values actually determined by Laboratory tests.	50.0	42.9	54.5	111.0	141.0	498.0	634.0	146.0	186.0	134.0	168.0
PART II	5.0	.532	.676	1.41	1.77	39.3	50.0	3.00	3.80	.....	.....
	7.5	1.38	1.63	6.36	8.08	62.8	80.0	6.82	8.64	.....	.....
Values for practical use; Average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	10.0	2.46	3.12	11.3	14.3	84.9	107.0	11.7	14.9	.....	.....
	15.0	5.33	6.76	22.6	28.7	124.0	157.0	22.9	29.1	.....	.....
	20.0	8.54	10.8	31.1	39.4	161.0	204.0	34.9	44.3	.....	.....
	30.0	16.0	20.5	53.6	68.2	233.0	296.0	59.6	75.6	.....	.....
	40.0	25.2	32.0	76.0	96.5	309.0	392.0	87.8	111.0	.....	.....
	50.0	33.3	43.6	88.9	114.0	390.0	507.0	117.0	149.0	.....	.....

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

VALUES ACTUALLY DETERMINED BY TEST	CRACK	PLAIN WINDOW		WEATHER-STRIPPED WINDOW							
		⅛"–¼"		⅛"		¼"		⅜"		½"	
	Clearance	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.	Leakage	B.t.u.
PART I Best Results	1/32	....	.....	1.32	1.67	1.48	1.87	1.63	2.07	1.79	2.27
	1/16	....	.....	1.56	1.98	1.72	2.18	1.88	2.39	2.05	2.59
	3/32	....	.....	1.67	2.11	1.83	2.32	2.00	2.54	2.17	2.75
	1/8	....	.....	1.71	2.17	1.89	2.39	2.06	2.62	2.24	2.84
	5/16	....	.....	1.74	2.20	1.94	2.45	2.13	2.70	2.33	2.95
	1/4	....	.....	1.75	2.22	1.96	2.48	2.17	2.75	2.38	3.02
PART II Average Results	1/32	4.3	5.45	1.85	2.30	1.99	2.42	2.21	2.81	2.56	3.25
	1/16	6.6	8.36	2.04	2.58	2.21	2.70	2.46	3.12	2.80	3.55
	3/32	8.9	11.9	2.15	2.72	2.33	2.84	2.58	3.28	2.94	3.72
	1/8	11.2	14.2	2.19	2.78	2.39	2.91	2.66	3.37	3.04	3.84
	5/16	15.7	19.9	2.23	2.82	2.44	2.97	2.74	3.47	3.15	3.99
	1/4	20.2	25.6	2.24	2.84	2.47	3.00	2.79	3.53	3.24	4.10
PART III Values for practical use; Average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	1/32	3.4	4.36	1.48	1.84	1.60	1.93	1.76	2.24	2.04	2.60
	1/16	5.2	6.68	1.63	2.06	1.76	2.16	1.96	2.49	2.24	2.84
	3/32	7.1	9.5	1.72	2.17	1.86	2.27	2.06	2.62	2.35	2.97
	1/8	8.9	11.3	1.75	2.22	1.91	2.32	2.12	2.69	2.43	3.07
	5/16	12.5	15.9	1.78	2.25	1.95	2.37	2.19	2.77	2.52	3.19
	1/4	16.1	20.4	1.79	2.27	1.97	2.40	2.23	2.82	2.59	3.28

around the sash perimeter and also for various clearances (Fig. 5) between the sash and the stop and parting bead.

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

Table 15 gives the leakage per mile wind velocity. This is based on the assumption that the leakage is proportional to the wind velocity, while this is practically true for a non weather-stripped window it is not so accurate for a weather-stripped window as indicated by the value for

FIG. 5. DIAGRAM ILLUSTRATING CRACK AND CLEARANCE

different velocities in Table 14. This accounts for the discrepancies in certain parts of the two tables. The two tables are, however, practically in agreement for a thirty mile wind velocity.

According to the authors of the paper: "The values given in the table are from the tests as made and are probably somewhat higher than those actually found in practice. They represent the leakage when the pressure drop through the window is a certain value which represents a definite wind velocity at right angles to the window. If the wind strikes the window at an oblique angle the component of the velocity at right angles to the window must be considered. Pressure difference between the outside and the inside surfaces of the window for an actual wind will be slightly less for a given velocity because of a building up of pressure within the room before the air leaks out the opposite side of the building. Attention is called to the fact that air leaks in on the windward side of the building and out on the leeward side and, since wind will blow from various directions at different times, heating for any room having only

one exposure must be based on the maximum loss. The heating plant, however, need not be figured on the sum of all maximum leakages, but in general only half of the total. However, the table gives accurate comparative figures which are probably not much too high for actual practice. In order to apply these values, a further study of the overall results as found in practice should be made, and the figures modified, if necessary, to fit practical conditions."

In their discussion of results as presented in the 1924 report of the TRANSACTIONS, the authors state:

"The principal facts brought out in the first report were that increasing the crack around the perimeter of a plain sash did not materially increase

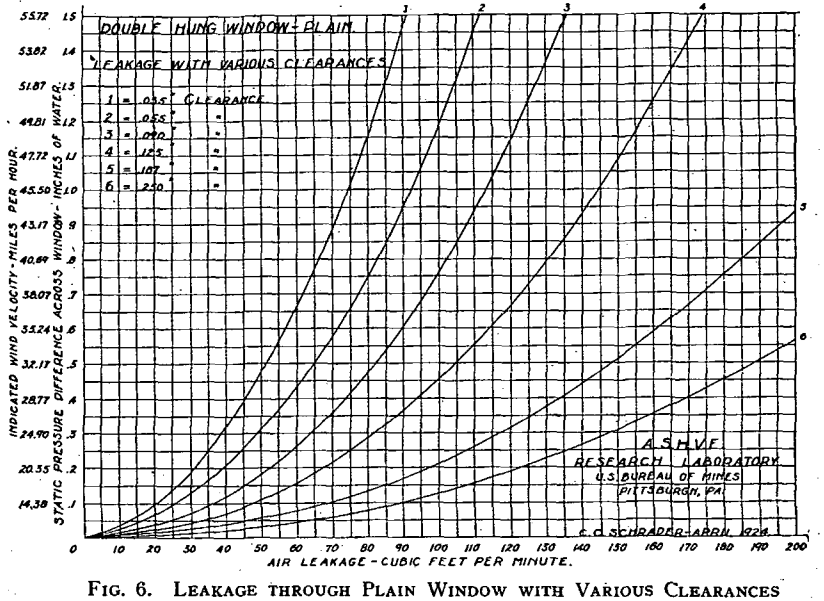


FIG. 6. LEAKAGE THROUGH PLAIN WINDOW WITH VARIOUS CLEARANCES

the leakage, and that weather-stripped sash, while permitting much less leakage, showed a small increase in leakage with increase in crack. These facts were established by making several hundred tests. The present report deals with the effect of increasing the width of the stile, that is, increasing the clearance.

"Fig. 5 illustrates what is meant by crack and clearance. The crack around the sash perimeter is equal to one half the difference between the width of the frame and the width of the sash, that is, the crack is the same on each side of the sash. The clearance is the difference between the width of the stile and the thickness of the sash. These terms are chosen arbitrarily to distinguish the two principal air passages which are found in double hung windows, and they will be used frequently throughout the report and should not be confused.

"Four sets of sash were fitted with cracks of 1/16, 1/8, 3/16 and 1/4 in.

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

"Fig. 6 gives the results of tests on a plain window with various clearances. The tests proved that the size of the crack around the perimeter of the sash has no appreciable effect on the leakage. Therefore the results apply to any window of the type tested with a crack of from 1/16 to 1/4 in. In practice most new sashes are fitted with the crack at least 1/16 in., and this crack becomes greater as the sash dries out and shrinks. It should be clearly understood that each curve is the average obtained from a number of tests, and the results of any one test may vary from the given curve by four or five per cent. The figure shows that the leakage increases rapidly with increase in clearance."

Calculations for Infiltrations

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

First, determine the average wind movement in miles per hour for the locality in question (Table 2);

Second, determine the inleakage of outside air per lineal foot of the given window or door crack in cubic feet per minute at the given wind velocity, Table 14 or 15;

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

Thus, for a plain window having 1/16 in. *crack* and 7/64 in. *clearance* (see Fig. 5), which means the air channel around the edge of the sash is approximately 1/16 in. wide, the heat equivalent of the air leaking in for a 0–70 deg. fahr. temperature difference is 157 B.t.u. per foot of crack per hour (Table 14, Part II). This value is found in the seventh column of the table. The computation for obtaining 157 is:

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

where

124 = cubic feet of air per foot of crack per hour for a 15 mi. wind for 7/64 in. clearance from the 6th column of Table 14.
0.075 = air density at 70 deg. fahr., pound per cubic foot.
0.24 = specific heat of air, and
70 = difference in temperature between inside and outside air.

The most convenient values for use in infiltration calculations are the coefficients of infiltration for the particular kind of crackage with a wind velocity of 15 miles per hour under average conditions, with 1/16 in. *crack* and 7/64 in. *clearance* reduced by 20 per cent (Table 14, Part II).

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

(1) Plain unstripped window:

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

(2) Weather-stripped window:

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

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

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

HEAT SOURCES

Heat Available from Sources other than Heating Plant

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

TABLE 16. HEAT GIVEN UP BY PERSONS AND LIGHTS

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

*For more detailed information see Table 17, Heat Emitted by Persons per Hour at Different Room Temperatures.

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

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

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

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

TABLE 17. HEAT EMITTED BY PERSONS PER HOUR AT DIFFERENT ROOM TEMPERATURES

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

$H = 13.2\ (98.6 - T)$ Heat due labor $= \frac{T \times HE}{100}$

Hl, Ha, or $Hh = 13.2\ (98.6 - T)$ plus $\frac{T \times HE}{100}$

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

*For children use one-half of table values.

Application to Factory Heating* (See Fig. 7)

Lowest outside temperature for Philadelphia, Pa. = −6 deg. fahr. (Table 2), hence use (−6 + 10) = +4 for heat loss computations. Average wind movement (Table 2) for December, January, February = 11.0 miles per hour from the Northwest. Long axis of building is north and south.

Inside breathing line temperature = 60 deg. fahr.

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

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

*In this example a design temperature only 10 deg. fahr. above lowest on record instead of 15 deg. fahr. above was used. Infiltration values were taken from Table 14 for a plain window.

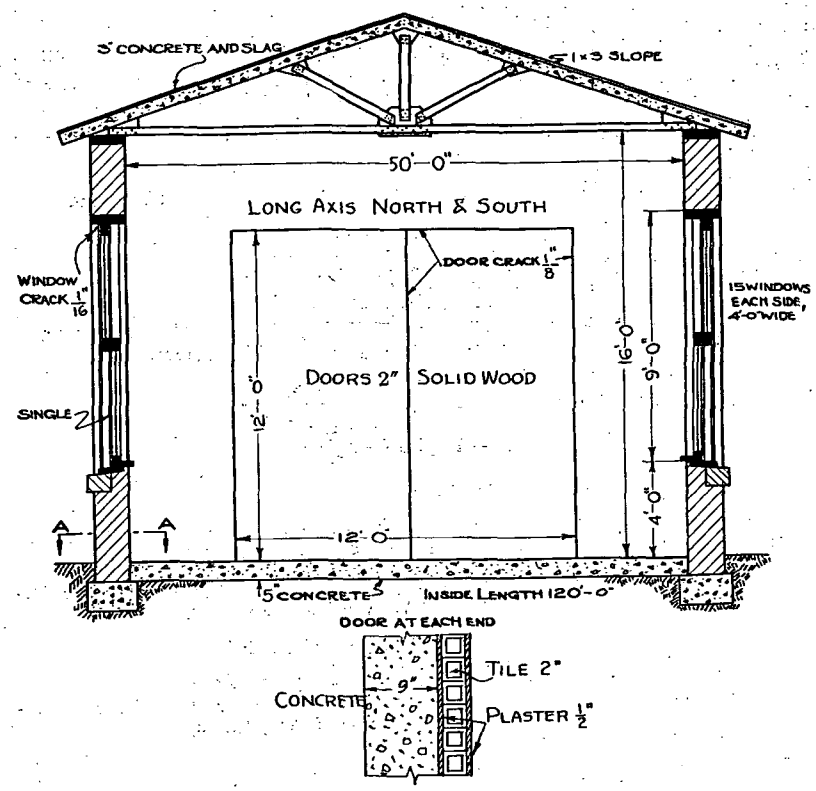


FIG. 7. ELEVATION OF FACTORY BUILDING

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

$= 0.304$

The air temperature at the mean height of inside walls is greater than at breathing line. Mean height of walls is $16 \div 2 = 8$ ft., which $8 - 5 = 3$ ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or $2 \times 3 = 6$ per cent, makes the mean air temperature $1.06 \times 60 = 63.4$ deg. fahr. The triangular areas in the end wall are practically at the mean height of the roof at which level the air temperature is 78 deg. fahr.

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

$U = 0.610$ (Roof No. 216-c, Table 10-A)

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

Floor: The 5 in. concrete floor is laid on the ground, and hence there is only one surface coefficient $K_1 = 1.34$ = Average for surface in still air (Table 3)

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

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

Windows and Doors: Wood sash and doors with single thickness of glass. Take coefficient U for glass as 1.13 B.t.u. per sq. ft. per degree per hour for heat transmission (Table 12-A). Doors are solid wood 2 in. thick and coefficient $U = 0.382$ B.t.u. per sq. ft. per degree per hour (Table 12-B).

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

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

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

CALCULATION SHEET
Entire Building
(See Fig. 7)

Building Material	Exposure	Width in Ft.	Height in Ft.	Area Sq. Ft. or Lin. Ft.	Coeffic. Trans. and Infilt.	Temp. Diff.	Net B.t.u.	Exposure Factor	Total B.t.u.
Concrete and Tile	N	½ × 50	8½	213	0.304	74.0	4,800	1.15	5,520
	N	50	16	656	0.304	59.4	11,850	1.15	13,630
Doors (2 in. wood)	N	12	12	144	0.382	56	3,080	1.15	3,550
⅛ in. Crack	N	1 pair doors		60	3.36	56	11,300	½* × 1.15	6,500
									29,200
Concrete and Tile	W	120	16	1380	0.304	59.4	24,950	1.15	28,700
Glass (Single)	W	15 × 4	9	540	1.13	59.4	36,200	1.15	41,600
⅛ in. Crack	W	Double Hung Windows (15)		450	1.68	59.4	44,900	½* × 1.15	25,800
									96,100
South Wall	Same as N	See above		.....	.....	.....	.....	½*	25,380
East Wall	Same as W	See above		.....	.....	.....	.....	½*	83,600
Roof, 3 in. Concrete and slag-surfaced built-up roofing	No Ceiling	52.5	120	6300	0.610	74	285,000	None	285,000
Floor, 5 in. Stone Concrete	On Dirt	50	120	6000	0.745	5	22,350	None	22,350
Grand total of heat required for building in B.t.u. per hour at + 4° with 11-mile Southwest wind									541,630

**Notes.*—(1) This building has no partitions and whatever air enters through the cracks on the windward side must leave through the cracks on the leeward side. Therefore, only one-half of the total crack will be used in computing infiltration for each side and each end of building.

(2) An exposure allowance of 15 per cent is also to be added to the wall and glass transmission losses and to the infiltration losses on the two adjacent sides of the building most nearly facing the prevailing wind as stated in last paragraph on page 44.

(3) It is also possible to compute the heat required to take care of infiltration on the basis of ½ of an air change per hour as given in Table 13 for a factory with minimum conditions. Volume = 50 × 120 × 20 (mean height) = 120,000 cu. ft. and heat required per hour is

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

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

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

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

CHAPTER II.

HEATING BY RADIATION

THE device used to transmit heat from the carrying medium to the air or surrounding space with either steam or hot water heating is called a radiator or is generally spoken of as radiation.

Radiation is divided into four general classes depending upon how it is used, namely, direct, semi-indirect, indirect and direct-indirect. If the radiator is placed within a room to be heated, and imparts its heat directly by radiation and convection to the objects and air to be heated, it is called a direct radiator. If it is placed outside of, and some distance away from the space to be heated and imparts heat to air passing over it which is then delivered to the space to be heated, it is called indirect radiation. If the radiator is placed within or immediately adjoining the room to be heated, but is hidden from view by an enclosure or otherwise, so that it only imparts heat to the air within the enclosure, which is then admitted to the room, it is called semi-indirect radiation. When air from outside flows over the heating element and then enters the room the heat is supplied by direct-indirect radiation.

Until the last few years all four types of radiation were made in a comparatively small number of fairly well standardized types and sizes and shapes. During the past few years, however, a great change has taken place in design of radiation and there are now innumerable types and sizes in use, and the number is rapidly increasing. This evolution is taking place faster than engineering data can be developed and made available for use by the engineer.

All four types of radiation may be made of pipe in which case, it is spoken of as pipe-coil. Until the past few years, most radiation was made of pipe, cast iron or pressed steel. More recently, however, an ever-increasing amount of non-ferrous metal radiation has been made, in various forms both with and without extended surface. Each of the various types has its own advantages for different forms of space heating depending upon the architectural beauty, weight, size and durability.

Direct cast iron radiators were until recently, standardized as column, window, and wall radiation for which accepted heat transmission constants are available. The so-called art or tubular type of direct cast iron radiation of more recent design which has in a large measure replaced the column type in popularity is not well standardized as regards height, width, number of tubes per section or spacing of sections, and as a result generally accepted heat-emission constants are not available. This is likewise true of the many types of semi-indirect radiation now in use.

As a result of this great diversity of design and lack of engineering data, a chaotic condition is rapidly developing which must be met by

Compiled especially for THE GUIDE from data supplied by R. V. Frost, Norristown, Pa., C. E. Bronson, Kewanee, Ill., and F. C. Houghten, Pittsburgh, Pa.

standardization of design and method of tests for rating. Already this need has been partially met by a Radiator Test Code recently adopted by the Society.

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

Heating effect or heating efficiency has recently become recognized as an important factor in heating by radiation. It has been shown by Brabbée, Frost, and others, that two radiators of different design may warm a given space to a comfortable temperature by condensing different amounts of steam or by emitting different amounts of heat. This variation in heating efficiency depends upon whether the radiator warms the lower part of the room where the occupants are while sending more or less heat to the ceiling. Heating efficiency may depend upon a number of factors including the size, height, and shape of the radiator, the relative amount of heat it emits by radiation and convection, whether or not it is in an inclosure, and its location in, and the size and shape of, the room being heated.

HEAT EMISSION OF RADIATORS

Tables 1 to 7 give the heat emitted by cast iron radiators of the column, wall, and window type, of various standard heights and numbers of columns when using steam at 215 deg. fahr. in a 70 deg. fahr. room. In the last three lines of each table the heat emitted in B.t.u. per intermediate section, and the B.t.u. emitted per rated square foot of intermediate and end sections are given.

Table 8 gives conversion factors for determining the heat emission of any radiator with steam or water at temperatures other than 215 deg. fahr. and with room temperatures other than 70 deg. fahr., when the emission for 215 deg. fahr. and 70 deg. fahr. are known.

Tables 9 to 11 give the heat emitted by cast iron, column, wall, and window radiators of various standard heights and numbers of sections for hot water heating with mean water temperature of 170 deg. fahr. and room temperature of 70 deg. fahr.

The tables were computed from data given in a report[1] of the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, resulting from experiments by John R. Allen and F. B. Rowley.

For reasons mentioned it is not possible at this time to give data on heat-emission for tubular or art radiation or for other types of direct and semi-indirect radiation on the market.

Tables 12 and 13 give the heat emission of various standard types of coil radiation for steam and hot water heating respectively.

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

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TABLE 1. HEAT EMITTED BY DIRECT RADIATION—SINGLE-COLUMN RADIATORS

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

Length Inches	No. of Sections	38 In.		32 In.		26 In.		23 In.		20 In.	
		Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
	1	3	1125	2.5	952	2	770	1.66	654	1.5	593
5	2	6	1849	5.0	1589	4	1293	3.33	1112	3.0	982
	3	9	2578	7.5	2217	6	1807	5.00	1555	4.5	1377
10	4	12	3307	10.0	2845	8	2321	6.66	1997	6.0	1772
	5	15	4035	12.5	3471	10	2835	8.33	2440	7.5	2168
15	6	18	4765	15.0	4098	12	3348	10.00	2882	9.0	2562
	7	21	5494	17.5	4725	14	3863	11.66	3324	10.5	2957
20	8	24	6223	20.0	5354	16	4377	13.33	3767	12.0	3353
	9	27	6950	22.5	5982	18	4891	15.00	4209	13.5	3748
25	10	30	7680	25.0	6610	20	5404	16.66	4652	15.0	4143
	11	33	8408	27.5	7236	22	5918	18.33	5095	16.5	4538
30	12	36	9137	30.0	7863	24	6432	20.00	5538	18.0	4932
	13	39	9867	32.5	8489	26	6947	21.66	5980	19.5	5327
35	14	42	10594	35.0	9117	28	7459	23.33	6422	21.0	5723
	15	45	11322	37.5	9744	30	7974	25.00	6865	22.5	6118
40	16	48	12053	40.0	10372	32	8489	26.66	7309	24.0	6514
	17	51	12781	42.5	10999	34	9000	28.33	7752	25.5	6908
45	18	54	13511	45.0	11624	36	9515	30.00	8193	27.0	7304
	19	57	14239	47.5	12250	38	10028	31.66	8635	28.5	7698
50	20	60	14964	50.0	12875	40	10544	33.33	9080	30.0	8094
B.t.u. per Intermed. Section			728	....	626	..	514	.....	443	....	395
" " Sq. Ft. " "			243	....	250	..	257	.....	266	....	263
" " " End Surface			375	....	380	..	385	.....	394	....	395

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Table 2. Heat Emitted by Direct Radiation—Two-Column Radiators

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

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

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Table 3. Heat Emitted by Direct Radiation—Three-Column Radiators

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

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

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Table 4. Heat Emitted by Direct Radiation—Four-Column Radiators

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

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

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Table 5. Heat Emitted by Direct Radiation—Hospital Radiators—Two Column

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

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

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Table 6. Heat Emitted by Direct Radiation—Wall Radiators

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

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

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Table 7. Heat Emitted by Direct Radiation—Window Radiators

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

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

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TABLE 8. HEAT EMITTED BY DIRECT RADIATION—CONVERSION FACTORS

PRESSURE		TEMP. OF STEAM IN DEG. FAHR.	TEMPERATURE OF ROOM IN DEG. FAHR.					
Vacuum In. Hg.	Lb. Absolute		80 deg. fahr.	75 deg. fahr.	70 deg. fahr.	65 deg. fahr.	60 deg. fahr.	50 deg. fahr.
23.4	3.71	150	2.188	2.053	1.934	1.828	1.733	1.572
19.7	4.75	160	1.898	1.795	1.701	1.621	1.546	1.412
15.3	5.99	170	1.669	1.590	1.517	1.451	1.391	1.285
12.3	7.51	180	1.488	1.425	1.364	1.311	1.261	1.175
8.7	9.33	190	1.339	1.287	1.239	1.195	1.155	1.081
6.5	11.52	200	1.215	1.172	1.135	1.095	1.060	0.999
LB. GAGE								
1	15.7	215	1.064	1.029	1.000	0.971	0.943	0.894
2	16.8	219	1.030	1.000	0.970	0.941	0.915	0.870
3	17.8	222	1.004	0.976	0.947	0.921	0.897	0.851
4	18.9	225	0.982	0.954	0.929	0.902	0.878	0.835
5	19.6	227	0.964	0.936	0.909	0.887	0.864	0.822
6	20.8	230	0.943	0.917	0.892	0.869	0.847	0.806
8	22.8	235	0.907	0.883	0.860	0.839	0.818	0.781
10	24.9	240	0.875	0.853	0.831	0.810	0.791	0.756

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

TABLE 9. HEAT EMISSION OF DIRECT CAST IRON RADIATION FOR HOT WATER—SINGLE COLUMN RADIATORS

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

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

TABLE 10. HEAT EMISSION OF DIRECT CAST IRON RADIATION FOR HOT WATER—THREE-COLUMN RADIATORS

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

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

TABLE 11. HEAT EMISSION OF DIRECT CAST IRON RADIATION FOR HOT WATER HOSPITAL RADIATORS—TWO-COLUMN

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

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

TABLE 12. HEAT EMISSION OF DIRECT PIPE COIL RADIATION FOR STEAM

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

WALL COILS—Coils Placed Vertical—Pipes Horizontal

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

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

WALL COILS—Coils Placed Vertical—Pipes Vertical

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

CEILING COILS—Coils Placed Horizontal—Pipes Horizontal

Emission is equal to that of a single row coil.

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

In this case use 167 B.t.u. per lineal ft. of pipe for 1 in. coils.
206 " " " " " " " 1¼ in. coils.
231 " " " " " " " 1½ in. coils.

Note.—This Table has been developed by a method of deduction from the available data on such experimental work on pipe coils as has been recorded, and does not represent definite results of tests as in Tables 17 to 30. The values are therefore approximate only but can be used with assurance that they are more accurate than those obtained by the usual method for calculating pipe coil surface.

TABLE 13. HEAT EMISSION OF DIRECT PIPE COIL RADIATION FOR HOT-WATER

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

WALL COILS—Coils Placed Vertical—Pipes Horizontal

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

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

WALL COILS—Coils Placed Vertical—Pipes Vertical

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

CEILING COILS—Coils Placed Horizontal—Pipes Horizontal

Emission is equal to that of a single row coil.

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

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

Note.—See note under Ceiling Coils for Steam.

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. 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 Tables 1 and 13. 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.

To determine the amount of radiation required for heating a given room, calculate first the total heat loss from the room as outlined in Chapter I, making proper allowance for exposure, wind velocity, height of ceiling, etc. Next decide upon the type (design, height, width, etc.) and number of radiators to be used. Then find in Tables 1 to 11 or from manufacturers' data the number of sections necessary in each radiator.

Example.—The heat loss from a given room calculated in accordance with Chapter I is estimated to be 14,216 B.t.u. per hour. How many sections are required in a three-column 38 in. radiator for heating this room?

Solution.—Table 3, column for 38 in. indicates that 12 sections will emit 13,530 B.t.u. and that 13 sections will emit 14,587 B.t.u. Therefore a 13-section radiator is required.

Example.—How many sections are required in a three-column 38 in. radiator to heat a room having a heat loss of 24,986 B.t.u. per hour?

Solution.—From Table 3, column for 38 in. find 21,990 B.t.u. as the heat loss for a 20-section radiator and 1057 as the heat loss per additional intermediate section.

$20 + \frac{24{,}986 - 21{,}990}{1057}$ or 23 are the required number of sections.

Example.—How many sections of 22 in. wall radiation are required to heat a room to 50 deg. with hot water at a mean temperature of 160 deg. fahr. The calculated heat loss from the room is 10,400.

Solution.—Conversion factor for water at 160 deg. and air at 50 deg. is 1.412. $10{,}400 \times 1.412 = 14{,}685$. Table 6, column for 22 in. indicates 8 as the number of sections necessary.

To determine the amount of semi-indirect radiation to heat a room, calculate the heat loss as in Chapter I, adding the proper amount for exposure, etc. Then add the required 40 per cent as shown in Cases *1* to *6* (on p. 77) and refer to Tables 1 to 13 to find the proper size radiator.

Example.—How many sections are required in a 45 in. three-column semi-indirect radiator installed according to Case *5* (p. 77) to heat a room whose heat loss is calculated to be 17,200 B.t.u.?

Solution.—17,200 ÷ 70 per cent = 24,500 B.t.u. Table 3, column for 45 in. indicated 19, as the required number of sections.

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

RADIATION FOR ROOM TEMPERATURES

The following table from the Establishment of Standard Methods of Proportioning Direct Radiation, by James A. Donnelly (TRANSACTIONS, Vol. 21, p. 535) gives the proportionate heat losses from buildings, the

TABLE 14. EFFECT OF ROOM TEMPERATURE ON HEAT LOSS AND SIZE OF RADIATOR

Room Temperature	Proportionate Loss in B.t.u.	Difference in Temperature Between Radiator and Room	Proportionate Transmission in B.t.u.	Room Temperature	Proportionate Surface Required Sq. Ft.
35	0.50	175	1.34	35	0.37
40	0.57	170	1.29	40	0.44
45	0.64	165	1.24	45	0.52
50	0.71	160	1.19	50	0.60
55	0.79	155	1.14	55	0.69
60	0.86	150	1.09	60	0.78
65	0.93	145	1.05	65	0.89
70†	1.00†	140†	1.00†	70†	1.00†
75	1.07	135	0.95	75	1.12
80	1.14	130	0.91	80	1.26
85	1.21	125	0.87	85	1.40
90	1.29	120	0.82	90	1.56
95	1.36	115	0.78	95	1.74
100	1.43	110	0.74	100	1.93
105	1.50	105	0.70	105	2.15
110	1.57	100	0.66	110	2.39
115	1.64	95	0.62	115	2.66
120	1.71	90	0.58	120	2.95

† Standard Conditions.

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

Assuming that the rate of transmission from a direct radiator to the air of a building is in proportion to their difference in temperature, with a variation in the rate of transmission of 2 per cent, greater or less, for each 10 deg. increase or decrease in their temperature difference, and considering 140 deg. difference in temperature (steam 210 deg., building 70 deg.) as standard, or 100 per cent transmission, the second column shows the proportionate transmission when the difference in temperature is as given in the first column.

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

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

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.

The preceding table may be used to find the proportionate amount of radiation necessary to heat a room to any desired inside temperature, other than 70 deg., when the outside minimum temperature is other than zero, and with a radiator temperature other than standard. Find the difference between the outside temperature and the room temperature in the first column; divide the proportionate heat loss opposite this amount, in the second column, by the proportionate transmission opposite the difference in temperature between the radiator and the room, as given in the fourth column, and the result will be the proportionate amount of radiation required.

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

Solution.—The difference in temperature between 20 deg. below outside, and 90 deg. inside, is 110 deg. Opposite 110, the proportionate heat loss or 1.57 is found in the second column. The difference in temperature between the radiator and the room (steam 240 deg., room 90 deg.) is 150 deg. Opposite this, the proportionate transmission 1.09 is found in the fourth column. Divide 1.57 by 1.09 and the quotient, 1.44 is the proportionate amount of radiation required.

EFFECT OF HUMIDITY

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

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

EFFECT OF AIR CIRCULATION

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

WARMING THE RADIATOR

It is often very important to know the maximum condensation that occurs in a radiator when steam is turned on. Fig. 2 shows the condensation rate in pounds per

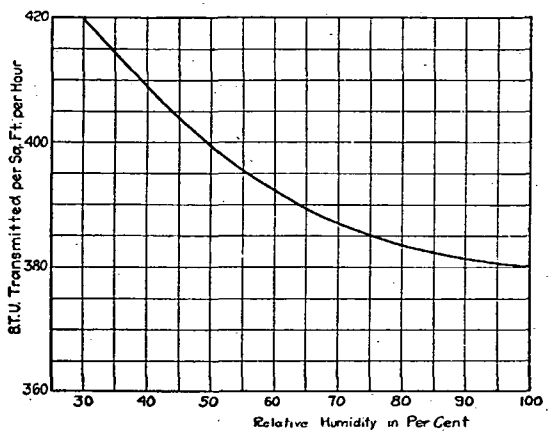


FIG. 1. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

hour for the time elapsing after steam is turned into the radiator. It will be noticed that the maximum condensation in the radiator occurs 10 min. after steam is turned on, and in that case it amounts to about three and one-half times normal condensation. After the end of 25 min., the radiator 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 when a plant is initially started up and the system filled with steam during a short period of time the demand made upon the boiler may be very much higher than the normal demand. In practice the rate of steam supply to the radiator while heating up is however, frequently retarded by controlled elimination of air through air valves or traps and if sufficient time is allowed for the heating up process, overload on the boiler may be practically eliminated.

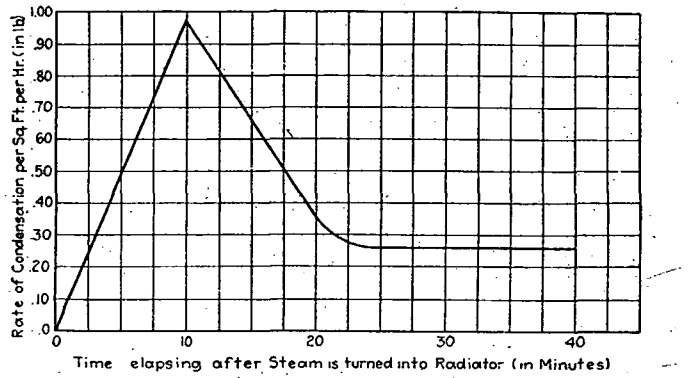


FIG. 2. CHART SHOWS DEMAND UPON BOILER FOR HEATING-UP

EFFECT OF PAINTING

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

Table 15 shows the effect of painting an experimental cast iron box of rectangular shape. *It should be noted that in this case all the surface emitted heat by direct radiation.* Column radiation having a larger ratio of convecting surface to radiating surface would show less effect due to painting.

TABLE 15. EFFECT OF PAINTING A RECTANGULAR RADIATOR

PERCENTAGE OF EFFECTIVENESS

Based on Values in Tables as 100 per cent

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

The effects of painting a six-section 32 in. three-column radiator as found by Wm. H. Severns are given in Table 16.

TABLE 16. EFFECT OF PAINTING 32 IN. THREE-COLUMN, 6-SECTION CAST IRON RADIATORS[1]

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

It is generally assumed that an enclosed radiator shows a decreased heat emission. This is borne out by results recently published by Kratz and Fahnestock, Table 17[2]. This data indicates that the heat emission from the enclosed radiator equals or exceeds that of an exposed radiator only in the case where the enclosure is much higher than the radiator so as to produce a pronounced chimney effect.

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

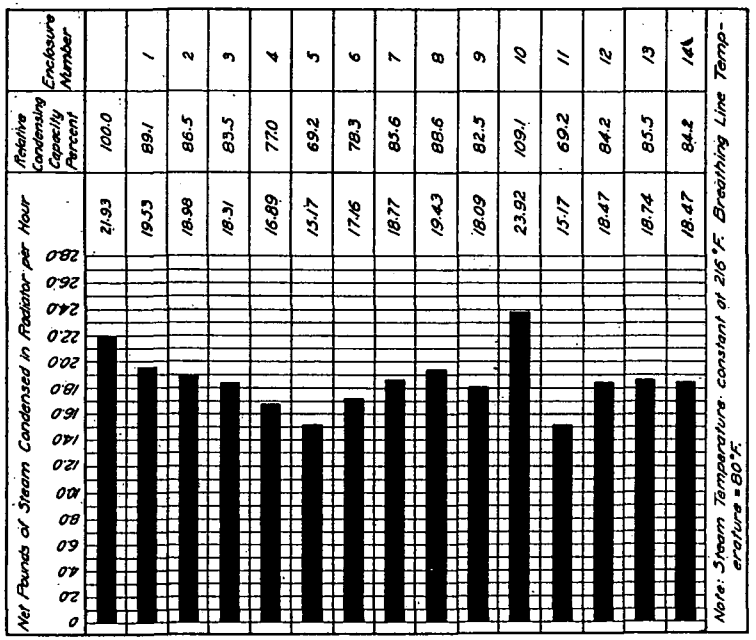
[2] Effect of Enclosures on Radiator Performance by A. P. Kratz and M. K. Fahnestock, JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, June, 1927.

TABLE 17. EFFECT OF ENCLOSURE ON HEAT EMISSION FROM RADIATOR

Enclosure Number.	Description of Enclosure			Free Area of Inlet sq. in.	Free Area of Outlet sq. in.	Net Pounds of Steam Condensed in Radiator per Hour	Relative Condensing Capacity Percent	Enclosure Number
	Height of Top of Enclosure Above Top of Radiator	Inlet	Outlet					
	Radiator not enclosed—Painted (not dipped) with two coats of Black Percora paint							
1	0.0"	4'-.50" Across front	9¼"-.50" Open top	200.0	462.5	21.93	100.0	
2	0.0"	4'-.50" Across front	9¼"-.50" Grilled top	200.0	209.4	19.53	89.1	1
3	0.0"	4'-.50" Across front	12½"-.50" Open front	200.0	625.0	18.98	86.5	2
4	0.0"	4'-.50" Across front	4'-.50" Open front	200.0	200.0	18.31	83.5	3
5	0.0"	4'-.50" Across front	4'-.50" Grilled front	200.0	92.1	16.89	77.0	4
6	17½"	4'-.50" Across front	4'-.50" Grilled front	200.0	92.1	15.17	69.2	5
7	34"	4'-.50" Across front	4'-.50" Grilled front	200.0	92.1	17.16	78.3	6
8	0.0"	4'-82½" Across front and ends	9¼"-.50" Grilled top	330.0	209.4	18.77	85.6	7
9	0.0"	2'-82½" Across front and ends	9¼"-.50" Grilled top	165.0	209.4	19.43	88.6	8
10	34"	4'-82½" Across front and ends	9¼"-.50" Open top	330.0	462.5	18.09	82.5	9
11	0.0"	4'-82½" Across front and ends	4'-.50" Grilled front	330.0	92.1	23.92	109.1	10
12	0.0"	Punched metal grille front and ends, solid top. Grille-work beginning 4" above floor. F.A. of grille = 44%				15.17	69.2	11
13	0.0"	Woven metal grille front and ends, solid top. Grille-work beginning 4" above floor. F.A. of grille = 53%				18.47	84.2	12
14	0.0"	Same as (13) with F.A. of Grille = 42%				18.74	85.5	13
						18.47	84.2	14

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

Net Pounds of Steam Condensed in Radiator per Hour



Note: Steam Temperature constant at 216°F. Breathing Line Temperature = 80°F.

Results reported by Frost and others indicate that the increased heating efficiency noted with enclosed radiation is due to increased air circulation caused by flue action of the enclosure. While the use of an enclosure often retards heat emission from the radiator it is counter-

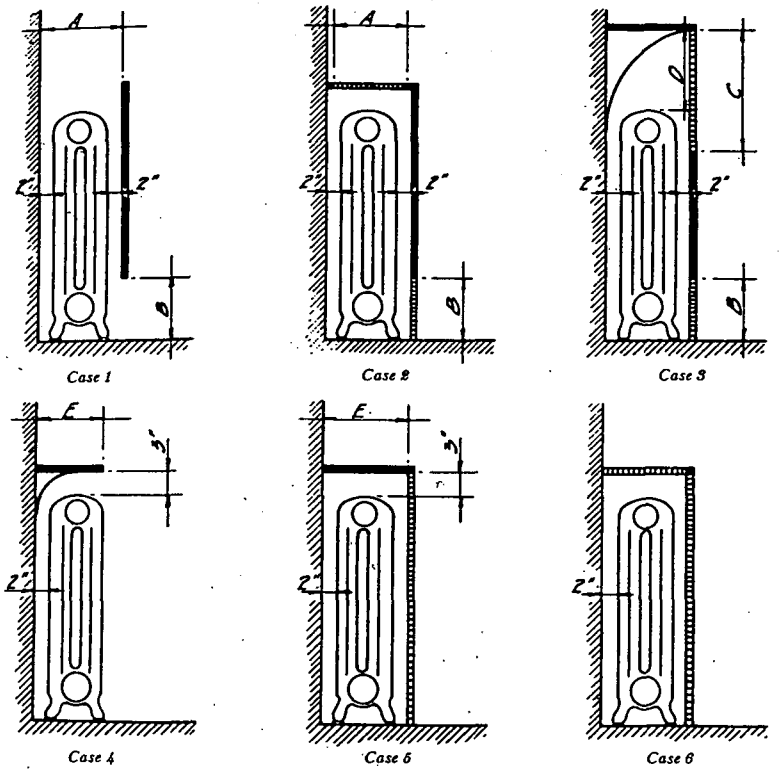


FIG. 3. DIFFERENT ARRANGEMENTS OF RADIATORS IN ENCLOSURES

balanced by the greater effectiveness of the heating. The heating effect for the enclosures shown in Fig. 3 follows:

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

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

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

1. Enclosures should be insulated with 1 in. magnesia or asbestos block, lined with bright tin or non-corrosive sheet metal, placed next to the radiator.
2. The surface of the radiator should be painted flat black, maroon japan, white enamel or white zinc. If the radiator is entirely concealed it may be unpainted.
3. The free area of the grill or opening at the outlet should be not less than the free area through the sections of the radiator.
4. The free area of the grill or opening at the inlet should be not less than 80 per cent of the free area at the outlet.
5. If the outlet is in the face of the enclosure so that the air flow is horizontal, the free area of the outlet should be at least 150 per cent of the free area about the radiator, and the clear height between the top of the radiator and the underside of the top of the enclosure should be not less than the depth of the enclosure.
6. Best results are obtained with a tight fitting enclosure, provided the free area about the radiator at point of greatest restriction is not excessive. As a general rule the efficiency of the radiator is inversely proportional to the depth of the enclosure.

EFFECT OF LOCATION OF RADIATION

The effect of position of radiator upon its heating effect has received a great deal of attention. It is generally accepted that the radiator best serves its purpose when placed under a window. This seems logical for the following reasons.

1. Heat emitted by radiation from the radiator will counteract the effect of heat radiated out through the window from occupants in the room.
2. Cold air leaking in through the window is warmed before it reaches the interior of the room.
3. Air currents from the radiators pass upward, mingling with the cold infiltering air, and across the top of the room then downward to the floor on the opposite side and back to the radiator for another cycle.

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

SPECIFICATION CLAUSES

Specifications for radiation should contain the following clauses:

1. Manufacturers must guarantee that the heat emission per radiator shall not fall below the values given in Tables 1 to 13.
2. Radiation must be free from flaws on surface and leaks at nipple connections, and guaranteed to stand a hydrostatic test of not less than 100 lb. per sq. in.
3. Radiation must be thoroughly cleaned of all core sand, and if for vapor or modulation steam systems must be washed out and the openings plugged before shipment.
4. Radiation must not be placed where dirt can get into the interior and if to be placed in the weather or damp location must be given a priming coat of paint before shipment or immediately upon delivery at location.
5. Long or low radiators should be crated, and the crating not removed until placed in final location.
6. Radiators supported from the wall or ceiling shall be supported on steel or wrought iron hangers.

CHAPTER III

STEAM HEATING SYSTEMS AND PIPING

INTRODUCTION

THE selection of proper pipe sizes for steam heating systems has been a perplexing problem to heating engineers and contractors for some years. No uniformity of practice is discernable, and of the numerous tables available to the profession many indefinite and variable factors have entered into the calculations with the result that a concerted effort has been made by committees of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *Heating and Piping Contractors' National Association* to study the subject on a scientific basis.

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

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

The information resulting from the cooperative effort of these two organizations it is anticipated will provide engineers and contractors with a standard method for selecting pipe sizes for steam heating systems, that will result in the design of plants that are scientifically correct. All data in this chapter are so arranged that the subject is covered under four general divisions—(1) A description of systems, (2) A discussion of steam distribution, (3) Pipe sizes Tables for steam heating systems and (4) Examples to show correct use of tables.

DESCRIPTION OF SYSTEMS

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

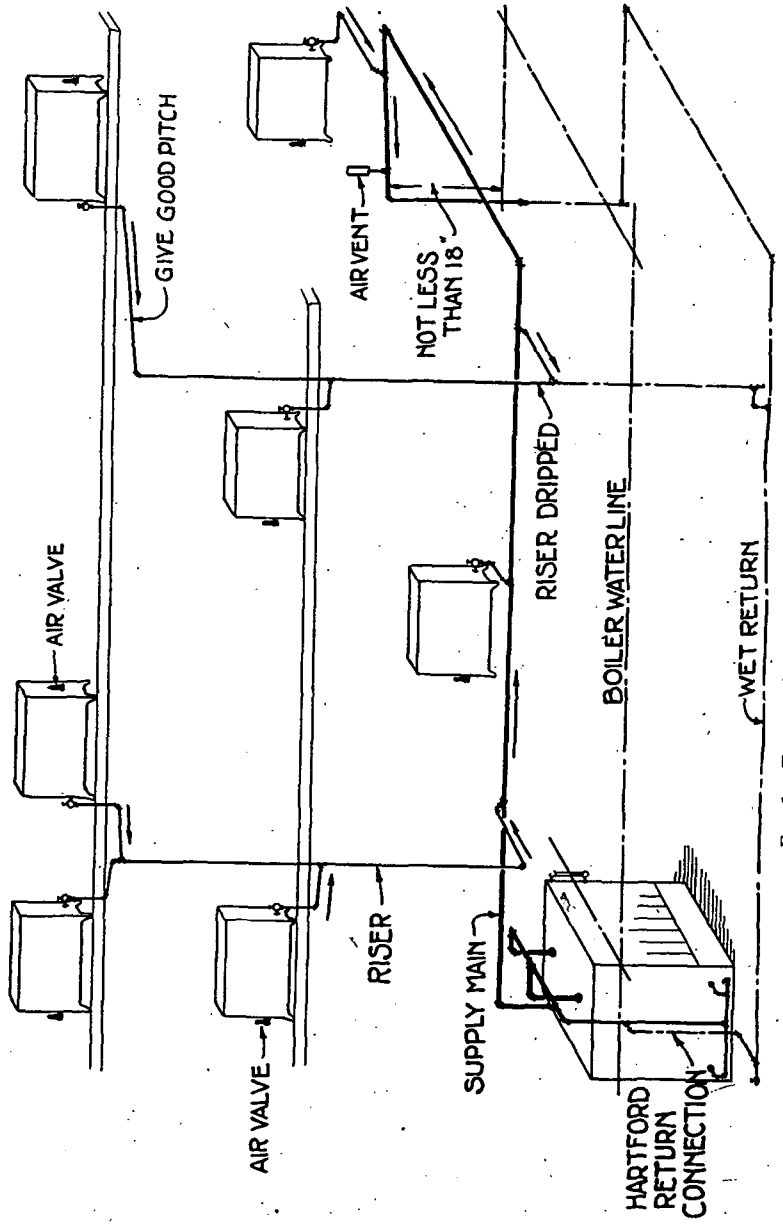


FIG. 1. TYPICAL GRAVITY ONE PIPE STEAM SYSTEM

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

Gravity one-pipe or vapor systems operating under low pressure or partial vacuum and vacuum pump installations have practically the same thermal efficiency.

The greatest difference between these various types of installations lies in the ease of operation, flexibility, adaptability to local conditions and cost of operation. It is essential that any system circulate steam uniformly throughout the entire installation, as too often certain defective features of a system will require that heat be kept on longer or to a greater degree than would otherwise be required to uniformly and satisfactorily heat the building. This will result in waste and overheating. The one important thing to be remembered in connection with all systems is that they shall circulate steam freely and uniformly to the radiators and remove and return condensation noiselessly.

Gravity One-Pipe Steam System.—The one-pipe system is generally the least expensive to install. It requires one combined supply and return connection at the bottom of each radiator to allow the condensation to flow back to the boiler in opposition to the incoming steam. Air valves must be used on all radiators, also near the ends of mains before dropping below the water line. Fractional control by means of radiator valves is not possible with one-pipe systems. During operation the radiator supply valve must be either entirely open or entirely closed. This is necessary to prevent the retention of water and the noise due to intermittent inflow of steam and outflow of water (which occurs when the valve is partly open).

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

Gravity one-pipe systems operating under slight pressures sometimes called the vacuum type are the same in design as the gravity one-pipe system, the only point of difference being the venting valves on the radiators and return main. These valves vent air from the system but prevent its return. Where pressure is not maintained constantly and especially with oil or gas fired boilers the system just described should show some fuel economy over the ordinary gravity one-pipe system.

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

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

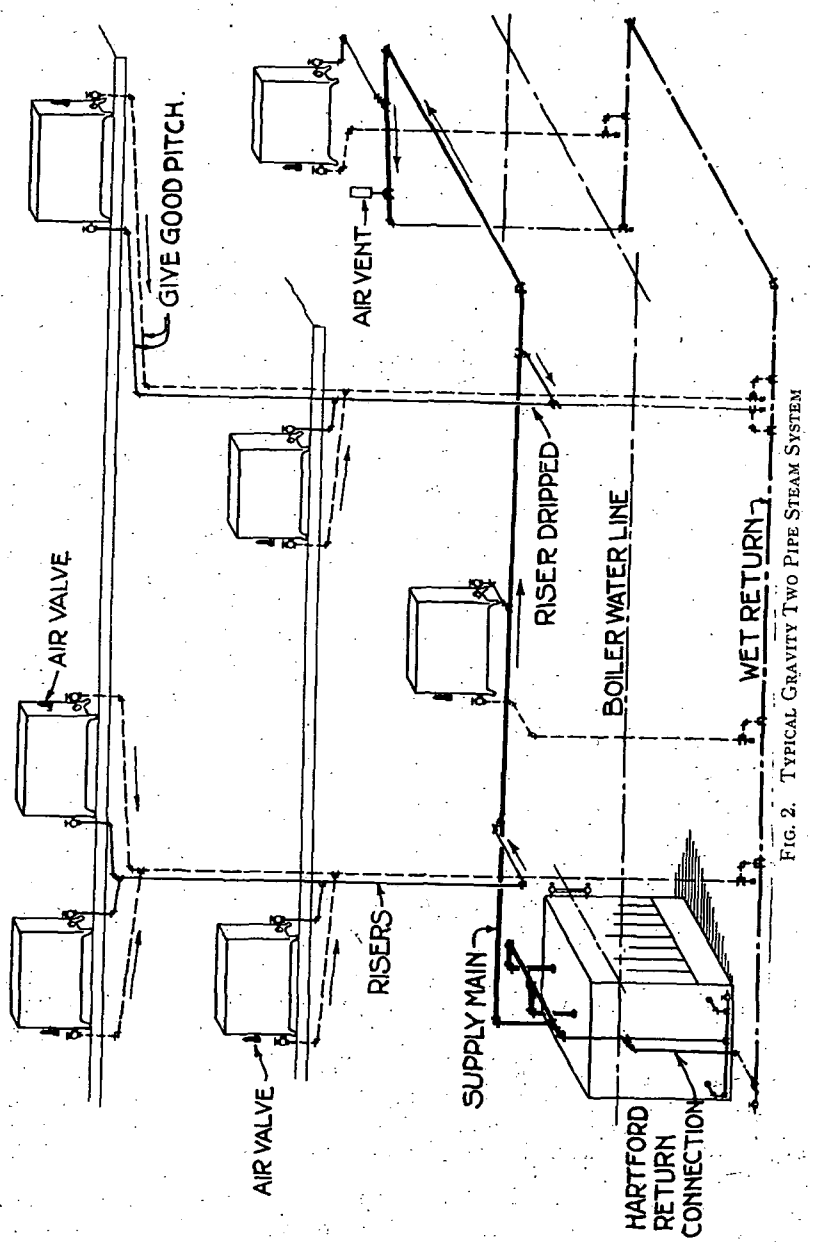


FIG. 2. TYPICAL GRAVITY TWO PIPE STEAM SYSTEM

This return system, if kept above the water line so as to remain dry, is usually filled with steam (plus the water of condensation), at a pressure somewhere between that of the supply and that of the atmosphere, depending upon the amount of steam passing through the radiator returns. This makes the gravity two-pipe system susceptible to the backing up of steam from one radiator to another if return valve is left open with troubles from water hammer, noise from the counterflow and mixing of steam from the return with the condensation leaving the radiators and air binding due to the premature closing of air valves by steam entering at the return end of the radiators. Sometimes check valves are used on the return end of radiators or coils to prevent steam backing into heating units which have been shut off. This practice is not desirable as condensation may collect in the heating units, endangering the boiler. Where the return mains are kept below the water line, so as to be wet, the troubles from the backing up of steam in the returns are generally eliminated when all radiator returns are connected separately into the wet return.

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

Vapor Systems.—Generally vapor systems are specially designed two-pipe systems, operated at a very low pressure. They differ from the gravity two-pipe systems in four important particulars—(1) That the steam is prevented from entering and building up pressure in the return system by means of thermostatic or other forms of traps on the return ends of all radiators, (2) That the air is eliminated with the condensation through the radiator returns into the return system and thence to the atmosphere through automatic vent valves or other forms of automatic air venting apparatus, instead of through individual air valves on the radiators in the rooms, (3) That the backing up of water in returns may be prevented by the carrying of exceedingly low supply pressures, (4) That real fractional control is possible.

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

Vapor systems are often provided with vacuum venting valves which prevent air from returning through the vent port also traps and thus permit the formation of a partial vacuum when generation of steam pressure above atmospheric ceases.

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

They are installed in buildings where it is required to operate at low initial pressures or where, by reason of the layout, radiators must be located below the water line of the boiler. This type of system is also well adapted to large groups of widely separated buildings. They are common where exhaust steam is available, as they may be operated on a low back pressure, without appreciably decreasing the capacity or

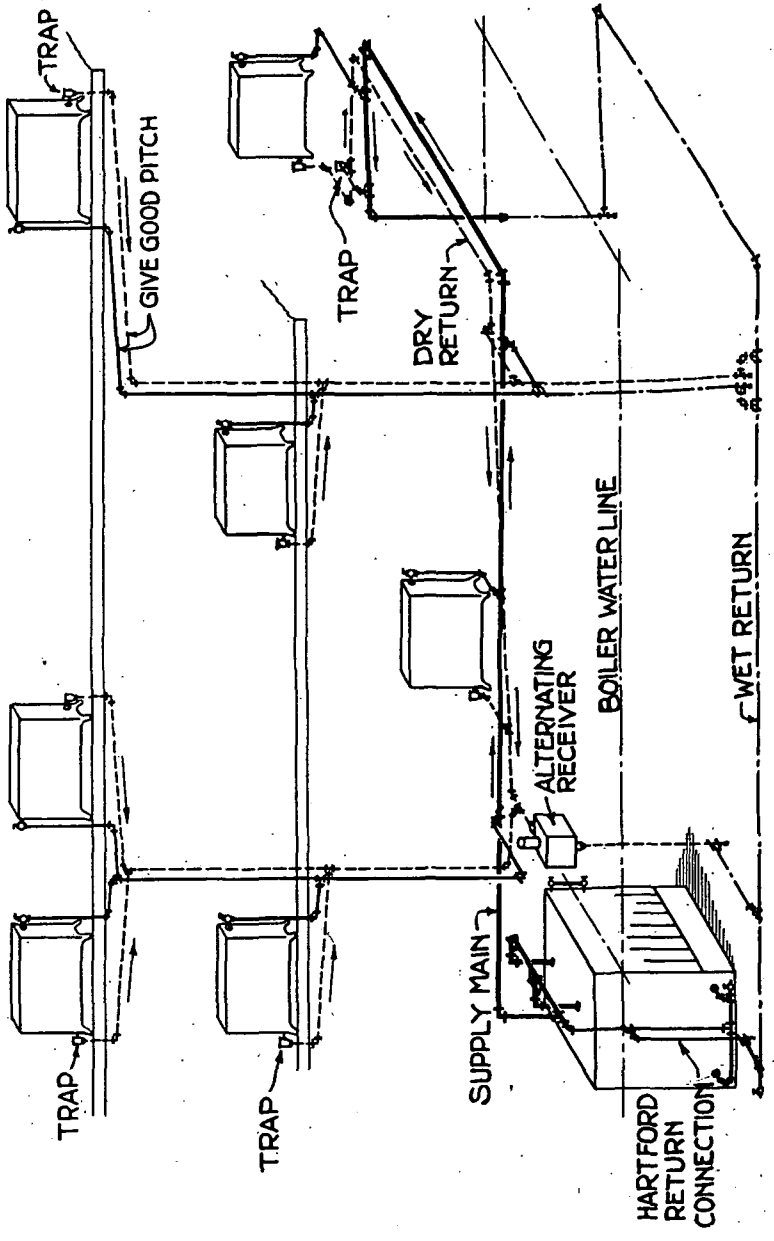


FIG. 3. TYPICAL GRAVITY VAPOR SYSTEM WITH RECEIVER

economy of steam engines. A vacuum pump is used to accelerate circulation by discharging both water and air; the water being returned to the boiler and the air vented to atmosphere.

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

STEAM DISTRIBUTION

The broad divisions that may be very definitely made in a discussion of pipe sizes for the heating of buildings with steam systems are (1) the distribution of the steam and (2) the use of the steam. The following capacity tables of steam mains and branches, radiator connections, etc., under average conditions can be applied for sizing pipes by the person who not only wants the data for immediate use but who may also want the basic data from which the calculations were made.

The conveyance of steam for any considerable distance is a problem by itself, needing separate analysis and altogether different handling from any of the problems concerning the use of the steam after it has arrived at the building. Steam flow tables should be used for this distribution, and tables giving the capacities of steam mains and branches, radiator connections, etc., (See Tables 1 to 20), under standard and average conditions of use should be applied for sizing the pipes within the buildings.

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

Transmission mains are those that have to do with the conveying of steam for a distance of considerable extent, through or between buildings and for collecting and returning the water of condensation from the several sections or buildings. Service piping is that part of the apparatus by which the radiating units are connected to the transmission mains.

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

STEAM HEATING PIPE SIZES

Generally, in using tables for steam heating pipe sizes, it is difficult to determine the length of run upon which they are based. Usually some allowance is made for one or more such items as: condensation in the pipe, equivalent length of pipe, for fittings, valves, etc., but it is generally difficult to determine what factors have been allowed for, and what percentage of allowance has been made. In compiling the Tables 1–20 and other data for THE GUIDE, 1928, every attempt has been made to eliminate such indefinite and conflicting factors.

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

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

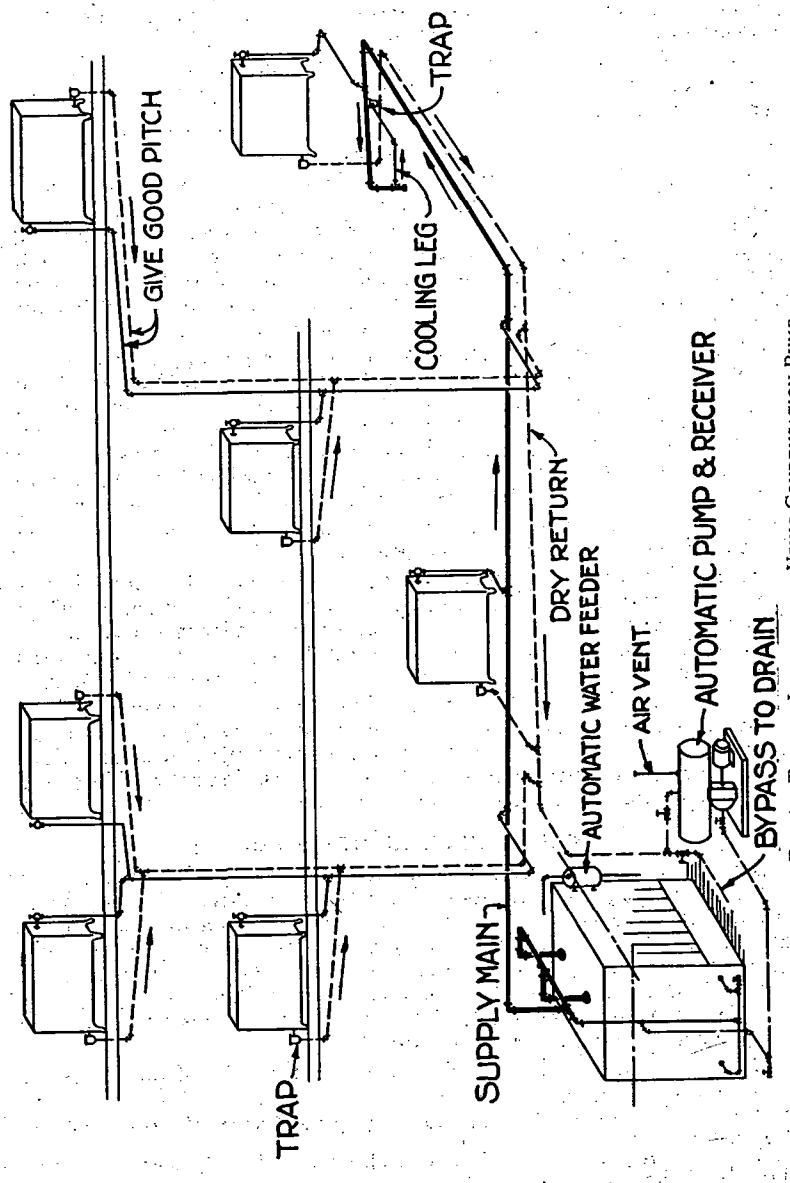


Fig. 4. Typical Installation Using Condensation Pump

Length of Run

The length of run must not only include the actual linear feet of straight pipe, but also the proper allowance for fittings, valves friction and other items which cause drop in pressure. (See Table 6.)

Pressure Drop

There are, theoretically, several factors to be considered, including: the initial pressure, the pressure required at the end of the line, fluctuations in the initial pressure, the distance between the low point of steam main and dry return and the water line of the boiler (where the condensation is to be returned by gravity), and any extra load on the system during heating-up periods.

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

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

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

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

In the matter of initial pressure and return of condensation it is undoubtedly true that with a constant initial pressure (such as is produced by a high pressure supply by means of a pressure reducing valve, or from the boiler direct where the pressure is maintained constant), somewhat higher drops in pressure and correspondingly smaller pipe may be successfully used. It is also undoubtedly true that, with mechanical circulation where a constant vacuum is maintained, fluctuations in initial pressure and the difficulties from high velocities are reduced, so that the pressure drops may be higher and the pipe sizes smaller.

Maximum Velocity

The capacity of pipe of a given size in any part of a steam or vapor heating system depends on water of condensation present in, as well as

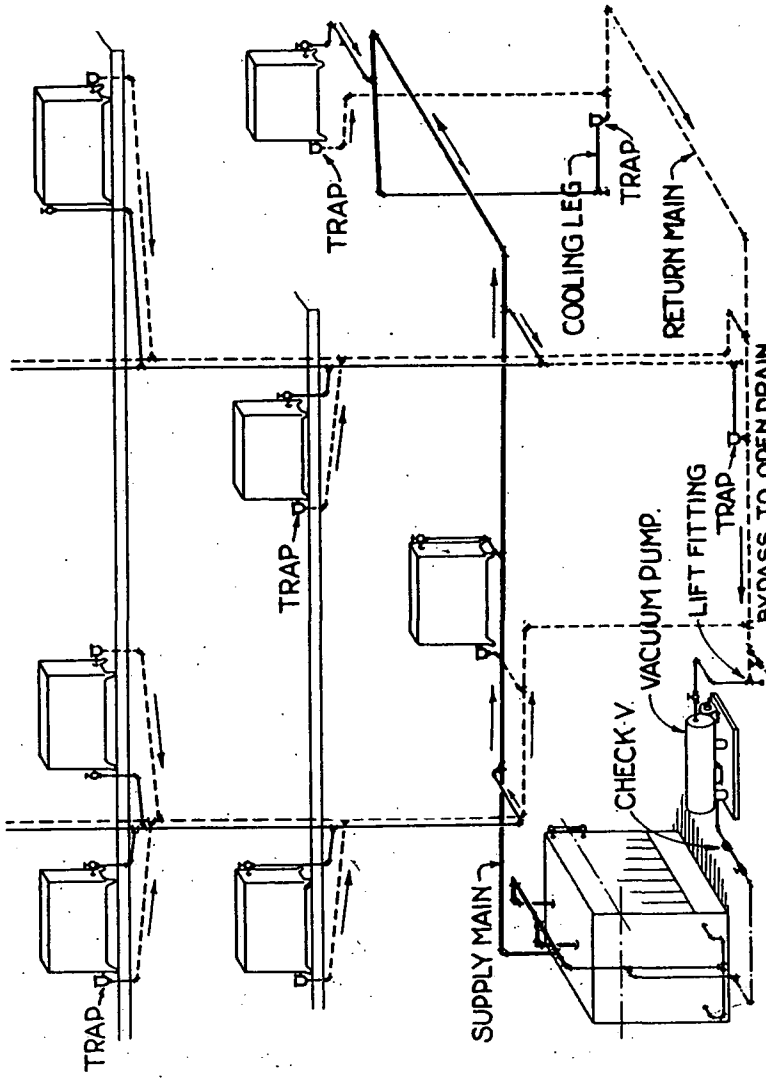


FIG. 5. TYPICAL INSTALLATION USING VACUUM PUMP

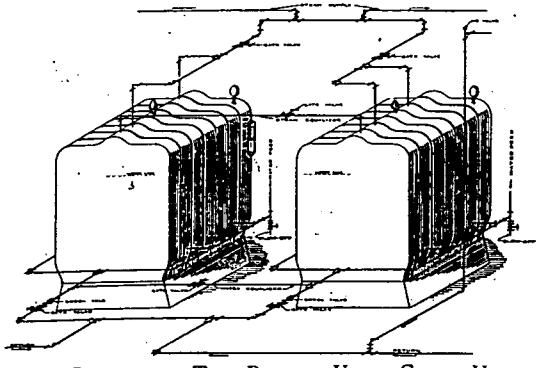


FIG. 6. CONNECTING TWO BOILERS USING CHECK VALVES AND EQUALIZERS IN RETURNS

upon the available pressure drop through the pipe. Where no water is present or where a limited quantity flows by gravity in the same direction as the steam the available pressure drop only need be considered.

Where water and steam flow counter to each other the velocity of the steam must not exceed certain values above which disturbance between the counter flowing steam and water may produce objectionable sounds,

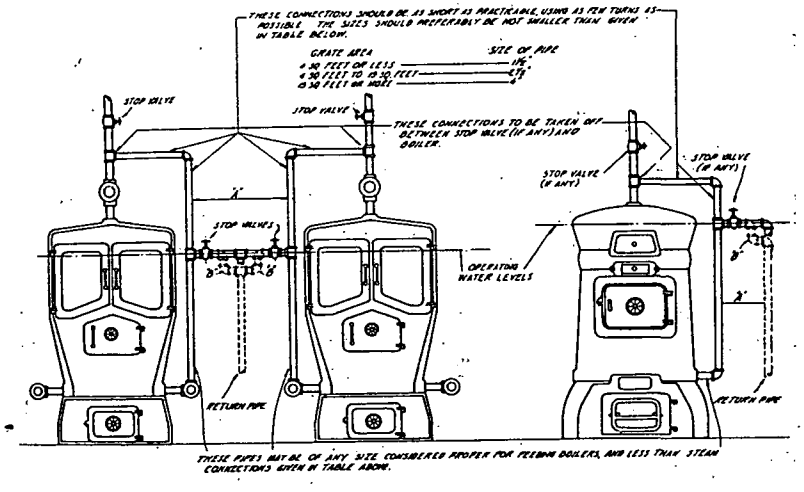


FIG. 7. CONNECTING TWO BOILERS USING THE APPROVED RETURN CONNECTION

TABLE 1. FLOW OF STEAM IN PIPES

Flow of Steam in Pipes

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

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

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

Pressure Loss in Ozs.	Col. 1 $87.0\sqrt{\frac{P}{100}}$	Pipe Size Nominal	Pipe Size Actual Internal Diameter	Internal Area of Pipe Sq. Ins.	Col. 2 $\frac{d^5}{1+\frac{3.6}{d}}$	Steam Press. by Gage	Col. 3 $\sqrt{D}$	Length of Pipe in Feet	Col. 4 $\sqrt{\frac{100}{L}}$
0.25	1.088	1	1.049	0.864	0.536	-1.0 *	0.187	20	2.240
0.50	1.538	1¼	1.380	1.496	1.178	-0.5 *	0.190	40	1.580
1.00	2.175	1½	1.610	2.036	1.828	0.0	0.193	60	1.290
2	3.076	2	2.067	3.356	3.710	0.3	0.195	80	1.120
3	3.767	2½	2.469	4.788	6.109	1.3	0.201	100	1.000
4	4.350	3	3.068	7.393	11.183	2.3	0.207	120	0.912
5	4.863	3½	3.548	9.887	16.705	5.3	0.223	140	0.841
6	5.328	4	4.026	12.730	23.631	10.3	0.248	160	0.793
7	5.755	4½	4.506	15.947	32.134	15.3	0.270	180	0.741
8	6.152	5	5.047	20.006	43.719	20.3	0.290	200	0.710
10	6.878	6	6.065	28.886	71.762	30.3	0.326	250	0.632
12	7.534	7	7.023	38.743	106.276	40.3	0.358	300	0.578
14	8.138	8	7.981	50.027	149.382	50.3	0.388	350	0.538
16	8.700	9	8.941	62.706	201.833	60.3	0.415	400	0.500
20	9.727	10	10.020	78.854	272.592	75.3	0.452	450	0.477
24	10.655	12	12.000	113.098	437.503	100.3	0.507	500	0.447
28	11.509	14	13.250	137.880	566.693	125.3	0.557	600	0.407
32	12.304	16	15.250	182.655	816.872	150.3	0.603	700	0.378
40	13.756	Column 1 × 2 × 3 × 4 = lb. of steam per minute that will flow through a straight pipe for a given condition.				175.3	0.645	800	0.354
48	15.069					200.3	0.685	900	0.333
80	19.454	*Example.*—1 oz. drop – 2 in. pipe = 1.3 lb. press. – 100 ft. equivalent length:						1000	0.316
160	27.512	2.175 × 3.710 × 0.201 × 1 = 1.6219 lb. per min. 1.6219 × 60 × 4 = 389.3 sq. ft. equivalent radiation.						1200	0.289
320	38.908	Table 1 does not allow for entrained water in low-pressure steam, condensation in covered pipe and roughness in commercial pipe as found in practice.						1500	0.258
480	47.652							2000	0.224

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

water hammer, or store water in some parts of the system. The velocity at which such disturbance takes place depends upon the size of the pipe, its location (whether, vertical or horizontal), its pitch and the quantity of water flowing counter to the steam.

Unusual Conditions

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

In public buildings, schools, offices, places of assemblage, and such buildings (where the occupants are normally at rest) the building should be heated to its required temperature at the beginning of each period of use. In some buildings (especially offices, schools and public buildings), the time between heating periods is relatively short; whereas in others (such as churches, theaters and places of assemblage), these periods are comparatively long. In other buildings, where the occupants are moving about, it is not always necessary for the building to be heated to the required temperature at the beginning of its period of use. In all cases heat given off by machinery, occupants and illumination, also the heat absorbed by the contents of the building should be taken into account.

GENERAL DATA ON PIPE SIZE TABLES

The following Tables 1 to 20 have been compiled for use in designing all types of steam heating systems, and may be used, by those experienced in the profession, with satisfactory results. The following general principals should be followed:

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

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

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

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

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

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

7. In using this method of proportioning a system, care must be exercised to see that no pipe carrying condensate counter to the steam, is loaded to a capacity above the maximum for the particular part of a system in question as shown in Tables 4, 5 and 8 to 16.

*This rule applies only when the amount of radiation on any riser does not exceed the values in Tables 4 and 5.

TABLE 2. PRESSURE LOSS, CAPACITY IN SQUARE FEET OF EQUIVALENT RADIATION AND VELOCITY RELATIONSHIP BASED ON TABLE 1, FOR VARIOUS PRESSURE DROPS WITH 1 LB. INITIAL STEAM PRESSURE

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

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

TABLE 2. (Continued)

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

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

Note 2.—For capacity of pipe with a given pressure drop, in a length other than 100 ft., multiply the capacity in this table for the given pressure per 100 ft drop by the factor for required length, Column *B*, Table 7.

Note 3.—For capacity with initial pressures other than 1 lb., multiply capacity given in this table by factor for the required initial pressure. Column 2, Table 7.

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

Note 5.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 6.)

Note 6.—All pipe should be well reamed and free from constrictions. (See Tables 18, 19 and 20.)

TABLE 3. FLOW OF STEAM IN POUNDS PER MINUTE THROUGH STANDARD PIPES AND PRESSURE DROP IN POUNDS PER 100 FT., EQUIVALENT LENGTH. VELOCITY, 4000 FT. PER MINUTE*

Pipe Size Inches	GAGE PRESSURE IN POUNDS PER SQUARE INCH—STANDARD PIPE																
	1	3	5	10	15	25	35	50	75	100	125	150	175				
¼	0.340	0.381	0.420	0.518	0.614	0.805	0.993	1.270	1.727	2.175	2.620	3.072	3.515	Flow			
	2.733	3.100	3.384	4.180	4.955	6.500	8.030	10.25	13.93	17.54	21.22	24.82	28.42	Drop			
⅜	0.597	0.668	0.737	0.908	1.077	1.411	1.740	2.225	3.029	3.814	4.593	5.382	6.160	Flow			
	1.610	1.803	1.990	2.452	2.900	3.805	4.700	6.000	8.190	10.29	12.37	14.53	16.66	Drop			
1	0.968	1.083	1.195	1.473	1.746	2.287	2.821	3.608	4.908	6.182	7.448	8.730	9.990	Flow			
	1.061	1.190	1.310	1.516	1.913	2.492	3.090	3.936	5.385	6.775	8.165	9.585	10.99	Drop			
1¼	1.675	1.873	2.068	2.548	3.023	3.958	4.882	6.241	4.490	10.70	12.88	15.11	17.28	Flow			
	0.657	0.734	0.811	1.000	1.185	1.555	1.915	2.448	3.330	4.190	5.045	5.938	6.796	Drop			
1½	2.281	2.551	2.816	3.471	4.113	5.388	6.650	8.500	11.57	14.457	17.56	20.56	23.53	Flow			
	0.505	0.566	0.624	0.770	0.910	1.194	1.472	1.883	2.564	3.222	3.889	4.555	5.222	Drop			
2	3.760	4.208	4.641	5.721	6.782	8.880	10.96	14.02	19.06	24.02	28.92	33.90	38.80	Flow			
	0.334	0.376	0.412	0.509	0.602	0.788	0.976	1.243	1.690	2.160	2.562	3.110	3.448	Drop			
2½	5.365	6.000	6.621	8.165	9.680	12.68	15.64	20.00	27.20	34.26	41.28	48.36	55.35	Flow			
	0.230	0.280	0.369	0.382	0.452	0.592	0.713	0.933	1.270	1.598	1.926	2.260	2.585	Drop			
3	8.280	9.260	10.22	12.60	14.93	19.57	24.13	30.85	42.00	52.88	63.70	74.62	85.45	Flow			
	1.77	0.199	0.220	0.272	0.322	0.421	0.520	0.664	0.905	1.138	1.370	1.610	1.840	Drop			
4	14.26	15.96	17.61	21.70	25.73	33.70	41.58	53.15	72.33	91.10	109.8	128.6	147.2	Flow			
	0.118	0.133	0.146	0.181	0.214	0.279	0.345	0.441	0.600	0.755	0.911	1.068	1.235	Drop			
5	22.43	25.08	27.68	34.12	40.45	52.96	65.32	83.60	113.7	143.2	172.4	202.2	231.3	Flow			
	0.085	0.096	0.106	0.130	0.154	0.202	0.249	0.318	0.433	0.546	0.656	0.768	0.883	Drop			
6	32.36	36.22	39.95	49.25	58.38	76.48	94.30	120.7	164.2	206.7	249.0	291.8	334.0	Flow			
	0.066	0.074	0.082	0.101	0.119	0.156	0.193	0.247	0.336	0.422	0.508	0.597	0.683	Drop			
8	57.30	64.10	70.72	87.15	103.4	135.4	166.9	213.6	291.0	365.9	440.8	516.6	591.0	Flow			
	0.045	0.051	0.056	0.069	0.082	0.107	0.131	1.67	0.229	0.287	0.346	0.406	0.465	Drop			
10	90.40	101.1	111.6	137.6	163.1	213.6	263.4	336.8	458.5	577.2	695.0	815.0	932.8	Flow			
	0.034	0.038	0.042	0.052	0.061	0.080	0.098	0.126	0.171	0.214	0.258	0.304	0.348	Drop			
12	128.6	143.8	158.8	195.7	232.0	303.9	374.6	479.3	652.0	821.5	989.0	1159.0	1327.0	Flow			
	0.027	0.031	0.034	0.042	0.049	0.064	0.079	0.101	0.137	0.172	0.208	0.280	0.313	Drop			

*Courtesy Crane Company.

PIPE SIZES

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

Table 2 is a basic table giving the theoretical capacities of pipe in square feet of direct cast iron radiation (Based on ¼ lb. steam per hour per square foot) and the resulting velocity in feet per second for various pressure drops in ounces per 100 ft. length of pipe or equivalent length and with an initial steam pressure of 1 lb. gage.

Table 3 gives the pounds of steam which will flow per minute through standard pipe at 4000 ft. velocity, and the resulting pressure drop in pounds per 100 ft. equivalent length. This table is particularly applicable to transmission mains and should not be used without particular consideration in designing distribution systems.

The capacity of a pipe in any part of a system is limited either by the allowable pressure drop along the pipe, or by the steam velocity through the pipe or both. If condensate, either from radiation supplied or from the pipe itself, is to return counter to the flow of steam the velocity of the steam must not exceed the maximum values given in Tables 4 and 5.

Capacities of up-feed, one-pipe risers based upon maximum allowable velocities as determined by the Society's Research Laboratory are given in Table 4. In some cases, the capacities as given in the table, have been cut down from those published by the Laboratory in order to allow a greater factor of safety. In designing a heating system no up-feed one-pipe riser should be figured to exceed the capacities indicated in this table.

Column *B* gives the velocity, and *C* the resulting pressure drop in ounces per 100 ft. equivalent length of pipe for the maximum capacities given in Columns *D*, *E*, and *F*, in equivalent square feet of direct radiation, B.t.u. and pounds of steam, supplied per hour.

Table 5 gives the maximum allowable capacity of up-feed two-pipe risers based upon the Laboratory's findings. Comparing it with Table 4 it will be noted that the capacity of a two-pipe riser is considerably greater than that of a one-pipe riser, a fact which has not been generally accepted in the past.

Table 6 gives the length of pipe in feet to be added to actual length of run to obtain equivalent length.

Table 7, Column 2, gives constant for calculating the capacity of pipe for steam at initial pressure other than 1 lb. when the capacity at 1 lb. pressure is known. Column *B* gives constant for calculating capacity of pipe of length other than 100 ft. when capacity of 100 ft. length is known.

In determining the length of pipe used in any system, the actual length must be increased for the various fittings, and values, in determining the equivalent length before applying any of the tables given. If it is desired to determine the capacity of a pipe for any other length than 100 ft. or for any initial pressure other than 1 lb. such capacity may

Table 4. Maximum Allowable Capacities of Up-Feed Risers for One-Pipe Low Pressure Steam

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

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

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

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

Note 3.—All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 18, 19 and 20.)

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

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

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

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

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

Note 3.—All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 18, 19 and 20.)

Table 6. Length in Feet of Pipe to be Added to Actual Length of Run to Obtain Equivalent Length

Size of Pipe	St'd. Elbow	Side Outlet Tee	Gate Valve	Globe Valve	Angle Valve
	Length in Feet to be Added in Run				
2″	5	16	2	18	9
2½″	7	20	3	25	12
3″	10	26	3	33	16
3½″	12	31	4	39	19
4″	14	35	5	45	22
5″	18	44	7	57	28
6″	22	50	9	70	32
7″	26	55	10	82	37
8″	31	63	12	94	42
9″	35	69	13	105	47
10″	39	76	15	118	52
12″	47	90	18	140	63
14″	53	105	20	160	72

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

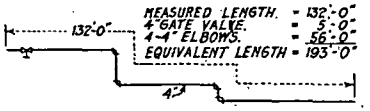


Table 7. Constants for Various Lengths and Initial Pressures

Steam Pressure Gage Lb.	Constant by Which to Multiply Capacity of any Pipe for 1 Lb. Gage Steam Pressure to Obtain Capacity of Same Pipe for Pressure in Col. 1	Length of Pipe Ft.	Constant by Which to Multiply Capacity of 100 Ft. Pipe to Obtain Capacity of Same Sized Pipe With Same Pressure, and Length as Given in Col. A
Col. 1	Col. 2	Col. A	Col. B
0	0.92	20	2.240
1	1.00	40	1.580
2	1.03	60	1.290
5	1.11	80	1.120
10	1.24	100	1.000
15	1.35	120	0.912
20	1.45	140	0.841
30	1.63	160	0.793
40	1.79	180	0.741
50	1.94	200	0.710
60	2.08	250	0.632
75	2.26	300	0.578
100	2.54	350	0.538
125	2.79	400	0.500
150	3.02	450	0.477
175	3.23	500	0.447
200	3.44	600	0.407
...	....	700	0.378
...	.....	800	0.354
...	....	900	0.333
...	.....	1000	0.316
...	....	1400	0.267

be found from Table 2 by multiplying the capacities found therein by constants given in Table 7.

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

Solution.—From Table 2 it is found that the capacity of a 100 ft. 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop, is 3475 sq. ft. Multiplying this value by 0.841 the constant for a 140 ft. length as given in Table 7 gives 2922 the capacity for the given conditions.

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

Solution.—From Table 2, find 2457, the capacity of the 4 in. pipe with 1 lb. initial pressure and 1 oz. pressure drop. Multiplying 2457 by 1.03 the constant found in Column 2 of Table 7 for 2 lb. initial pressure gives

TABLE 8. PIPE SIZES FOR ONE-PIPE, GRAVITY, LOW-PRESSURE STEAM HEATING SYSTEM, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO THE FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

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

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 6).

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

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

2531 as the capacity of the 4 in. pipe with 2 lb. initial pressure and a pressure drop of 1 oz. per 100 ft. length.

Table 8 is a pipe sizing table for small one-pipe gravity low-pressure steam heating systems. This table was designed to meet the requirements of those laying out small systems where the equivalent length of run from the boiler or pressure reducing valve to the farthest radiator is no greater than 200 ft. The capacities are based upon 1 oz. drop in pressure per 100 ft. equivalent length of run excepting where the maximum allowable velocity limits the capacity below this value. The capacities of supply mains as given in Column *B* are based upon a pressure drop of 1 oz. per 100 ft. equivalent length. The capacities of up-feed risers as given in Column *C* are based upon the maximum velocity. The

TABLE 9. PIPE SIZES FOR TWO-PIPE, GRAVITY, LOW PRESSURE STEAM, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

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

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6.)

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

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

capacities of branches to risers and radiators are based upon past experience and the Laboratory's findings.

Table 9 is for small two-pipe systems, and is similar to Table 8. It gives values for parts of a two-pipe system. It was designed for laying out small two-pipe systems where the greatest equivalent length of run from the boiler to the farthest radiator does not exceed 200 ft.

Table 10 is recommended for laying out small vapor systems.

Table 11 and 12 were designed for larger one and two-pipe low-pressure gravity steam heating systems, respectively. These tables are based upon a 4 oz. pressure drop from the boiler to the farthest radiator and give capacities based upon such pressure drop for equivalent lengths ranging from 100 to 600 ft. These tables can be used for determining the size

TABLE 10. PIPE SIZES FOR TWO-PIPE, GRAVITY, VAPOR† SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

PIPE SIZE INCHES	SUPPLY MAIN DRIPPED AND BRANCHES TO RISERS DRIPPED Steam and Condensate flowing in same direction.	SUPPLY RISERS Up-Feed	BRANCHES TO SUPPLY RISERS AND RADIATORS NOT DRIPPED	RETURN RISERS	WET RETURN MAIN	DRY RETURN MAIN
A	*B*	*C*	*D**	*E*	*F*	*G*
¾	....	30	....	190	.....	.....
1	56	56	26	450	700	320
1¼	122	122	58	990	1200	670
1½	190	190	95	1500	1900	1058
2	386	386	195	3000	4000	2300
2½	635	635	395	.....	6700	3800
3	1163	1129	700	.....	10,700	7000
3½	1737	1548	1150	.....	.....	10,000
4	2457	2042	1700	.....	.....	.....
5	4546	.....	3150	.....	.....	.....
6	7462	**Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¼ in.**				

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

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6.)

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

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

of pipe necessary to handle a given amount of radiation, either in a main, branch to the riser, riser, or radiator branch. Risers, or branches to risers or radiators, must not, however, be loaded above the maximum capacities for different parts of the system as given in the tables.

Tables 13 and 14 are for sizing pipe for vapor systems where the equivalent length of run exceeds 200 ft. Table 13 is for systems up to 400 ft. equivalent length and is based upon a total pressure drop of 2 oz. from the source of steam supply to the farthest radiator. Table 14 is for larger systems where the equivalent length of run from the boiler or source of steam supply does not exceed 600 ft. It is based upon a total pressure drop of 4 oz. Risers and branches to risers and radiators should not be loaded above their maximum capacity as given in Columns *F* and *G*.

Table 15 is a pipe sizing table for small vacuum pump systems where the equivalent length of run from the boiler or source of steam supply to the farthest radiator ranges from 100 to 600 ft. The table is based upon a total pressure drop in the entire equivalent length from steam supply to farthest radiator of 4 oz. Up-feed risers, branches to risers and radiators should not be loaded beyond the maximum capacities given in Columns *H* and *I*.

Table 16 is similar to Table 15 and is for larger systems where the equivalent length of run ranges up to 1200 ft. It is based on a total pressure drop of 8 oz. in the entire equivalent length.

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

TYPICAL EXAMPLE

Example in the use of the tables for determining the size of pipe necessary in various parts of the vacuum pump system are shown in the accompanying diagram (Page 109):

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by any supply main (or the radiator on floor *g* Riser *E*) is between 600 and 800 ft.—therefore size the entire run according to Column *H*, Table 16, observing *Note 4* as regards maximum capacity of up-feed supply risers given in Column *K*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *E*	*f* to *g*	400	2½
" "	*e* to *f*	600	2½
" "	*d* to *e*	800	3
" "	*c* to *d*	1000	3
" "	*b* to *c*	1200	3½
" "	*a* to *b*	1400	3½
Branch	to Riser *E*	1400	4
Supply Main	*D* to *E*	1600	3½
" "	*C* to *D*	2400	4
" "	*B* to *C*	3200	5
" "	*A* to B	4800	6

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by riser *D* is between 500 and 600 ft.—therefore size riser *D* and its branch according to Column *G* observing *Note 4* as regards maximum capacity of up-feed risers given in Column *K*. Note that the maximum allowable capacity of the

Table 11. Pipe Sizes for One-Pipe, Gravity, Low Pressure Steam Heating Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. Based on 4 oz. Total Pressure Drop						Maximum Capacities		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Radiator Valves and Vertical Connections
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*
1	111	79	65	56	49	46	45	20	20
1¼	245	173	141	122	110	100	98	55	55
1½	380	269	220	190	165	155	152	81	81
2	771	546	446	386	345	315	288	165	165
2½	1270	898	734	635	568	518	464	260	.....
3	2326	1645	1342	1163	1040	948	799	475	.....
3½	3474	2457	2006	1737	1552	1419	1144	745	.....
4	4914	3475	2828	2457	2196	2011	1520	1110	.....
5	9092	6429	5250	4546	4062	3712	.....	2180	.....
6	14,924	10,553	8618	7462	6669	6094	.....	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....	.....

Pipe Size Inches	Dry Return Main. Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet						Wet Return Main. Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	322	275	1400	1000	820	700	640	580
1¼	962	868	770	670	579	480	2400	1700	1390	1200	1080	990
1½	1512	1362	1210	1058	909	757	3800	2700	2180	1900	1710	1570
2	3300	2960	2640	2300	1980	1630	8000	5600	4520	4000	3560	3240
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	6000	5300
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,500	10,700	9400	8500
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	18,500	16,000	14,400	13,200
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	25,500	22,000	19,900	18,300

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*L* to *Q*) for dry return mains; (*R* to *W*) for wet return mains for sizing the entire run.

Risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser.

Determine the distance to the farthest radiator then use the figures in the corresponding Column (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts in Column *H*, step up to necessary size indicated in that column.

Note 5.—Where it is necessary to drip a steam main, branch to riser or riser, same should be dripped separately into wet return.

Note 6.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators at least ½ in. in 10 ft.

Table 12. Pipe Sizes for Two-Pipe, Gravity, Low Pressure Steam Heating Systems where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. Based on 4 oz. Total Pressure Drop						Maximum Capacities			
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Rad. Supply Valves and Vertical Connections	Radiator Return Valves and Connections
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*	*K*
¾	.....	.....	.....	.....	.....	.....	30	.....	30	122
1	111	79	65	56	49	46	56	26	56	190
1¼	245	173	141	122	110	100	122	58	122	386
1½	380	269	220	190	165	155	190	95	190	.....
2	771	546	446	386	345	315	386	195	386	.....
2½	1270	898	734	635	568	518	635	395	.....	.....
3	2326	1645	1342	1163	1040	948	1129	700	.....	.....
3½	3474	2457	2006	1737	1552	1419	1548	1150	.....	.....
4	4914	3475	2828	2457	2196	2011	2042	1700	.....	.....
5	9092	6429	5250	4546	4062	3712	.....	3150	.....	.....
6	14,924	10,553	8618	7462	6669	6094	.....	.....	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....	.....	.....

Pipe Size Inches	Dry Return Main. Equivalent Length of Run from Boiler to Farthest Radiator in Feet						Wet Return Main. Equivalent Length of Run from Boiler to Farthest Radiator in Feet					
	100	200	300	400	500	600	100	200	300	400	500	600
M	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*	*X*	*Y*
1	460	412	368	320	322	275	1400	1000	820	700	640	580
1¼	962	868	770	670	579	480	2400	1700	1390	1200	1080	990
1½	1512	1362	1210	1058	909	757	3800	2700	2180	1900	1710	1570
2	3300	2960	2640	2300	1980	1630	8000	5600	4520	4000	3460	3240
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	6000	5300
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,500	10,700	9400	8500
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	18,500	16,000	14,400	13,200
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	25,500	22,000	19,900	18,300

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*N* to *S*) for dry return mains; (*T* to *Y*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *G*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where supply riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*N* to *S*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. A drip for a two-pipe system may be taken into a dry return through an adequate seal.

Note 6.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators, at least ½ in. in 10 ft.

TABLE 13. PIPE SIZES FOR TWO-PIPE VAPOR† HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR Exceeds 200 FT.

Capacity in Sq. Ft. Equivalent Radiation

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. BASED ON 2 OZ. TOTAL PRESSURE DROP				MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	*G**	*H*
¾	....	....	....	....	30	....	190
1	79	56	46	39	56	26	450
1¼	173	122	100	87	122	58	990
1½	269	190	155	134	190	95	1500
2	546	386	315	273	386	195	3000
2½	898	635	518	449	635	395	.....
3	1645	1163	948	822	1129	700	.....
3½	2457	1737	1419	1228	1548	1150	.....
4	3475	2457	2011	1738	2042	1700	.....
5	6929	4546	3712	3214	.....	3150	.....
6	10,553	7462	6094	5276	Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.		
8	21,967	15,533	12,682	10,983			
10	40,085	23,345	23,144	20,043			
12	64,336	45,492	37,145	32,168			

PIPE SIZE INCHES	DRY RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET				WET RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET			
	100	200	300	400	100	200	300	400
I	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
1	355	320	285	248	1000	700	580	500
1¼	745	670	595	520	1700	1200	990	850
1½	1173	1058	943	822	2700	1900	1570	1350
2	2680	2300	2140	1880	5600	4000	3240	2800
2½	4300	3800	3470	3040	9400	6700	5300	4700
3	7800	7000	6250	5480	15,000	10,700	8500	7500
3½	11,100	10,000	8800	7880	22,000	16,000	13,200	11,000
4	16,700	15,000	13,400	11,700	31,000	22,000	18,300	15,500

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

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material of workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *E*) for supply mains; (*J* to *M*) for dry return mains; (*N* to *Q*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *E*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *F*. Where supply riser capacities are found to be in excess of amounts shown in Column *F*, step up to necessary size indicated in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*J* to *M*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or vacuum system may be taken into a dry return through a steam trap.

Note 6.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators, at least ½ in. in 10 ft.

TABLE 14. PIPE SIZES FOR TWO-PIPE VAPOR† HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR Exceeds 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction. BASED ON 4 OZ. TOTAL PRESSURE DROP						MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**	*J*
¾	.....	....	....	....	....	....	30	....	190
1	111	79	65	56	49	46	56	26	450
1¼	245	173	141	122	110	100	122	58	990
1½	380	269	220	190	165	155	190	95	1500
2	771	546	446	386	345	315	386	195	3000
2½	1270	898	734	635	568	518	635	395	.....
3	2326	1645	1342	1163	1040	948	1129	700	.....
3½	3474	2457	2006	1737	1552	1419	1548	1150	.....
4	4914	3475	2828	2457	2196	2011	2042	1700	.....
5	9092	6429	5250	4546	4062	3712	.....	3150	.....
6	14,924	10,553	8618	7462	6669	6094	Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.		
8	31,066	21,967	17,935	15,533	13,880	12,682			
10	56,689	40,085	32,730	28,345	25,334	23,144			
12	90,985	64,336	52,530	45,492	40,660	37,145			

PIPE SIZE INCHES	DRY RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET						WET RETURN MAIN — EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	322	275	1400	1000	820	700	590	600
1¼	962	868	770	670	579	480	2400	1700	1420	1200	1020	860
1½	1512	1362	1210	1058	909	757	3800	2700	2260	1900	1560	1300
2	3300	2960	2640	2300	1980	1630	8000	5600	4500	4000	3360	2800
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	5700	4800
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,300	10,700	9300	7800
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	24,000	16,000	13,600	11,400
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	26,000	22,000	20,500	15,400

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

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

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in that corresponding Column (*B* to *G*) for supply mains; (*L* to *Q*) for dry return mains; (*R* to *W*) for wet return mains for sizing the entire run.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Column (*B* to *G*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where supply riser capacities are found to be in excess of amounts shown in Column *H*, step up to *necessary size indicated* in that column. For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*L* to *Q*) for sizing each riser.

Note 5.—Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or a vacuum system may be taken into a dry return through a steam trap.

Note 6.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators, at least ½ in. in 10 ft.

Table 15. Pipe Sizes for Vacuum Pump Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped— Steam and Condensate flowing in same direction. Based on 4 oz. Total Pressure Drop**						Maximum Capacities	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I**
¾	.....	....	....	....	....	....	....	....
1	111	79	65	56	49	46	56	26
1¼	245	173	141	122	110	100	122	58
1½	380	269	220	190	165	155	190	95
2	771	546	446	386	345	315	386	195
2½	1270	898	734	635	568	518	635	395
3	2326	1645	1342	1163	1040	948	1129	700
3½	3474	2457	2006	1737	1552	1419	1548	1150
4	4914	3475	2828	2457	2196	2011	2042	1700
5	9092	6429	5250	4546	4062	3712		3150
6	14,924	10,553	8618	7462	6669	6094	.....	.....
8	31,066	21,967	17,935	15,533	13,880	12,682	.....	.....
10	56,689	40,085	32,730	28,345	25,334	23,144	.....	.....
12	90,985	64,336	52,530	45,492	40,660	37,145	.....	.....

Pipe Size Inches		Return Mains and Risers					
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.
J	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
....	¾	800	568	462	400	358	326
¾	1	1400	994	810	700	626	570
1	1¼	2400	1704	1387	1200	1073	976
1¼	1½	3800	2696	2195	1900	1698	1547
1½	2	8000	5680	4622	4000	3575	3256
2	2½	13,400	9510	7745	6700	5990	5453
2½	3	21,400	15,190	12,360	10,700	9565	8710
3	3½	32,000	22,710	18,490	16,000	14,300	13,020
3½	4	44,000	31,220	25,430	22,000	19,660	17,910

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connection to be of same size as valve and trap used. Return horizontal runout to be no less than ¾ in.

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

**It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Column (*B* to *G*) for sizing the entire run.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser. Determine the distance to the farthest radiator then use figures in that corresponding Column (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column.

Note 5.—Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in that corresponding Column (*L* to *Q*) for sizing entire return riser (Column *J*) and return main (Column *K*). *The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.*

Note 6.—Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through a steam trap into vacuum return. Never drip a supply riser into a vacuum return except through a steam trap.

Note 7.—Lift fittings. (See page 184).

Note 8.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators, at least ½ in. in 10 ft.

Table 16. Pipe Sizes for Vacuum Pump Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Pipe Size Ins.	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 4.*) Supply Main Dripped and Branches to Risers Dripped— Steam and Condensate flowing in same direction. Based on 8 oz. Total Pressure Drop**									Maximum Capacities	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L**
1	157	111	92	79	70	65	56	49	46	56	26
1¼	346	245	200	173	154	141	122	110	100	122	58
1½	538	380	310	269	240	220	190	165	155	190	95
2	1091	771	630	546	487	446	386	345	315	386	195
2½	1797	1270	1036	898	803	734	635	568	518	635	395
3	3289	2326	1896	1645	1470	1342	1163	1040	948	1129	700
3½	4913	3474	2838	2457	2196	2006	1737	1552	1419	1548	1150
4	6950	4914	4022	3475	3106	2828	2457	2196	2011	2042	1700
5	12,858	9092	7424	6429	5747	5250	4546	4062	3712	.....	3150
6	21,105	14,924	12,168	10,553	9433	8618	7462	6669	6084	.....	.....
8	43,934	31,066	25,364	21,967	19,638	17,935	15,533	13,880	12,682	.....	.....
10	80,171	56,689	46,288	40,085	35,836	32,730	28,345	25,334	23,144	.....	.....
12	128,672	90,985	74,290	64,336	57,516	52,530	45,492	40,660	37,145	.....	.....
16	240,245	169,879	138,381	121,012	107,389	98,500	84,849	75,917	69,671	.....	.....

Pipe Size Inches		Return Mains and Risers								
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.
M	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
....	¾	1130	800	653	568	505	462	400	358	326
¾	1	1977	1400	1143	994	884	810	700	626	570
1	1¼	3390	2400	1960	1704	1515	1387	1200	1073	976
1¼	1½	5370	3800	3103	2696	2400	2195	1900	1698	1547
1½	2	11,300	8000	6533	5680	5050	4622	4000	3575	3256
2	2½	18,925	13,400	10,940	9,510	8460	7745	6700	5990	5453
2½	3	30,230	21,400	17,460	15,190	13,510	12,360	10,700	9,565	8,710
3	3½	45,200	32,000	26,130	22,710	20,200	18,490	16,000	14,300	13,020
3½	4	62,180	44,000	35,950	31,220	27,800	25,430	22,000	19,660	17,910
4	5	109,300	77,400	63,200	54,920	48,800	44,720	38,700	34,600	31,500
5	6	175,100	124,000	101,200	88,000	78,200	71,700	62,000	55,410	50,450

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connection to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.

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

**It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

Note 1.—These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 18, 19 and 20).

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

Note 3.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 6).

Note 4.—Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Column (*B* to *J*) for sizing the entire run.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser. Determine the distance to the farthest radiator then use figures in that corresponding Column (*B* to *J*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *K*. Where riser capacities are found to be in excess of amounts shown in Column *K*, step up to necessary size indicated in that column.

Note 5.—Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in that corresponding Column (*O* to *W*) for sizing entire return riser (Column *M*) and return main (Column *N*) *The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.*

Note 6.—Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through a steam trap into vacuum return. Never drip a supply riser into a vacuum return except through a steam trap.

Note 7.—*Lift fittings.* (See page 184).

Note 8.—Pitch of pipe should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators, at least ½ in. in 10 ft.

riser as given in Column *K* and not Column *G*, determines the size of some sections of the riser.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *D*	*f* to *g*	200	2
" "	*e* to *f*	300	2
" "	*d* to *e*	400	2½
" "	*c* to *d*	500	2½
" "	*b* to *c*	600	2½
" "	*a* to *b*	700	3
Branch	to Riser *D*	700	3

Size riser *C* in manner similar to that used for riser *D*.

The equivalent length of run from the source of steam supply *A* to the farthest radiator supplied by main *BF* (or the radiator on floors *g* riser *F*) is between 400 and 500 ft.—therefore size the entire run from *B* to top of riser *F*, according to Column *F*, Table 16, observing *Note 4* as regards maximum capacity of up-feed supply risers given in Column *K*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SUPPLIED, SQ. FT.	PIPE SIZE, INCHES
Riser *F*	*f* to *g*	400	2½
" "	*e* to *f*	600	2½
" "	*d* to *e*	800	3
" "	*c* to *d*	1000	3
" "	*b* to *c*	1200	3½
" "	*a* to *b*	1400	3½
Branch	to Riser *F*	1400	4
Main	*B* to *F*	1600	3½

The equivalent length of run from the farthest radiator served by any return main (or that on floor *g* return riser *G*) to the vacuum pump is between 600 and 800 ft.—therefore size entire run according to Column *U*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *G*	*g* to *f*	400	¾
" " "	*f* to *e*	600	¾
" " "	*e* to *d*	800	1
" " "	*d* to *c*	1000	1
" " "	*c* to *b*	1200	1
" " "	*b* to *a*	1400	1¼
Branch	to Return Riser *G*	1400	1½
Return Main	*G* to *H*	1600	1½
" "	*H* to *I*	2400	2
" "	*I* to *J*	3200	2
" "	*J* to *L*	4800	2½

The equivalent length of run from the farthest radiator served by return riser *H* to the vacuum pump *L* is between 500 and 600 ft.—therefore size return riser *H* according to Column *T*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *H*	*g* to *f*	200	¾
" " "	*f* to *e*	300	¾
" " "	*e* to *d*	400	¾
" " "	*d* to *c*	500	¾
" " "	*c* to *b*	600	¾
" " "	*b* to *a*	700	¾
Branch	to Return Riser *H*	700	1

The equivalent length of run from the farthest radiator served by riser *I* to the vacuum pump is between 300 and 400 ft.—therefore size that riser according to Column *R*.

Size the return riser *I* in a manner similar to that used for riser *H*.

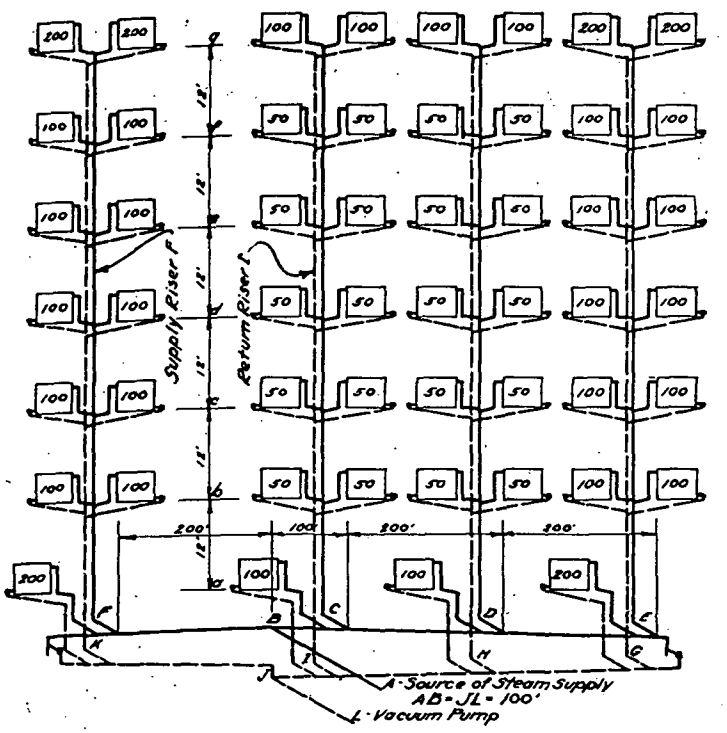


FIG. 8 LAYOUT OF VACUUM PUMP SYSTEM

The equivalent length of run from the farthest radiator served by return main *JK* to the vacuum pump is between 400 and 500 ft.—therefore size entire run from top of return riser *K* to *J* according to Column *S*.

PART OF SYSTEM	SECTION OF PIPE	RADIATION SERVED, SQ. FT.	PIPE SIZE, INCHES
Return Riser *K*	*g* to *f*	400	¾
" "	*f* to *e*	600	¾
" " "	*e* to *d*	800	1
" " "	*d* to *c*	1000	1
" " "	*c* to *b*	1200	1
" " "	*b* to *a*	1400	1
Branch	to Return Riser *K*	1400	1¼
Return Main	*K* to *J*	1600	1½

RESULTS OF LABORATORY EXPERIMENTS

The Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has investigated this subject[1], and has found the limiting velocity for one and two-pipe risers (that is where all the

[1]Reports by Houghten, Ebin & O'Connell, TRANSACTIONS, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vols. 28–33, inclusive.

condensate returns counter to the steam and where only the condensate from the riser so returns) are given in Tables 4 and 5. Investigation of limiting velocities for horizontal pipe with varying degrees of pitch has not yet been carried to a conclusion but the limiting velocities given in Table 17 are offered as safe. Further study of the subject may allow them to be increased.

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

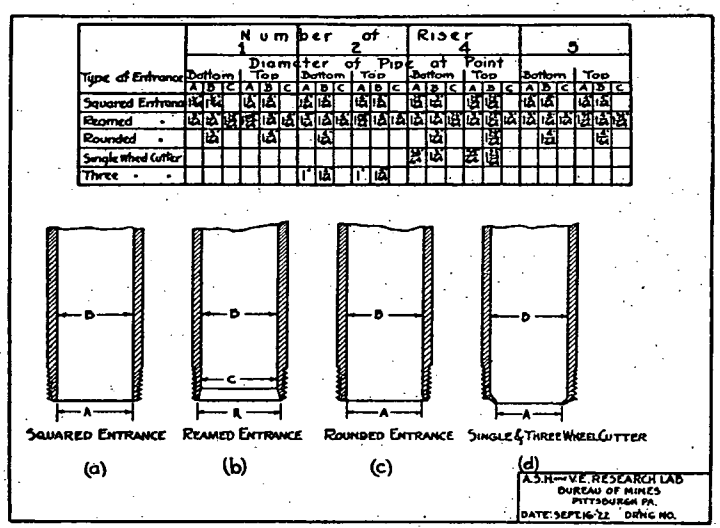


Fig. 9. Effect of Reaming Entrance to One-Pipe Risers

it at joints. Iron pipe should also be examined for constricting blisters, Fig. 9 and Table 18, from the Laboratory reports show the importance of these factors.

Table 20 shows variation in capacity of a pipe as affected by variation of size and smoothness of pipe generally found on the market. The maximum and minimum results were obtained by picking out very smooth and very rough pipe from the stock room of a large manufacturer.

Free area of valves, unions, and other fittings as found on the market are not always equal to the inside area of pipe of the same nominal size.

Globe valves show a maximum capacity below that of pipe of the same nominal size. The maximum capacity of such valves in a horizontal pipe depends upon whether the stem is vertical or horizontal.

Table 19 shows capacities found for valves picked at random from the stock of a large supply house.

Table 17. Comparative Capacity of Steam Lines at Various Pitches*

Pitch of Pipe in Inches per 10 Ft.

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

Table 18. Effect of Reaming Entrance to One-Pipe Risers*

See Fig. 9

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

Table 19. Results of Tests on Angle and Globe Valves*

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

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

Table 20. Per Cent Difference in Capacity Due to Variation of Pipe Size and Smoothness*

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

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

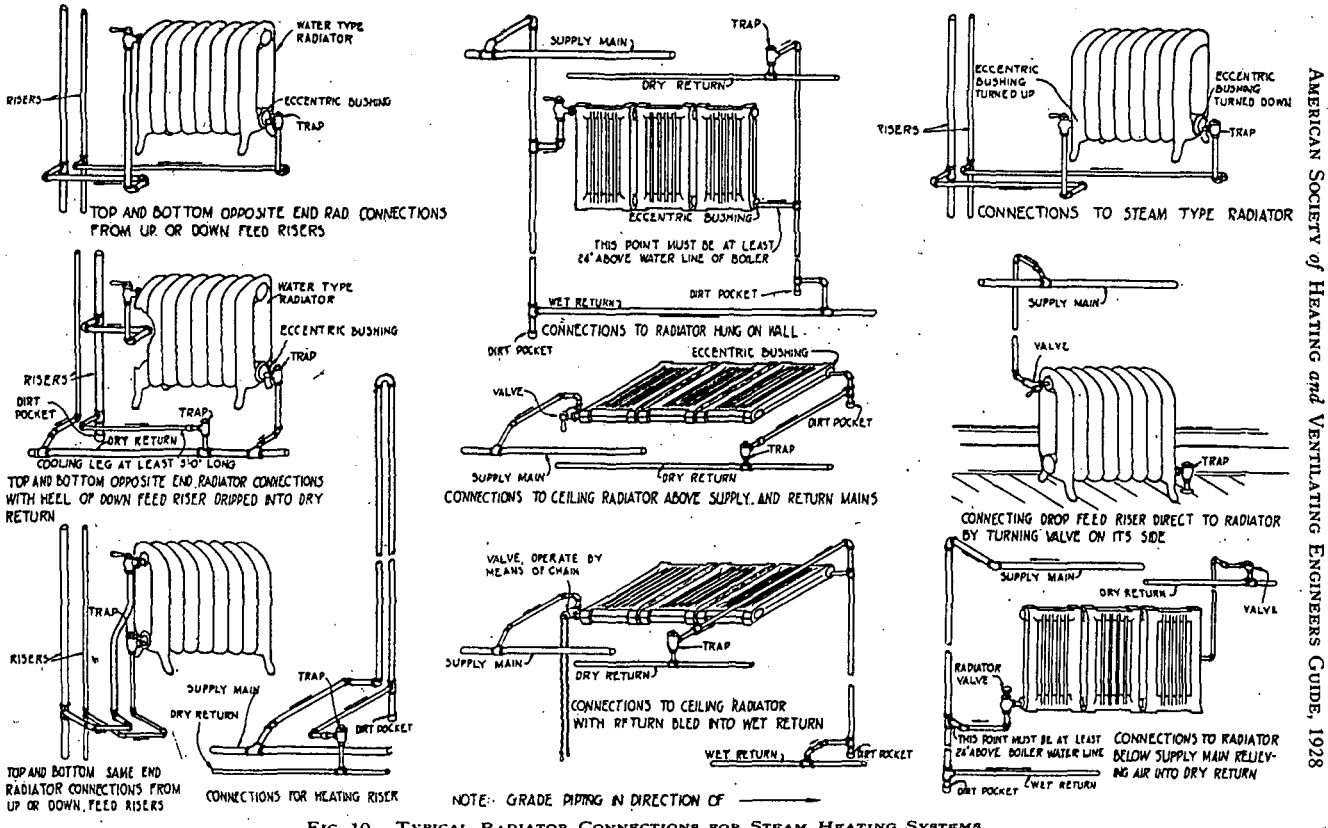


Fig. 10. Typical Radiator Connections for Steam Heating Systems

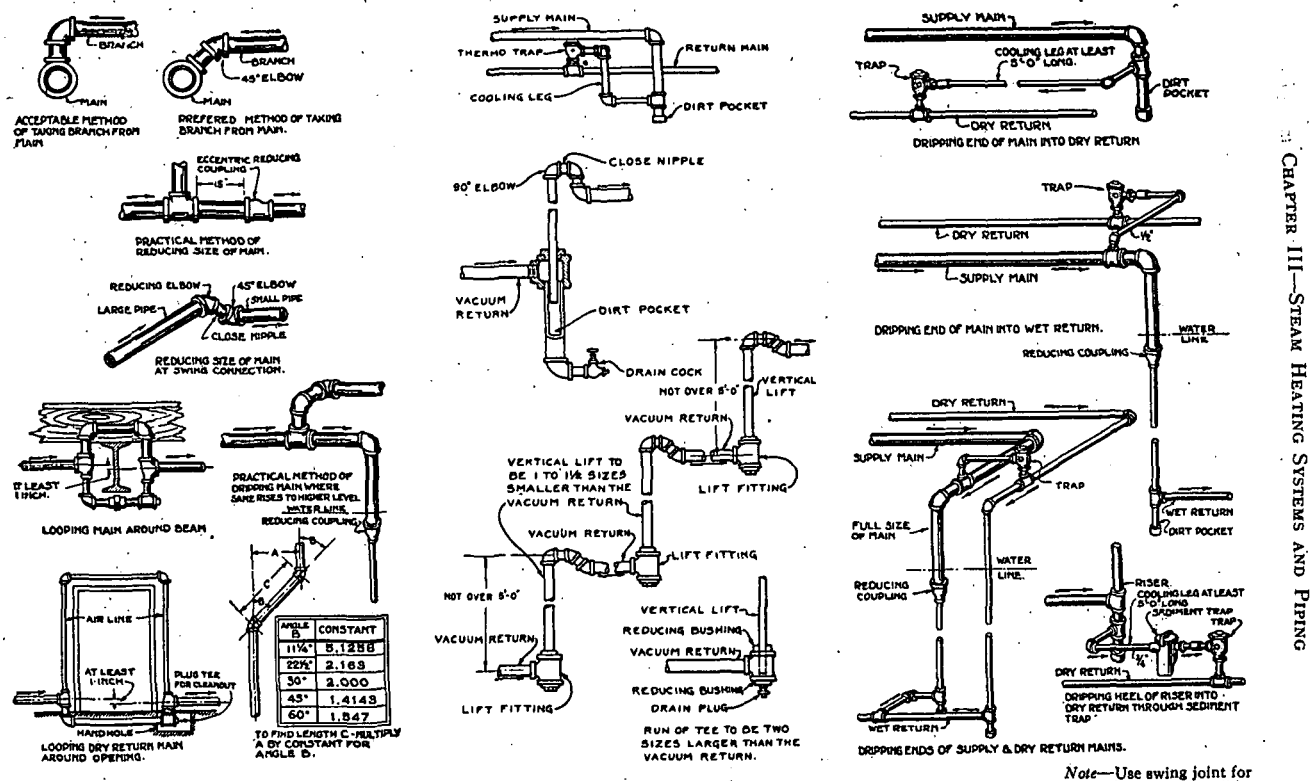


Fig. 11. Typical Steam Piping Connections

Note—Use swing joint for expansion when possible.

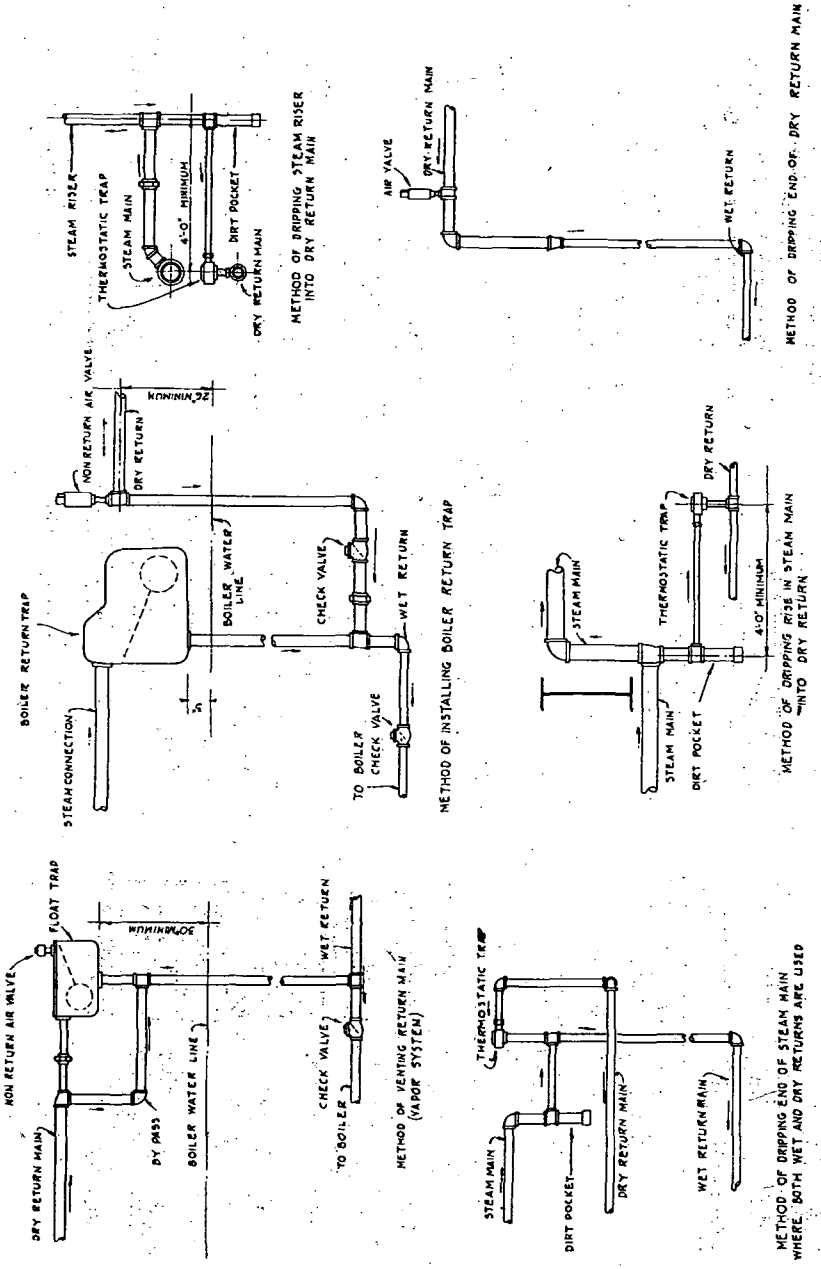


FIG. 12. TYPICAL STEAM PIPING CONNECTIONS

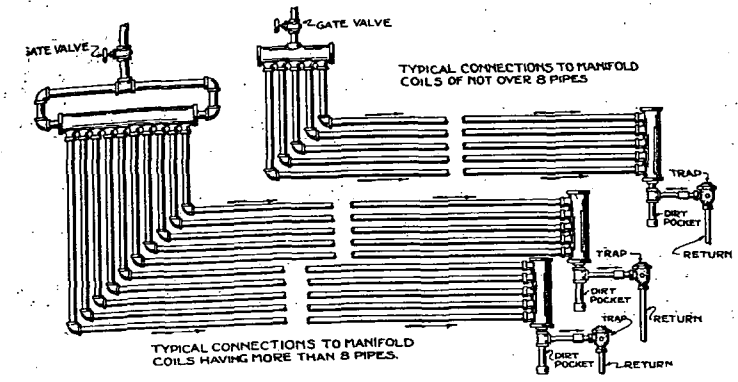
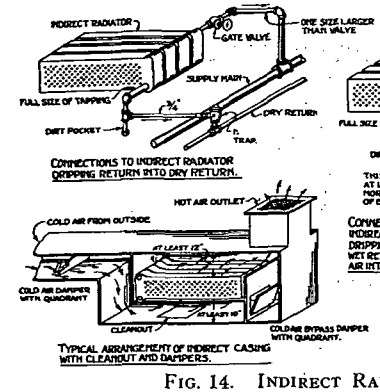
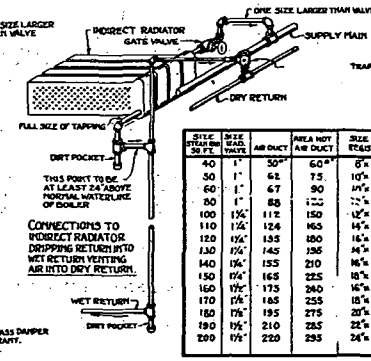


FIG. 13. TYPICAL CONNECTIONS TO MANIFOLD COILS HAVING MORE THAN 8 PIPES





SIZE STEAM END 30 FT.	SIZE RAD. VALVE	AIR DUCT	AREA HOT AIR DUCT	SIZE OF REGISTER
40	1"	50"	60"	8"x 12"
50	1"	62	75	10"x 12"
60	1"	67	90	11"x 15"
80	1"	88	[illegible]	[illegible]"x 15"
100	1¼"	112	150	12"x 18"
110	1¼"	124	165	14"x 18"
120	1¼"	135	180	16"x 18"
130	1¼"	145	195	14"x 20"
140	1¼"	155	210	16"x 20"
150	1¼"	165	225	18"x 20"
160	1½"	175	240	16"x 24"
170	1½"	185	255	18"x 24"
180	1½"	195	275	20"x 24"
190	1½"	210	285	22"x 24"
200	1½"	220	295	24"x 24"

FIG. 14. INDIRECT RADIATOR CONNECTIONS

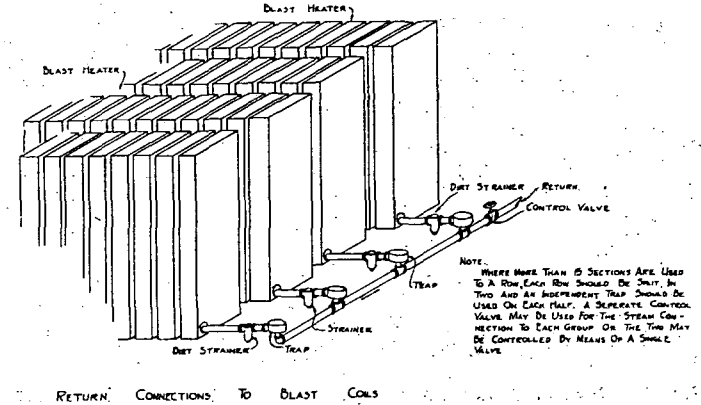


FIG. 15. RETURN CONNECTIONS TO BLAST COILS

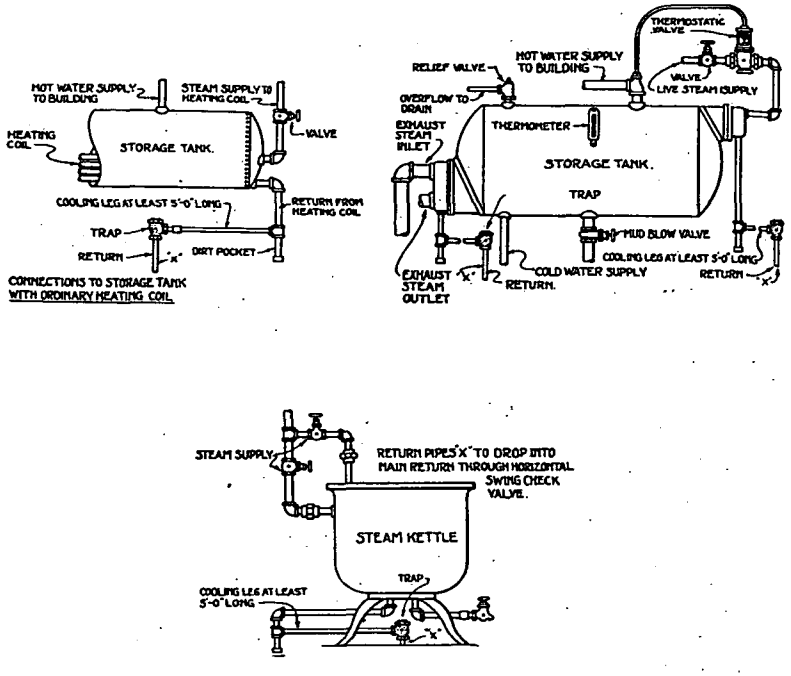


FIG. 16. CONNECTIONS TO COILS IN TANKS

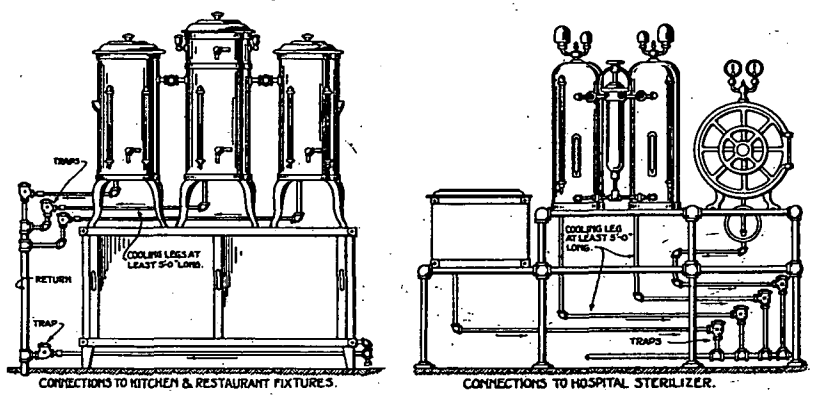


FIG. 17. TYPICAL CONNECTIONS TO KITCHEN AND HOSPITAL EQUIPMENT

CHAPTER IV

HOT WATER HEATING SYSTEMS AND PIPING

THE feature which distinguishes hot-water heating systems from all other types is that water serves as the medium by which heat is conveyed from the heater to the radiators. Water has a large capacity for heat and for that reason it is well suited to perform the service of conveying heat.

The design of a hot-water heating system should include the radiators, the heater or heaters, and the piping system. These three subjects will be considered in the order named.

RADIATION

To proportion the radiation it is necessary to know the quantity of heat, *i.e.*, the number of B.t.u. which are lost in a unit of time by the room or space in which the radiator is to be located and which must be replaced by the heat dissipated by the radiator so that the room or space may remain at the desired temperature.

The methods of determining the heat losses from a building or part of a building are explained in Chapter I.

Knowing the number of B.t.u. which a particular radiator is to dissipate (see Chapter II), it is necessary to assume the temperatures at which the water is to enter and to leave the radiator. Having done this, it is customary to assume that the mean of these two temperatures is the average temperature of the water in the radiator. For example, if the water is to enter the radiator at a tempearture of 200 deg. and to leave it at a temperature of 180 deg., it is assumed that the average temperature of the water in the radiator is 190 deg. If, in this case, the average room temperature is to be 70 deg., the average difference of the temperature of the water in the radiator and of the air surrounding the radiator is 120 deg. This temperature difference, water to air, is used as the basis for the design of the radiator.

The transfer of heat from the radiator to the surrounding space takes place partly by radiation, partly by convection, and partly by conduction. The quantity of heat dissipated by a radiator per square foot of surface, per hour, and per degree of temperature difference, water to air, is the heat dissipation coefficient of the radiator. This coefficient is generally represented by the letter k. A little reflection will convince the reader that the value of k, for a given type radiator, must decrease as the length of the radiator is increased, as its height is increased, as the number of columns in the radiator are increased, and as the temperature difference,

Chapter especially prepared for THE GUIDE by F. E. Giesecke, Director, Engineering Experiment Station, University of Texas, Austin, Texas.

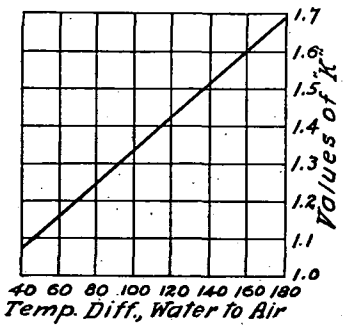


FIG. 1. HEAT DISSIPATION COEFFICIENT—*K*—OF A 38-IN., 3-COL. 20 SEC. HOT WATER RADIATOR AS DETERMINED AT THE UNIVERSITY OF ILLINOIS

water to air, is decreased. The writer conducted a series of tests in the laboratory of the Department of Mechanical Engineering, University of Illinois, to determine the values of *k* for a 38-in., 3-col., 20-sec. radiator, when the temperature difference, water to air, varied from about 55 deg. to about 145 deg., and when the water entered the radiator through the upper tapping and was discharged through the lower tapping. The results of this series of tests are shown in Fig. 1.

Using the values of Fig. 1 as a basis and assuming that the heat dissipation coefficient of a hot water radiator varies with the height of the radiator and with the number of columns of the radiator in substantially the same manner in which the heat dissipation coefficient of a steam radiator varies, as determined by Professor Allen and other investigators, Fig. 2 shows the values of *k* for the most common types of hot water radiators. It can be used to determine the size of the radiator when the type of the radiator to be used, the average temperature difference, water to air, and the quantity of heat to be dissipated per hour by the radiator are known.

An inspection of Figs. 1 and 2 shows that it is very important to maintain a high average water temperature in every radiator. For

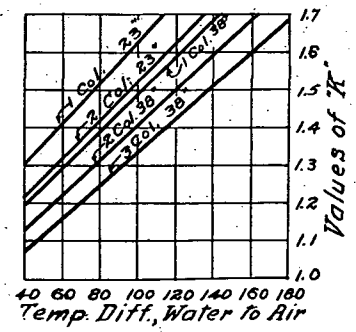


FIG. 2. SUGGESTED VALUES FOR THE HEAT DISSIPATION COEFFICIENTS—*K*—OF VARIOUS TYPES OF HOT WATER RADIATORS

example, if a 38-in., 3-col., radiator, located in a room having a temperature of 70 deg., is to dissipate 12,000 B.t.u. per hour, a 100-ft. radiator must be selected if the average water temperature in the radiator is 160 deg., whereas we may use a 70-ft. radiator if the average water temperature is 190 deg., or a 60-ft. radiator if the average water temperature is 205 deg.

It will be shown in the discussion of the design of the pipe system, that a decrease in pipe sizes results in an increase of friction, in an increase in the difference of the temperatures of the water in the flow and return risers, and consequently, in a decrease in the average temperature of the water in the radiator.

It is evident from the preceding discussion of radiator design that any economy which may have been effected by reducing pipe sizes will be offset in part, and may be totally offset, by the increased sizes of the radiators, particularly as the cost of a hot-water heating system is frequently based on the total radiation surface.

To illustrate the use of the diagrams of Fig. 2, let it be required to find the size of the radiator to be used if 8000 B.t.u. are to be dissipated by a 38-in., 3-col. radiator when the average temperature difference, water to air, is 170 − 70, or 100 deg. The value of *k* for this case, from Fig. 2, is about 1.34. The total surface required is 8000/1.34 or 60 sq. ft.

HEATER

To determine the heater it is necessary to know the quantity of heat which is to be transmitted to the water in the heater, and whether hard coal, soft coal, gas, steam, or electricity is to be used for heating the water.

The engineer designing a hot water heating system does not, as a rule, design the heater. He simply selects a heater suited to his needs from those available on the market. In selecting a heater for large installations, it is generally desirable to install at least two heaters, so that if one should fail the other will be available. When two heaters are installed, it may be advisable to select them of different sizes, the larger one having a capacity about 75 per cent greater than the smaller heater. If this is done, the heaters should be selected of such sizes that both may be used during extremely cold weather and the smaller or the larger during milder weather, depending on the outside temperature so that, at all times, the heating plant may be operated at a fairly high efficiency. There is frequently an advantage in having the two heaters of the same size so they may be interchangeable. This arrangement is very satisfactory, especially in the colder climates, if each heater is made of a size sufficient to carry about two thirds of the maximum load.

PIPING SYSTEM DESIGN

To design the piping for a hot water heating system many factors must be considered. For any given combination of heater and radiator, several different systems of piping may be designed so as to secure successful and satisfactory operation of the system.

There is only one general rule for the design of pipe systems that is applicable in all cases. It is this: *When the heating system is functioning*

at a uniform rate, that is when, in a given time, the radiators dissipate exactly the same quantity of heat that is delivered to the water in the heater, and when, consequently, the water in the system is circulating with a uniform velocity, the friction head in every circuit leading from the heater to a radiator and back again must be exactly equal to the pressure head for that particular radiator, *i.e.*, to the pressure head which tends to make the water flow from the heater to that radiator and back again, along the circuit referred to previously.

Before applying this general rule to the design of a piping system, it is necessary to assume:

1. The maximum temperature of the water leaving the heater when the outside temperature is the minimum for which the system is to be designed;
2. The drop in the temperature of the water while it is flowing through the radiator.
3. Whether the circulation of the water in the system is to be effected by gravity or by circulating pumps.
4. The arrangement of the piping connecting the heater with the several radiators.

These four preliminary steps will be discussed in the order named.

MAXIMUM WATER TEMPERATURE

For some time it has been customary to select 180 deg. as the maximum temperature of the water leaving the heater. With this maximum temperature and a temperature drop of 20 deg. through the radiator, the average water temperature in the radiator will be 170 deg. If the temperature of the room is to be 70 deg., the temperature difference, water to air, will be 100 deg. The corresponding value of k for a 38-in., 3-col. radiator is 1.34 and the heat dissipated by the radiator per square foot per hour is 134 B.t.u. A steam radiator of similar size and design and supplied with low pressure steam will dissipate about 210 B.t.u. per square foot an hour. Under these conditions, a hot water heating system would require about 210 sq. ft. of radiation for every 134 sq. ft. required by the steam heating system. The first cost of the hot water system would, consequently, be considerably higher than that of the corresponding steam system. This higher first cost of a hot water system is frequently the cause of the installation of a steam system.

If, on the other hand, 220 deg. is selected as the temperature of the water leaving the heater, the average temperature of the water in the radiator will be about 210 deg., practically the same as that in low pressure steam radiation, and the total radiation required for the hot water system will be about the same as that required for the corresponding steam system. The cost of the pipe system for hot water is probably a little higher than the cost of the pipe system for steam, but the cost of valves and traps for a steam system is higher than the cost of the valves for a hot water system, so that, finally, the cost of a hot water heating system will not be higher, and is frequently lower, than the cost of a corresponding steam heating system, if the maximum temperature of the water is selected sufficiently high.

The selection of 220 deg. as the maximum water temperature is entirely proper because the minimum outside temperature for which the heating system is designed and for which the heat losses are calculated, occurs only a few times in any one year and perhaps never in some years.

Consequently, it is very seldom and in some years never necessary to heat the water to the assumed maximum temperature.

If 220 deg. is selected as the maximum temperature, it is necessary to provide sufficient pressure of the water in all radiators and in the entire pipe system so that the water will not boil at that temperature. This can be accomplished easily in all closed systems and also in all open systems. In the latter case, it is only necessary to place the expansion tank at a sufficient altitude above the highest point of the heating system. For example, if the expansion tank is located 10 ft. above the highest point in the system and if the expansion tank riser is filled with 200 deg.

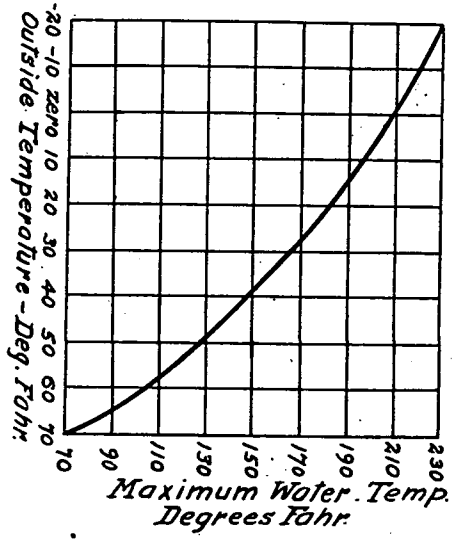


FIG. 3. AN ILLUSTRATION OF THE VARIATION, WITH THE OUTSIDE TEMPERATURE, OF THE REQUIRED MAXIMUM WATER TEMPERATURE IN THE HEATING SYSTEM

water when the flow risers carry 220 deg. water, the pressure at the highest point of the heating system will be about 4.2 lb. per sq. in. The corresponding boiling point is about 226 deg. and there would be no danger of boiling the water in the heating system at 220 deg.

In such cases the expansion tank riser should be connected to the return main. Precautions must always be taken to prevent freezing of the water in the expansion tank or in the expansion tank riser.

Having assumed the maximum temperature of the water for the minimum outside temperature, the required maximum temperature of the water for any other outside temperature may be found as follows:

If 220 deg. is selected as the maximum temperature of the water when the minimum outside temperature is −10 deg., if the inside temperature is to be 70 deg. and the temperature drop through the radiator is to be 20 deg., if R represents the total radiation in square feet, and if it is assumed that the total heat losses are proportional to the temperature differences, inside and outside, the total heat loss will be $1.52\,R\,(210 - 70)$

or 212.8 R. In this calculation, 1.52 is the value of k for a 38-in., 3-col. radiator. When the maximum water temperature is 180 deg., the total heat loss will be 1.34 R (170 − 70) or 134 R. Similarly, when the maximum water temperature is 140 deg. the total heat loss will be 69.6 R. Since a heat loss of 212.8 R corresponds to a temperature difference, inside to outside, of 80 deg., heat losses of 134 R and 69.6 R, correspond, respectively, to 49 deg. and 25.5 deg. of temperature differences. Consequently, the two assumed maximum water temperatures correspond, respectively, to outside temperatures of 21 deg. and 44.5 deg. From such data, a curve like that shown in Fig. 3 may be constructed and used to determine the maximum water temperature for any given outside temperature.

Such a curve will, however, not show the correct water temperatures for all times heat loss of buildings depend to a considerable extent upon the direction and velocity of the wind. The values shown by the curve must, therefore, be modified from time to time by the operating engineer according to the character of the wind prevailing at that particular time.

TEMPERATURE DROP THROUGH THE RADIATOR

For any given radiator, the drop in the temperature of the water as it flows through the radiator is determined by the quantity of water flowing through the radiator in a given time. For example, if a radiator is to dissipate 10,000 B.t.u. per hour with a temperature drop of 10 deg., it is necessary that 1000 lb. of water flow through the radiator per hour. If, on the other hand, the temperature drop is to be 20 deg., only 500 lb. of water must flow through the radiator per hour. If, in both cases, the same size pipe is used, the velocity of the water must be twice as high in the former case as in the latter, and since the friction of water in pipes varies almost as the square of the velocity, it follows that the friction head is almost four times as great in the former case as in the latter. If, in both cases, the friction head must have a fixed value—the same as that of the available pressure head, it is evident that the temperature drop through the radiator decreases as the pipe sizes are increased. It was shown above that the required size of the radiator decreases as the temperature drop through the radiator decreases.

Reducing the temperature drop through the radiator, then, decreases the sizes of the radiators but increases the sizes of the piping; in other words, it decreases the cost of the radiators but increases the cost of the piping. There is, consequently, an optimum temperature drop through the radiators for every installation which carries with it the lowest cost of installation. This optimum temperature drop can be determined by a few trial calculations. As a rule, such calculations are never made; the temperature drop is selected arbitrarily.

A temperature drop of from 20 to 30 deg. is common and generally quite satisfactory.

THE MOTIVE FORCE

Whether gravity circulation or forced circulation is to be adopted for any particular installation is generally evident from the nature of the case.

In almost all residence systems and in a good many installations in

larger buildings, gravity circulation is entirely satisfactory and should be adopted because its operation is much more simple and also cheaper than that of forced circulation.

For installations which are too large to function well as gravity systems and for all general heating systems which serve a group of buildings, forced circulation should be adopted.

The optimum velocity of the water in forced circulation systems is subject to calculation. As the velocity is increased, the size, and therefore also the cost, of the piping and radiation is decreased but the cost of the pump and the cost of operating the pump are increased. As a general rule, a velocity of from 6 to 10 ft. per second will be found satisfactory.

In gravity circulation systems, the velocity of the water generally varies from about 1 to about 6 in. per second.

ARRANGEMENT OF PIPING

Having determined the location of the heater and the locations of the several radiators, there are a large number of different ways in which the piping can be arranged to connect the heater and the radiators so as to secure an entirely satisfactory operation of the system, provided the radiators and the several pipes of the system are of correct size so that, in every case, the pressure head for every radiator is exactly equal to the friction head in the circuit of that radiator, when the system is operating at a uniform rate and when each radiator is dissipating its correct quantity of heat.

Fig. 4 shows a very small heating system consisting of a heater, located in the basement, two radiators on the first floor, and two on the second floor. Ten different methods of connecting the heater to the radiator for this small system are shown. It is evident that the ten methods shown are not the only methods which could be used. It is also evident that for a larger heating system, a larger number of different methods of connecting the heater to the radiators exist.

Several attempts have been made to assign distinctive names to the several methods or types of piping for hot water heating systems. The result is not satisfactory because it is possible to have so many variations of each typical method or system of piping. The following definitions, supplemented by the illustrations of Fig. 4, will serve to describe the more common general types of piping:

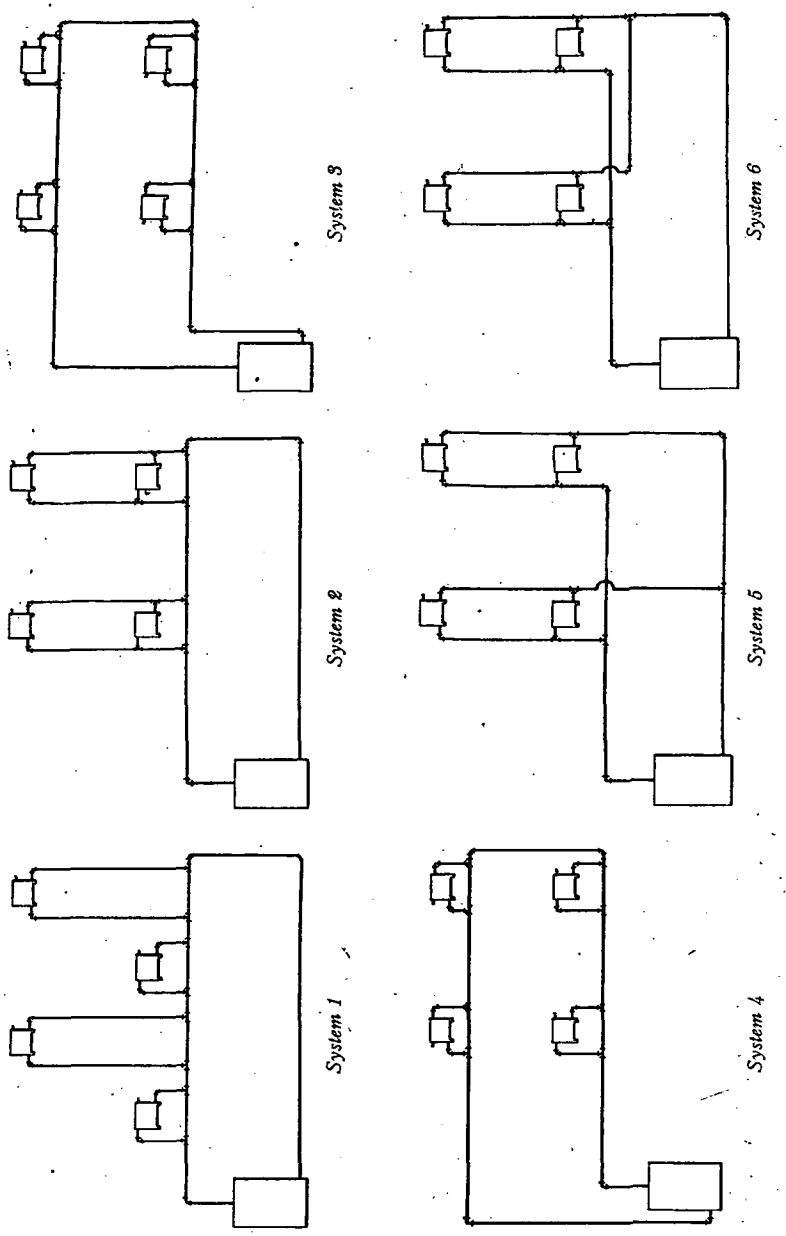
1. A *one-pipe* system is one in which the water flows through more than one radiator before it returns to the heater.

2. A *two-pipe* system is one in which all water returns to the heater after it has passed through one radiator. In a two-pipe system all radiators are supplied with water at the temperature at which the water leaves the heater, neglecting the slight cooling which takes place in the pipe leading from the heater to the radiator.

Systems 1, 2, 3, and 4 of Fig. 4 have one-pipe mains and two-pipe risers. Systems 7 and 8 have two-pipe mains and one-pipe riser. Systems 5, 6, 9, and 10 have two-pipe systems throughout.

3. An *Over-head* distribution system is one in which a main flow riser extends from the heater to the attic, the distributing main is located in the attic, and the return main in the basement. Systems 7, 8, 9, and 10 illustrate this type.

4. An *under-foot* distribution system is one in which the main flow riser extends only to the basement ceiling, and the main flow line as well as the main return line is located below the basement ceiling. Systems 1, 2, 3, 4, 5, and 6 illustrate this type.



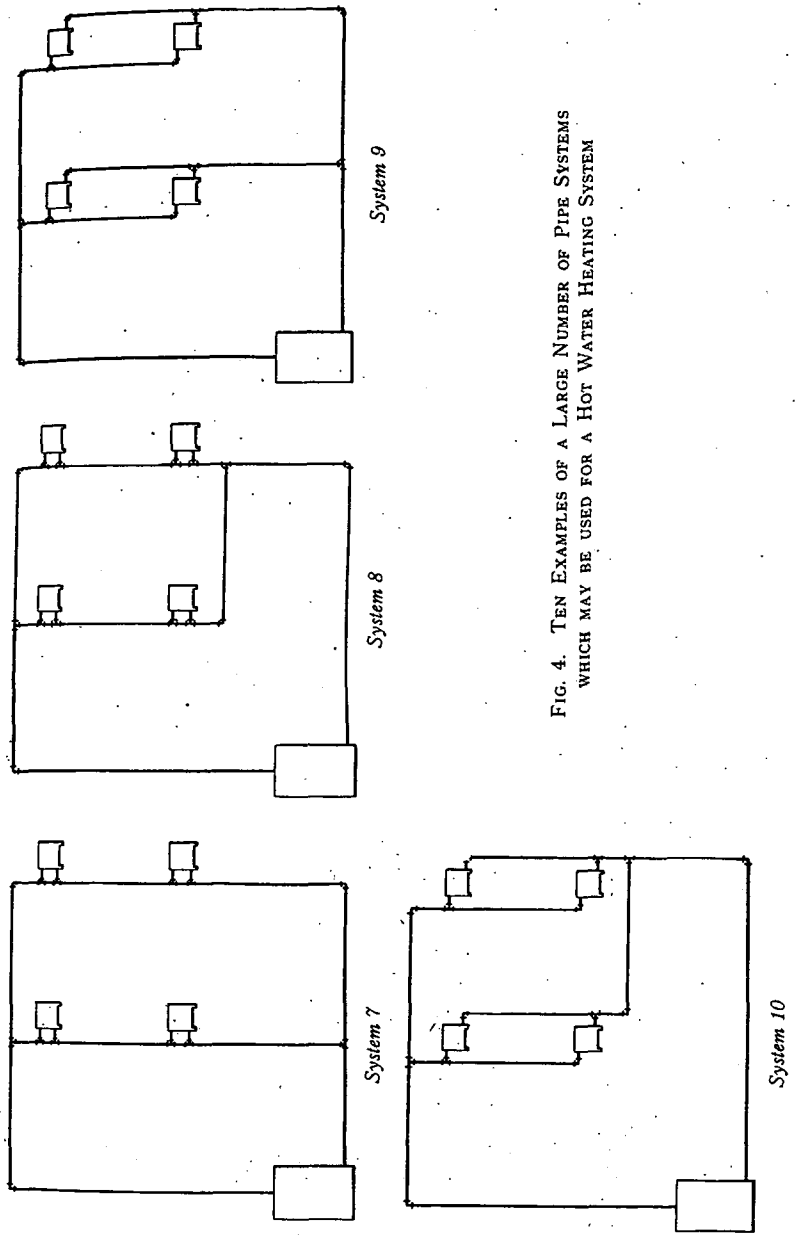


Fig. 4. Ten Examples of a Large Number of Pipe Systems which may be used for a Hot Water Heating System

5. A *direct-return* system is one in which the water is returned to the heater along a direct path, so that the total distance traveled by the water is the shortest feasible distance, and so that there is a considerable difference in the lengths of the several circuits composing the system.

6. A *reversed-return* system is one in which the water from the several radiators is returned along paths arranged so that all circuits composing the system, or composing major sub-division of the system, are practically of equal length. A reversed-return system is to be preferred to a direct-return system because it is easier to arrange the circuits so that, in every case, the friction head is equal to the pressure head, and because, in starting the system, all circuits of the reversed-return system being to function practically at the same time, whereas, in a direct-return system, the longer circuits require considerable more time to begin operating than the shorter circuits. The direct-return system is illustrated by Systems 5, 7, and 9. The reversed-return system is illustrated by Systems 6, 8, and 10.

DETERMINING PIPE SIZES

Having settled on the arrangement of the circuits for the system, generally by selecting a scheme similar to one of those shown in Fig. 4, it is customary to assume the pipe sizes and, having done that, to calculate the pressure head and the friction head for every circuit. If the two heads happen to be practically equal, the assumed pipe size is the correct one. If there is a material difference between the two, a change is made in the assumed size of the pipe, or of a portion of the pipe, and a new friction head calculation is made. This process is repeated until the correct size has been found.

To illustrate the method, let it be required to find the correct size for the pipe of the elementary system shown in Fig. 5. This system is to dissipate 12,000 B.t.u. when the temperature of the water is 200 deg. in the flow riser and 180 deg. in the return riser. The center of the radiator is to be 7 ft. above the center of the heater. The pressure head results from the difference in the weights of two columns of water, 7 ft. high, one having a temperature of 200 deg. and the other one of 180 deg. This difference in weight can be calculated. However, it can be determined more easily from the diagram of Fig. 6. It appears from this diagram that for 200 deg. in the flow riser and 180 deg. in the return riser, the pressure head is 90 milinches per foot of water column. The pressure head for the system is, therefore, 7 × 90, or 630 milinches of water.

TABLE 1. ELBOW EQUIVALENTS

1 90 deg. elbow	1.0
1 45 deg. elbow	0.7
1 90 deg. long turn elbow	0.5
1 Open return bend	1.0
1 Tee	2.2
1 Open gate valve	0.5
1 Open globe valve	12.0
1 Angle radiator valve	2.0
1 Radiator	3.0
1 Heater	3.0

These relations are very nearly correct for the low velocities obtaining in gravity circulation; for the higher velocities employed in forced circulation, they are sufficiently accurate because every radiator has practically the same number of valves and tees in its circuit and is, therefore, affected equally by any variation from the ratios given above.

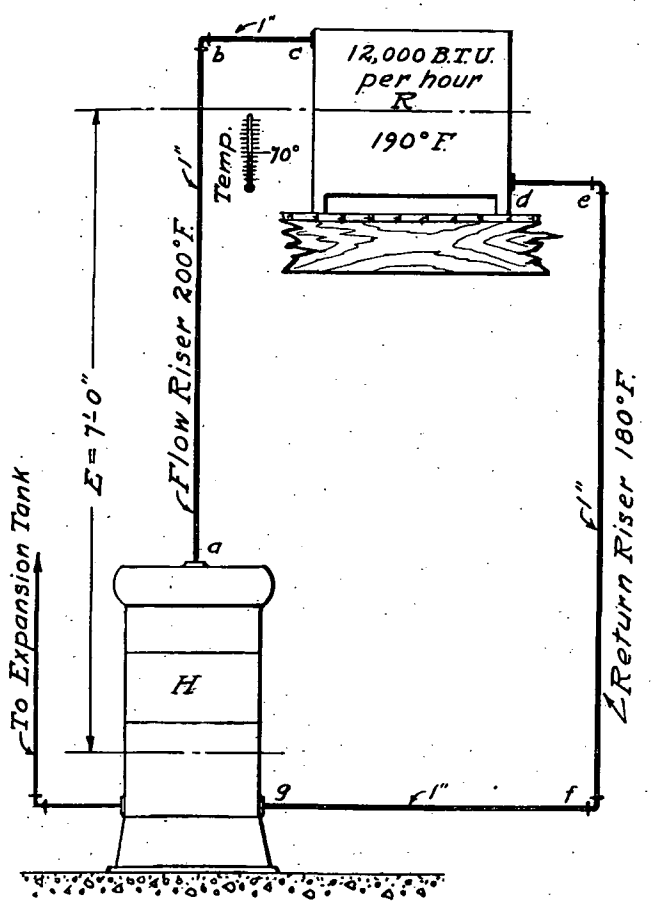


FIG. 5. AN ELEMENTARY HEATING SYSTEM

In other words, the pressure head causing circulation in the system is the same as that produced by a column of water 5/8 in. high.

This calculation shows clearly that the motive force involved in gravity circulation hot water heating is very small and that great care must be taken to adjust the friction heads to the pressure heads when the water can flow along any one of several available circuits.

To calculate the friction head in the circuit, we note, first, that the circuit consists of 22 ft. of pipe, 3 elbows, 1 heater, and 1 radiator; and, second, from Table 1, that the frictional resistance of 1 heater and 1 radiator is, for each, equivalent to the frictional resistance of 3 elbows. Consequently, the friction head of the entire circuit is equal to that in 22 ft. of pipe and 9 elbows. Assuming, now, that 1-in. pipe is to be used,

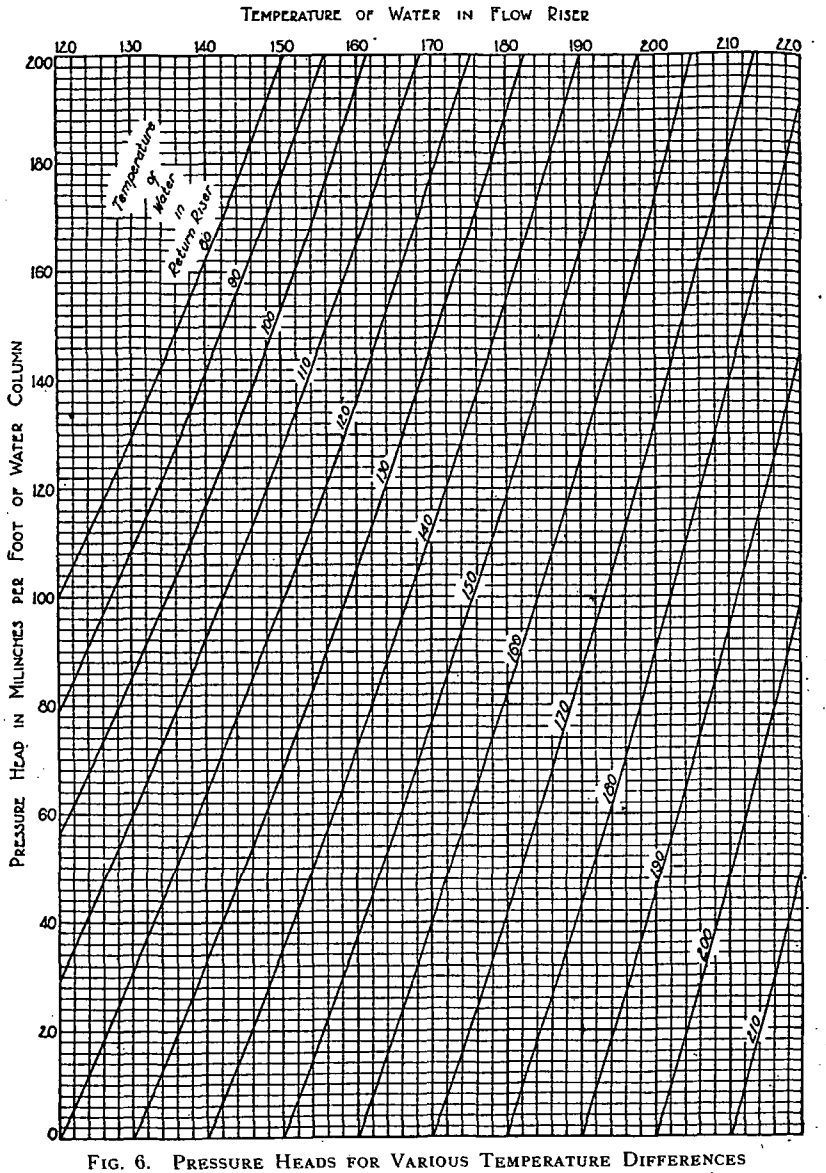


FIG. 6. PRESSURE HEADS FOR VARIOUS TEMPERATURE DIFFERENCES

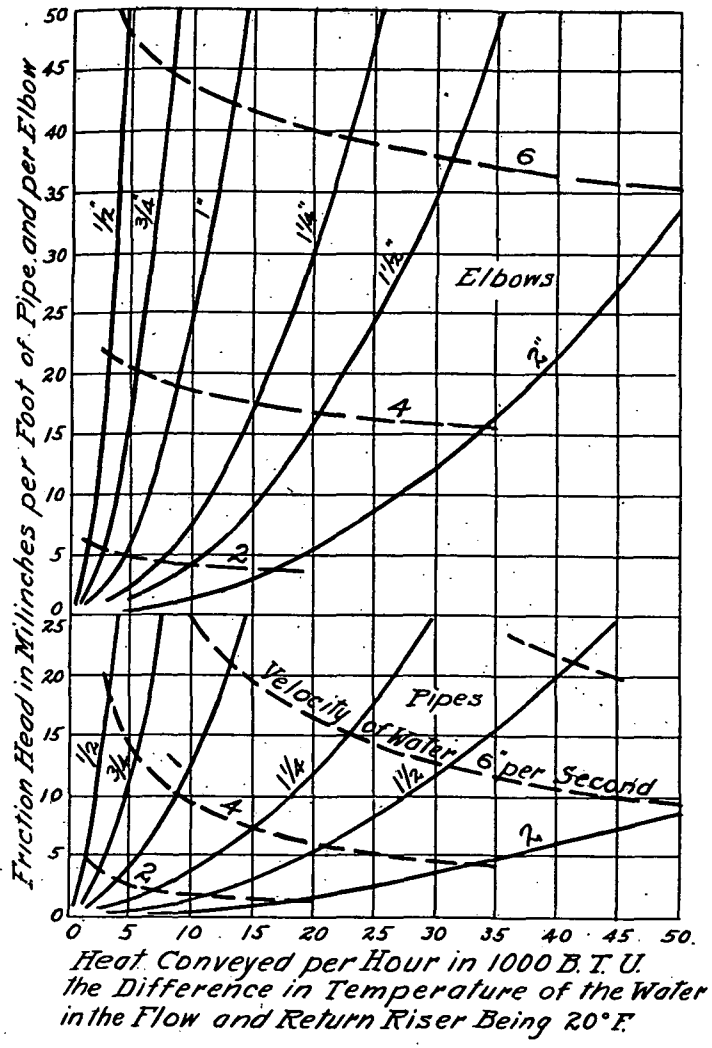


FIG. 7. FRICTION HEADS, IN PIPES AND ELBOWS, FOR A 20 DEG. TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

the friction heads in the pipe and in the elbows can be calculated by known formulae, or, they can be determined more readily from the diagrams of Figs. 7 and 8. It will be noted from Fig. 7, that for a 1-in. pipe, for 12,000 B.t.u. per hour, and for a temperautre drop of 20 deg., the friction head is 18 milinches per foot of pipe and 35 milinches

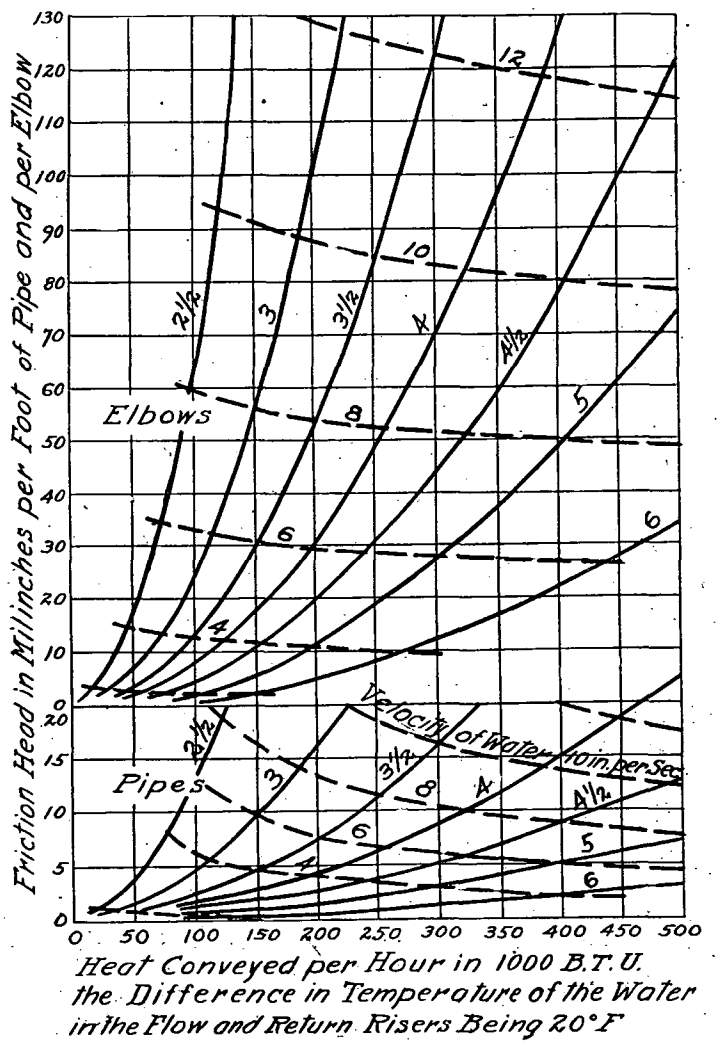


FIG. 8. FRICTION HEADS, IN PIPES AND ELBOWS, FOR A 20 DEG. TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

per elbow. Incidentally, we note also that the velocity will be about 5 in. per second.

The total friction is, therefore,

$$22 \times 18 = 396$$
$$9 \times 35 = 315 \quad 711 \text{ milinches.}$$

As this is slightly more than the available pressure head of 630 milinches, a 1-in. pipe is a trifle too small. However, the difference between the calculated friction head and the available pressure head is so small that the 1-in. pipe can safely be used.

If a 1¼-in. pipe were used, the pressure head would be

$$22 \times 5 = 110$$
$$9 \times 11 = 99 \quad 209 \text{ milinches, or less}$$

than one-third of the available pressure head. Consequently, a 1¼-in. pipe would be entirely too large.

The calaculation shows how easily friction head calculations can be made. For more complicated installations, the calculations are more complicated, but in all cases, they are fairly simple. More detailed instructions than can be given here for such calculations may be found in text books and in magazine articles.

EMPIRICAL RULES

A very great demand exists for empirical rules or tables by means of which pipe sizes for hot water heating systems can be determined according to the radiation which the pipe is to serve and without the necessity of friction head and pressure head calculations.

It is not possible to prepare such tables or rules which would have any degree of accuracy.

For example, in the elementary heating system shown in Fig. 5, a 1-in. pipe is practically the correct size. If the radiator were placed about 10 or 14 ft. above the heater instead of 7 ft., a 1-in. pipe would be entirely too large; or, if the radiator were placed at a considerably greater distance from the heater so that the number of elbows and the length of the pipe of the circuit were increased materially, a 1-in. pipe would be too small. So in this simple case, under different circumstances, a ¾-in. pipe, a 1-in. pipe, or a 1¼-in. pipe would be the correct size to select. In the 10 types of pipe systems shown in Fig. 4, it is quite evident that no empirical rule could be devised which would correctly give the pipe sizes to be used in every one of the ten cases shown there.

There are a number of empirical rules, however, contained in the Catalogue Data of the various manufacturers of hot water heating apparatus which may be used with success if properly applied to such ordinary problems as these manufacturers have found them applicable to where the runs are not long and the various branches of the system can be fairly well equalized as to length of run and amounts of radiation, these practical rules, when applied to residences and other relatively small buildings of ordinary ceiling lengths, prove quite successful.

There are also a number of practical suggestions, to be found in these data, as to piping details and different kinds of connections.

GRAVITY HOT WATER HEATING* FOR SMALLER INSTALLATIONS

In the average small hot water heating system such as is used for bungalows, cottages and even the modest sized home or residence, it is

*Compiled by H. L. Alt, New York.

TABLE 2. AREAS OF STANDARD SIZE PIPES OF STANDARD WEIGHT

Nominal Size of Pipe Inches	Area of Pipe Sq. In.
⅜	0.192
½	0.305
¾	0.533
1	0.863
1¼	1.496
1½	2.038
2	3.356
2½	4.784
3	7.388
3½	9.887
4	12.73
5	19.99
6	28.89
8	50.04
10	78.84
12	113.10

not usually the case to find much attention given to complicated formulae and curves; this is for the reason that the saving on installations involving only a few hundred dollars is so small as not to justify elaborate engineering calculation besides which the work itself is generally installed by a competition contractor and no funds are available for which a proper designer could be employed. As a general rule the contractor himself does all the designing which is necessary and he doesn't want to be bothered with any complication which can in any way be avoided.

Probably the simplest way of determining hot water pipe sizes in the ordinary small gravity system is the old method of taking the area of each radiator connection or valve and adding these areas together where the lines join, making the area of combined line practically equal to the sum of all the areas which the line supplies.

Thus if a pipe is feeding three radiators, one with a ¾-in. connection, one with a 1-in. connection and the third with a 1½-in. connection the sum of these areas is as follows:

1 in.	0.863 sq. in.
1½ in.	2.038
¾ in.	0.533
	3.434 sq. in.

Referring back to the table it will be found that the pipe which has practically the same area is a 2-in. pipe which has an area of 3.356 sq. in.

For jobs of somewhat larger character where too much refinement is

TABLE 3. SQUARE FEET OF RADIATION ALLOWABLE ON RISERS UP TO 100 FT. HEIGHT

Nominal Pipe Size Inches	Distance above the Boiler in Feet									
	10	20	30	40	50	60	70	80	90	100
¾	40	50	60	70	80	90	100	110	120	130
1	70	80	90	100	110	120	130	140	150	160
1¼	110	120	135	150	160	175	185	200	210	225
1½	180	185	210	230	250	265	285	300	315	330
2	300	350	400	500	575	625	700	775	825	900

unnecessary but at the same time closer results than that given in the above are desired, the table given below which takes into the consideration the height of the riser available to circulate the line may be recommended.

The risers are then connected up to the mains on the basis of allowing a factor for each size of pipe and then adding these factors to obtain the factor corresponding to the proper size of basement main. These factors are as follows:

TABLE 4. FACTORS FOR VARIOUS SIZES OF PIPE IN GRAVITY HOT WATER HEATING

Nominal Size of Pipe Inches	Factor
¾	5
1	10
1¼	20
1½	30
2	60
2½	110
3	175
3½	260
4	380
5	650
6	1050
8	2250
10	.....
12	.....

Thus, if the three radiators previously considered were set and sized as follows; the ¾-in. radiator with 20 sq. ft., and located 40 ft. above the boiler; the 1-in. radiator with 40 sq. ft. and set 20 ft. above the boiler and the 1½-in. radiator with 75 sq. ft., and set 10 ft. above the boiler all being on the same riser, the riser size would be as follows:

Riser for 20 sq. ft. radiator 40 ft. above	¾ in.
Riser for 40 sq. ft. radiator 20 ft. above	¾ in.
Riser for 75 sq. ft. radiator 10 ft. above	1¼ in.

To combine into one riser take the factors and add;

¾ in.	5 factor
¾ in.	5
1¼ in.	20
Total	30

and the factor 30 is equivalent to a 1½-in. riser.

Even if these radiators had all been placed on the first floor, (or 10 ft. above the boiler), the riser size of 1½-in. would still have been sufficient for the three or their equivalent in one radiator. This indicates that the method of combiming valve areas gives about one pipe size larger than when more accurately figured.

AIR SEALED OR CLOSED HOT WATER SYSTEMS*

For many years the closed system of hot water heating in some form has been used successfully abroad, but there has been little thought given to and no research work done in connection with the air sealed system in this country, so that available data is meagre. For design

*Prepared from data submitted by R. H. Feltwell, Philadelphia and H. A. Thrush, Peru, Ind.

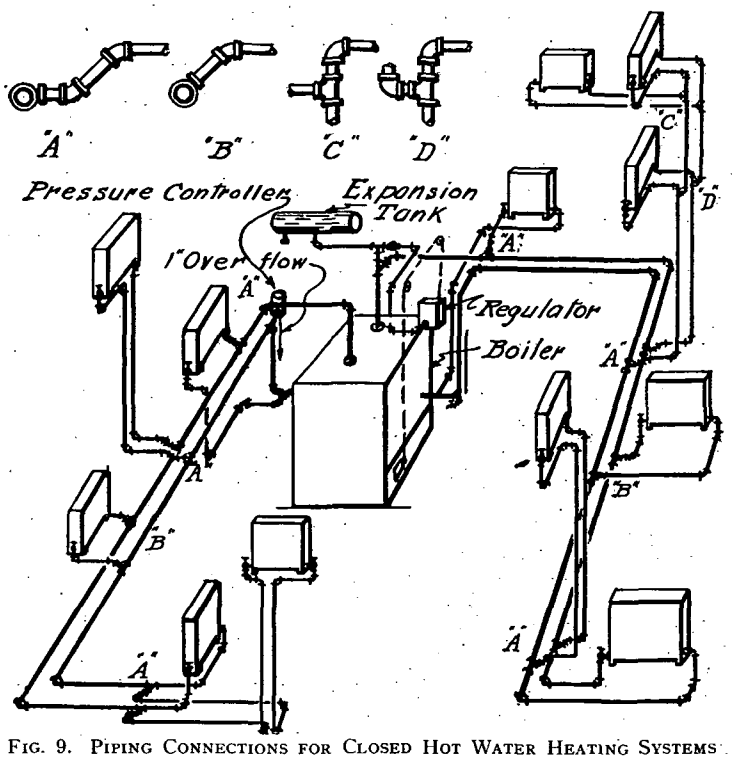


FIG. 9. PIPING CONNECTIONS FOR CLOSED HOT WATER HEATING SYSTEMS

work the engineer, architect or heating contractor, finds little on pipe sizes, etc.

Due to the more rapid circulation of water in an air sealed system 50 per cent more radiation can be supplied than by a gravity connection. Therefore the rules as set forth by F. E. Giesecke, N. S. Thompson and C. A. Fuller in their books on hot water heating can be used to advantage by adding 50 per cent to their formula for house heating. The following table would then be applicable for air sealed hot water system.

TABLE 5. PIPE SIZES AND CONNECTIONS FOR CLOSED SYSTEMS

Amount of Radiating

PIPE SIZE INCHES	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	FOURTH FLOOR
½	30	40	50	60
¾	60	75	90	110
1	110	120	135	150
1¼	165	180	200	225
1½	270	290	315	350
2	450	525	600	750

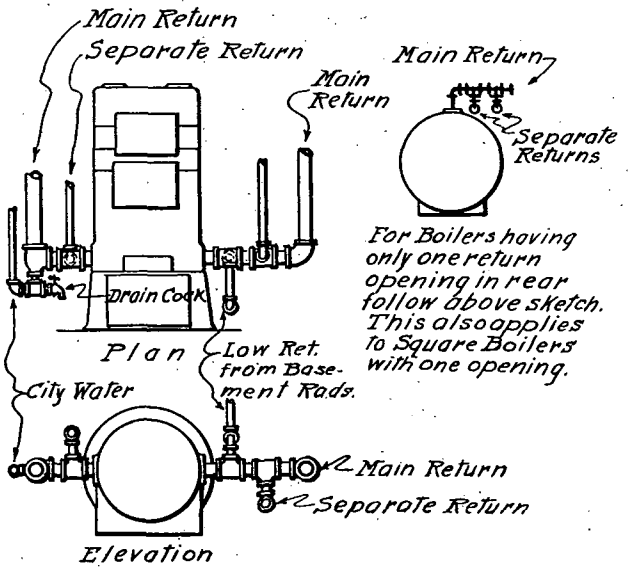


FIG. 10. CONNECTING SEPARATE RETURNS TO BOILER

The piping layout should be designed to conform to the best engineering experience of the engineer. It is not necessary except on very small mains to continue the mains full size to the end for they should end two sizes larger than the last radiator they supply. In all cases mains should end in the first floor radiator. Where a riser extends beyond the last first floor radiator the line running out to it should be treated as a lateral. See plan Fig. 9.

In each case the lateral leading from the main need be no larger than the radiator valve it supplies but care should be exercised that allowance is made for the proper distribution of the water to the radiators. Connections as shown in plan Fig. 9 are recommended, the *B* connection being used on all first floor radiators except right at the boiler where the *A* connection can often be used to advantage. The *C* connection is used on upper floors on the same level to supply two or more radiators from one riser and the *D* connection is used on risers feeding more than one floor and the style of connection should be used on the different floors of a building where it is desired to extend to a floor above.

The area of mains both flow and return must equal or exceed the total area of the valve sizes they are to supply. It is recommended that nearby radiators to the boiler have separate returns and that these return enter the boiler as shown in Fig. 10.

Many sealed systems of hot water heating do not function properly on account of lack of air in the air sealed expansion tank. Tank sizes should conform to the amount of water contained in the heating system, and are based on 12½ lb. of water to the gallon, for tank capacity. The

makers of air sealed tank in basement equipment furnish tank sizes for the different amounts of radiation as follows:

Square Feet of Radiation	Gallons	Square Feet of Radiation	Gallons
250 to 350	18	1400 to 1600	54
350 to 450	21	1600 to 1800	60
450 to 650	24	1800 to 2000	70
650 to 900	30	2000 to 2400	80
900 to 1100	35	2400 to 2800	90
1100 to 1400	40	2800 to 3000	110
		3000 to 3500	120

By using the sealed system of hot water heating it has been found that there is a ready absorption of heat by the water, a rapid circulation and uniform distribution of the water in the radiator and the possibility of close regulation depending on the use of the pressure obtained by the expanding water against the air in the sealed tank. The pressures obtained for different temperatures when tank capacities are as outlined are as follows:

Outside Temperature	Temperature of Water Required to Heat Building	Approximate Position of the Hand on Pressure Gage
60 deg.	100 deg.	At the static head required to fill the system.
50 deg.	120 deg.	1 lb. pressure above static head.
32 deg.	140 deg.	2 lb. pressure above static head.
20 deg.	150 deg.	3 lb. pressure above static head.
15 deg.	160 deg.	4 lb. pressure above static head.
10 deg.	170 deg.	5 lb. pressure above static head.
0 deg.	180 deg.	6 lb. pressure above static head.
−10 deg.	190 deg.	7 lb. pressure above static head.
−20 deg.	200 deg.	8 lb. pressure above static head.
−25 deg.	210 deg.	9 lb. pressure above static head.
−30 deg.	220 deg.	10 lb. pressure above static head.

The table also gives the outside temperature and the corresponding boiler temperature of the water in the radiators necessary to warm to 70 deg., when radiation is figured on the basis of heating rooms to 70 deg.

CHAPTER V

GREENHOUSE HEATING SYSTEMS

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

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

Although the same tables, formulae and other data that are used to estimate the heating requirements of systems in the usual types of buildings are also applicable to greenhouse heating and although the same pumps, traps, regulators, valves and other devices and fittings are used in greenhouses as in other systems, there are many differences that must be kept in mind so that due allowances may be made in the specification of a plant.

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

Greenhouse fires are banked during the day almost always throughout the firing season, even in midwinter when the sun is shining, and fuel consumption is heaviest at night; this in marked contrast to practically all other types of heating systems where the fires are banked at night.

Greenhouse radiation is almost exclusively made up of piping. The temperature demands are almost always below 70 deg. and horizontal piping carries a higher co-efficient of emission than the radiating surfaces used in other systems; special care must, therefore, be given to the selection of the boiler; the demands on it will be higher than with any other form of radiation in quiet air; its surplus must be greater than with boilers for any other sort of quiet air heating.

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

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

Long runs of pipe are used and expansion and contraction require more consideration than in house heating work; piping must be tied up, anchored, installations must be flexible; expansion joints are no more desirable in greenhouse heating than elsewhere; expansion must be compensated for by "spring" of pipe and by swivel fitted joints, and expansion joints used where expansion may not be compensated otherwise.

TABLE 1. TEMPERATURE REQUIRED FOR DIFFERENT PURPOSES

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

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

The temperatures required in houses are given in Table 1.

ESTIMATING HEATING REQUIREMENTS

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

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

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

The cubic contents in ratio to the surrounding glass surface, the size and the shape are, of course, more or less factors, but as previously stated, only the glass and glass equivalent enter into the calculation for the quantities of radiating surface. The engineer may modify somewhat the quantities so obtained because of the ratio of the contents to the enclosing glass, or the size or shape of the structure, or because of its geographical position or its elevation, or because the greenhouse is in a particularly exposed position. The calculation is merely that of dividing the glass and the equivalent surface by the proper divisor; and where proper allowances are made for special conditions and where boilers are sufficiently large so that a liberal factor of safety or proper surplus is provided to cover these conditions over which the designer has no control, there is no better method known than the application of the table of divisors given in Table 2. The conditions for which the engineer must provide, and which are largely out of his control are as follows:

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

WATER TEMPERATURE

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

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

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

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

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

where

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

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

TABLE 2. FACTORS FOR GLASS SURFACES

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

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

Greenhouses do not respond exactly to figures in various ways: The same amount of glass may in two different houses enclose vastly different volumes; the air loss between the laps, though probably never calculated, may be quite different per square foot of glass in two houses of the same size, design and construction, on account of the difference in workmanship or of glass quality, or of both. The humid atmosphere of greenhouses —and for some purposes the atmosphere is much more humid than for others, as for instance, for rose growing—at some temperatures causes the laps to seal with condensation, checking, or stopping the air loss through the laps. At lower temperatures these laps are sealed with ice and at still lower temperatures the inside surface of the glass is entirely frosted over so that its conductivity is changed. It may be much more difficult to heat a greenhouse at 15-20 deg. above zero, or even at 25 deg. above zero, with the wind blowing, than at zero or below, because the low temperature house may be sealed with ice, as stated.

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

RATIO OF AIR CONTENT TO GLASS SURFACE

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

Fig. 1 shows in section two conventional, even span, adjacent greenhouses of the ridge and furrow, or saw-tooth type, converted by extending the roof lines until they bisect each other, into one even span house; and the sketch also shows at once that above the eaves line the cubic contents contained by the same amount of glass in the large house is just twice the quantity contained above the eaves lines in the two small ones, and, obviously, it requires less heat units to heat the one large house than it does the two small houses, although the glass surfaces are the same. But how much less heat? Who can say? Glass laid by eye measurement, and glass of varying quality are inconstants. How may the air loss be determined?

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

Glass : Contents :: 1 : 2.34

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

Glass : Contents :: 1 : 9.8

KINDS OF PIPE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

POSITION OF RADIATION

Greenhouses are piped in all sorts of ways to suit the great number of different ideas of greenhouse owners and operators; their different ideas on the subject of plant bench or plant bed arrangement which arrangements govern largely the location and arrangement of the piping; and to suit the special requirements of the plants or flowers to be grown in the houses. In houses for vegetable growing, where planting is directly on the floor of the greenhouse, piping should be, mainly and if possible, entirely on the sides so as to provide the maximum growing surface. For rose growing the piping is required to be more scattered or distributed than for any other purpose—if there are raised benches, some heating surface must be under every bench; if there are solid beds, some radiating surface must be in every walk.

The bulk of the piping for all purposes, however, should be on the side walls, or just inside the outer walls of the greenhouse. For sweet pea growing, most of the pipe surface should be on the side walls and some on the pipe columns, generally high enough to permit walking under; however there is much latitude in the placing of pipe coils and it may be said that the greenhouse heating engineer does not always place piping, the radiating surface, just where it belongs, or just where he should place it, but rather he places it where he may, or the operator's planting arrangement permits.

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

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

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

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

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

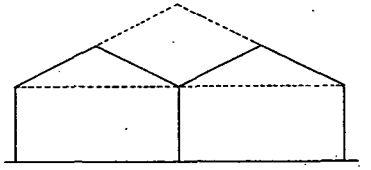


FIG. 1. SKETCH SHOWS RELATION OF CUBIC CONTENTS AND ROOF GLASS SURFACES

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

For steam heating, 1¼-in. pipe is used almost exclusively, and the greenhouse man has found that where one line of 3½-in. pipe is required to produce a certain specified temperature with hot water as the heating medium, one line of 1¼-in. steam pipe at low pressure will do the same work. This fact is inconsistent with the application of the divisors given for quantities of radiation, but the difference is probably accounted for by the fact that 1¼-in. pipe, being of so much higher temperature, is better distributed. Much of it is distributed in single lines; most of it in flat coils, and seldom in two rows, one over the other, and even then the coils are constructed so as to provide drainage, with a pitch from the supply end to the return bends at the opposite end, and back from the return bends to the return header, so that the coils converge and are not close

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

LARGE RANGES HAVE STEAM SYSTEMS

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

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

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

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

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

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

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

CHAPTER VI

PIPING FOR WATER SUPPLY SYSTEMS

THE lack of data upon which to base water pipe sizes for plumbing fixtures, branches and mains is probably due to the great number of variables which enter into their proper determination.

Plumbing fixtures in common use, having what is known as good water flow, deliver the quantities of water per outlet as given in Table 1.

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

	NUMBER OF FIXTURES									
	1	2	4	8	12	16	24	32	40	
Water Closets—										
Gal. per Min.	8	16	24	48	60	80	96	128	150	Tanks
Pipe Size	½	¾	1	1¼	1½	1½	2	2	2	
Gal. per Min.	30	50	80	120	140	160	200	250	300	Flush
Pipe Size	1	1¼	1½	2	2	2	2½	2½	2½	Valves
Urinals—										
Gal. per Min.	6	12	20	32	42	56	72	90	120	Tanks
Pipe Size	½	¾	1	1¼	1¼	1¼	1½	2	2	
Gal. per Min.	25	37	45	75	85	100	125	150	175	Flush
Pipe Size	1	1¼	1¼	1½	1½	2	2	2	2	Valves
Lavatories and Wash Sinks— Based upon Each Faucet										
Gal. per Min.	4	8	12	24	30	40	48	64	75	
Pipe Size	½	½	¾	1	1	1¼	1¼	1½	1½	
Bath Tubs—										
Gal. per Min.	15	30	40	80	96	112	144	192	240	
Pipe Size	¾	1	1¼	1½	2	2	2	2½	2½	
Shower Baths—										
Gal. per Min.	8	16	32	64	96	128	192	256	320	8" rain
Pipe Size	½	¾	1¼	1½	2	2	2½	2½	3	Head
Acid and Slop Sinks, Manufacturing, Kitchen and Laundry—										
Gal. per Min.	15	25	40	64	84	96	120	150	200	per bibb
Pipe Size	¾	1	1¼	1½	1½	2	2	2	2½	per bibb

Note.—The above sizes are based upon a pressure drop of 30 lb. per 100 ft.

In estimating risers and mains, the number of gallons for W. C. and urinals where flush valves are used are to be as given for tanks.

The hot water faucets are to be disregarded when estimating cold water risers and mains.

Water flowing in pipes is retarded by friction, the extent of which depends upon the velocity, which is the cause of unsatisfactory service when pipes are too small. The amount of head necessary to overcome this friction is known as the friction head, which is usually expressed in feet. It is also known as pressure drop, usually expressed in lb. per sq. in. per 100 ft. of pipe. The total pressure needed to discharge a given

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

quantity of water is the pressure necessary to overcome friction in the pipes (when horizontal) plus the static pressure when the discharge is higher than the supply.

Table 6, column 1, gives the vertical rise in feet to any fixture up to 150 ft. in height; column 2, gives the static head in lb. per sq. in. corresponding with the vertical rise.

The underlying principle involved in determining the proper pipe sizes for mains, risers and branches is to so regulate the size of these pipes that they will carry the maximum amount of water required of them and absorb by friction and static head, all the pressure at the source and still deliver water at the fixture in sufficient quantity but at a pressure practically equalling zero or slightly above except that due to velocity of flow through the fixture.

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

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

In estimating the pipe size for any part of a riser in a building of several stories, take 60 per cent of the water to be used on any floor and all floors above as determined from Table 1 and deduct 10 per cent for each floor above. This reduction in estimated amount is to take care of probable use. Thus, if 100 gal. are used on each floor of a 10-story building the size or pipe will be determined as in Table 2:

TABLE 2. WATER RISERS FOR MANUFACTURING BUILDINGS, LOFT BUILDINGS, APARTMENT HOUSES, HOTELS

	G. P. M.	G. P. M.	PIPE SIZE WITH DROP PER 100 FT. RUN		
			5 lb.	10 lb.	20 lb.
10th Floor	100 x 0.60	60% = 60	2″	2″	1½″
10 and 9	200 x 0.60	90% = 108	2½″	2½″	1½″
10 and 9 and 8	300 x 0.60	80% = 144	3″	2½″	2″
10 to 7 incl.	400 x 0.60	70% = 168	3½″	3″	2½″
10 " 6 "	500 x 0.60	60% = 180	3½″	3″	2½″
10 " 5 "	600 x 0.60	50% = 180	3½″	3″	2½″
10 " 4 "	700 x 0.60	40% = 184	3½″	3″	2½″
10 " 3 "	800 x 0.60	40% = 192	3½″	3″	2½″
10 " 2 "	900 x 0.60	40% = 216	3½″	3″	2½″
10 " 1 "	1000 x 0.60	40% = 240	3½″	3″	2½″

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

The pressure drop of 30 lb. per 100 ft. of run will give satisfactory results for branches on the top floor but a higher pressure drop can be used on floors below corresponding with the pressures as given in Table 5 which show that for a building 100 ft. in height, a pressure drop of 100 lb. can be used on the fixture lowest branches and that for a building 50 ft. in height, a pressure drop of 52 lb. can be used on the lowest fixture branches; Table 1, however, can be used with safety on any of the floors

but will give pipe sizes larger than necessary for the lower floors in a very tall building.

Table 5 gives the amount of water in gallons which may be passed through pipes of ¾ in. to 4 in. diameter with pressure drop from 5 lb. to 150 lb. per 100 ft. of run. This table may be used in sizing horizontal and vertical mains.

For example, if the water main pressure available is known, say 90 lb., and the horizontal run from water main to vertical riser is 100 ft., and the vertical riser is 100 ft. to top branch; it will require 43.31 lb. for static head (see Table 6), and 15 lb. pressure at a minimum should be allowed for the uppermost fixture or a total of 58.31 lb. which would leave available for friction 90 − 53.31 = 16.69 for friction in 200 ft. run, or 8.34 lb. per 100 ft. The main can thus be sized from the 7 lb. pressure drop of Table 5.

TABLE 3. APARTMENT HOUSE SUPPLY RISERS

Based upon One, Two, and Three Baths per Apartment

ONE (1) BATH APARTMENT			TWO (2) BATH APARTMENT		THREE (3) BATH APARTMENT	
1 bath	15 gal.		2 baths	24 gal.	3 baths	30 gal.
1 W. C.	8 gal.		2 W. C.	14 gal.	3 W. C.	18 gal.
1 sink	4 gal.		1 sink	4 gal.	1 sink	4 gal.
1 lav.	4 gal.		2 lavs.	6 gal.	3 lavs.	9 gal.
	31 gals.			48 gals.		61 gals.
50% demand—15 gals. per min.			40%—20 gals. per min.		40%—24 gals. per min.	
		Riser		Riser		Riser
Top Floor	15 gal.	1¼″	20 gal.	1¼″	24 gal.	1¼″
Next	28 "	1¼″	38 "	1½″	43 "	2″
"	38 "	1½″	54 "	2″	64 "	2″
"	51 "	2″	68 "	2″	82 "	2″
"	60 "	2″	80 "	2″	96 "	2½″
"	67 "	2″	90 "	2″	108 "	2½″
"	71 "	2″	98 "	2½″	117 "	2½″
"	78 "	2″	104 "	2½″	124 "	2½″
"	81 "	2″	108 "	2½″	134 "	2½″
"	83 "	2″	110 "	2½″	143 "	2½″
"	84 "	2″	110 "	2½″	143 "	2½″
"	85 "	2″	110 "	2½″	143 "	2½″

Note.—The pipe sizes are based upon a drop of 10 lb. water pressure for each 100 ft. run. The size of branch for each Apartment should be not less than 1¼ in.

Example—What is the riser size needed for a six-story apartment house having one bath for each apartment?

Table 3 gives 2 in. diameter for all from four to twelve stories with 1¼ in. to supply the top floor and next to top and 1½ in. for floor below.

What is the size of riser needed for a twelve-story apartment house with three baths to each apartment?

Table 3 gives 2½ in. for all floors up to eighth floor, 2 in. for ninth, tenth and eleventh, and 1¼ in. for top floor.

What is the riser size for a two bath apartment six stories high?

Table 3 gives 2 in. for the first four floors with 1½ in. at fifth floor and 1¼ in. on the top floor.

TABLE 4. APARTMENT HOUSES. SIZES OF WATER SUPPLY MAINS AND METERS

Based upon pressure drop of 10 lb. per 100 ft. run

FOR 4 AND 5 STORIES

Apartments per Floor

	Four		Six		Eight		Ten	
	Gal.	Main	Gal.	Main	Gal.	Main	Gal.	Main
1 bath	120	2½″	160	3″	200	3″	240	3″
2 baths	160	3″	200	3″	240	3″	280	3″
3 baths	200	3″	240	3″	280	3″	320	3½″

FOR 6, 7 AND 8 STORIES

1 bath	150	2½″	190	3″	230	3″	270	3″
2 baths	190	3″	230	3″	270	3″	310	3½″
3 baths	230	3″	270	3″	310	3½″	350	3½″

FOR 9, 10, 11 AND 12 STORIES

1 bath	200	3″	250	3″	300	3½″	350	3½″
2 baths	250	3″	300	3½″	350	3½″	400	3½″
3 baths	300	3½″	350	3½″	400	3½″	450	4″

Note.—The gallons per minute given above are approximated maximum demand for conditions stated.

Example—What is the required size of water main for apartment house eight stories high, six apartments per floor, each having three baths?

Answer from Table 4 is 3 in.

Example—What is the required size of main for a ten-story apartment house with six apartments per floor, each having two baths?

Answer from Table 4 is 3½ in. main.

Note.—Table 4 gives the sizes of mains for apartment houses of one, two or three baths for each apartment, and with four, six, eight or ten apartments per floor and from four to twelve stories in height.

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

Friction Pressure Drop Lb. per Sq. In. per 100 Ft. Run	Pipe Sizes in Inches								
	¾	1	1¼	1½	2	2½	3	3½	4
	Gallons per Minute								
5	5.4	11	19	30	62	109	171	252	353
7	6.4	13	23	36	74	129	203	298	418
10	7.6	15	27	43	88	154	242	357	499
20	10.8	22	38	61	125	218	343	504	706
30	13.2	27	47	76	153	267	420	618	864
40	15.0	31	54	86	176	308	485	714	998
50	17.0	35	60	96	197	345	542	800	1115
75	21.0	43	74	117	242	423	665	978	1365
100	24.0	49	85	136	278	485	769	1130	1578
125	27.0	55	96	152	311	544	858	1260	1765
150	30.0	60	105	166	341	598	939	1380	1930

TABLE 6. SHOWING WATER PRESSURE REQUIRED TO DELIVER WATER TO TOP OF VERTICAL RISER WITH 15 LB. PRESSURE AT THE TOP BRANCH AND TO GIVE ADEQUATE SERVICE AT VERTICAL HEIGHTS GIVEN

*Water Pressure in Lb. Required to Deliver Water to Top of Riser with 15 Lb. Terminal Pressure				Static Head in Lb. per Sq. In.	Vertical Rise of Water *from* Main to Highest Fixture Branch	**Water Pressure in Lb. Required to Give Adequate Service at Vertical Heights Given			
Pressure Drop per 100 Ft.						Horizontal Run from Supply to Riser			
5 lb.	7 lb.	10 lb.	20 lb.			25′ 0″	50′ 0″	75′ 0″	100′ 0″
15	15	15	15	0	0	22.8 lb.	25.3 lb.	27.8 lb.	30.3 lb.
20.5	20.7	21	22	4.33	10	28.1 "	30.6 "	33.1 "	35.6 "
25	25.4	26	28	8.66	20	33.5 "	36 "	38.5 "	41 "
29.5	30.1	31	34	12.99	30	38.8 "	41.3 "	43.8 "	46.3 "
35	35.8	37	41	17.32	40	44.1 "	46.6 "	49.1 "	51.6 "
39.5	40.5	42	47	21.65	50	49.5 "	52 "	54.5 "	57 "
44	45.2	47	53	25.99	60	54.8 "	57.3 "	59.8 "	62.3 "
49.5	50.9	53	60	30.32	70	60.1 "	62.6 "	65.1 "	67.6 "
54	55.6	58	64	34.65	80	65.2 "	67.7 "	70.2 "	72.7 "
58.5	60.3	63	72	38.98	90	70.8 "	73.3 "	75.8 "	78.3 "
64	66	69	79	43.31	100	76.1 "	78.6 "	81.1 "	83.6 "
68.5	70.7	74	85	47.64	110	81.5 "	84 "	86.5 "	89 "
73	75.4	79	91	51.97	120	86.8 "	89.3 "	91.8 "	94.3 "
77.5	80.1	84	97	56.30	130	92.1 "	94.6 "	97.1 "	99.6 "
83	85.9	90	104	60.63	140	97.5 "	100 "	102.5 "	105 "
87.5	90.5	95	110	64.96	150				

**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.

***Note.*—Based upon 10 lb. pressure drop per 100 ft. run of pipe and a terminal pressure of 15 lb. at the uppermost fixture. A terminal pressure of 15 lb. has been selected for operation of flush valves. For terminal pressure of 10 lb., deduct 5 lb. from the figures given above; *or for* a terminal pressure of 5 lb. deduct 10 lb. from above values.

Example.—What are the sizes required for mains and branches in a building 100 ft. high, supplied with a water pressure of 75 lb. per sq. in. with 100 gal. of water per minute required on each floor?

This is worked out in Table 2 and gives the pipe sizes for the main riser with a 10 lb. drop for 100 ft. of run and shows that a 3 in. main, reduced to 2 in., would be required: branches to the various groups of fixtures can be taken from Tables 5 and 6. On the top floor it will be necessary to use a 1½ in. branch to carry 60 gal. per min. with a pressure drop of 30 lb. but that at 30 ft. vertically from the supply, a 1¼ in. branch pipe will carry 60 gal. per minute, therefore 1¼ in. pipe could be selected for this branch. Assuming that the pressure drop in the main riser is 10 lb. per 100 ft. run and the pressure drop on the top floor in the branch does not exceed 15 lb. in all and the static head for building 100 ft. as given in column 2 of Table 6 is 43.31 lb. making a total of 58.31 lb.; it will be seen that 75 lb.—58.31 lb., which equals 16.59 lb., is the amount of pressure over and above that required, and that this pressure can be utilized to overcome the friction drop in the main feed line running from the source of supply to the base of the riser.

From Table 2 it is found that 240 gal. per min. will flow at the first floor, and assuming that this water supply is to be brought in a main 300 ft. long; Table 5 will show that a 3½ in. supply would be necessary.

Example—What pressure is required in the water supply main to give 15 lb. pressure at the uppermost fixture in a building where the riser is 100 ft. high and is located 75 ft. from the water main in a horizontal direction, when the other fixtures within the building are in use to their estimated average capacity?

Answer is found to be 75.8 lb. at the intersection of 100 ft. vertical height and 75 ft. horizontal run.

Note.—If only 10 lb. be required at the uppermost fixture, then 70.8 lb. would be the answer.

WHEN TANK IS ON ROOF

If tank is elevated about 35 ft. above highest fixture, which would be about 25 ft. above the roof, similar computations will apply for branch connections and main risers except that the main riser will have its

greatest diameter at the top. It will be seen that 35 ft. elevation will give the necessary 15 lb. pressure at the highest fixture and that the pressure drop may be made equal to the static head from the top fixtures down, or 40 lb. per 100.

FRICTION IN ELBOWS

Friction caused by elbows should be added to straight pipe friction. Each elbow in a line will add friction equal to a length of straight pipe forty times the diameter of the pipe:

Pipe Size	¾	1	1¼	1½	2	2½	3	3½	4
Equivalent length of straight pipe in feet	2.5	3.3	4.1	5	6.7	8.3	10	11.7	13.3

The water supply formula herewith makes it possible to accurately compute the flow of water in gallons through any pipe with any friction head and also gives formula for the additional head due to water entering the main, which, if extremely accurate calculations are necessary, should be added to the head required for friction; generally, however, this can be neglected as it is comparatively small.

WATER SUPPLY FORMULA

CF = Cu. ft. per min. discharged
G = Gal. per min. discharged
H = Friction head of water in feet = pressure × 2.31; if water is raised vertically, deduct number of feet raised, from head due to pressure.
L = Length of pipe in feet—including horizontal and vertical runs.

$$CF = 0.16\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \quad (1) \qquad G = 1.2\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \quad (2)$$

$$H = \frac{(CF)^2 \times L}{.0768\ (3d)^5} \quad (3) \qquad H = \frac{(G)^2 \times L}{4.32\ (3d)^5} \quad (4)$$

The above formula neglects the head due to entry, which need not be computed except when L is very short. H_1 = head due to entry in feet.

$$H_1 = \left(\frac{0.83\ G}{d^2 \times 13}\right)^2 \text{ or } H_1 = \left(\frac{6.25\ CF}{d^2 \times 13}\right)^2$$

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

$H = 30 \times 2.31 - 30 = 39.3$. Formula (2) $G = 1.2\sqrt{\frac{(3 \times 2)^5 \times 3 \times 39.3}{100 + 30}} = 100.8$

In the above case the head due to entry would be $H_1 = \left(\frac{0.83 \times 100.8}{2 \times 2 \times 13}\right)^2 = 2.56$ ft.

Usually this can be neglected except for very close calculations.

HOT WATER SUPPLY

Tables 7, 8 and 9 give the hot water requirements for several kinds of buildings in terms of gallons per maximum hour and per day.

Pipe sizes for hot water systems may be calculated from the foregoing data on cold water systems; using the same quantities for the gallons of hot water required per min. as is given for the cold water. It may be borne in mind that a column of hot water is lighter than one of cold water amounting to about 2½ ft. per 100 ft. in the height of columns of equal weight. In case the cold water must first be fed down from roof tanks to heaters in the basement and then back up to the top floor fixtures, the extra length of run must be taken into consideration. As a check on the total quantity of hot and cold water required per day it is well to know that this generally runs from 2 to 3 times the amount of hot water required and from 80 to 100 gal. per occupant of the building.

TABLE 7. HOT WATER REQUIREMENTS FOR APARTMENT BUILDINGS

Class	Hot-Water Fixtures per Apartment						Gallons Hot Water per Apartment per Maximum Hour
	Lavatories	Bath Tubs	Showers Over Tubs	Kitchen Sinks	Laundry Trays	Separate Showers	
A	1	1	1	1	2	0	25
A	2	2	1	1	2	0	30
A	2	2	2	1	2	0	35
A	2	1	1	1	2	1	55
B	1	1	0	1	2	0	20
C	1	1	0	1	1	0	15

Note.—The quantity of hot water required per day is usually about 10 times the maximum hour requirement.

TABLE 8. HOT WATER REQUIREMENTS FOR HOTELS

Class	Gallons		Add for Kitchens per Meal Capacity		Add for Laundry		
	Hot Water per H. W. Fixture per Day	Per H. W. Fixture per Maximum Hour	Per Day	Per Maximum Hour	Per Piece per Day	Per Washer per Day	Per Washer per Maximum Hour
High-Class Transient	85	6.8	3.0	1.0	1.0	1200	250
Medium-Class Transient	70	6.5	2.5	0.80	1.0	1000	200
Apartment Hotels	50	5.0	2.0	0.60	1.0	1000	200

Note.—Instantaneous demand rate for laundry-washers from 25 to 50 gal. per minute.

TABLE 9. HOT WATER REQUIREMENTS FOR OFFICE BUILDINGS

Class	Hot Water per Hot-Water Fixture	
	Per Day	Per Maximum Hour
Having Hot Water in public toilets only	50	5.0
Having Hot Water in Private Offices as well as in Public Toilets	30	3.0
For Self-Closing Hot Water Fixtures Deduct	40%	25%

As a check on the sizes of hot water mains, Table 8 will give safe sizes for gravity systems fed from roof tanks set not less than 20 ft. from the water line in tanks to the highest fixtures.

TABLE 10. SIZES OF HOT WATER MAINS

Gallons per Maximum Hour	Size of Hot Water Main, Inches
500	2
750	2½
1000	2½
1250	3
1500	3
1750	3½
2000	3½
2500	4
3000	4

CHAPTER VII

STEAM AND HOT WATER HEATING BOILERS

THE boiler is the heart of any heating system and its selection, as to type, size, rating, capacity, draft requirements, firing periods, kinds of fuel, principles of operation, efficiency and construction, should be made with great care. Particular consideration should be given to the ultimate use of the boiler. Fuel and pressure are classed as primary factors in boiler selection because these two items require certain characteristics in the boiler itself which no outside alteration is able to obviate while the secondary factors can, in almost every case, be overcome by a modification in the conditions under which the boiler is installed.

Draft can be increased by adding to the chimney height and, up to certain limits, to the chimney diameter; headroom may be secured by raising the height of the boiler room; the height of the water line can be adjusted by lowering the boiler room floor; floor space is always possible to obtain by enlarging the boiler room and the size of the units can usually be arranged to suit some possible condition that can be secured. But a low pressure boiler may not be properly used for high pressure nor will a boiler constructed for the use of anthracite coal give the same service when fired with bituminous in spite of any change which may be made in the environment in which the boiler is located.

In all the numerous types of boilers now on the market the selection of the one particular type which will be most efficient for any particular installation is a monumental task.

As a matter of fact the service secured from a boiler depends largely on the operator; a very high class boiler may not give as much satisfaction when improperly operated as a boiler whose design is not quite so good but which is intelligently handled. Of course, a good operator and a good boiler will give the best results of all, but this combination is frequently lacking.

TYPES OF BOILERS

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

Compiled for THE GUIDE from data supplied by C. W. Obert, New York, E. A. May, Chicago; E. R. Fish, St. Louis, Mo., and H. L. Alt, New York.

the rectangular vertical section cast-iron boilers and the steel fire-tube boilers of the firebox pattern are used; the makes of either are numerous, and many detail differentiations in construction are to be noted.

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

On account of their sectional construction and the usual practice of being shipped knocked down and assembled on the job, they are easily handled through small openings at any stage of construction. Their design also facilitates the removal and replacing of damaged parts as well as an increase or decrease in capacity by the addition or removal of sections. Most sectional boilers are comparatively cheap in first cost but the labor of assembling is a factor which must be considered.

There are other forms of the boilers in the smaller sizes well adapted for heating small buildings, which embrace vertical section cast-iron construction, steel vertical tubular, and steel firebox construction, which have merit for particular classes of service. The features that are of greatest importance in such boilers are *grate area* sufficient to burn the particular fuel contemplated at a moderate rate when carrying the rated load, a depth of fire-pot sufficient to receive a liberal charge of fuel, an advantageous disposal of direct heating surface in the furnace for absorption of the radiant heat of the fire, sufficient indirect heating surface to extract the heat from the gases by convection, yet without interposing an undesirable resistance of flow to the chimney, and simple yet effective means for control of the draft and rate of combustion.

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

Fire-tube boilers are usually constructed of steel, which shows the greatest resistance to splitting, cracking or similar stress due to the expansion and contractional strains of temperature differences of too excessive pressures, or temperature. They are well adapted to oil burning on account of this resistance to the wide temperature ranges encountered with this type of fuel. They have large water and steam

spaces so that while they may heat up and steam slowly they retain heat and supply steam for comparatively long periods with a receding fire, thus tending to compensate for fluctuations in firing by the fly wheel effect of their water and steam capacities. Their large steam capacity also tends to prevent priming and fluctuation of the water line. They are comparatively steady under sudden and wide variations in load conditions and require little attention on this account. Steel boilers may be built for high or low pressure and are therefore flexible in converting from one pressure to another.

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

Water-tube boilers are usually constructed with steel or iron tubes, steel drums and either steel, cast steel or cast-iron headers. On account of the smaller diameter of drums and the fact that the tubes are the only parts to come into direct contact with the hot furnace gases it is generally felt that this type of boiler is safer to operate, especially on high pressure. They heat up and steam rapidly but also lose their heat and steam pressure quickly. The water and steam spaces are moderate and their performance on rapid and wide variations of load is accordingly fair.

The principal heating surface consisting of tubes with the water inside and the heated gases outside, is easy to clean from the inside with hydraulic or pneumatic tube cleaners and from the outside with steam or air jet soot blowers although with highly scaling waters the scale formation on the inside of a small tube may be comparatively rapid.

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

BOILER RATING

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

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

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

Unfortunately there are wide differences in the ratings of boilers by the various manufacturers due largely to the fact that there has never been a full and complete cooperation in the establishment of a standard code* on which to rate. For this reason the selecting of a cast-iron boiler, as far as capacity is concerned, is one of considerable uncertainty unless the manufacturer's guarantee is secured that the boiler will carry the load as existing in that particular installation. The method used by some engineers for handling this is to determine the number of pounds of steam required per hour as a maximum, including all losses, and then calling for a manufacturer's guarantee that the boilers supplied, when fired on 8-hour firing periods with anthracite coal and connected to a chimney of a certain size and height, will deliver the number of pounds of steam necessary at the pressure required. For the larger sizes of boilers and with other fuels, particularly bituminous or soft coal, from 1 to 2 hour firing periods are generally considered.

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

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

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

where

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

*Code for Rating of Low Pressure Solid Fuel Steam Heating Boilers reported at A. S. H. & V. E. meeting, June, 1927, accepted as a preliminary draft and to be presented for adoption, January, 1928.

In boiler selection certain allowances should be made if quick heating up is desired but a boiler oversized is not an economical proposition under any condition and when it is considered that the average winter load is approximately one-half of the maximum load it can be seen that the boiler, which is just sufficient, will operate under normal conditions at only 50 per cent of its rating in actual capacity. Some boilers are designed to show a very good efficiency from 40 to 60 per cent of their maximum production and generally speaking a boiler which has its highest efficiency around 50 per cent of its maximum capacity will be the most economical in fuel consumption in the long run.

A great deal has been said at various times about the overload thrown onto a boiler during the time of heating up the system; a large part of this idea is not borne out either in practice or by calculation. The whole matter boils down to a time element and a compromise between having a boiler big enough to heat up in a reasonable length of time and at the same time not so large as to force it to operate at too small a faction of its load during all normal periods.

SELECTION OF HEATING BOILERS

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

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

TERMINOLOGY

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

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

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

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

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

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

NUMBER OF UNITS

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

IMPORTANCE OF DRAFT

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

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

According to their height, heating plant chimneys are divided into three classes, the erratic, uncertain and reliable. Chimneys less than 36 ft. high are erratic in their action. The head produced by such a low height

is so small that the least unfavorable condition or interference practically puts the chimney out of commission.

At best the head produced by chimneys up to 64 ft. in height is so small that the draft is frequently affected by surrounding conditions making the draft a doubtful one. Chimneys over 64 ft. in height are not usually so affected, because as a rule the chimney is designed by an engineer and must be well built to sustain such a heavy load and the height is such as to produce considerable head or force to offset unfavorable weather conditions, etc. Chimneys in this class produce about 0.009 in. draft per ft. of height in zero weather with 600 deg. in the stack according to the formula:

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

where

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

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

TABLE 1. CHIMNEY SIZES

Warm Air Furnace Capacity in Leader Pipe Sq. In.	Steam Boiler Capacity Sq. Ft. of Radiation	Hot Water Heater Capacity Sq. Ft. of Radiation	Nominal Dimensions of Fire Clay Lining In.	Rectangular Flue			Round Flue		
				Actual Inside Dimensions of Fire Clay Lining In.	Actual Area Sq. In.	Effective Area Sq. In.	Inside Diameter of Lining In.	Effective Area Sq. In.	Height in Ft. from Grate
790	590	973	8½x13	7x11½	81	70			
1000	690	1140					10	79	
	900	1490	13x13	11¼x11¼	127	99			
	900	1490	8½x18	6¾x16¼	110	100			
	1100	1820					12	113	
	1700	2800	13x18	11¼x16¼	183	156			
	1940	3200					15	177	
	2130	3520	18x18	15¾x15¾	248	195			
	2480	4090	20x20	17¼x17¼	298	234			
	3150	5200					18	254	
	4300	7100					20	314	
	4600	7590	20x24	17x21	357	278			
	5000	8250	24x24	21x21	441				
	5570	9190		24x24*	576	380			
	5580	9200					22	380	
	6980	11500					24	452	
	7270	12000		24x28*	672	468			
	8700	14400		28x28*	784	531			
	9380	15500					27	573	
	10150	16750		30x30*	900	616			
	10470	17250		28x32*	896	635			
	11800	19500					30	707	
	14700	24300					33	855	
	17900	29500					36	1018	

As height necessary is dependent upon the draft requirements of the varying designs these factors should be known before height can be accurately determined.

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

Chimneys recommended for larger boilers 15 to 250 hp. are proportioned in accordance with the report made by a joint Committee of the *American Boiler Manufacturers Association* and *Stoker Manufacturers Association* and approved by these organizations. The sizes are given in Table 2.

Table 2. Height of Stack for Average Installations (Sea Level)

Forced Draft Stokers

Per Cent Rating	100	150	200	250	300
Draft Furnace	0.15	0.15	0.15	0.15	0.15
Friction Loss (Boiler)	0.18	0.4	0.65	0.9	1.20
Friction Loss (Breeching)	0.10	0.10	0.10	0.10	0.10
Total Draft Required	0.43	0.65	0.90	1.15	1.45
Height of Stack (Ft.)	80	112	145	178	220

Diameter of Chimney in Inches for Horizontal Return Tubular Boilers				Height of Stack in Feet—For Sea Level and 60 deg. fahr. Outside Temp. Assumed Friction Loss in Stack 0.1 in. per 100 ft.			
Nominal H. P.	100% Rating	150% Rating	200% Rating	Draft at Base of Stack	100% Rating	150% Rating	200% Rating
15	13	14	17	0.12	21	22	25
20	14	16	18	0.15	26	28	30
25	16	18	20	0.20	35	37	41
30	17	19	21	0.25	43	46	51
35	18	20	22	0.30	52	56	61
40	19	21	23	0.35	60	65	71
50	20	23	25	0.40	69	74	81
60	21	24	27	0.45	78	84	91
75	23	26	29	0.50	86	93	101
90	25	28	31	0.55	95	102	111
100	26	29	33	0.60	104	112	122
115	27	31	34	0.65	112	121	132
125	28	32	35	.....	.....	.....	.....
150	30	34	38	.....	.....	.....	.....
175	32	36	40	.....	.....	.....	.....
200	33	38	43	.....	.....	.....	.....
210	34	38	44	.....	.....	.....	.....
225	35	40	45	.....	.....	.....	.....
250	36	41	47	.....	.....	.....	.....

Data on Which Tables are Based

Rating	100%	150%	200%	Stack Temp, deg. fahr.	450	500	550
Efficiency	65%	65%	63%	Lbs. of Gas	85	77	73
CO_2	8%	9%	10%				

Average Friction Loss Through Boilers

Per Cent Rating	100	150	200	250	300
Loss Ins., Water	0.1 to 0.3	0.2 to 0.6	0.3 to 0.9	0.5 to 1.4	0.7 to 1.9

Friction loss through boiler varies according to construction.

For Furnace Draft.—Allow 0.15 for forced draft. *For Natural Draft* 0.35 in. or higher should be used depending upon rate of combustion and fuel used.

For Breeching Friction Loss.—Allow 0.05 in. for each right angle bend and 0.1 in. per 100 ft. of length. Cross sectional area should be 20 per cent larger than that of stack.

Height of Stack in Feet

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

Total Draft Required In. for Furnace Boiler and Breeching	Per Cent of Boiler Rating				
	100	150	200	250	300
0.3	56	.....	.....	.....	.....
0.4	74	69	.....	.....	.....
0.5	93	86	81	.....	.....
0.6	111	103	97	.....	.....
0.7	130	120	113	108	.....
0.8	148	138	129	123	.....
0.9	.....	155	145	139	132
1.0	.....	172	161	154	147
1.1	.....	190	177	170	162
1.2	.....	.....	194	185	176
1.3	.....	.....	209	200	191
1.4	.....	.....	226	216	206
1.5	.....	.....	.....	231	221
1.6	.....	.....	.....	.....	236
1.8	.....	.....	.....	.....	265
Assumed Flue Gas Temp	500	550	600	650	700

Correction for Altitude

Height Above Sea Level (Ft.)	Ratio Increase in Diameter	Ratio Increase in Height
0	1.000	1.000
1,000	1.015	1.046
2,000	1.030	1.097
4,000	1.063	1.205
6,000	1.096	1.321
8,000	1.130	1.456
10,000	1.165	1.612

The principal factors which affect the loss of draft through the fuel bed according to J. G. Mingle,[1] are:

1. Character of fuel burned,
2. Amount of fuel burned per square foot of grate surface per hour, or the rate of combustion.

The loss of draft through the boiler is affected mainly by:

1. Type and size of boiler,
2. Rate of operation.

The required height of a chimney is affected by the following:

1. Character of fuel burned,
2. Rate of combustion,

[1]Draft and Capacity of Chimneys.

3. Type and size of boiler,
4. Rate of operation,
5. Quantity of gases flowing,
6. Temperature of flue and chimney gases,
7. Length of breeching,
8. Size of breeching,
9. Coefficient of friction,
10. Density of chimney gases,
11. Atmospheric pressure,
12. Length of chimney duct,
13. Diameter of chimney,
14. Temperature of outside air.

CHAPTER VIII

CODE FOR TESTING LOW-PRESSURE STEAM-HEATING BOILERS

REVISION OF 1923

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

OBJECT OF THE CODE

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

ESSENTIALS NECESSARY TO DETERMINE HEAT EFFICIENCY

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

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

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

PREPARATIONS FOR TEST

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

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

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

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

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

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

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

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

APPARATUS AND INSTRUMENTS

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

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

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

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

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

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

A Ringelmann chart shall be used for smoke observations.

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

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

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

DURATION OF TEST

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

METHOD OF STARTING AND STOPPING TEST

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

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

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

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

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

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

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

METHOD OF FIRING

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

FUEL SAMPLING

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

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

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

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

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

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

STANDARD FORM

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

RESULTS

Of a Test on a Low-Pressure Boiler

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

GENERAL PARTICULARS OF BOILER AND FUEL

BOILER

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

SMOKE PIPE AND CHIMNEY

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

FUEL

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

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

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

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

HEAT VALUE (GROSS)

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

CHARACTER OF FUEL

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

METHOD OF FIRING

PRINCIPAL RESULTS OF TEST

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

DETAILED RESULTS OF TEST

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

GENERAL INFORMATION

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

FUEL

11. Heat value, as fired.....B.t.u. per lb.
12. Number of Times Fuel Charged during Test.....
13. Intervals between Charging, hrs. Longest.....Shortest.....Average.....
14. Intervals between Attention of any Kind to the Fire, including firing, hr.
Longest.....Shortest.....Average.....
15. Average Fired per Charge[3].....lb.
16. Depth on Grate at Start of Test (After Firing).....in.
17. Depth on Grate at Finish of Test.....in.
18. Weight as Fired during Test[3].....lb.
19. Weight as Fired per Hour[3].....lb.
20. Moisture in Fuel.....per cent
21. Weight Fired per Hour less Moisture:[3]
$\frac{100 - \text{item } 20}{100} \times \text{item } 19$.....lb.

ASH AND REFUSE

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

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

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

TEMPERATURE

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

DRAFT INTENSITY

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

OUTPUT

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

STEAM AND WATER

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

HEAT BALANCE

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

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

FUEL USED

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

ASH AND REFUSE

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

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

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

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

LOG SHEET NO. 1

GENERAL SHEET

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

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

Time | General Notes

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

LOG SHEET NO. 2

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

FUEL, ASH AND REFUSE

Detailed Record of Coal Fired During Test

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

Detailed Record of Ash and Refuse Removed

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

Special observations for New Fire Method of starting:

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

LOG SHEET NO. 3

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

Observations of Feed Water, Pressures, and Temperatures

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

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

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

LOG SHEET NO. 4

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

Detailed Record of Gas Analysis

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

LOG SHEET NO. 5

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

Smoke Readings

No.	TIME	RINGELMANN CHART	No.	TIME	RINGELMANN CHART	REMARKS

CHAPTER IX

PUMPS FOR HEATING AND VENTILATING EQUIPMENT

INTRODUCTION

THE various kinds of pumps ordinarily used in connection with heating and ventilating installations may be classed under the following heads:

1. Boiler feed pumps.
2. Condensation return pumps.
3. Return line vacuum heating pumps.
4. Sump pumps.
5. Forced circulation hot-water heating pumps.
6. Circulating pumps for water brine, etc.
7. Refrigeration pumps and compressors.

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

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

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

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

Standards for Condensation to be Handled—The quantities of condensate

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

to be handled from direct radiation, direct-indirect radiation and indirect or fan blast radiation may be estimated as follows:

For direct radiation $W = 0.3\ R$
For direct-indirect radiation $W = 0.6\ R$
For indirect radiation $W = \frac{Q \times 60 \times T}{55.6 \times H}$

where

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

The normal capacity of pumps to be based on condensate at a temperature of not over 180 deg. fahr. For temperature of condensate above 180 deg. fahr. capacity should be increased above that estimated for 180 deg. fahr. condensate as per the following Table 1.

TABLE 1. TEMPERATURE OF CONDENSATE AT PUMP SUCTION

Deg. fahr.	Factor
190	1.15
200	1.56
204	2.00

To use Table 1, multiply the quantity of condensate to be handled by the factor corresponding to the temperature of the condensate at the pump suction and select a pump suitable for the quantity thus found.

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

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

BOILER FEED PUMPS

Types.—Boiler Feed Pumps may be of the following types:

1. Direct acting steam driven reciprocating pumps.
2. Power driven reciprocating pumps.
3. Centrifugal pumps.
4. Screw pumps.

Capacities.—The capacity of a boiler feed pump should be based on 34.5 lb. of water per hour per maximum boiler horsepower served, with a slippage allowance of 10 per cent in the water cylinders and a factor of safety allowance of 2 for intermittently operating pumps and a factor of safety allowance of 1½ for continuous operating pumps, to provide for unusual demands when the water in boilers becomes low or excessive loads are carried.

Piston Speeds in Feet per Minute.—For reciprocating boiler feed pump

not to exceed 10 times the square root of the number of inches in the length of stroke of the water pistons.

Direct acting reciprocating steam driven or power driven boiler feed pumps are generally found to be more efficient for smaller installations especially with widely fluctuating loads as the efficiencies of centrifugal

TABLE 2. DIRECT ACTING STEAM DRIVEN DUPLEX RECIPROCATING BOILER FEED PUMPS

Dia. of Steam Cyl. in Inches	Dia. of Water Cyl. in Inches	Length of Stroke in Inches	No. of Strokes per Min.	Discharge in Gallons		Equivalent Dia. of Single Cyl. Pump	Boiler H. P. Served Without Factor of Safety	Size Pipe, Inches			
				Per Stroke	Per Min.			Steam	Exhaust	Suction	Discharge
3	2	3	70	0.04	5.6	2⅞	80	½	¾	1¼	1
4½	2¾	4	60	0.10	12.0	4	180	½	¾	1½	1¼
5¼	3½	5	50	0.20	20.0	5	300	¾	1¼	2	1½
6	4	6	50	0.33	33.0	5⅝	480	1	1½	2½	2
7½	4½	6	50	0.42	42.0	6⅜	600	1½	2	3	2½
7½	5	10	40	0.85	68.0	7	1000	1½	2	3	2½
10	6	10	40	1.22	97.6	8½	1400	2	2½	4	3
12	7	12	35	2.00	140.0	9⅞	2000	2½	3	5	4

TABLE 3. HORIZONTAL DUPLEX PISTON PACKED POWER DRIVEN BOILER FEED PUMPS FOR 100 LB. WORKING PRESSURE

Size of Pump Cylinders in Inches		No. of Revolutions per Min.	Displacement Gallons		Boiler H. P. Served Without Factor of Safety	H. P. Required to Drive Pump	Pipe Sizes Inches	
Dia.	Stroke		Per Rev.	Per Min.			Suction	Discharge
2½	4	30	0.34	10.2	148	1.5	1½	1¼
3	4	30	0.49	14.7	213	4.0	2	1½
3½	5	30	0.83	24.9	361	3.5	2½	2
4	6	25	1.30	32.5	471	4.0	3	2½
8	10	20	8.69	173.8	2520	18.0	5	4

TABLE 4. RECIPROCATING SINGLE ACTING POWER DRIVEN TRIPLEX BOILER FEED PUMPS FOR 150 LB. WORKING PRESSURE

Size of Pump Cylinders in Inches		No. of Revolutions per Min.	Displacement Gallons		Boiler H. P. Served Without Factor of Safety	H. P. Required to Drive Pump	Pipe Sizes Inches	
Dia.	Stroke		Per Rev.	Per Min.			Suction	Discharge
1½	2	50	0.045	2.25	33	0.40	¾	¾
1¾	2½	50	0.078	3.90	57	0.65	1	1
2	3	40	0.122	4.88	70	0.80	1¼	1
2½	4	30	0.255	7.65	110	1.15	1½	1¼
3	4	30	0.367	11.01	160	1.40	1½	1¼
4	4	30	0.652	19.56	280	4.60	2	1½
4	6	25	0.978	24.45	355	3.10	2½	2
5	8	20	2.041	40.82	592	5.00	3	2½
6	8	20	2.938	58.76	852	6.00	3½	3
8	10	20	6.520	130.40	1891	14.00	4	3

boiler feed pumps drop off very rapidly for the smaller sizes of pumps and for low load conditions. For this reason centrifugal pumps are not

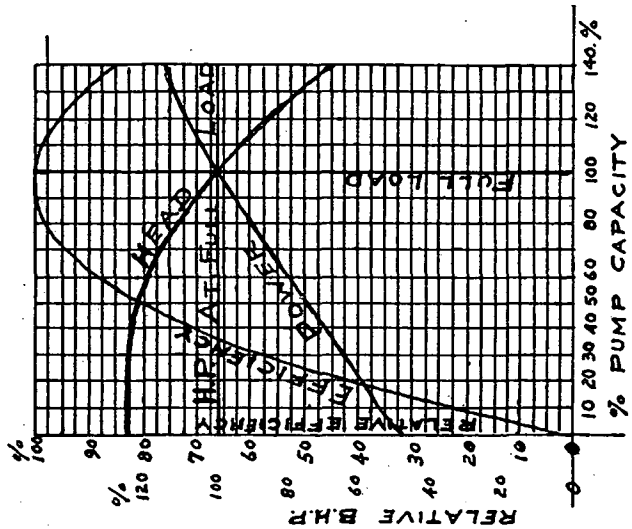

Fig. 2. For Selection of Size and Stage of Centrifugal Boiler Feed Pumps

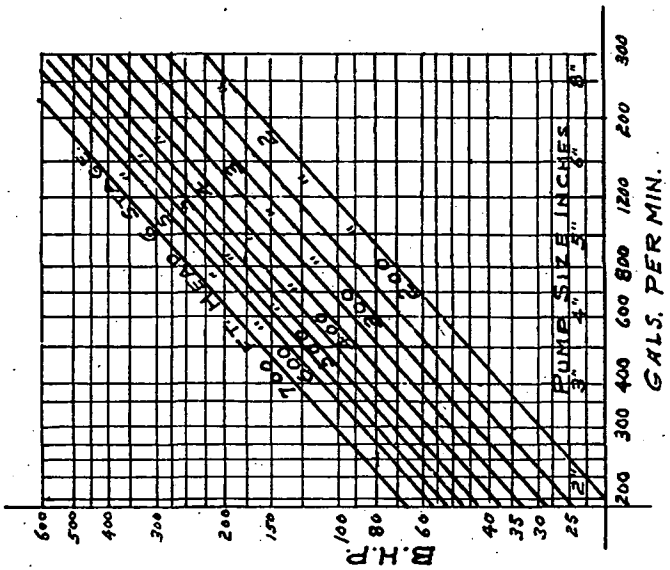

Fig. 1. Typical Characteristics of Centrifugal Boiler Feed Pumps

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

Table 5. Screw Pumps

Since the capacity and pressure at which Screw Pumps will operate is almost infinite, we can only give some idea of their capacity. Efficiencies range from 60 per cent to 70 per cent.

Size	G. P. M.	Max. Rev.	Suction Inches	Discharge Inches
2	2– 15	1600	2	1½
2½	10– 20	1600	2	1½
3	20– 50	1600	2½	2½
3¼	40– 60	1600	3	2½
3½	55– 100	1500	4	3
4	85– 200	1400	4	4
5	175– 275	1200	5	4
5¼	200– 325	1200	5	4
6	275– 475	1200	6	6
7	300– 600	1000	8	6
8	450– 750	875	8	8
9	700–1000	720	10	10
10	800–1400	700	12	12
12	1200–2100	600	14	14
16	1750–4200	425	16	15

Table 6. Sizes, Revolutions per Min. Heads Pumped Against, Power Required and Boiler Horse Power for Several Commercial Sizes of Centrifugal Boiler Feed Pumps

Size of Pump Inches	H. P.	Pipe Sizes Inches		Capacity Gallons per Min.	Boiler H. P. Served Without Factor of Safety
		Suction	Discharge		
Two Stage for 100 lb. Working Pressure					
2	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000
Three Stage for 150 lb. Working Pressure					
2	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000
Four Stage for 250 lb. Working Pressure					
2	.....	2½	2	100	1450
2½	.....	3	2½	150	2175
3	.....	4	3	225	3262
4	.....	5	4	400	5800
5	.....	6	5	620	8990
6	.....	8	6	900	13,000
8	.....	10	8	1600	23,000

CONDENSATION RETURN PUMPS

Condensation return pumps may be of the following types:

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

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

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

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

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

TABLE 7. DUPLEX PISTON TYPE RETURN PUMPS WITH RECEIVERS STANDARD PRESSURE

SIZE OF PUMP	RECEIVER CAPACITY GALLONS	SQ. FT. DIRECT RADIATION	LB. CONDENSATE PER HOUR	MINIMUM STEAM PRESSURE
3 × 2 × 3½	12	6000	2000	50
4½ × 2¾ × 4	20	10,500	3500	40
5¼ × 3½ × 5	40	19,500	6500	35
6 × 4 × 6	60	30,000	11,000	35
7¼ × 5 × 6	100	45,000	15,000	30
Low Pressure				
4½ × 2 × 4	12	6000	2000	25
5¼ × 2½ × 5	20	10,000	3500	20
6 × 2½ × 6	40	120,000	4000	15
6 × 3 × 6	40	180,000	6000	20
6 × 3½ × 6	60	290,000	9000	25

TABLE 8. CENTRIFUGAL RETURN PUMPS WITH RECEIVERS

SIZE OF PUMP DISCHARGE INCHES	RECEIVER CAPACITY GALLONS	SQ. FT. DIRECT RADIATION	LB. CONDENSATE PER HOUR	H. P. TO DRIVE	TOTAL HEAD FT.
1	40	12,000	4000	1	25
1½	60	25,500	8500	1½	50
2	100	42,000	14,000	2	50

TABLE 9. CHARACTERISTICS OF CENTRIFUGAL PUMPS AND RECEIVERS DELIVERING AGAINST 15 LB.

SIZE	SQ. FT. EQUIVALENT DIRECT RADIATION	GAL. PER MIN.	R. P. M.	ACTUAL H. P.	H. P. MOTOR SUPPLIED	FLOOR SPACE	SHIPPING WEIGHT
101	8000	11	1725	0.4	¾	5′ 3″x3′ 8″	700
102	16,000	22	1725	0.6	¾	5′ 3″x3′ 8″	700
103	26,000	35	1725	0.8	1	6′ 5″x3′ 8″	750
104	40,000	60	1140	1.0	1½	7′ 6″x4′ 2″	1050
105	65,000	90	1140	1.4	2	7′ 6″x4′ 2″	1100

RETURN LINE VACUUM HEATING PUMPS

These may be of the following types:

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

High pressure traps should never discharge directly into a vacuum return. An excessive amount of vapor will form due to re-evaporation of a considerable part of the hot condensation. This may cause a very material reduction in the vacuum maintained by the pump. Fig. 3 shows a method of disposing of the greater part of the vapor of re-evaporation and at the same time lowering the temperature of the condensate.

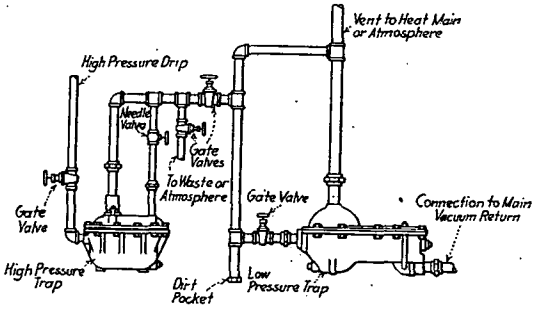

FIG. 3. METHOD OF DISCHARGING HIGH-PRESSURE APPARATUS INTO LOW-PRESSURE HEATING MAINS AND VACUUM RETURN MAINS THROUGH A LOW-PRESSURE TRAP

DISPOSAL OF VACUUM PUMP DISCHARGE

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

Wherever a suitable location may be obtained the freely vented air

separating tank is generally used. The tank must be located high enough so that the pressure produced by the water column in the discharge pipe will be sufficient to overcome that in the low-pressure boiler feed water heater or other point of disposal. Fig. 4 shows the proper arrangement of vacuum pump, air separating tank and feed water heater.

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

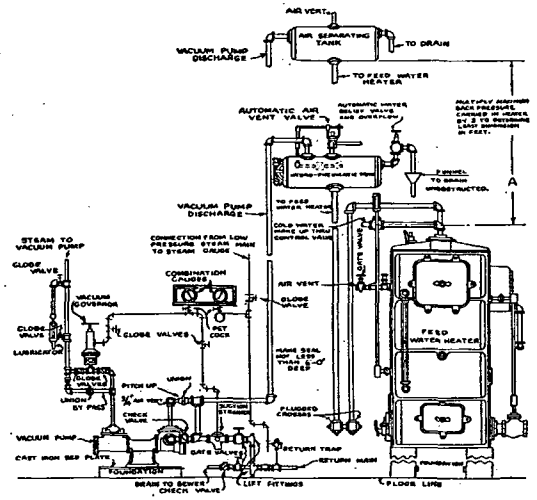

FIG. 4. METHOD OF CONNECTING VACUUM PUMP, FEED WATER HEATER AND SINGLE CONTROL HYDRO-PNEUMATIC TANK OR AIR SEPARATING TANK

Where an open tank cannot be located at a height sufficient to provide gravity head to discharge the tank contents against the maximum pressure in the heater or boiler, the hydro-pneumatic tank is used. A float controlled valve is placed on the air outlet of the separating tank and so arranged that when the water of condensation has not sufficient head to flow by gravity to the point of use, the air will be confined in the upper part of the tank. As the pump continues to deliver water and air to the tank the pressure within the tank increases until sufficient to discharge the water, thus lowering the water-line and eventually permitting escape of the surplus air through the float controlled air valve. The confined air pressure in the tank plus the gravity head in the tank discharge pipe must be sufficient to cause flow to the place of disposition. This confined air pressure plus the column of mixed air and water in the pump discharge to the tank is the total head against which the pump must act. Fig. 4 shows a hydro-pneumatic tank, Figs. 5, 6 and 7 show vacuum pump connections for several different conditions of service.

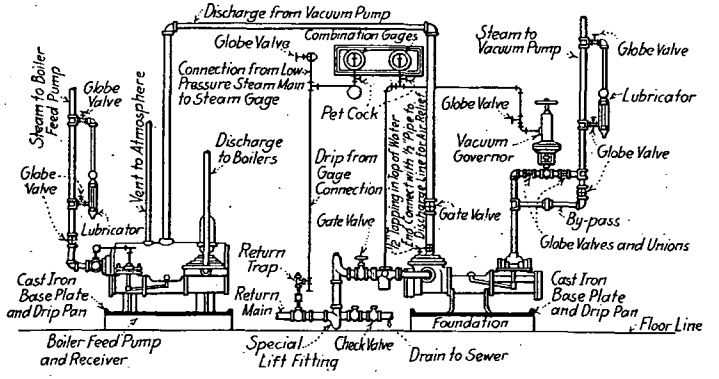

FIG. 5. METHOD OF CONNECTING VACUUM PUMP AND AUTOMATIC BOILER-FEED PUMP AND RECEIVER

Table 10 gives the sizes of plain or hydro-pneumatic tanks for air separating purposes and also those for storage of returns. In the latter case the tanks are based upon storing the quantities of water which will be discharged during five minutes at the basis of hourly rates given in the first column.

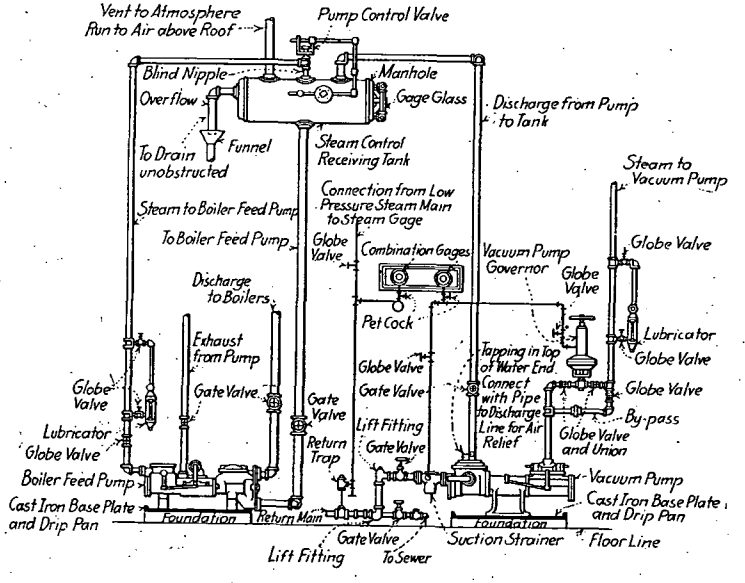

FIG. 6. METHOD OF CONNECTING VACUUM PUMP, BOILER-FEED PUMP AND STEAM-CONTROL RECEIVING TANK

TABLE 10. SIZE OF PLAIN AND HYDRO-PNEUMATIC TANKS

COMPENSATION LB. PER HR.	SIZES OF PLAIN AND HYDRO-PNEUMATIC TANKS			
	FOR AIR SEPARATOR ONLY		FOR AIR SEPARATOR AND WATER STORAGE	
	Diameter In.	Length In.	Diameter In.	Length In.
4000	12	24	24	36
6000	12	36	24	48
8000	18	30	24	72
10,000	18	48	30	48
16,000	24	48	30	60
24,000	30	48	36	60
	24	72	36	72
34,000	36	60	36	96
	36	72	42	72
45,000	42	60	42	96
	36	96	---	---
60,000	42	72	48	72
	42	96	48	96

LIFT FITTINGS

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

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

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

STEAM DRIVEN RECIPROCATING RETURN LINE VACUUM PUMPS

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

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

Steam driven pumps can be economically used with steam pressures of 15 lb. or over and where the exhaust steam can be completely utilized.

Where the supply of exhaust steam from engines or other sources is continuously in excess of that necessary to supply the heating system the electric driven pump is generally the most efficient and is also preferable when the steam pressure is too low to operate a steam driven pump.

TABLE 11. DIRECT DOUBLE ACTING STEAM DRIVEN RECIPROCATING VACUUM PUMPS

DIAMETER IN INCHES WATER CYLINDER	CONDENSATION LB. PER HR. FOR PUMPS WITH STROKE EQUAL TO BORE	DIRECT CAST IRON RADIATION SERVED	PIPE SIZES		DISCHARGE IN.	PUMPS HAVING UNEQUAL STROKE AND BORE	
			Steam In.	Suction In.		Stroke Bore	Capacity Factor
3	510	1700	½	1¼	¾	2.50	1.58
4	1047	3490	½	1½	1	2.25	1.48
5	1830	6100	½	2	1¼	2.00	1.38
6	2890	9633	½	2½	1½	1.90	1.34
7	4250	14,166	¾	2½–3½	1½–2	1.80	1.31
8	5920	19,733	¾	3–3½	2	1.75	1.29
9	7980	26,600	¾	3½–4	2	1.70	1.27
10	10,350	34,500	1	4–4½	2½	1.67	1.25
12	16,300	54,333	1	4½–5	2½	1.60	1.23
14	24,000	80,000	1¼	5–6	3	1.50	1.10
16	33,500	111,666	1¼	6–7	3½	1.40	1.15
18	45,000	150,000	1½	7	4	1.33	1.13
20	58,500	195,000	1½	7–8	4½	1.30	1.12
22	74,300	247,666	2	8	4½	1.25	1.10
24	92,300	317,666	2	8–10	5	1.20	1.08
26	112,800	376,000	2½	10	6	1.10	1.04
28	135,800	452,666	2½	12	6	1.00	1.00
30	161,300	537,666	2½	12	6	0.90	0.96
32	189,600	632,000	3	14	7	0.80	0.91
34	221,000	736,333	3	14	7	0.75	0.89
36	254,000	846,666	3	14	8	0.70	0.87
						0.67	0.85
						0.60	0.82
						0.50	0.78

The capacities given in Table 11 are for pumps having water cylinder with the length of stroke equal to the diameter of the water piston.

The capacities for pumps of a greater or less length of stroke may be found by use of the last two columns in this table as follows:

Divide the stroke by the piston diameter and find the corresponding ratio in the column headed stroke-bore. The capacity factor opposite this in the last column is then multiplied by the capacity given in the table to give the capacity of the pump in question.

Proportioning of Steam End of Reciprocating Vacuum Pumps

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

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

From which we have

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

in which

A_s = Area of steam piston in square inches.
A_w = Area of water piston in square inches.
P_b = Boiler pressure in pounds per square inch.
P_d = Discharge pressure in pounds per square inch.
V = Vacuum at pump expressed in inches of mercury.
$\frac{V}{2}$ = Approximate vacuum in pounds per square inch (2 in. mercury = approximately 1 lb. per sq .in.)

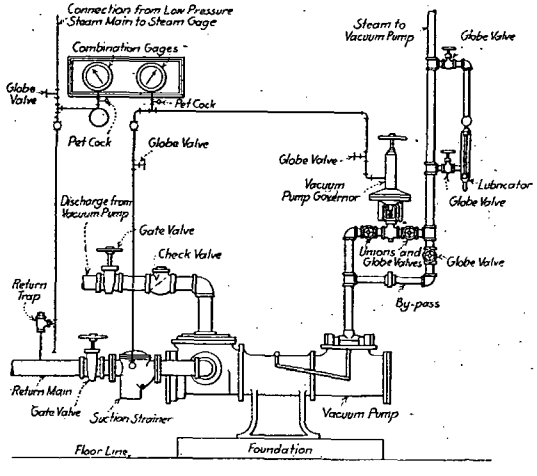

FIG. 7. METHOD OF MAKING CONNECTION TO STEAM-OPERATED VACUUM PUMP

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

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

Where the head on the delivery side of steam driven pumps exceeds 15 lb. it is good practice to deliver the condensation to a vented receiver located close to the level of the vacuum pump outlet. This receiver should be connected to a separate steam or power driven water pump capable of delivering against the maximum head and controlled by a throttle valve, actuated by the water line in the receiving tank.

MOTOR DRIVEN RETURN LINE VACUUM PUMPS

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

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

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

a. One pumping unit and motor for handling both air and condensate.

b. One pumping unit and motor for handling air and a separate pumping unit and motor for handling condensate.

c. One pumping unit and motor for handling condensate with an air ejector operated by a recirculated portion of the condensate for handling the air.

d. One pumping unit for handling condensate and another for handling the air, both operated by one motor.

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

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

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

TABLE 12. RECEIVER TANK CAPACITIES

SQ. FT. EQUIVALENT DIRECT CAST IRON RADIATION SURFACE	TOTAL RECEIVER TANK CAPACITY IN GALLONS	RECEIVER TANK CAPACITY BETWEEN HIGH AND LOW WATER LIMITS WHERE AUTOMATIC WATER LINE CONTROL IS USED.
8,000	28	20
16,000	33	24
26,000	40	29
40,000	49	35
65,000	63	47
100,000	80	63

The air capacities recommended, referred to cubic feet of air per 1000 sq. ft. of equivalent cast iron direct radiation, may be assumed on a decreasing ratio as the system increases in capacity of equivalent square feet of radiation, in accordance with the following Table 13. It should be noted that while water capacities of pumps to be added for fan blast

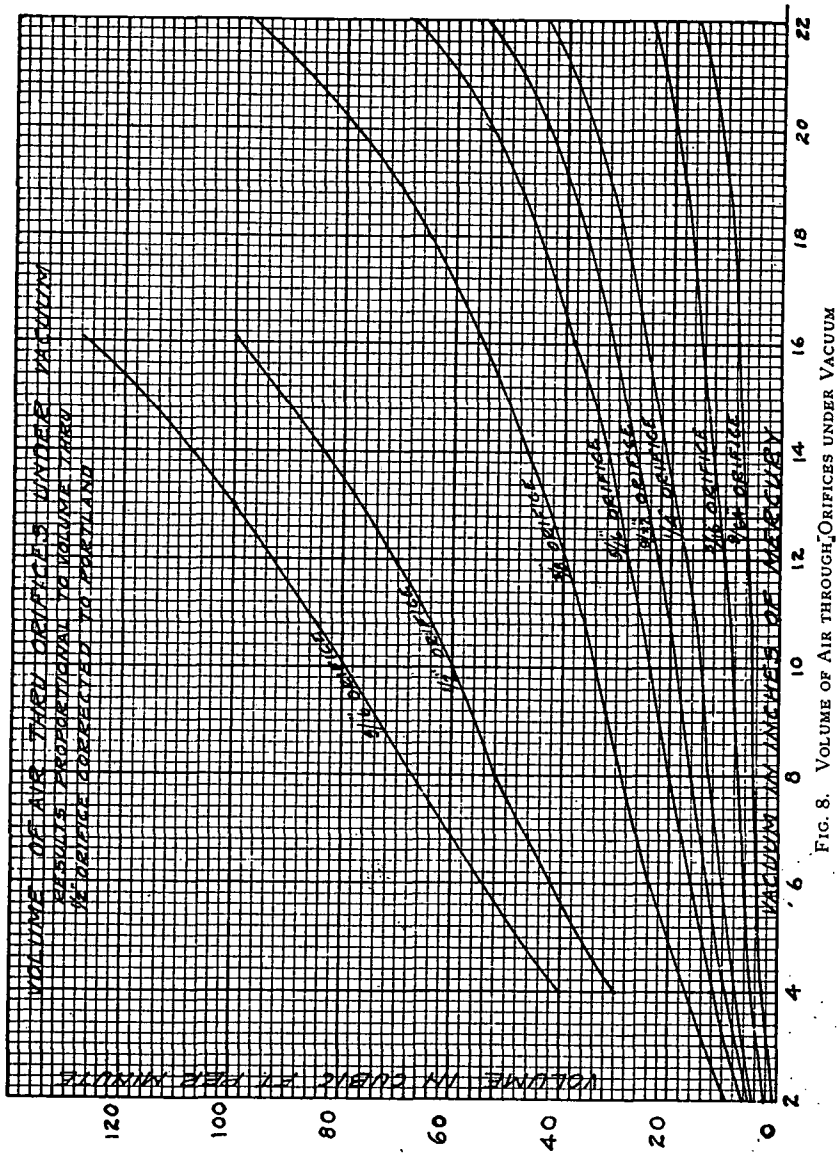

Fig. 8. Volume of Air through Orifices under Vacuum

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

Table 13. Air Capacities

Sq. Ft. Direct Equivalent Radiation Surface	Diameter Orifice Vac. 10″	Air Capacity Cu. Ft. per Min.
8,000	9/64″	5
16,000	3/16″	9
26,000	1/4″	15
40,000	9/32″	19
65,000	3/8″	34
100,000	1/2″	60
150,000	9/16″	80
250,000	Three 1/2″	180

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

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

The accompanying Fig. 8 may be used to give the quantity of air handled, corresponding to several sizes of orifices and different degrees of vacuum met with in practice.

The water capacity of the pump when operating against 8 in. of mercury vacuum should be not less than three-tenths (0.3) of a pound of water per hour per square foot of equivalent cast iron direct radiation based upon condensation at a temperature of not over 180 deg. fahr. when the pump is delivering water against a specified gage pressure at the water discharge of the pump. For pumps handling both air and water the above water capacity must be delivered, when the pump is maintaining a vacuum of 8 in. of mercury and handling air through a standard orifice corresponding to the air capacity of the pump as herein specified.

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

Table 14. Sizes, Speeds, Horse Powers and Capacities Motor Driven Condensation Return Pumps

Rating in Sq. Ft.	0–2000		2000–4000		4000–8000		8000–16000	
Discharge Pressure, Lb.	10	20	10	20	10	20	10	20
Gallons per Min.	3	3	6	6	10	10	20	20
H. P. Motor	3/8	3/4	3/8	3/4	3/8	3/4	3/8	3/4
R. P. M. 60 Cycle and D. C.	1700	1700	1700	1700	1700	1700	1700	1700
R. P. M. 25 Cycle	1440	1440	1440	1440	1440	1440	1440	1440
Shipping Weight	330	350	350	370	420	440	535	565

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

PUMP SPECIFICATIONS

Reciprocating and power driven pumps should be specified as to make, size, water and steam working pressures, piston speed, temperature of water to be handled, electric motor characteristics, etc.

TABLE 15. MOTOR DRIVEN CONDENSATION PUMP CAPACITIES FOR DELIVERING AGAINST VARIOUS PRESSURES

Radiation in Sq. Ft. of Direct Radiation	Minimum Gallons per Min.	Maximum Boiler Pressure Lb.	Motor H. P.	Suggested Size of Piping Inches	Radiation in Sq. Ft. of Direct Radiation	Minimum Gallons per Min.	Maximum Boiler Pressure Lb.	Motor H. P.	Suggested Size of Piping Inches
4000	6–8	10	¼	1	15,000	25–30	10	¾	2
4000	6–8	15–40	½	1	15,000	25–30	15	1	2
4000	6–8	50–60	¾	1	15,000	25–30	20–30	1½	2
					15,000	25–30	40	2	2
					15,000	25–30	50–60	3	2
6000	9–12	10	¼	1¼	20,000	30–40	10	¾	2
6000	9–12	15–40	¾	1¼	20,000	30–40	15	1	2
6000	9–12	50–60	1	1¼	20,000	30–40	20	2	2
					20,000	30–40	30–40	3	2
					20,000	30–40	50–60	5	2
8000	12–16	10	½	1¼	25,000	40–50	10	1	2½
8000	12–16	15	¾	1¼	25,000	40–50	15	1½	2½
8000	12–16	20	1	1¼	25,000	40–50	20	2	2½
8000	12–16	30–60	1½	1¼	25,000	40–50	30–40	3	2½
					25,000	40–50	50–60	5	2½
10,000	15–20	10	½	1½	30,000	50–60	10	1	2½
10,000	15–20	15	¾	1½	30,000	50–60	15	1½	2½
10,000	15–20	20–30	1	1½	30,000	50–60	20	2	2½
10,000	15–20	30–40	1½	1½	30,000	50–60	30–60	5	2½
10,000	15–20	50–60	2	1½					

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

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

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

The following should also be included in the specifications, total head to be pumped against including suction lift, friction head, velocity head and head against which the pump must discharge. The vacuum under which return pumps are required to operate and as to whether two or more units are to operate in parallel or separately.

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

TABLE 16. ONE PUMP ONE MOTOR RETURN LINE SYSTEM

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

TABLE 17. TWO PUMP ONE MOTOR RETURN LINE SYSTEM VACUUM PUMPS

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

TABLE 18. TWO PUMP TWO MOTOR RETURN LINE SYSTEM VACUUM PUMP

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

The exhaust from steam driven pumps supplying steam for heating purposes should be taken through an efficient oil separator before entering any part of the heating system or other apparatus.

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

CHAPTER X

HEATING WITH AIR

THERE are several common methods of heating with air which are in common use today and are suitable for heating the smallest house or the largest factory: (1) Gravity warm-air furnace system (See Chapter XI); (2) Furnace fan heating; (3) Fan blast heating (See Chapter XIX); (4) Unit heating system; (5) Indirect radiation (See Chapter II.)

Each system has its particular application: Number 1 being intended particularly for residences and small structures; Number 2 for residences, small theatres, churches and stores; Number 3 for large buildings, theatres, schools, churches and factories; Number 4 for shops, factories and other large enclosures and Number 5 for homes, hotels, schools, etc.

FURNACE FAN HEATING

A furnace fan heating system consists of a warm-air furnace with fan attachment in suitable housing between the bottom of the heater and the cold air supply duct, while stacks connect with the various rooms as for the ordinary gravity warm-air heating plant. Four of the fundamental requirements of a fan furnace system are: (1) Capacity in cubic feet per minute equal to maximum quantity of air to be circulated per minute for delivering amount of heat required; (2) Operating efficiency high enough that power cost will be proportionate to heating efficiency; (3) Quiet operation; (4) Ample capacity to operate both as gravity and fan system.

The fan installed in the air supply duct tends to establish a uniformity of air flow over the heating surfaces of the furnace should be increasing but air velocity through the casing established a positive pressure at the bonnet. The operation of a furnace fan system may be constant or intermittent as required. It is effective for quick heating up and it may be installed for automatic operation as the demand for heat increases.

Fans used for these installations are of propeller or multivane type and should be selected on the basis of their capacity to deliver a certain number of cubic feet of air per minute. The selection of a fan is based on the loss of heat from the structure but it is essential that fans have a capacity in cubic feet equal to at least three times the quantity of air circulated when the system operates as a gravity plant.

For example, assume that the inside temperature is to be 70 deg. and that air will leave the register at 175 deg. also that the heat loss from a building is 70,000 B.t.u. per hour, therefore, temperature difference 105 deg. times 0.24 (specific heat of air) equals 25.20 B.t.u. (heat given up per pound of air) then 70,000 B.t.u. divided by 25.2 equals 2777 lb. of air per hour delivered by the register therefore, 2777 divided by 60 equals 46 lb. of air delivered per minute, the volume of this year at 175 deg. temp. is therefore, 46 divided by 0.06355 equals 723 cu. ft. of

air per minute. While this essentially represents the amount of air to be handled by the fan the actual volume handled will be the weight in pounds per minute divided by the weight of 1 cu. ft. at the temperature handled. The air temperature on which to figure will be dependent upon whether the air supply will come from outdoors, indoors or will be a combination.

Some results of tests showing the effect of using a centrifugal fan as an auxiliary to a furnace heating system appear in the report in the University of Illinois Bulletin 37.

CENTRAL FAN SYSTEMS

Systems of heating using a fan to circulate the air and distribute it through a system of ducts lends itself admirably to many applications (See Chapter XIX). When used for heating only it is most frequently applied to industrial service where infiltration of outside air is sufficient for ventilating purposes. Recirculation of some air is practised in severe weather. The amount of heat required[1] is governed by the following: (1) Size and shape of building; (2) Materials of construction, infiltration, etc.; (3) Temperature required; (4) Heat produced by processes, occupants, etc.

Some loss in temperature will occur in conveying the heated air to the point of discharge if the ducts are exposed or run underground, therefore, the provision should be made for increasing the temperature of air leaving the heater by an amount corresponding to the loss. Three factors to be considered in heating a building with the fan system are: Total heat loss, air quantity required for heating, and final temperature desired and temperature rise[2] of air passing through the heater.

The temperature rise through a heater will depend upon the air velocity, number of sections deep and temperature of heating medium and entering air. The air velocity through the heaters will vary with the character of the installation. Generally the rule is that the velocity should not exceed more than that which would cause a friction loss through the heater of one-half the static pressure of the entire system. For industrial heating the friction through heaters ordinarily should not exceed 1 in.

UNIT HEATER[3]

The unit heater for industrial plant application is comprised of a radiator or heating element enclosed by a casing in which a power driven fan or fans are mounted. The fans draw or force air over the heating surface where it is heated and discharge it in selected directions. Unit heaters are placed directly within the room to be heated and discharge the heated air into the enclosure where it is distributed uniformly over wide areas under the direct impulse of the fans and by the currents of circulation set up.

The function for which unit heaters are designed are: To circulate the air in the building at a more rapid rate to promote uniformity of

[1] See Chapter I.
[2] See Chapter XIX.
[3] Prepared by D. E. French, Chairman, Engineering Committee, *Industrial Unit Heater Association.*

temperatures and quick heating-up; to control and direct the heated air for the positive and economical placing of the heat where it is effective; to distribute heat over wide areas, to reduce the number of units and simplify piping and installation; to increase the capacity of the heating surface by passing the air over it at high velocity to economize material; to provide a system by which room temperatures are easily controlled manually or by thermostats at slight cost.

There is a type of unit heater to suit any purpose. Most employ a heating coil to be supplied with steam or hot water. Some are designed primarily for mounting on the floor, others for suspension overhead. Heating surfaces in the form of pipe coils, non-ferrous tubes or shapes with extended surfaces, cast iron, pressed and built up sections of the cartridge or automotive type are all used in one or more of makes available. Fans employed are the disc or propeller, housed centrifugal and cone types.

Unit heaters may be arranged to re-circulate the air or to supply warmed air from the outside for ventilation or to make up air exhausted. One type combines a means for exhausting air with the above functions. In addition to their prime function of plant heating, they may be adapted to a number of industrial processes, such as drying, curing, etc. Here the use of heated air in more rapid circulation with uniform distribution is of particular advantage. They may be used for moisture absorption, such as fog removal in dye houses or the prevention of condensation on roofs or cold surfaces of buildings where process moisture is given off. When such conditions are bad, it is necessary that the heaters draw air from outside in enough volume to provide a rapid air change and that they operate in conjunction with ventilators or fans for exhausting the moisture laden air.

Unit heaters are made to operate on hot water, vacuum or vapor steam systems or steam at any pressure up to 200 lb. or more. When high pressure steam is used, a heater must be selected with the coil especially designed to withstand the maximum pressure that will exist.

It is usual to rate unit heaters in B.t.u. per hour at a given temperature of air entering the heater and a given steam pressure maintained on the coil. Steam at 2 lb. pressure and air entering at 60 deg. fahr. are taken as standard. The B.t.u. capacity of a heater increases as the steam pressure increases, and decreases as the entering air temperature increases. The B.t.u. capacity for any condition of steam pressure and entering air temperature may be calculated from any given rating by the use of factors in Table 1.

The B.t.u. required to heat a building with unit heaters is determined in the same way as for any other heating equipment (Chapter I). Unit heaters of the number and size needed to furnish this B.t.u. are then selected from the manufacturers rating tables, using their ratings at the steam pressure to be used and at the temperature at which the air will enter the heater. For re-circulating heaters with intakes at the floor level, use the temperature to be maintained in the room as the temperature of the air entering the heater. For suspended heaters re-circulating, the entering air temperature will be higher than the specified room temperature by approximately 1 deg. fahr. for each foot of elevation between the 5 ft. level and the level of the heater intake. Heaters

Table 1. B.t.u. Constants for Various Steam Pressures and Temperatures of Entering Air

Steam Pressure Lbs.	Temperature of Air Entering Heater												
	−10°	0°	10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°
0	0.975	0.93	0.89	0.84	0.80	0.76	0.73	0.71	0.69	0.67	0.64	0.62	0.60
2	1.01	0.96	0.92	0.87	0.83	0.79	0.76	0.74	0.72	0.70	0.68	0.65	0.63
5	1.04	**1.00**	0.96	0.91	0.87	0.82	0.80	0.78	0.76	0.74	0.71	0.69	0.67
10	1.06	1.05	1.01	0.97	0.92	0.88	0.85	0.83	0.81	0.79	0.76	0.74	0.72
15	1.15	1.10	1.05	1.01	0.97	0.92	0.90	0.88	0.86	0.83	0.81	0.79	0.76
20	1.18	1.14	1.09	1.05	1.00	0.96	0.94	0.92	0.89	0.87	0.85	0.83	0.81
30	1.25	1.21	1.16	1.12	1.08	1.03	1.01	0.98	0.96	0.94	0.92	0.90	0.88
40	1.30	1.26	1.22	1.17	1.12	1.08	1.06	1.04	1.02	1.00	0.97	0.95	0.93
50	1.35	1.31	1.27	1.22	1.18	1.13	1.11	1.09	1.07	1.04	1.02	1.00	0.98
60	1.39	1.35	1.31	1.26	1.22	1.18	1.16	1.13	1.11	1.09	1.07	1.05	1.03
80	1.49	1.43	1.38	1.34	1.29	1.25	1.23	1.20	1.18	1.16	1.14	1.12	1.10
100	1.53	1.49	1.44	1.40	1.35	1.31	1.29	1.26	1.24	1.22	1.20	1.18	1.16
125	1.59	1.56	1.51	1.46	1.42	1.37	1.36	1.33	1.31	1.29	1.27	1.24	1.22
135	1.61	1.57	1.53	1.48	1.44	1.39	1.37	1.35	1.33	1.30	1.28	1.26	1.24
140	1.62	1.58	1.54	1.49	1.45	1.41	1.38	1.36	1.34	1.32	1.29	1.27	1.25
150	1.64	1.60	1.55	1.51	1.46	1.42	1.40	1.38	1.35	1.33	1.31	1.28	1.26

Note.—To get B.t.u's at any steam pressure and entering temperature, multiply constant from table by rated B.t.u's at 0 deg. entering and 5 lb. pressure.

supplied with super-heated steam will have less B.t.u. capacity than with saturated steam at the same pressure. When superheated steam is supplied or when the steam in the heater coils is superheated by throttling from the heater at a higher line pressure, the heater manufacturer should be asked for a special rating for the conditions of the case.

The present day tendency for straight heating is to use steam at low-pressure when the boiler supplies steam for heating purposes only and when the transmission lines are short. Many industrial plants, however, generate steam at high pressure either for long distance transmission or process uses. When such high pressure steam is available in sufficient quantity for the heating load, it is most often more economical to select heaters with coils good for high pressure. Thus the line pressure may be turned into the coils directly without reducing valves, fewer or smaller heaters can be used and the condensation can be boosted to overhead returns whenever desirable to do so.

Among the unit heaters available are types having from one to four outlets that can be arranged to discharge in selected directions and that will project their heating effect over distances of from 30 to 200 ft. from the heater, depending upon the capacity of the heater and the design of the fans and outlets. This leaves the engineer comparatively free to select the heater location best suited to the production layout.

The smaller capacity propeller fan type heaters with outlet velocities from 300 to 600 ft. per minute may be placed from 60 to 100 ft. apart. The larger capacity housed fan high outlet velocity heaters may be placed up to 400 ft. apart, depending upon their design. Heaters may be distributed through the central portions of a room discharging toward exposed surfaces, or spaced around the walls, discharging along the walls and inward as well, when there are considerable roof losses. In general, it is better to direct the discharge from the unit heater in

such fashion that rotational circulation is set up by the system rather than having the heaters discharge in random and counter directions.

Usually hot blasts in the working zone are objectionable, so heaters mounted on the floor should have their discharge outlets above the head line and suspended heaters should not be placed so low or turned in such direction that the heated air will penetrate the working zone. In the interest of economy, however, the elevation of the heater outlet and the direction of discharge should be so selected that the heated air is brought as close to the head line as possible, but not into the working zone.

Unit heaters should be carefully air vented and usually a blast type trap of at least 50 per cent excess capacity should be used to take care of the load during the heating-up period. During that period the temperature of the air entering the heaters is low and the heaters therefore condense more steam than they do when the building is up to temperature. Steam pressures below 5 lb. can be used with safety for re-circulating heaters when proper provision is made for returning the condensation. If heaters are to take in air that might be at a temperature below freezing, a steam pressure of at least 5 lb. should be maintained on the heater coils.

Stopping the fan motor but with steam on the coils reduces the heat output 70 or 80 per cent, depending upon the design of the heater. Thus room temperatures can be controlled by starting or stopping the fan motor on one or more of a group of units. This can be done manually or by means of a simple thermostat which makes and breaks the circuit either direct to the motor for fractional horsepowers or through an automatic starting switch. Of course the heat output of the heater may also be controlled by the throttle valve to the heater coil. This can be done thermostatically either with a graduated or with an on and off action. In some applications thermostatic controls to both the motor and the steam valve are used in conjunction.

What has been said relates generally to units in which steam or hot water is used as the heating medium. On rare occasions electrical resistances are used as the heating element but are applied only where electric power is abundant and cheap and other forms of fuel scarce and expensive.

DIRECT FIRED UNITS

In places where these heating mediums are not available the direct fired type of heater is used. Here the heating element is a fire box in which coal, coke, oil or gas is burned directly. This fire box is enclosed in a casing in which fans are mounted so as to draw air over the fire box, and combustion chamber and discharge it directly into the room. This type of heater is also used for temporary heat or where the installation of a steam or hot water plant is for some reason not justified.

CHAPTER XI

GRAVITY WARM-AIR FURNACE HEATING

IN this chapter of THE GUIDE consideration will be given to the design of gravity circulating warm-air heating systems. For fan circulating systems see Chapter XXI on Design and Construction of Air Ducts. Complete engineering data, including the procedure to be followed in designing a typical system, are presented in the first part of the chapter, while the last part of the chapter presents a Standard Code Regulating the Installation of Gravity Warm-Air Heating Furnaces in Residences, approved by the *National Warm Air Heating and Ventilating Association*, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *National Association Sheet Metal Contractors*, *Western Warm Air Furnace and Supply Association*, and the *Midland Club*, as a workable Code for furnacemen.

DEFINITIONS

In general, warm-air furnace heating plants consist of a fuel burning furnace or heater enclosed in a casing of sheet metal or brick, which is placed in the basement of the building. The heated air, taken from the top or sides near the top of the furnace casing, is distributed to the various rooms of the building through sheet metal warm-air pipes. The warm-air pipes in the basement are known as leaders, and the vertical warm-air pipes which are run in the inside partitions of the building are called stacks. The heated air is finally discharged into the rooms through registers which are set in register boxes placed either in the floor or in the side wall, usually at or near the baseboard.

The air supply to the furnace may be taken (1) entirely from inside the building through one or more recirculating ducts, or the air supply may be taken (2) entirely from outside the building, in which case no air is recirculated. Sometimes a combination of the inside and outside air supply system is employed.

Furnace heating plants may be (1) of the gravity circulating type in which the motive head producing flow depends upon the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing, or (2) of the fan circulating type in which a fan may supply all or part of the motive head producing flow. In most house installations, the former type of system is in general use.

Material for this section was prepared especially for THE GUIDE by Arthur C. Willard, Professor of Heating and Ventilation and Head of the Department of Mechanical Engineering, University of Illinois, Urbana, Illinois.

All figures and much of the engineering data which follow are from Bulletin No. 141, "Warm Air Furnaces and Heating Systems," Part II, by Professors A. C. Willard, A. P. Kratz and V. S. Day, Engineering Experiment Station, University of Illinois.

DESIGNING A FURNACE HEATING SYSTEM

The design of a furnace heating system involves the determination of the following items:

a. Heat loss in B.t.u. from each room in the building.

b. Area and diameter in inches of warm-air pipes in basement known as leaders.

c. Area and dimensions in inches of vertical pipes known as wall stacks.

d. Free and gross area and dimensions in inches of warm-air registers.

e. Area and dimensions of (1) recirculating or (2) outside air supply ducts in inches. There may be one or more of each.

f. Free and gross area and dimensions in inches of recirculating registers.

g. Size of furnace necessary to supply the warm air required to overcome the heat loss from the building. This "size" should include square inches of leader pipe area which furnace must supply. It is also desirable to call for a minimum bottom fire-pot diameter in inches, which is the nominal grate diameter.

h. Area and dimensions in inches of chimney lining and smoke pipe. If an unlined chimney is to be used, that fact should be made clear.

HEAT LOSSES FROM BUILDING

The heat which will be required for each room in the building depends on (1) the heat transmission losses through walls and glass as well as through floors and ceilings when the latter two are next to unheated spaces, and (2) the infiltration of cold air through the cracks around outside windows and doors. Calculations for the heat required in B.t.u. per hour should be made as indicated in Chapter I, Heat Losses from Buildings.

LEADER SIZES

In a gravity circulating warm-air furnace system the size of the leader to a given room depends on the temperature of the warm-air entering the room at the register. A reasonable air temperature at the registers must, therefore, be agreed upon before the system can be designed. The *National Warm Air Heating and Ventilating Association* has approved an air temperature of 175 deg. fahr. at the registers as satisfactory. At this temperature, the heat carrying capacity (heat available above 70 deg. fahr.) per square inch of leader pipe per hour for first, second or third floors is shown by Fig. 1 at 175 deg. fahr. to be 105, 170 and 208 B.t.u. respectively. For average calculations, the values 110, 166 and 200 will simplify the work and may be satisfactorily substituted for these heat carrying capacities. If H represents the total heat to be supplied any room, the resulting equations are:

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

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

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

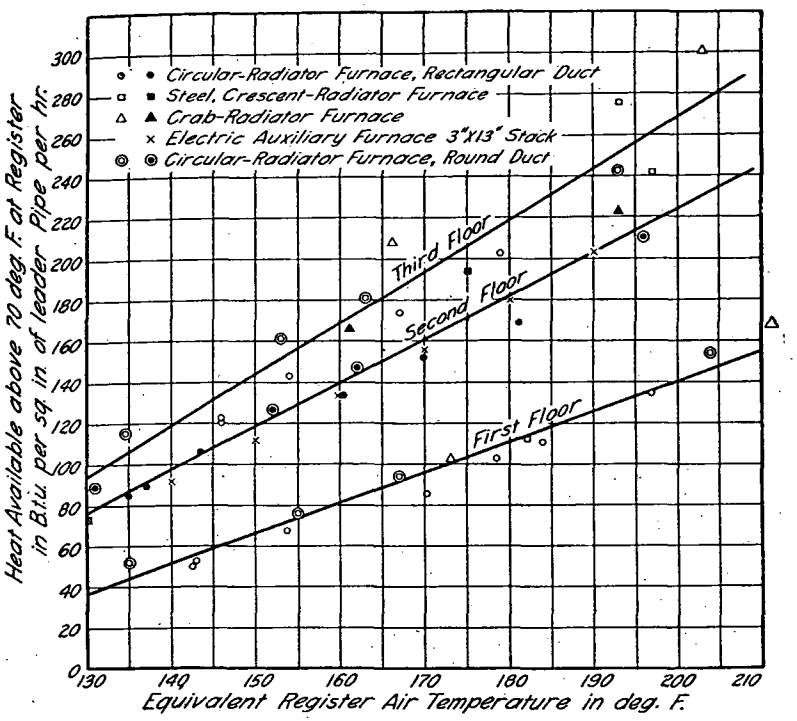

FIG. 1. VALUE OF SQUARE INCH OF LEADER PIPE AREA FOR FIRST, SECOND, AND THIRD FLOORS

In designing for a lower warm-air register temperature, say 160 deg. fahr., the factors 110, 166 and 200 become 80, 140 and 166 (Fig. 1 at 160 deg. fahr.), and the resulting equations are:

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

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

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

These equations are applicable to straight leaders from 6 to 8 ft. in length. Longer leaders must be very thoroughly covered or else the vertical stacks must be increased in area as discussed under wall stacks. If some provision is not made for these longer leaders, the air temperature may be much lower than anticipated and the room will not be properly heated.

While Fig. 1 takes care of the drop of temperature in straight leaders up to 8 ft. in length connected to stacks having about 75 per cent the

area of the leader, the designer must make allowances for all other conditions. The temperature drop in leaders of various lengths at three different register temperatures is shown in Fig. 2.

Leader sizes should in general be not less than obtained by equations (1) to (3) nor should leaders less than 8 in. in diameter be used. It is not considered good commercial practice to specify diameters except

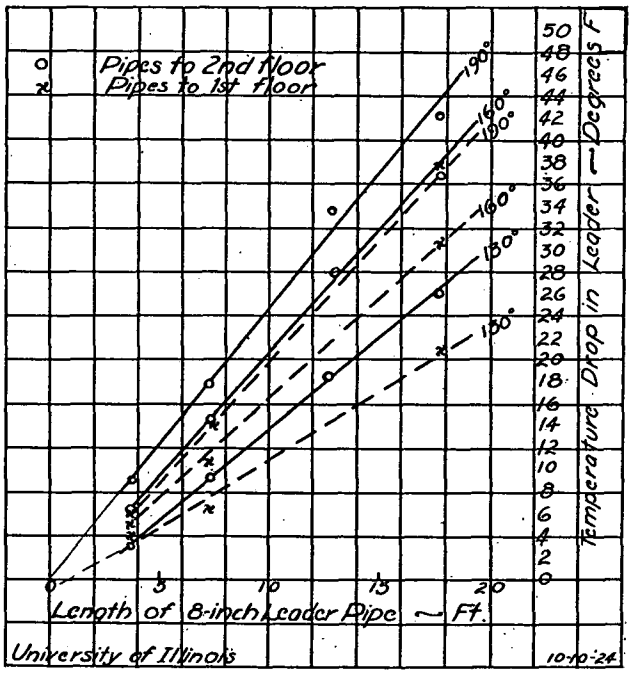

FIG. 2. LOSS IN TEMPERATURE IN 8 IN. LEADER PIPE OF VARIOUS LENGTHS AT DIFFERENT REGISTER TEMPERATURES

Note.—Pipe bare, bright tin except asbestos strips for joints.

in whole inches, although there is no real reason for not using half inches if necessary. The tops of leaders should be at the same elevation as they leave the furnace bonnet, and from this point there should be a uniform up-grade of 1 in. per foot of run in all cases. Leaders over 12 ft. in length are to be avoided or receive very special attention.

WALL STACKS

The wall stack for an upper floor should be made not less than 70 per cent of the area of the leader which has been selected from Fig. 1. So long as the leader is short and straight as was the case for Fig. 1, such a practice is probably justified since the loss (Fig. 3) in capacity occasioned by the smaller stack is not very serious for ratios above 70 per cent. For leaders over 8 ft. in length or for leaders which are not

straight, the ratio of stack area to leader area should be greater than 70 per cent in order to offset the greater temperature losses (Fig. 2) in the longer leader. In gravity circulating systems, this stack to leader

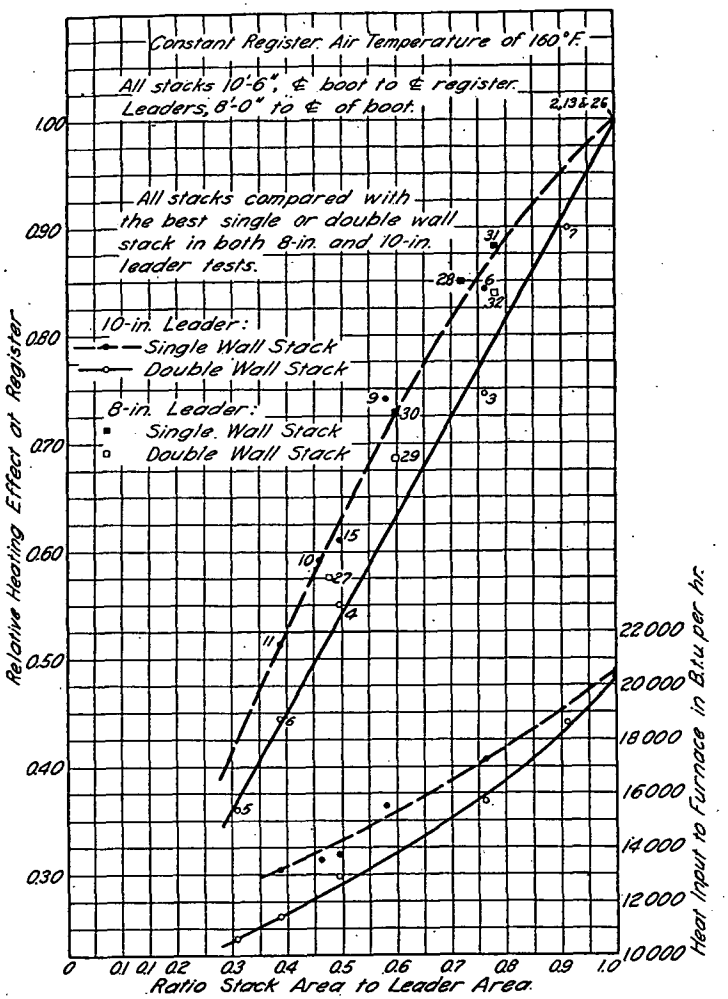

FIG. 3. RELATIVE HEATING EFFECT OF STACKS AT CONSTANT REGISTER AIR TEMPERATURE

area ratio is a very important consideration. Specific data for a great variety of cases are presented in Figs. 4 and 5 and the designer should check his stack to leader combinations with the nearest comparable case as shown in these figures. Any second floor stack supplying heat

to a room whose heat loss is 9000 B.t.u. or above (See Figs. 4 and 5 which show that high temperatures are necessary if rooms of more than 9000 B.t.u. requirement are heated by stacks in 4-in. studding), should be run within 6-in. studded walls or should have multiple stacks. Stack

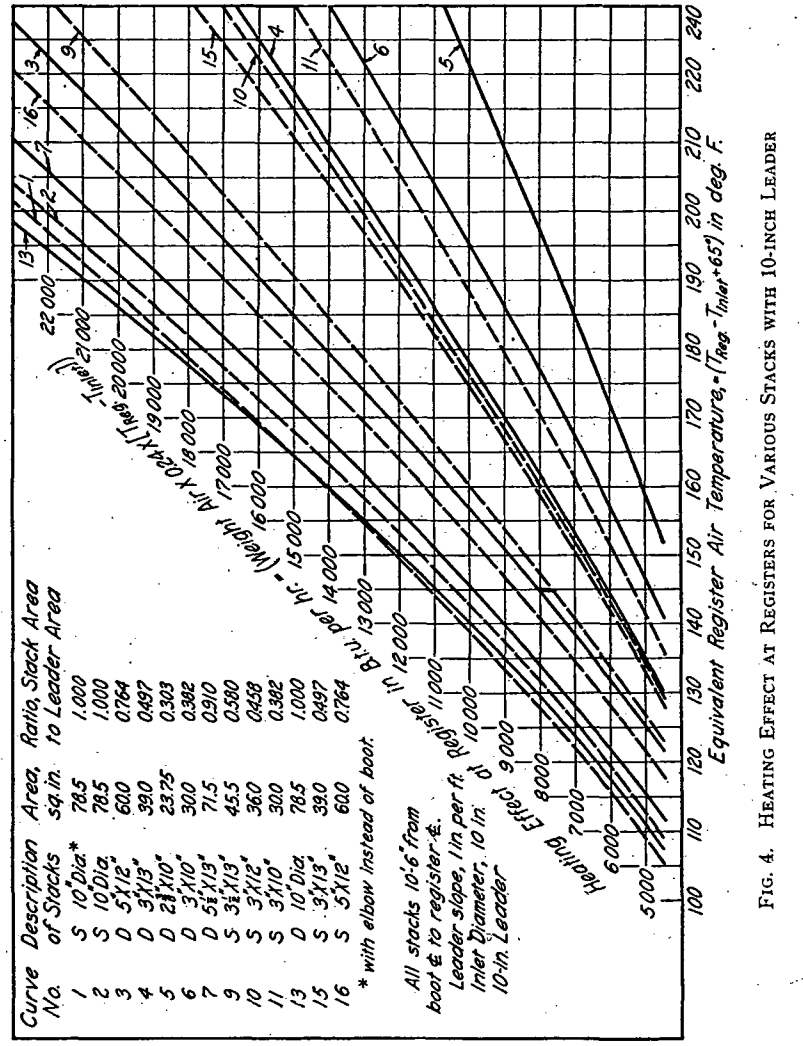

FIG. 4. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 10-INCH LEADER

sections, wherever possible, should be changed from the thin rectangular to the more nearly square shape. Stack heads should have upper end curved to provide easy flow of warm air to the room. Splitters in the upper end of the duct increase the air discharge.

WARM-AIR REGISTERS

The registers used for discharging warm-air into the rooms should have free or net area not less than the area of the leader in the same run of piping. The free area should be at least 70 per cent of the gross area

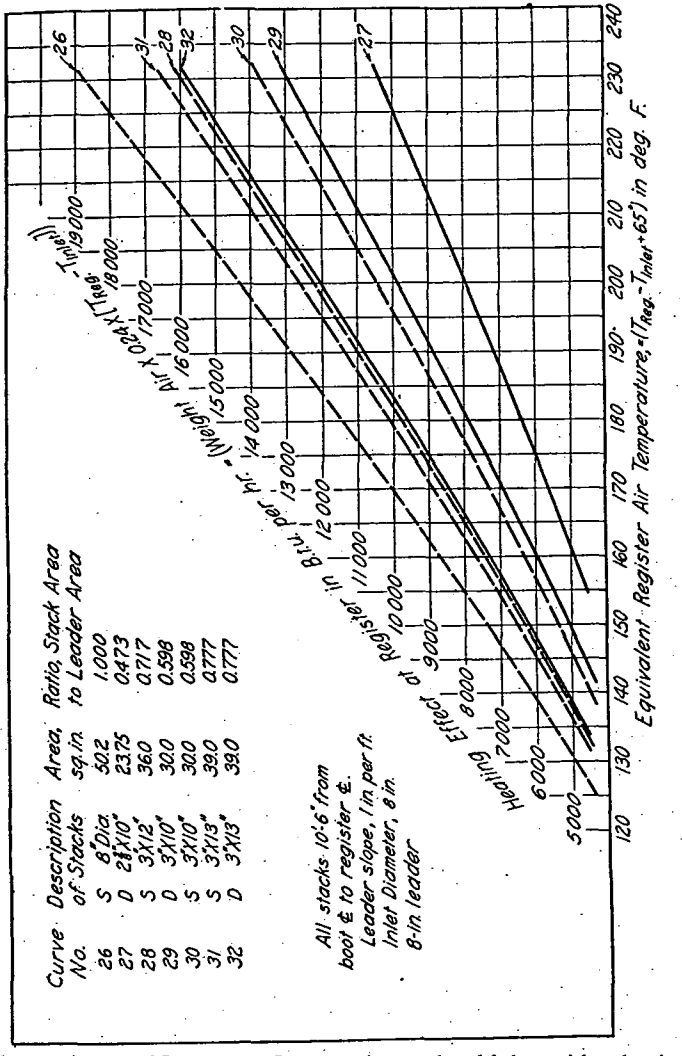

FIG. 5. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 8-INCH LEADER

of the register. No upper floor register should be wider horizontally than the wall stack, and it should be placed either in the baseboard or side wall, and not in the floor. First floor registers may be of the base-

board or floor type with the former location preferred. No first floor register should require a register box more than 14-in. wide, although it may be longer than 14-in.

AIR SUPPLY DUCTS

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

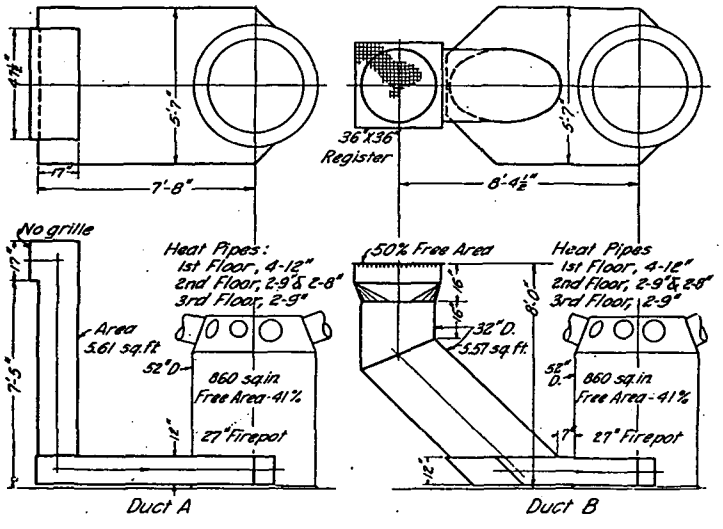

FIG. 6. TWO TYPES OF RECIRCULATING DUCT TESTED

as possible without sharp elbows is shown by the comparative performance on the same plant of two ducts (Fig. 6), as presented in Table 1.

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

TABLE 1. HEAT AVAILABLE AT REGISTERS FOR TWO TYPES OF RECIRCULATING DUCTS

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

the round duct using two 45 deg. instead of two 90 deg. elbows is very apparent. Values given in Fig. 1 are based on such a duct. Outside duct connections, if used, should be made to a window frame the full area of duct and such window should be in a wall exposed to prevailing winter winds. The inside type of recirculating duct or ducts is always preferred for residence installations.

RECIRCULATING REGISTERS

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

FURNACE

The size of furnace should, of course, be such as will provide the necessary air heating capacity, usually expressed in square inches of leader pipe area, and at the same time provide a grate of the proper area to burn the necessary fuel at a reasonable chimney draft. The total leader pipe area required is easily obtained by finding the sum of the leader pipe areas as already designated.

The grate area will depend on several factors of which four are very important. First of all, the air temperature at the register for which the plant has been designed must be determined. Usually, this temperature is taken as 175 deg. fahr. Second in importance is the combustion rate, *which must always correspond with the register air temperature*, as is shown by reference to a set of typical furnace performance curves (Fig. 7) for a cast-iron circular radiator furnace with a 23-in. diameter grate and 50-in. diameter casing. The conditions shown on these curves which seem to approximate nearest to the 175 deg. register warm-air temperature are—combustion rate 7 lb., warm-air register temperature 173 deg., efficiency of the furnace 58.5 per cent. The third factor is efficiency, which, in turn, is a function of the combustion rate varying with it as shown by the efficiency curve of Fig. 7. The fourth factor is the heat value per pound of fuel burned, which was 12,790 B.t.u., but is not shown on the curves since it was constant for all combustion rates.

From the relation existing between these factors it is found (Fig. 7) that the capacity of the furnace under test is 147,750 B.t.u. per hour for the total grate, which gives the capacity at the furnace bonnet per square foot of grate as 51,300 B.t.u. and per square inch of grate as 356 B.t.u. per hour.

Suppose it is desired to select a furnace to deliver air to the rooms at a register temperature approximating 160 deg. rather than 175 deg. Referring to the curves, the relation is—combustion rate 5.5 lb., register warm-air temperature 160 deg. and efficiency of the furnace 62 per cent.

Under this condition the capacity of the furnace at the furnace bonnet per square foot of grate area is 43,300 B.t.u. per hour, and per square inch of grate it is 300 B.t.u. per hour. From these performance values, the grate area for any plant requirement will be, (allowing 20 per cent heat loss between furnace and registers):

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

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

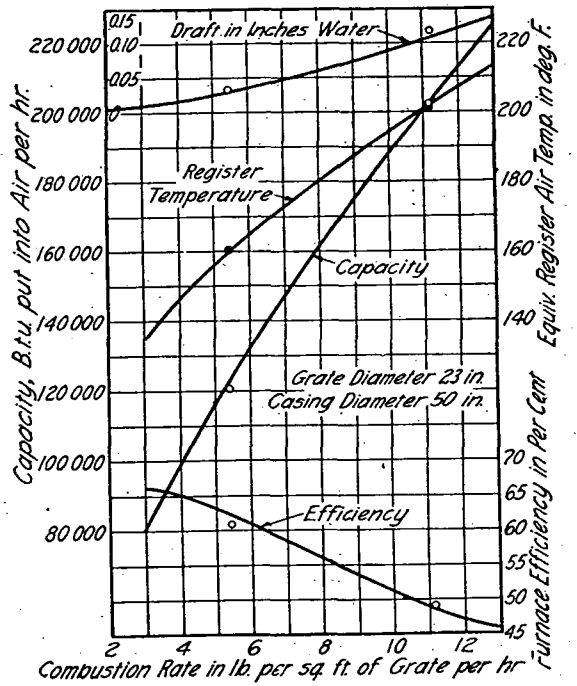

FIG. 7. TYPICAL PERFORMANCE CURVES FOR A WARM AIR FURNACE AND INSTALLATION IN A THREE-STORY TEN LEADER PLANT, OPERATING ON RECIRCULATED AIR

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

*Let H = B.t.u. heat loss from the entire house per hour = summation of all room losses $H_1 + H_2$ + etc. + the B.t.u. necessary to heat the fresh air if any, at intake. This fresh air loss in B.t.u. will be approximately 1.27 times the cubic feet of air admitted through the intake per hour on a zero day. For systems which recirculate all the air this value will be zero. For systems which have a fresh air intake, controlled by damper, this value might well be approximated, since this loss will probably be reduced to a minimum on a zero day. Assume for such cases, that the building loss is increased by 25 per cent, and that there is the usual 20 per cent loss between furnace and registers.

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

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

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

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

The air temperature at the registers corresponding to the conditions covered by equation (10) would be approximately 160 deg. fahr. and for 175 deg. fahr. and 12,000 B.t.u. the combustion rate should be at least 7.5 lb. with an efficiency of about 57 per cent, using curves of Fig. 7 as a guide.

CHIMNEYS

The construction, location, height and area of the chimney to which the warm-air furnace is connected affect the operation of the entire heating system. Most residence chimneys are built of brick and may be either lined or unlined, but in either case the *walls must be air tight* and there should be *only one smoke opening* into the chimney. Cleanout, if provided, must be *absolutely air tight* when closed.

The walls of brick chimneys shall be not less than 3¾ in. thick (width of a standard size brick) and shall be lined with fire-clay flue lining. Fire-clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, and shall be adapted to withstand high temperatures and the action of flue gases. They shall be of standard commercial thickness but not less than ¾ in. All fire-clay flue linings shall meet the standard specification of the *Eastern Clay Products Association.* The flue sections shall be set in special mortar, and shall have the joints struck smooth on the inside. The masonry shall be built around each section of lining as it is placed, and all spaces between masonry and linings shall be completely filled with mortar. No broken flue lining shall be used. Flue linings shall start at least 4 in. below the bottom of smoke-pipe intakes of flues, and shall be continued the entire heights of the flues and project at least 4 in. above chimney top to allow for a 2 in. projection of lining. The wash or splay shall be formed of a rich cement mortar. To improve the draft the wash surface should be concave wherever practical.

Flue lining may be omitted in brick chimneys, provided the walls of the chimneys are not less than 8-in. thick, and that the inner course shall be a refractory clay brick. All brick work shall be laid in spread mortar, with all joints push-filled. Exposed joints both inside and outside shall be struck smooth. No plaster lining shall be permitted.

Chimneys shall extend at least 3 ft. above flat roofs and 2 ft. above the ridges of peak roofs when such flat roofs or peaks are within 30 ft.

of the chimney. The chimney shall be high enough so that the wind from any direction shall not strike the top of the chimney from an angle above the horizontal. The chimney shall be properly capped with stone, terra cotta, concrete, cast-iron, or other approved material; but no such cap or coping shall decrease the flue area.

The size or area of flue lining or of brick flue depends on height of chimney and capacity of heating system. For chimneys not less than 35 ft. in height above grate line, the net internal dimensions of lining should be at least 7 x 11½ in. for a total leader pipe area up to 790 sq. in. Above 790 and up to 1000 sq. in. of leader pipe area the lining should be at least 11¼ x 11¼ in. inside. In case of brick flues not less than 35 ft. in height with no linings, the internal dimensions should be

FIG 8. ELEVATION OF THE WARM AIR RESEARCH RESIDENCE

at least 8 x 12 in. up to 790 sq. in. of leader area, and at least 12 x 12 in. for leader capacities up to 1000 sq. in. Chimneys under 35 ft. in height are often unsatisfactory in operation and hence should be avoided.

TYPICAL EXAMPLE

The application of the preceding data to an actual example may be of assistance to the designer. Figs. 8, 9, 10, 11 and 12,* represent the plans of the Warm Air Research Residence of the *National Warm Air Heating and Ventilating Association* recently erected at the University of Illinois.

Assuming all air recirculated, the minimum furnace for the plant will be:

Grate Area = 0.0034 × 132,370 = 450 sq. in. = 24 in. diam. at 175 deg. register temperature. (7)

Grate Area = 0.0040 × 132,370 = 530 sq. in. = 26 in. diam. at 160 deg. register temperature. (8) (10)

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

If provision shall be made for certain outside air circulation, then increase the building heat loss by, say 25 per cent and obtain by equation (7) a 27-in. grate and by equations (8) and (10) a 29-in. grate.

SUMMARY OF DATA APPLIED TO WARM AIR RESEARCH RESIDENCE

Rooms	From Chapter I on Heat Losses from Buildings B.t.u. Heat Losses *H*	Leader Area Sq. In.	Stack Area Sq. In. 0.7 × *LA*	Leader Diameter Inches	Stack Size Net	Register Size Gross
First Floor		= 0.009*H*				
Living	17250	155	....	14	.....	14 × 18
Dining	6810	61	....	9	.....	8 × 12
Breakfast	2300	21	....	8	.....	8 × 10
Kitchen	9210	83	....	11 or 12	.....	12 × 14
Sun	25710	230	....	Two 12	.....	Two 12 × 14
Hall and stair	12570	113	....	12	.....	12 × 14
Second Floor		= 0.006*H*				
Owners	15030	90	63	11 or 12	5 × 12	12 × 14
S. W. Bed	9800	59	41	9	3½ × 12	8 × 12
Bath	2450	15	10	8	3 × 10	8 × 10
N. Bed	14800	89	62	11 or 12	5 × 12	12 × 14
Third Floor		= 0.005*H*				
E. Bed	8220	41	29	8	3 × 10	8 × 10
W. Bed	8220	41	29	8	3 × 10	8 × 10

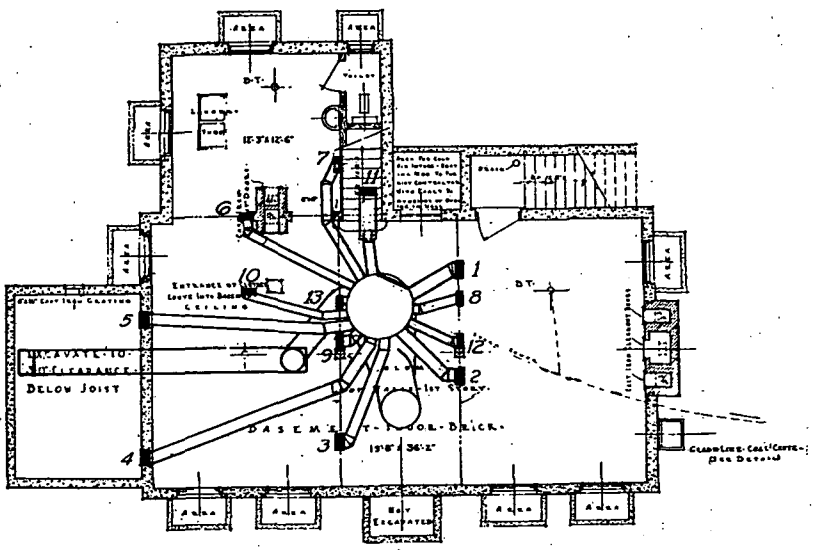

FIG. 9. BASEMENT PLAN

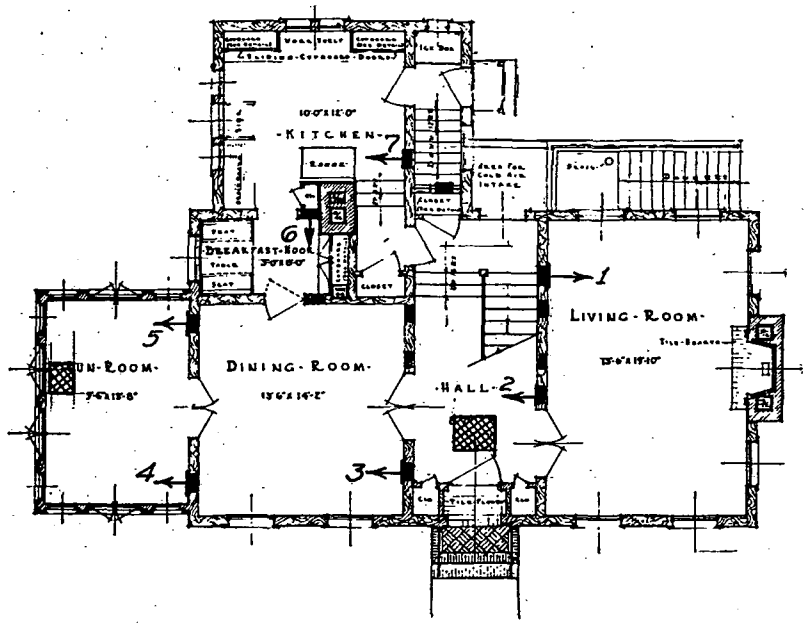

FIG. 10. FIRST FLOOR PLAN

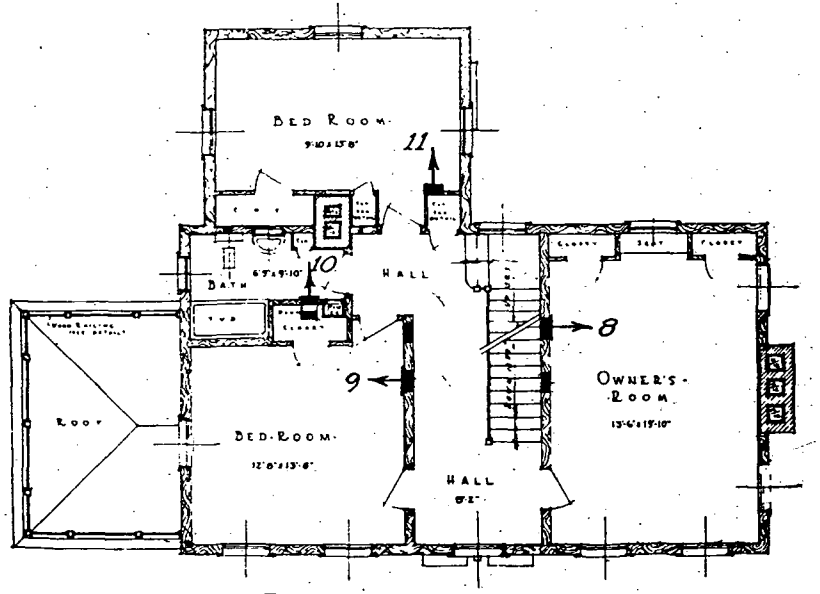

FIG. 11. SECOND FLOOR PLAN

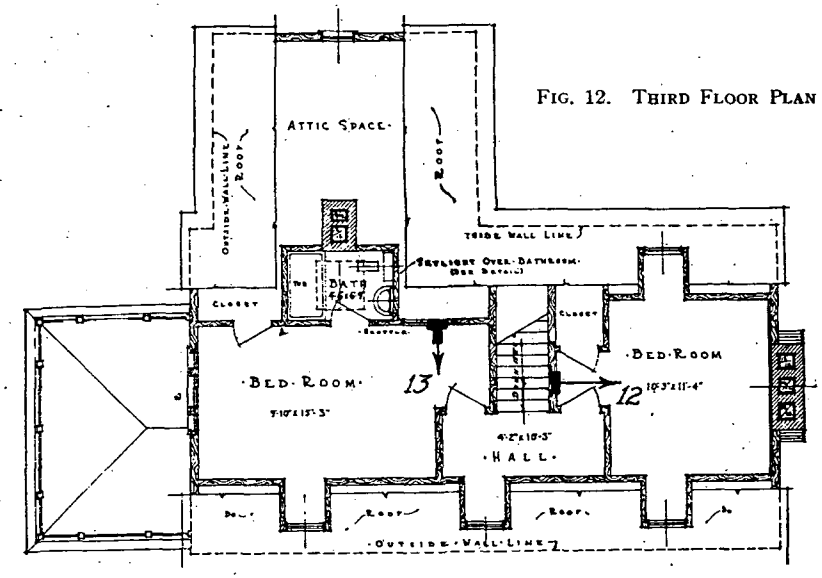

FIG. 12. THIRD FLOOR PLAN

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

FOURTH EDITION
May 1, 1927

*This Code is approved and issued by authority of the *National Warm Air Heating & Ventilating Association*, THE AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, *National Association Sheet Metal Contractors, Western Warm Air Furnace and Supply Association* and *The Midland Club*. First edition, October 1, 1922; 2nd edition, February 1, 1923; 3rd edition, June 1, 1924.

ARTICLE No. 1.—Meaning of the Term "Gravity Warm Air Furnace Heating System"

Gravity Warm Air Heating Systems, to which this code refers, shall consist of one or more warm-air furnaces, enclosed within casings, together with necessary appurtenances thereto, consisting of warm-air pipes and fittings, cold air or recirculating pipes, ducts, boxes and fittings, smoke pipes and fittings, registers, borders, faces and grilles, the same being intended for heating buildings in which they may be installed.

ARTICLE No. 2.—Provisions to be made in Buildings under Construction for Reception of Gravity Warm Air Heating Systems

Section 1. a. The following provisions shall be made by the owner or building contractor, in any building wherein a gravity warm air heating system is to be installed.

b. Where warm-air register boxes, heads, pipes or stacks are to be installed, joists shall be set not less than sixteen inches (16″) on centers and shall be butted and not lapped. Studding shall be set directly over and under joists, leaving a space of not less than fourteen inches (14″) between studs and joists. Wherever joists are cut, headers must be put in to support joists.

c. All first story single or sub-floors shall be continuous. In all houses having studded exterior walls, these floors shall be extended to the outside sheathing and all spaces between studding shall be closed at the attic line.

Note 1.—It is strongly recommended that the attic be tightly floored or ceilings insulated to reduce heat losses.

d. All partition walls (or sections of these walls) in which heat stacks to second or third floor rooms are to be installed, shall be of sufficient size to accommodate stacks required to heat said rooms.

Chimneys

Section 2. a. The owner shall provide a chimney for the furnace constructed in a manner to comply with the following specifications.

b. The chimney must be absolutely smoke tight throughout its entire length, and must extend at least three feet (3') above a flat roof or two feet (2') above the ridges of peak roofs.

c. If built of a single thickness of brick or of cement blocks, it shall be lined throughout its entire length with fire clay flue lining, having not less than three-fourths inch (¾") thickness. Flue lining to be laid in mortar and made air tight.

d. The furnace flue must have no other opening for attaching any fireplace, furnace, stove, range, water heater, gas or ventilating connection.

e. If necessary to offset the flue, it must be done in such a manner as not to reduce the cross sectional area or create a ledge or obstruction, where loose material may lodge.

f. Its narrowest internal dimension shall not be less than eight inches (8") and no flue smaller than 8" x 8" rectangular or eight inch (8") diameter round will be considered suitable when hard coal is to be burned, or 8" x 12" rectangular or ten inch (10") round for soft coal or wood.

g. It is strongly recommended that nothing less than 8" x 12" internal dimensions be used in any case.

Note 2.—It is recommended that the height above the furnace grate be not less than twenty-six feet (26').

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

ARTICLE No. 3.—Method for Determining Sizes of Warm Air Pipes, Wall Stacks and Furnaces for Use in Residences

Method for Determining Sizes of Basement Warm Air Pipes

Section 1. Each First Floor Room.

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

{The sum of:
Glass (sq. ft.) (*Note 4*) ÷ 12
Net Wall (sq. ft.) (*Note 5*) ÷ 60
Cubic Contents ÷ 800
} × 9 = Area of Basement Pipe

Section 2. Each Second Floor Room.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 60,
(See Table A)
Divide cubic contents by 800,
Add together the above and multiply by 6.
The result is the area of the basement pipe.
(See Section 9, *b*)

{The sum of:
Glass (sq. ft.) (*Note 4*) ÷ 12
Net Wall (sq. ft.) (*Note 5*) ÷ 60
Cubic Contents ÷ 800
} × 6 = Area of Basement Pipe

Section 3. Each Third Floor Room.

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

{The sum of:
Glass (sq. ft.) (*Note 4*) ÷ 12
Net Wall (sq. ft.) (*Note 5*) ÷ 60
Cubic Contents ÷ 800
} × 5 = Area of Basement Pipe

Basis of Working Rules for Pipes

a. These formulae are for 70 deg. temperature difference (outside temperature zero, inside temperature 70 deg. fahr.). When temperature difference is more than 70 deg., add 1½ per cent per deg. to final figures. When temperature difference is less than 70 deg., deduct 1½ per cent per deg. room final figures.

b. The values as given in Table A for use in the working rules, Article 3, Section 1, 2 and 3 are derived as follows:

Example.—The factor 60 in Table A, Item No. 1, is based upon a coefficient of heat transmission of 0.23 B.t.u. per square foot per degree difference per hour, thus:

$W \times 0.23 \times 70 \div 111 =$ sq. in. first floor leader to compensate for the heat loss through walls only. In this,

W = net area of exposed wall in sq. ft.
0.23 = coefficient of transmission in B.t.u. per sq. ft. per degree difference per hr.
70 = difference in temperature of air on inside and outside of wall.
111 = heat delivering capacity of 1 sq. in. of first floor leader pipe for a register temperature of 175 deg. fahr.

Reduced to its simplest approximate form this is

$$\frac{W \times 9}{60}$$

Likewise substitute 167 for second floor and 200 for third floor in place of 111.

The values in Table A for the different types of walls were obtained by substitution of proper coefficient of heat transmission instead of 0.23 in the above formula.

TABLE A

(The factor 60 used in Art. 3, Secs 1, 2 and 3 is for buildings constructed as in item No. 1. When other types of walls are used substitute the appropriate factor as given below)

No. 1.—Frame wall constructed of siding, paper, sheathing, studding, lath and plaster	60
No. 2.—Frame wall constructed of siding or stucco direct to sheathing (no paper), lath and plaster	52
No. 3.—9 in. Brick Wall (no plaster)	40
No. 4.—9 in. Brick Wall, plastered one side	48
No. 5.—9 in. Brick Wall, air space, furred and plastered	65
No. 6.—13 in. Brick Wall, no plaster	53
No. 7.—13 in. Brick Wall, plastered one side	57
No. 8.—13 in. Brick Wall, air space, furred and plastered	75
No. 9.—4 in. Brick, 4 in. hollow tile, plastered	55
No. 10.—4 in. Brick, paper, sheathing, studding, lath and plaster (brick veneer)	68
No. 11.—8 in. Hollow tile stucco and plaster	67
No. 12.—8 in. Hollow tile, stucco furred and plastered	90
Roofs	
No. 13.—1 in. T & G. Sheeting, Tar and Gravel	48
No. 14.—1 in. T & G. Sheeting and Composition roof	40
No. 15.—1 in. T & G. Sheeting and Tin	24
No. 16.—Corrugated Iron on strips	9.3
Ceilings	
No. 17.—Lath and plaster without floor above	50
No. 18.—Lath and plaster with tight floor above	90
No. 19.—Metal without floor above	40
No. 20.—Metal with tight floor above	70

Method for Determining Size of Wall Stacks

Section 4. First Floor Rooms.

Same as Section 1.

Section 5. Second Floor Rooms.

Not less than 70 per cent of basement pipe area as determined in Section 2.

Where one stack is used to convey heat to two rooms, its net area shall be determined by adding together the areas of the two single stacks, which would be required to take care of the heat losses for each room where single stacks used.

Section 6. Third Floor Rooms.

Not less than 70 per cent of basement pipe area as determined in Section 3.

Explanatory Notes

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

Note 5.—To obtain net outside wall multiply height by width and deduct the glass in all windows and outside doors. For all rooms with attic spaces immediately above full ceiling areas shall be taken into account, using Table A.

Note 6.—For rooms having unusual exposure, ordinarily north, northeast and northwest, add 15 per cent to pipe area. For east and west exposure, add 10 per cent.

Note 7.—Use no warm-air pipe less than 8 in. in diameter. If a basement warm-air pipe figures greater area than any standard commercial size then the nearest commercial size shall be used, provided however, that the total pipe area shall in no case be less than the total requirements according to Sections 1, 2 and 3.

Note 8.—It is understood in using the above values for determining basement warm-air pipe areas, that these pipes should be run comparatively straight and that they should not be over 10 to 12 ft. in length. Sharp turns and long pipes should have extra capacity.

Note 9.—The value of 800 (used in cubic contents) is for an estimated air change of one room volume per hour. If it is desired to provide for 1½ room volume use the figure 600. If for two room volumes use the figure 400.

Transition Fittings and Stacks

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

b. All first floor fittings and connections, shall maintain a free area equal to the round basement pipes leading to them.

Method for Determining Size of Registers

Section 8. All registers shall have a free area at least equal to the area of the basement pipes leading to them.

Method for Determining Size of Furnace

Section 9. a. Add together the areas (expressed in square inches) necessary for heating the building, as determined by the foregoing calculated requirements, Art. 3, Sec. 1, 2 and 3, and install a furnace, rated by the following formula:

Furnace Rating Formula

$$L = 1.75\,G\,[\,1 + 0.02\,(R - 20)\,]$$

L = square inches of warm-air pipe connected to the furnace as calculated.

G = grate area in square inches; the area of the firepot at the grate level; its most restricted area.

R = ratio of heating surface area to grate area;

1.75 = a constant based upon the results obtained in the Association Research on a furnace having 20 sq. ft. of heating surface for each square foot of grate, and including factors for:

E = efficiency of heater;
C = combustion rate;
F = calorific value of fuel;
0.75 = percentage of heat available at registers;
136 = B.t.u. delivering value of 1 sq. in. of pipe, assuming half of the heat is sent to each floor. This value is based on an operating temperature of 175 deg. fahr. at the register.

The formula allows 1.75 sq. in. of warm-air pipe are for each square inch of grate area, for the furnace having a ratio of heating surface to grate surface of 20 to 1. For furnaces having other ratios of heating surfaces to grate surface, it adds 2 per cent or deducts 2 per cent for each unit above or below a ratio of 20.

Application:

		No. 1 Positive Correction	No. 2 No Correction	No. 3 Negative Correction
Grate area, square inch.	=	346	346	346
Heating surface area, square inch.	=	7540	6920	5665
Ratio heating surface area to grate area	=	21.8 to 1	20.0 to 1	16.4 to 1
$R - 20$	=	1.8	0.0	−3.6
Correction per cent	=	3.6	0.0	−7.2
$1.75\,G$	=	606	606	606
$L = 1.75\,G$ + correction	=	628	606	562

Certified Measurements

Certified measurements on warm-air furnaces together with the name and number of that furnace, will be issued by authority of the *National Warm Air Heating and Ventilating Association*, when, if and as, the grate areas and heating surfaces have been accurately measured and approved by the Research Advisory Committee.

b. In second floor duplex, flats or apartments where separate heating plants are used, add 50 per cent to the total net *calculated* areas as determined in Art. 3, Sec. 5. This represents the required warm-air pipe capacity in square inches of the furnace for the second floor.

ARTICLE No. 4.—Installation—Location of Furnace

Section 1. The location of the furnace shall equalize the length of warm-air runs as far as possible, yet give necessary preference to pipes supplying living rooms, dining rooms and main halls.

Foundation

Section 2. Furnace foundation of brick, cement, or other incombustible material must be provided. Said foundation to extend at least fifteen inches (15″) at rear and sides of furnace casing and at least thirty-six inches (36″) in front of furnace casing. Foundation to be level.

Setting or Assembling of Furnace

Section 3. a. The base ring of the furnace shall be cemented to the foundation, making an air-tight joint. The furnace parts shall be assembled plumb and level, and in a workmanlike manner.

b. All sections and joints shall be properly fitted. Joints requiring cement shall be well filled and all bolts shall be drawn up tightly.

Casings

Section 4. a. Warm air furnaces shall be enclosed in metal casings or walls of brick, tile or concrete.

b. Portable. Sheet metal casings including casing tops shall be made of galvanized sheets, not lighter than 26 U. S. standard gauge. They shall fit the castings and casing rings closely, so as to be dust tight, and shall be securely fastened to the front. The casing shall be lined from the upper casing ring down to a line on a level with the grate.

c. When side collars are used the casing top must be of sufficient height so that the largest warm-air pipe can be taken from side without ovaling. In no case shall a distance less than eight inches (8″) be maintained between the top of any furnace and the top line of the bonnet.

d. Any furnace, the casing top of which shall come within twelve inches (12″) of a combustible floor, ceiling or joist, shall be protected by a metal shield, extending not less than eighteen inches (18″) beyond the casing of said furnace. This shield shall be suspended at least 2 in. below woodwork, allowing free air space between shield and woodwork. No furnace casing or top, coming nearer than six inches (6″) of ceiling or joists shall be allowed in any case.

e. Openings for side casing collars shall be cut into the casing top, so that the tops of all openings are on a level. Casing collars shall be fitted into place with a proper flange, or bead on the outside and drawn up on the inside, making a dust-tight joint. All collars shall be of same size as the warm-air pipes to which they are to be connected.

f. Brick, cement or hollow tile casings shall be constructed as follows: Walls shall be not less than eight inches (8″) in thickness, and shall be constructed air-tight. The least inside dimension of rectangular casings shall be the same as that of the portable casing of a corresponding size of furnace. Walls shall be carried to the same height as the portable walls, allowing not less than eight inches (8″) between the top of the furnace and the bottom of the top cover. After placing the collars for the warm-air pipes, continue the masonry up two inches (2″) above the top of the collars, lay single or tee irons across the furnace top, spaced eight inches (8″), cover these with sheet metal not less than 26 U. S. standard gauge, cover the sheet metal with masonry or sand and run the side walls four inches (4″) above the roof of the furnace. A galvanized iron casing bonnet may be used on a brick set furnace.

Provision shall be made in the walls for a manhole to give ingres to heater.

Warm Air Pipes in Basement

Section 5. a. All warm-air pipes shall be made of bright tin not lighter than IC, or galvanized iron. Side seams shall be locked seams. All joints shall be either double seamed or lapped not less than one and one-quarter inches (1¼″) and such joints shall

be match-beaded, or beaded and soldered, or riveted. All pipes and fittings shall be properly secured to ceiling or joist. No solder or riveted joint is required where round pipe slips over the casing collar or enters boot or box. Any pipe twelve inches (12″) or greater in diameter shall not be made of material lighter than IX tin or No. 26 U. S. standard gauge galvanized iron.

Note 10.—It is recommended that all warm-air pipes in the basement shall have an upward pitch of not less than one inch (1″) per running foot.

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

c. All warm-air pipes in the basement shall be provided with dampers supported on both sides not more than two feet (2′) from the casing.

d. Where warm-air pipes pass through a masonry wall, a metal thimble shall be provided, having a diameter at least 1 in. greater than the pipe, and pipe supported in such a manner that the air space is uniform on all sides.

Wall Stacks

Section 6. a. Single Stacks. All single wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of bright tin or galvanized iron and shall be covered with not less than one thickness of 12 lbs. per one hundred (100 sq. ft.) square feet of asbestos paper. All studding and other woodwork facing said pipe shall be lined with metal and metal lath used in place of wood lath. An air space of not less than five-sixteenths ($\frac{5}{16}$″) of an inch shall be allowed on the two sides nearest the vertical studs. All such pipes shall be braced in a proper manner so as not to obstruct the flow of air but to retain the full capacity throughout. All joints shall be locked and held in place by means of lugs, or straps. No joint shall depend wholly upon solder to make it tight.

b. Double Stacks. All double wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of bright tin, not lighter than IC or galvanized iron and shall be made double, from and including the boot or foot piece in basement to the top of each and every stack and register head on all floors. There shall be continuous uniform air space of not less than five-sixteenths ($\frac{5}{16}$″) of an inch, which must be maintained between the outer and inner walls of all such pipes and fittings of all kinds, styles and descriptions; such pipes, heads, boots and other fittings to be of the styles, or equal to those accepted by the *National Board of Fire Underwriters*.

All stacks and fittings either single or double must be secured firmly in place by lugs or straps attached to the outer walls of stacks and fittings, and no nails shall be driven through these stacks or fittings at any point. No lugs or straps shall be formed by cutting holes in outer walls of stacks or fittings. No wall pipes or fittings shall be used which depend wholly on soldered joints. The various members shall be so made that all joints are locked or soldered and the several members shall be attached to each other with slip joints, which are, for the purpose intended, air tight.

Registers

Section 7. a. When baseboard or wall registers are used, they shall be properly and permanently attached to the stack head in such a manner that will prevent any leakage of air between the head and the register.

b. Floor registers shall be provided either with register borders, or double register boxes of tin or galvanized iron with an air space of not less than five-sixteenths ($\frac{5}{16}$″) of an inch between inner and outer boxes.

c. Registers for warm-air and warm-air pipes shall not be located in outside walls. The warm-air registers in the various rooms shall be located in or near the inside walls in all cases.

d. Any furnace system having not more than two warm-air registers, at least one of the registers shall be without valve or louvers and the pipe thereto shall be without damper.

Air Supply to Furnace

Section 8. a. The air supply to furnace for warm-air heating plants may be taken from outside or from within the building or may be taken partially from outside and partially from within. In no case, however, shall air be supplied to any furnace from any basement or furnace room.

b. The cold air intake or return where air is taken from within the building shall have a net area throughout its entire length of not less than the combined net area of all warm air pipes leading from the furnace. This may be maintained in one or more ducts. No reverse incline or air trap will be allowed in any section thereof.

c. When the cold air supply is taken wholly from the outside of the building the supply duct at its most contracted area must equal or exceed eighty per cent (80%) of the combined area of all warm-air pipes leading from the furnace.

d. Cold air ducts shall be constructed of metal, tile or other incombustible material having smooth inner surface and shall maintain a constant net area throughout their entire length and shall be made dust-tight. Horizontal return ducts shall have at least 10 per cent greater area than vertical connecting pipes. Where a boot or shoe is connected to the casing at the base, the opening shall not extend higher than a line on the level of the grate of the furnace. The width of the shoe shall be of proper measurement to make the area at least equal to that of the round or square pipe to which it is connected.

e. Wherever the space between joists is used to convey cold air over head, the joists and all wooden surfaces between such joists shall be lined with metal and a sheet metal pan constructed to extend not less than two inches (2″) below said joists. The connection from this pan to the boot or shoe shall be made of galvanized iron not lighter than No. 26 U. S. standard gauge, and shall have a transition collar, the top area of which shall be at least 10 per cent greater than the area of the connecting pipe.

f. When it is necessary to set the furnace over a pit and connect up cold air under the basement floor, such pit or cold air trench shall not exceed eighteen inches (18″) in depth below the casing ring and the width of the trench or trenches shall be of proper measurement to make the area at least equal to the pipe to which it is connected. The connection between the cold air pipe or duct and the underground pit shall be made with converse transition joint as described in Article IV, Section 8 (*b*) and (*d*).

g. The cold air face or faces shall be made of wood, or metal, When set in floors the top of same shall be flush with floor. Where cold air face is placed in a seat or side wall (whether furnished by owner, general contractor or furnace contractor) the open work of face must extend to within at least one inch (1″) of the floor line.

The free area of cold air faces shall be at least equal to the free area of the duct or ducts to which they are connected.

Note 11.—The effective area of a vertical cold air face lies within fourteen inches (14″) of the floor line, hence, the capacity of any vertical cold air face shall be determined by multiplying the base line in inches by not to exceed fourteen inches (14″) in height and deducting for the grilles or cross bars.

Smoke Pipes

Section 9. a. The smoke pipe shall be as short and direct as consistent with the location of the furnace. It shall be made of metal not lighter than No. 24 U. S. standard gauge, and not less than the full size of the collar on the furnace throughout its entire length. It must have no opening for attaching any fireplace, stove, range, water heater, gas or ventilating connection. It shall be lock seamed or riveted; all joints shall lap not less than one and one-half inches (1½″) and it shall be rigidly secured. Cast iron smoke pipe may be used.

b. All smoke pipes shall be provided with check dampers, placed on the side of the pipe or at the end of a tree; when cast iron smoke pipe dampers are used they must be placed between the check damper and the furnace and supported on both sides of the pipe.

c. Where the smoke pipe enters the flue, a thimble shall be cemented into the flue and the connections thereto made air-tight. Should any smoke pipe come within eighteen inches (18″) of any combustible material, such combustible material must be covered with asbestos paper and a metal shield so fastened that a two inch air space exists between this shield and the combustible material. This shield shall be no less in size than twice the diameter of the smoke pipe and of sufficient length to cover the combustible material at all points.

d. No smoke pipe shall project through any external wall or window. No furnace connection is to be made to a flue without a cast iron or steel cleanout having first been provided in the flue (not more than eight inches (8″) below the smoke pipe opening). The base of the flue shall be filled up to the bottom of the cleanout, all of which must be made air-tight.

Pipeless or One-Pipe Furnaces

Section 10. a. When but one duplex grating is used for both warm-air and cold air in a so-called pipeless furnace, the area of the cold air intake shall be at least equal to the area of the warm-air outlet of the grating. Art. 4, Sec. 4, relative to casing shall not govern when this type of furnace is installed, but the following specification shall be followed: The inner and outer casing of this type of furnace may be made of either black or galvanized iron not lighter than No. 26 U. S. standard gauge. A uniform air space shall be maintained at all points between the inner and outer casing. In no case shall the top of the heater be allowed closer than twelve inches (12″) to any ceiling or joists above the furnace.

b. Where joists are cut to accommodate this furnace, headers shall be put in and braced.

c. Art. 3 for determining area of warm-air pipe shall not govern in figuring a pipeless furnace.

d. Where one warm-air register face is used and separate face or faces for cold air supply are used, then Art. 4, Secs. 5, 7 and 8 shall apply.

CHAPTER XII

INDUSTRIAL AND DOMESTIC OIL HEATING

INDUSTRIAL OIL BURNING

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

Oil as a fuel is desirable because it is liquid in form, being petroleum in its constituent parts. There is claimed for liquid fuel, the advantages of space for storage, simplicity in location of storage adjacent to boilers and means of transportation from the remote points of storage to boiler, reduction in labor and handling of fuel, the elimination of ash removal, ease of control of furnace temperatures, and the elimination of the expense of banked fires. Each case, however, where the liquid fuel is contemplated will have, of necessity, to stand on its merit. The heating engineer must figure out the operating cost both with coal and with oil, and the user will have to evaluate the extra convenience, after which a decision can be made as to what type of fuel should be used.

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

In the selection of burner equipment and in the determination of storage facilities, it is well to decide what grade of oil is to be used, its Baumè gravity, viscosity, flash point, and cold test, or temperature at which it will cease to be fluid.

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

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

TABLE 1. DATA ON FUEL OILS

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

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

AIR REQUIRED FOR OIL BURNING*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Since the minimum car of oil is 8,000 gal., it is well not to plan any tankage of less than 10,000 gal. capacity, where carload deliveries are possible. Where oil companies maintain reserves of oil, smaller storage can be provided for than in districts where all the oil has to be brought in by car. In this case, there should be enough storage for a reasonable period. One ton of coal is equivalent to approximately 140 gal. of fuel oil.

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

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

DOMESTIC OIL HEATING*

Because of the large number of domestic oil heating units that are available, there is considerable confusion as to the relative merits of each burner. Certainly it is important to look into the construction of the burner as to design, workmanship and materials, but a point that should be kept in mind is that the Architect and Engineer is recommending not

*From data prepared by H. F. Tapp, technologist, *American Oil Burner Association.*

only a burner but an installation. The ability of the man making the installation and adjusting the burner to meet the needs of each application should receive careful consideration when making a choice of oil heating equipment. A further consideration in making a choice is the stability of the manufacturer and dealer.

BURNER TYPES AND CHARACTERISTICS

There are two distinct types of oil burners used for oil heating—the natural draft burner and the mechanical draft burner. Their names indicate the manner in which the air for combustion is obtained.

The natural draft burner requires no motor and usually has no moving parts. The air for combustion is supplied by the pull of the chimney and is, therefore, dependent upon the construction of the latter. This type of burner is often incorrectly referred to as a "gravity" type burner. Gravity indicates the manner in which the fuel is fed to the burner and a gravity system is applicable to either natural draft or mechanical draft burners. This type of burner is more sensitive to changes in the weather, wind currents about the chimney and other factors which cause a variation in the draft intensity than is the mechanical draft burner. This variation in draft can be decreased by a well designed chimney and the use of a draft regulator. A natural draft burner is usually limited to small heating loads and for best operation requires the use of lighter oils. It has in its favor a low first cost, simplicity of design, and requires no power for operation.

The mechanical draft burner is motor driven and the air for combustion is supplied by a fan or blower. Generally where a fan is used it is of sufficient capacity to supply the entire amount of air for combustion when the burner is operating at its maximum capacity. Where a blower, either centrifugal or positive pressure, is used, only a portion of the air required is supplied under pressure, the balance being induced by the injector action of the air from the blower plus the natural draft from the chimney. The air from the blower is usually used to aid in the atomization of the fuel. The fan or blower produces a more constant supply of air under varying draft conditions and therefore maintains a uniformly efficient combustion condition.

A second classification of burners used is with reference to the means employed to prepare the fuel for combustion. The terms are vaporizing and atomizing burners.

In the vaporizing burner the fuel is prepared for combustion by the addition of heat. The heat serves to convert the liquid fuel into a vapor which is mixed with the air for combustion either just before or during the combustion process. Blue flame combustion is sometimes advocated but as a blue flame radiates very little heat it is of no particular advantage in a boiler or furnace that has been designed for coal burning, wherein the major heat transfer is through radiation. By vaporizing the fuel, moving parts can be eliminated and it is easy to control at low combustion rates. However it requires a light fuel for best results and with poor design there is the possibility of carbon trouble due to "cracking" or decomposition of the oil in the vaporizing chamber.

In the atomizing burner the fuel is broken into a fine mist which is mixed with the air for combustion either just before or progressively during the combustion process. The particles are so fine that they are quickly vaporized by the heat of combustion and if properly mixed with sufficient air will burn with a clean hot flame. There are many ways to atomize oil—under pressure through a small orifice, by compressed air or steam, by centrifugal force from the edge of a rapidly rotating cup or disc and numerous other equally effective methods. Any of the methods used will break the oil into very fine particles and when applied with intelligence will give satisfactory results. With the atomizing type of burner cheaper oils may be utilized; they will start readily from a cold condition and can be applied to installations requiring a high fuel consumption.

The perceptible sound incident to the combustion of oil is dependent largely upon the means employed to mix the oil and air and the rate of B.t.u. liberation per unit of combustion volume. It is obvious that this characteristic can be controlled to some degree by the design of the burner and the method of application to the combustion chamber of the boiler. A further controllable factor is the amount of mechanical sound, this will vary with design, mechanical condition and the adjustment of the unit. The transmission of both mechanical and combustion sounds can be governed to some extent by the utilization of some means to absorb vibration.

IGNITION SYSTEMS

In most natural draft burners the oil is lighted manually with a torch through the fire door, although some of them are provided with a gas pilot. Full automatic burners are ignited with either an electric spark from a high tension transformer or from a gas pilot light. This gas pilot, in some designs, burns constantly while in others a combination of the electric and the gas system is used, the spark igniting the gas and the gas flame igniting the oil. The type of ignition system used is dependent to some extent upon the design of the burner and upon the personal opinion of the designer. Several burners are being designed so as to make the means for ignition optional with the purchaser. Where gas is used the application of the burner may be limited to a territory having a gas supply although it can be used with gas supplied in containers. Under average conditions the cost of ignition with gas is slightly greater.

AUTOMATIC BURNER CONTROLS

There are two systems of control instruments. The low voltage (15-20 volts) and the high voltage (110 or 220 volts). Both systems are used with complete satisfaction.

A room thermostat is used to indicate the temperature of the room and to control the operation of the burner so as to maintain the desired temperature between a limiting plus or minus 2 deg. This instrument is mechanically accurate and will function according to the temperature conditions of its location. Therefore, it should be located with care. Most people prefer to have it located in the living room. It should be

on an inside wall about 5 ft. from the floor at the breathing level, protected from abnormal drafts such as stairways, or entrances; it should not be placed near chimney, radiators, registers, hot water or steam pipes or other sources of heat. Special care should be taken to avoid concealed steam or hot water pipes. Another important factor in maintaining a satisfactory uniform heating throughout the house, which cannot be controlled by the thermostat is the matter of installed radiation. It is important that the radiation be carefully proportioned so that when the desired temperature is reached in the room with the thermostat, the same temperature will have been reached in all of the rooms of the house. (See Chapters II and XIV.)

The boiler or furnace control is provided to control the operation of the burner so as to prevent overheating of the boiler or furnace and in the case of a steam boiler to prevent the development of abnormal pressures. A safety control is provided to establish a time limit within which the oil must be ignited every time the burner is started and to shut the burner down if for any reason the ignition does not take place or if there is a cessation of combustion. Nearly all of the burners use standard control instruments which in some cases are modified to meet some peculiarity of the design.

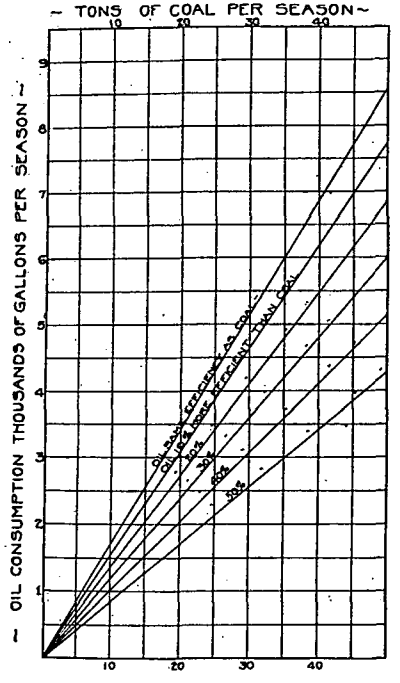

FIG. 1. CONSUMPTION OF OIL AND COAL AT VARIOUS EFFICIENCIES

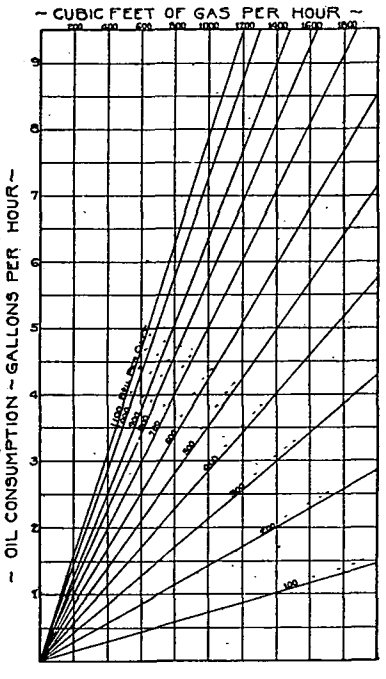

FIG. 2. CONSUMPTION OF OIL AND GAS

The majority of the burners operate on the intermittent system but there are several that operate on a system known as the high-low where the burner is always burning but the flame intensity is varied to meet the temperature variation as indicated by the thermostat. There is considerable discussion among designing engineers as to the relative merits of the two systems but as the high-low may have the edge during the coldest weather the intermittent burner will be more economical during the milder weather so that over the entire heating season the total amount of fuel used will be very nearly the same.

BURNER INSTALLATIONS

Most burners are installed in boilers designed for coal and the results in most cases are entirely satisfactory. Where a boiler is being purchased for use with oil heating equipment care should be taken to select a boiler that has long flue passes that do not short circuit the gases from the combustion chamber to the flue. There are several boilers that have been designed especially for oil burning that are very efficient and economical. All boilers should be provided with automatic feed water regulator as the boiler is often neglected on account of the automatic features eliminating the necessity of a daily inspection.

With many of the cast iron water tube sectional boilers it has been found possible to increase their rating to some extent by using oil heating equipment. This increase amounts to from 10 to 25 per cent, but boiler equipment should not be selected on this basis without the knowledge and approval of the boiler manufacturer. This increase in rating is usually not possible with round boilers. Where round boilers are used with oil heating equipment it is best to select a boiler that is relatively small in diameter with extra heating surface in the form of intermediate sections.

For warm air installations a furnace of welded construction should be selected as it is more suitable for the conditions imposed by oil heating and will require less attention. Cast iron sectional furnaces will give satisfactory results if care is taken to insure tight joints and a careful inspection made each year.

For hot water supply an indirect heater is quite satisfactory with steam or vapor and with suitable controls on the hot water tank can be used the year round at a very reasonable cost. Small size burners are made that are suitable for installing under small hot water heaters and operating automatically from a control on the hot water tank. A coil in the combustion chamber is not generally satisfactory.

Installations should always be made by trained men as every burner has peculiarities that should be given consideration when the installation is made. It is also important that the burner be correctly adjusted for each installation as a greater loss in efficiency often results from poor adjustment rather than from poor design. A burner should have sufficient capacity to develop full rating of the boiler and it is preferable that it have some excess; it should also be adjustable over a range from 50 to 100 per cent rating. The flame adjustment is best determined by a flue gas analysis but a good check can be made by noting the color of the flame. A white flame indicates excess air, a red smoky flame insufficient

air and a orange flame just tipped with red indicates an efficient and clean combustion. The boiler room should be well ventilated so that the burner can obtain a good supply of fresh air at all times.

Burner and tank installation and all electrical work should be installed in accordance with local ordinances. If no local rules are in force the rules recommended by the *National Board of Fire Underwriters* should be followed.

TANK INSTALLATIONS

Inside exposed tanks are permitted where the maximum capacity does not exceed 275 gal. This amount may be fed to the burner by gravity if desired and proper precautions are taken to prevent an abnormal flow

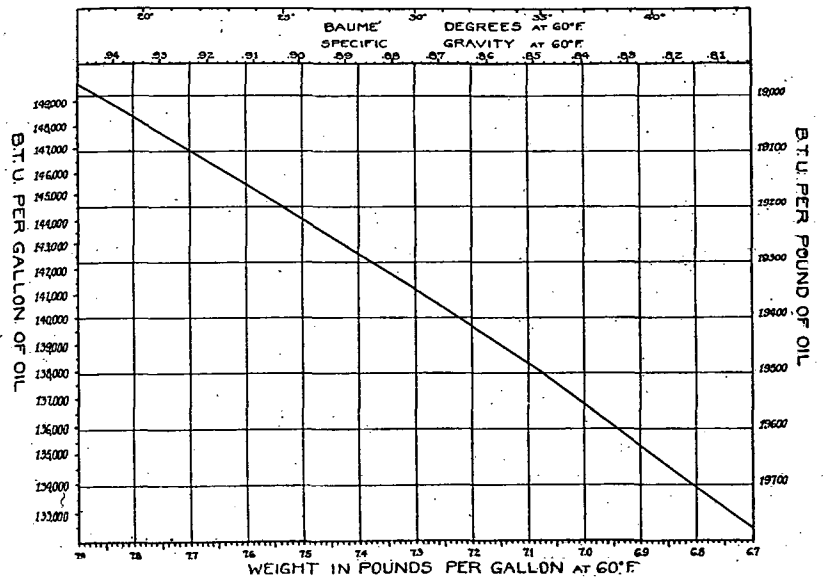

FIG. 3. B.T.U. VALUE OF FUEL OILS

of oil. These tanks should be installed on noncombustible supports and located at least 10 ft. from the boiler. The best installation is with an outside buried tank, of at least 1100 gal. capacity, preferably located below the level of the burner. Where this is impractical some means must be used to prevent syphoning of the oil from the tank in case of a break in the fuel supply line. There are several devices of this nature approved by the Underwriters Laboratory. The use of a large tank eliminates the necessity of watching the fuel supply and will often permit fuel to be purchased at a price enough lower to pay for the difference in installation cost. Tanks should be located so that the fill line is near the drive or curb so as to facilitate delivery from the tank truck.

CHIMNEY DESIGN

Although slightly less draft is required for oil heating equipment than is required for coal fires and a smaller chimney area would be satisfactory it is recommended that the chimney be designed to meet the boiler manufacturers requirements as specified for coal burning. It is preferable to have the oil burner flue isolated from other flues as this may be helpful in preventing any mechanical sound from being transmitted to the rooms of the house. A well designed chimney that will insure uniform draft conditions is just as important to an oil burner as it is to a coal fired heating plant.

DOMESTIC FUELS

There are two grades of oils generally used for oil heating in domestic installations; furnace oil which is about 38 deg. A.P.I. gravity and light domestic fuel oil that is sometimes known as 28–32 deg. A.P.I. gravity. In some localities there are special grades of fuel that may vary as to gravity but their other physical characteristics are quite similar to those of the oils mentioned. These oils do not require preheating for pumping or atomizing.

The amount of oil for a heating season can be estimated from the chart, Fig. 1, if the average coal consumption is known. The chart figures should be corrected if the heat value of the fuels used is different than those upon which the chart is based.

COMPARATIVE COSTS

Comparative cost figures for various fuels depend entirely on the heat content of each fuel and the efficiency with which each is utilized. Charts shown as Fig. 1 and 2 give comparative consumption of oil against a seasons coal requirement and against hourly gas consumption. These figures are based on an oil containing 140,000 B.t.u. per gallon. By refering to Fig. 3 these figures can be corrected for other grades of oil.

CHAPTER XIII

HEATING WITH GAS

HEATING buildings with gaseous fuel brings in no new or peculiar problems so far as the distribution and utilization of the heat are concerned. The only problem peculiar to heating with gas is one of fuel utilization. Gas is a high grade fuel, supplied in a form that makes it easy to handle and control. This ease of control renders great economy and luxury possible, and the appliances in which it is used should therefore be designed and selected to take full advantage of this potential economy and luxury.

The use of gas for building heating purposes has been stimulated within the past year or two by the increasing tendency of manufactured gas companies to grant special rates to users of gas for heating. Realizing that the load is a valuable and desirable one, they are making what are in some cases, quite radical concessions in the way of reduced rates. The most recent tabulation of rates compiled by the *American Gas Association* lists 208 communities in the Continental United States and Canada, in which the corporations supplying manufactured gas quote what they term House Heating Rates. These communities are of a widely diversified character as to size, climate, geographical situation, and industries. They are served by both large and small corporations and by both privately and municipally owned plants. There are no boundaries, of a geographic nature, or of any other nature, to limit the advance of gas as a fuel for heating buildings.

There are many other communities aside from those included in the enumeration above, in which the basic rates for domestic gas supply are sufficiently low to attract a large number of people to use it for heating. In the natural gas territory, the rates, while showing a tendency to increase, are still such that gas is a cheap fuel for any purpose. Natural gas companies have not gone so far in the making of special house heating rates, partly because a special rate is not needed to encourage the use of gas for heating and partly because reduced rates would encourage the waste of a valuable natural resource. The most marked effect of more costly natural gas has been the increasing demand for efficient appliances.

The user of gas for heating is in the very peculiar situation of having the corporation from which he purchases his fuel, display a continued interest in the upkeep and efficient operation of the fuel burning appliance. This is in marked contrast with the situation in which the user of solid or liquid fuel finds himself. A large proportion of the gas burning heating appliances that are installed are marketed through gas companies. The gas company then stands ready to see that the purchaser of the

Material compiled for this chapter by W. E. Stark, Cleveland, O.

appliance enjoys uninterrupted and efficient service from it. It is common practice among gas companies to make periodical inspections of the heating appliances on their lines and some even go so far as to light the pilots when the heating season approaches so that the appliance stands ready to respond to the thermostat's call for heat when cool weather comes.

A notable development of comparatively recent date is the offering of gas burning boilers designed with the object of meeting the requirements peculiar to large scale heating. Compact, automatic in operation, and with large steam releasing area and storage space; these large unit boilers are adaptable to the heating requirements of office buildings, college buildings, and hospitals; as well as to the production of large amounts of low pressure steam for industrial and process work.

TYPES OF GAS HEATING APPLIANCES

Gas burning heating appliances in general use may be classified as follows:

1. Central heating plants:
   - *a.* Steam heating boilers
   - *b.* Water heating boilers
   - *c.* Warm air furnaces
2. Room (or space) heaters:
   - *a.* Radiant heaters (blue flame)
   - *b.* Reflector heaters (luminous flame)
   - *c.* Convection type unit heaters.

CONVERSIONS VERSUS ORIGINAL INSTALLATIONS

(for central heating plants)

During the years when gas heating was limited to those localities where a cheap supply of natural gas was available, practically all installations were what are termed *conversions*. By conversion is meant an appliance designed to burn coal, with gas burners inserted. This practice, however, has not been followed in manufactured gas territory, for certain definite and scientific reasons; and the increasing price of natural gas eventually will bring it to an end in that territory.

No two fuels burn and give off heat in exactly the same manner; and no two fuels differ so widely in this respect as do coal and gas. In coal boilers or furnaces, the path traveled by the hot gases is relatively short. Most of the heat made available by the combustion of coal is given off as radiant energy by the incandescent coke and flame. This radiant energy is absorbed very rapidly by the heating surfaces which are so placed that they can *see* the fuel bed and flame. Very little remains to be absorbed by the heating surfaces that are placed farther on in the boiler or furnace. A coal burning appliance is therefore designed with a large combustion chamber with heat-absorbing walls so placed that they will *see* the heat radiating flame. Close confinement of the products of combustion is not necessary except in the last passes of the appliance.

Gas, on the other hand, burns most satisfactorily and most completely when air is mixed with it previous to ignition. The resultant flame is

blue, as in the familiar Bunsen burner. A blue flame has very little radiating power. The combustion is complete within a few inches of the burner. After combustion is complete, the hot gases must immediately be brought into close contact with the heat-absorbing surfaces and kept in contact with them until the maximum possible amount of heat has been absorbed. A gas burning appliance is therefore designed with a small combustion chamber and with many thin passages for the hot gases to pass through so that they can be brought into intimate contact with the heat absorbing surfaces.

In order for gas to be burned with reasonable economy in an appliance designed for coal, an intricate baffling arrangement must be built up within the combustion chamber so that the products of combustion will be caused to wipe over the walls of the combustion chamber. Even when this is done, the appliance will not generally develop its full rated output with economy because it will not have sufficient indirect heating surface beyond the combustion chamber so arranged that it will break the gas up into the fine streams necessary to insure complete heat absorption. Appliances for gas burning must be so designed that each particle of hot gas is brought very close to a heat absorbing surface. The general practice of gas companies interested in heating is to discourage conversions.

GAS BOILERS

Gas boilers have taken on a well defined form just as coal boilers have. The usual boiler is sectional in construction with a number of independent burners placed beneath the sections. In most boilers each section has its own burner. Some makers fashion their sections so as to give the effect of a horizontal tubular boiler so as to accelerate water circulation. Other makers either do not incorporate the tubular feature in their designs or depend on internal baffling to give the tubular effect. In all cases the sections are placed very close together, much closer than would be possible with any soot forming fuel. Extended heating surfaces, such as lugs, pins, or fins are features of some designs. In all cases, the effort of the designer is to break the hot gas up into thin streams.

Because there is no fuel bed resistance and because the gas company supplies the motive power to draw in the air necessary for combustion (in the form of the initial gas pressure) draft losses through gas boilers are low. A gas boiler will therefore operate with a very slight draft, thus making it possible to operate at very low stack temperatures. Terminal temperature differences as low as 50 deg. are not uncommon.

All gas boiler designers strive to make their product as light as is compatible with strength and to render all heating surfaces easily accessible for cleaning.

INSTALLATION AND CONTROL OF BOILERS

One feature of the piping installation that adds to the satisfactory service rendered by gas boilers is provision for adequate and rapid venting of the air from steam heating systems. It is particularly necessary that the air vent out freely when a gas control that either permits the gas to burn at full rated amount, or shuts it off completely, is used. This

system of control is most economical in gas consumption, but if air leaks into the steam distribution system during the periods that the gas is turned off and then vents out slowly when the thermostat calls for heat, the result will be a further cooling of the premises between the time that the thermostat calls for heat and the time that steam reaches the radiators. The combination of "all on or all off" control with a freely venting steam or vapor system gives maximum gas economy and minimum temperature variation.

Although a gas appliance will operate with a very slight draft, it is none the less necessary that it be connected to an adequate chimney. A chimney so situated that it is subject to momentary down drafts presents no difficulties, but a gas appliance should not be expected to operate against a continuous down draft any more than a coal appliance is expected to. Lack of chimney draft results in stagnation of the gases in the chimney with consequent condensation of the water vapor that is always present in the products of the combustion of gas. Table 1 gives the minimum cross section areas of chimneys (in square inches) for various amounts of heat supplied to the appliance and for various chimney heights.

TABLE 1. CHIMNEY SIZES FOR GAS APPLIANCES

HEIGHT OF CHIMNEY FEET	GAS CONSUMPTION IN THOUSANDS OF B.T.U. PER HOUR								
	75	125	175	300	500	750	1000	1500	2000
10	24.0	35.7	46.6	71.6	107.5	148.5	187.0	259.0	327.0
25	14.8	21.9	28.7	43.8	66.0	91.2	114.6	159.0	200.0
50	13.6	20.2	26.5	40.5	60.9	84.1	105.5	146.1	183.9
70	13.3	19.8	25.8	39.5	59.6	82.2	103.4	143.1	180.5
100	12.9	19.4	25.3	38.8	58.4	80.8	101.4	140.6	176.7

Gas appliances, because of their small heat storage and quick response, are particularly adaptable to thermostatic control and should always be so installed. Any standard thermostatic control system is generally applicable. In addition to provision for operation under thermostatic control, practically all gas boiler manufacturers provide their product with gas pressure regulators, steam pressure regulators, low-water gas cut-off devices on steam boilers, and water temperature controls on water boilers. Thermostatic pilot controls, that shut off the main gas supply in the event of the pilot becoming extinguished, are also quite generally standard equipment.

Gas burning boilers for hot water heating systems present no particular problems in their installation. Like steam boilers they should always be under thermostatic control with a water temperature control to serve as a limiting device.

WARM AIR FURNACES

Gas burning warm air furnaces are obtainable in sizes from those sufficient to heat the largest residence, down to sizes applicable to a single room. The practice of installing a number of separate furnaces to handle individual rooms is peculiar to mild climates, such as Southern

California. Small furnaces, frequently controlled by electrical valves actuated by push-buttons in the room above, are often installed to heat bedrooms and other rooms where heat may be desired for an hour or so each day.

Manufacturers offer gas furnaces made wholly of cast iron or of a combination of cast iron and sheet metal, usually lead coated to resist corrosion. High efficiencies are obtainable with either type. The remarks in a previous paragraph, relative to the great desirability of using an appliance designed for gas when gas is to be the fuel, perhaps apply even more strongly to furnaces than they do to boilers.

Codes for the proportioning of warm air heating plants, such as that formulated by the *National Warm Air Heating and Ventilating Association* (See Chapter X), are equally applicable to gas furnaces and coal furnaces; with the exception of some furnaces which are designed to give a rather low air temperature. In that case the warm air pipes should be liberal in size. Recirculation should always be practiced with gas fired warm air furnaces. It not only aids in heating but is essential to economy.

SPACE HEATERS

In residence heating work, the space heater is most commonly used in the form of a *radiant heater*. Radiant heaters make admirable auxiliary heating appliances to be used during the occasional cool days at the beginning and end of the heating season; when heat is wanted in some particular room for an hour or two. The radiant heater gives off its heat in the form of radiant energy emitted by an incandescent refractory that is heated by a Bunsen flame.

Radiant heaters are frequently installed in places where venting to outdoors is either very poor or totally non-existent. This is a potential source of danger to the occupants of the space heated unless precautions are taken to insure safe operation. The gas should not be turned any higher than is necessary to make the radiants glow two-thirds of the way to the top. Radiants glowing clear to the top indicate the possibility of incomplete combustion. Burners should be kept clean and broken radiants should be promptly replaced.

Radiant heaters, and all other types of space heaters as well, should be flue connected if it is at all possible, and should never be operated in unvented rooms, particularly bedrooms.

Luminous flame reflector heaters diffuse a large part of their heat by virtue of the radiating power of the bright yellow flame. They are usually backed by a polished copper sheet which reflects radiant heat into the room. The flame must never be so long that it strikes any part of the heater.

Convection type heaters are typified by the *gas-fired steam radiator*, the *gas-fired tubular heater* (built in radiator form) and the *floor furnace*. The radiator types of gas-fired heaters provide an economical form of heating apparatus for intermittently heated spaces, such as stores, small churches, and some types of offices and apartments. Since they give off the greater portion of their heat by convection they do not produce a "hot spot" within the room and are therefor capable of being operated under thermostatic control.

These appliances should always be vented, both from the standpoint of safety and also on account of the damage that can be done by the water vapor in the products of combustion being condensed within the room.

Another variety of heater that falls under the preceding head is the *floor furnace*. This is a convection type heater that is hung underneath the floor. It is generally installed with a duplex register having a warm air outlet and a cold air return, so that complete recirculation is secured.

THE COMBUSTION OF GAS

As has been previously mentioned, most gas appliances burn with a blue or Bunsen flame, although some room heaters use a luminous or yellow flame. Bunsen flames and luminous flames differ in the way in which the air necessary for combustion is supplied. Gas requires for complete combustion, air in the proportion of about 1 cu. ft. for each 110 to 120 B.t.u. of gross heat value. If gas is forced directly into the atmosphere through a small hole, the air required for combustion is drawn into the jet and the gas burns with a long yellow flame. As the holes in such burners must be small in order to impart sufficient momentum to the gas jet to draw in enough air for combustion and to keep the flame from being too large to apply easily, the appliances using them cannot burn gas in large quantities. A luminous flame cannot be allowed to touch any cold surface as this will result in incomplete combustion with the formation of soot and carbon monoxide.

Blue flame or Bunsen type burners are provided with an external mixer in which a portion of the air (about 2 cu. ft. per cubic foot of gas) is mixed with the gas previous to ignition. This is called primary air. The flame issuing from the port of the burner has two distinct parts: a pale blue inner cone and a darker cone surrounding it. The heat of the flame issuing from the burner port draws currents of air past the flame and into it in sufficient quantity to cause complete combustion. This is known as secondary air. The flame should sit squarely on the port and should not have a yellow tip. A yellow tip indicates insufficient primary air, and is corrected by opening the adjustable air shutter.

It should be noted here that the proportions of the orifice at the entrance to the burner tube, and the proportions of the burner ports must suit the heat content of the gas being burned. A burner proportioned for natural gas is not suitable for water gas or coal gas, which are much bulkier in relation to their heat contents.

Table 2 shows the heat values of a cubic foot of gas and air mixture, the gas being mixed with the amount of air theoretically required to burn it. In practice excess air must be admitted to the fire in order to insure complete combustion.

TABLE 2. VOLUME OF AIR REQUIRED FOR COMBUSTION OF DIFFERENT GASES

GAS	B.T.U. PER CUBIC FOOT	CU. FT. AIR TO BURN CU. FT. GAS	B.T.U. PER CU. FT. OF MIXTURE
Natural Gas	1131	10.70	96.8
Coke Oven Gas	490	4.18	94.5
Mixed Coke Oven and Water Gas	525	4.05	104.0
Producer Gas	140	1.13	65.6

It will be noted that for any gas which is low in nitrogen (typified by natural, coke oven, and water gas) the heat content per cubic foot of air and gas mixture has no relation to the initial heat value of the gas. For gases high in nitrogen, such as producer and blast furnace gas, the heat value per cubic foot of mixture is much lower.

HEAT VALUE AND EFFICIENCY

A gas may be said to have two heat values; a gross or higher heat value and a net or lower heat value. The higher heat value is the entire heat that is liberated by the gas when it is burned completely. The complete combustion of a gas results in the formation of water vapor; the amount depending on the proportion of hydrogen or hydrocarbons in the gas. In order to utilize completely all of the heat of combustion of the gas it would be necessary to condense the water vapor in the products of combustion; thus reclaiming its latent heat of vaporization, and then to cool down the water to the starting temperature.

To condense any of the water vapor in the products of combustion it is necessary to cool them down to the dewpoint, which will always be below 212 deg. This is what is done in a calorimeter, but it is obviously impossible to do it in any commercial gas-burning appliance. Since it is not possible to utilize all of the heat liberated by the gas in burning, the heat value is sometimes expressed in terms of the lower value; obtained by deducting from the higher value, the total heat of the water vapor down to the starting temperature. The lower heat value is always about 10 per cent less than the higher heat value.

Although it is practically impossible to utilize the higher heat value in any house heating appliance, it is nevertheless customary to express boiler and furnace efficiencies in terms of this higher value. This gives a lower efficiency than one calculated from the lower heat value and is of course based on an unattainable standard, but it is a more accurate and consistent way of expressing efficiencies. An appliance may reclaim a little bit of the latent heat of the water vapor. If the test efficiency of such an appliance is calculated from the lower heat value, one is placed in the position of crediting the appliance with some heat that was not charged against it. Although quoted efficiencies are usually based on the higher heat value, care should always be taken to understand which standard guaranteed efficiencies are based on.

For example.—Take an hypothetical gas having a gross heat value of 550 B.t.u. per cu. ft. and a net heat value of 500 B.t.u. per cu. ft., burned in a steam boiler giving an evaporation of 465 lb. of water (from and at 212 deg.) per 1000 cu. ft. of gas burned:

$$\text{Efficiency} = \frac{\text{B.t.u. in steam}}{\text{B.t.u. in gas}} \times 100 = \frac{465 \times 970.4}{\text{cu. ft.} \times \text{heat value}} \times 100$$

$$\text{With Gross Value Efficiency} = \frac{451{,}235}{550{,}000} \times 100 = 82.04 \text{ per cent}$$

$$\text{With Net Value Efficiency} = \frac{451{,}235}{500{,}000} \times 100 = 90.25 \text{ per cent}$$

It will be noted from the example cited that when the efficiency is based on the net or lower heat value, the appliance apparently absorbs 8.21 per cent more of the heat supplied to it than when the efficiency is based on the gross heat value.

Table 3 following, shows the maximum possible efficiencies obtainable when burning a typical manufactured gas with various stack temperatures. These are based on the gross heat value and do not include any correction for radiation from the boiler covering. Radiation would reduce these efficiencies from 2 to 10 per cent depending on the insulating properties of the covering. The gas is assumed to be burned with 35 per cent excess air and has the following composition:

CO_2	8.6 per cent	
H_2	52.5 " "	
CH_4	31.6 " "	
C_2H_4	1.1 " "	Heat value per cubic foot at 60 deg. fahr.
C_6H_6	1.1 " "	and 30 in. hg., 535 B.t.u.
O_2	0.1 " "	Specific gravity 0.58 (air = 1)
CO_2	1.5 " "	Air Temperature 60 deg. fahr.
N_2	3.5 " "	Atmospheric moisture neglected.
	100.0	

TABLE 3. PRODUCTS OF COMBUSTION AND THEORETICAL EFFICIENCIES WITH A TYPICAL MANUFACTURED GAS

Stack Temperature (deg. fahr.)	250	275	300	350
Heat in Dry Flue Gas above 60 deg. (%)	3.57	4.05	4.52	5.48
Heat in Water Vapor above 60 deg. (%)	9.13	9.22	9.30	9.47
Heat absorbed by boiler, or efficiency (%)	87.30	86.73	86.18	85.05
	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 11.18% O_2 5.63% N_2 83.19%

RATINGS

Since a gas appliance has a heat generating capacity that can be predicted accurately to within 1 or 2 per cent, and since this capacity is not affected by such things as chimney draft, condition of fuel bed, and soot accumulation; makers of these appliances have an opportunity to rate their product in exact terms. Consequently, practically all makers give their product an *hourly B.t.u.* rating. This is the amount of heat that is available at the outlet of a boiler in the form of steam or hot water; or at the bonnet of a furnace in the form of warm air. To use this rating it is only necessary to increase the calculated heat loss by an appropriate amount for starting and piping loads and select the boiler or furnace with the proper B.t.u. rating.

The *hourly B.t.u* rating divided by 240 for steam and by 150 for water, gives what is called the *A. G. A.* (*American Gas Association*) rating. It is used in the selection of a boiler just exactly as the *hourly B.t.u.* rating is used.

In addition to *hourly B.t.u.* and *A. G. A.* ratings, some manufacturers also list *nominal* ratings. These are comparable with the nominal 8 hr. ratings of coal boilers and are intended to be used in the same manner.

Furnace manufacturers also rate their product in terms of the square inches of leader area that they can handle, a form of rating that fits in very nicely with the *National Warm Air Heating and Ventilating Association's* Code for calculating leader sizes. (See Chapter X.)

Gas boilers are available with B.t.u. ratings up to more than 2,000,000 B.t.u. per hour, while furnaces with ratings up to about 250,000 B.t.u. per hour are available.

HEATING COSTS

It is a fact, based upon observation, that the user of a gas-fired central heating appliance uses more heat during the course of a year than he does when depending upon solid fuel. The extreme ease of starting and operating a gas burning appliance leads to the pilot light being lighted on the first cool day of the season. Thereafter, the system generally operates entirely under thermostatic control and is left in operation on many days when very little heat is required to keep the inside temperature at 70 to 72 deg.; days when it would be impracticable to keep a coal fire going. On many cold days, the gas unit is kept operating continuously at maximum capacity so that the premises are never permitted to cool below the temperature ordinarily maintained. A great deal of data is available covering the fuel requirements of steam and hot water heating systems. Not so much seems to be available on warm-air furnace systems.

A study of local climatic conditions is essential in considering gas heating systems for it affects both the design and the size of the equipment as well as the gas consumption. House heating requires gas practically in inverse proportion to the temperature so that on the coldest day there will be greatest use of fuel. The wind velocity and the amount of sunshine are also factors affecting the amount of gas required also whether the house owner wants a constant temperature day and night or desires to have 70 in the day time and 60 at night.

In making an estimate of the gas that will be consumed by a gas-fired boiler during the average heating season, two variables must be taken into account. The first is the size of the heating system, usually expressed in terms of square feet of direct cast-iron radiation. The other one is the duration and intensity of the heating season. This is easiest expressed in terms of "degree-days," a unit adopted by the *American Gas Association*. The term "degree-day" means one day of time and 1 deg. of temperature. It has been found that below a mean daily temperature of 65 deg. fahr. people require heat. Therefore each locality has a certain number of degree-days which represents the heating season for that place. Studies of the *American Gas Association* have established the number of "degree-days" for over 300 cities in the United States and Canada and it is easy to calculate the heating demands of a particular city. Gas consumption then will be proportional to the number of degree-days. A very complete chart giving the characteristics of the heating season for all parts of the entire Continental United States was published by the *Heating and Ventilating Magazine* in 1925. Table 4, gives values of degree-days for several representative cities:

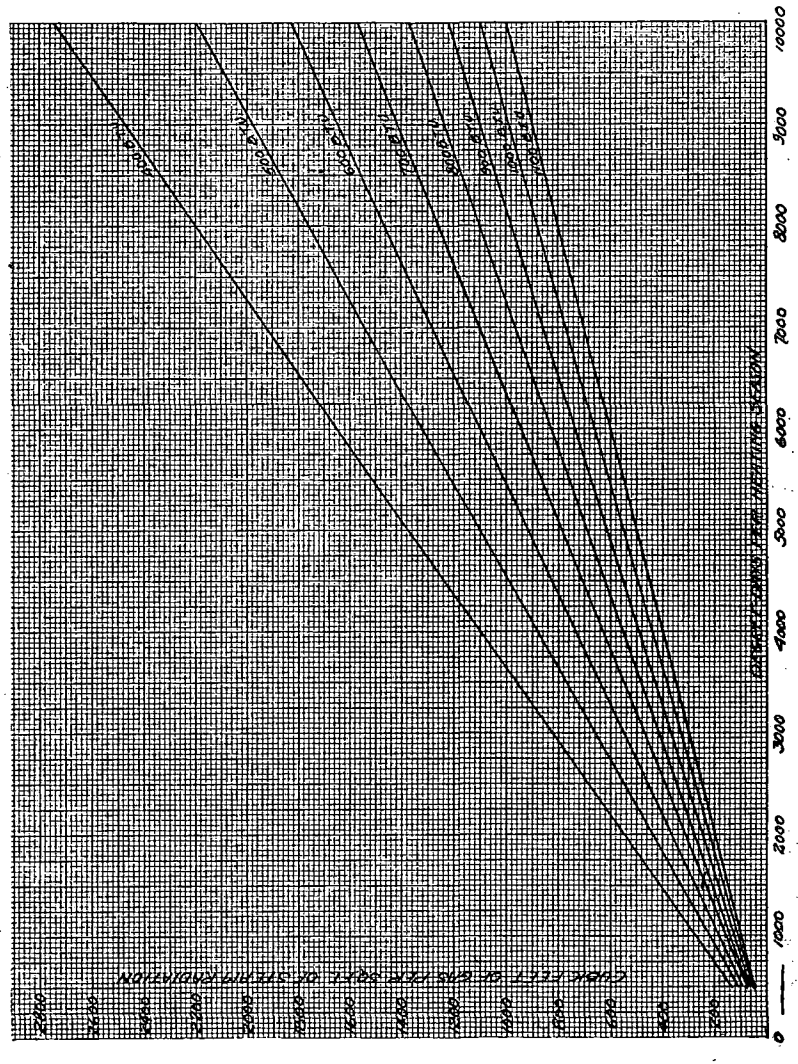

FIG. 1. GAS CONSUMPTION PER SQUARE FOOT OF STEAM RADIATION

By averaging the records of a large number of gas-boiler installations, the following equations have been derived:

$$\text{For Steam } G = \frac{110 \times R \times D}{H} \qquad \text{For Water } G = \frac{64 \times R \times D}{H}$$

where G = cubic feet of gas per season
R = square feet of direct cast-iron radiation (as calculated)
D = degree-days per season
H = B.t.u. (gross) per cubic foot of gas

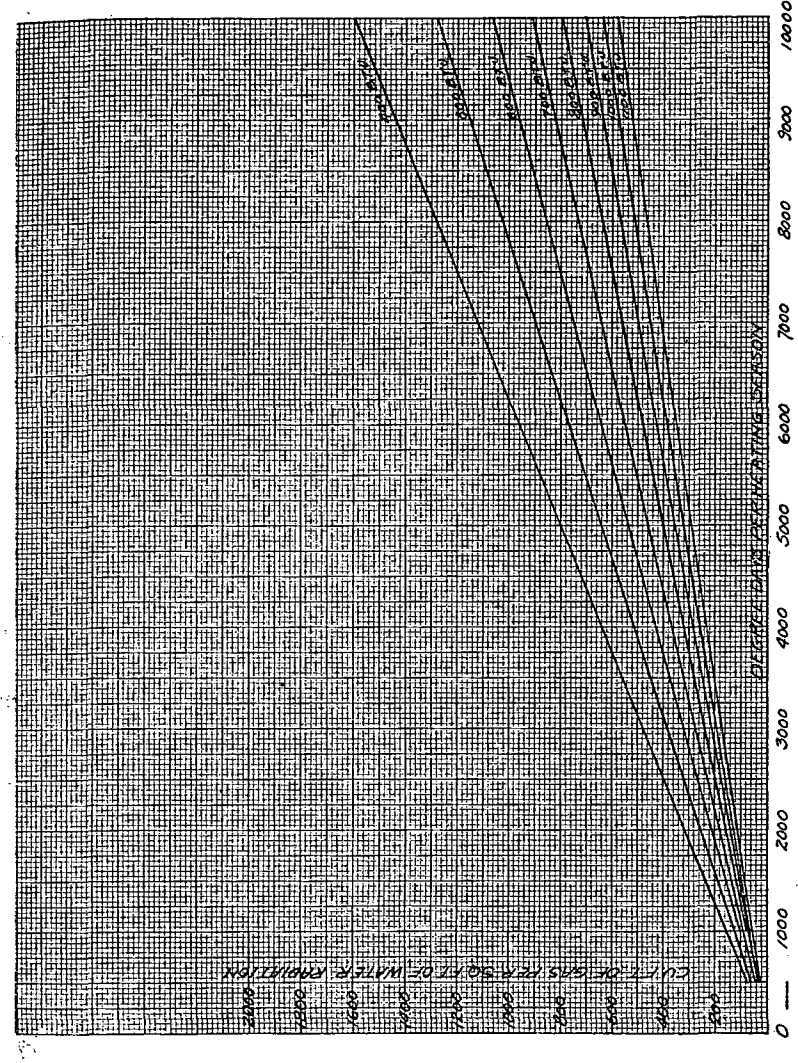

FIG. 2. GAS CONSUMPTION PER SQUARE FOOT OF HOT WATER RADIATION

Example.—To estimate the gas consumption for the average heating season for a 200 sq. ft. steam heating system in Chicago.

From Table 4 it is found that the average heating season in Chicago has 6007 degree-days. The gross heat value of the gas supplied to that city is 535 B.t.u. per cu. ft. Substituting in the equation:

$$G = \frac{110 \times 200 \times 6007}{535} = 247{,}017 \text{ cu. ft.}$$

TABLE 4. DURATION OF HEATING SEASON

CITY	DEGREE—DAYS FOR HEATING SEASON	CITY	DEGREE—DAYS FOR HEATING SEASON	CITY	DEGREE—DAYS FOR HEATING SEASON
Atlanta	2880	Denver	5880	Pittsburgh	5327
Boston	6055	Detroit	6202	San Francisco	3450
Buffalo	6750	Jacksonville	1080	St. Louis	4583
Cincinnati	5302	Kansas City	5302	Philadelphia	4950
Cleveland	6096	Minneapolis	7953	Seattle	5156
Chicago	6007	New York	5303	Washington	4562
Dallas	2455	Oklahoma City	3827		

Observe in the equation that the calculated theoretical amount of radiation is to be used. By this is meant the actual amount of radiation that is required, as determined by accepted methods of heat loss calculations. Over-radiation will not materially affect the gas consumption while under-radiation will merely reflect itself in inability to heat in extremely cold weather. The amount of gas consumed for heating a building during any given heating season may vary decidedly from an estimate made according to the method outlined above but the variation will be in almost direct proportion to the difference between the actual degree-days for the season in question and the average degree-days as shown in Table 4.

The charts Figs. 1 and 2 graphically represent the number of cubic feet of gas per square foot of radiation for the heating season in any climate, the climate being expressed in degree-days and applicable to any heating condition in the United States.

Gas consumption will also vary according to the use to which the building is to be put. Factories and stores, usually maintained at a lower temperature than residences, will not require heat for as many hours during the season as a residence will, although the rate of heat consumption per square foot of radiation will be greater, due to the lower temperature maintained.

Observation of a large number of installations seems to indicate that the cost of heating with a warm-air furnace is about 10 per cent less than the cost of heating with steam. Estimates on warm-air heating may therefore be made exactly the same as for steam; by calculating the heat loss, reducing it to equivalent direct steam radiation by dividing the heat loss in B.t.u. per hour by 240; and calculating as above with the 10 per cent correction for increased economy introduced into the calculation.

Figs. 1 and 2 adapted from a similar chart in the House Heating Manual of the *American Gas Association*, give the two previous equations in graphical form.

CROSS-CONNECTING COAL AND GAS BOILERS

Quite frequently, when a customer already has a coal boiler in his home, it is desirable to leave the coal boiler in place, and to cross-connect the gas boiler with it. For very small gas companies or any others where there is any possible chance of a shortage or failure of gas, it would seem to be good practice to encourage cross-connecting as the

customer would realize very little for a second-hand coal boiler, and it is worth more to him as a safeguard against failure of his gas system than he would realize by selling it. It also produces a more secure feeling in the customer's mind when putting in gas-fired house-heating equipment, if he knows that he can burn coal at any time he has occasion to.

In hot water heating systems, it is necessary to valve off the return pipes on the coal boiler, which prevents circulation through the latter when the gas boiler is in use. Since the gas boiler holds comparatively little water and is almost always insulated, no valves are needed on the return pipes to the gas boiler. Hence, by opening the valves on the coal boiler, it may be operated independently or in conjunction with the gas boiler.

For steam or vapor installation, it is necessary to valve off all of the returns and flows on each boiler unless the gas boiler is set so that the water line in both boilers is at the same level, in which case it is necessary to valve off only the coal boiler to prevent the heating of the water in the coal boiler when it is not in use.

The gas boiler should be set as close to the coal boiler as practicable, and the flows and returns should cut into the flows and returns of the coal boiler as near to the latter as possible.

HEATING INDUSTRIAL BUILDINGS WITH GAS

As has been mentioned previously, great advances have been made within the past year or two toward extending the field of gas heating from the residence class of building into the class of larger buildings, such as factories and office buildings; and new apparatus has been developed with this end in view. Office and store buildings in large cities, where coal and ashes can be handled only by truck and where cleanliness is of some value, can often be heated with gas to the profit and satisfaction of the occupants. The same thing is true of institutional heating. Several large factory installations, where gas boilers are used to supply steam to indirect heaters of the unit type, are now in use. A number of smaller industrial buildings are being successfully heated with gas-fired warm-air furnaces, provided with fans for air distribution. This type of heating plant is particularly applicable to garages because the entire heating plant takes up very little space (it may even be put on the roof) requires no attention, and aids in ventilation.

INSULATION

For reasonable economy with gas heating, heat losses should be reduced in every possible way and adequate provision should be made wherever possible for cutting down losses from infiltration and transmission through walls and roofs as well as reduction of losses from mains and risers. Summarizing the advantages of building wall insulation in its relation to gas fuel it has been said that through the use of insulation it is possible even at the present rates for gas heating to cut the fuel cost down to a figure comparable to the present cost for coal operation. It is also true that a house owner can use insulation to equal advantage with

other fuels but with a certain sum provided for heating, it is likely that the owner will choose the system that is best adapted to his requirements.

Structures of the ordinary constructions may be perfectly tight against the entrance of rain or snow but they may lose heat at a surprising rate and this results in a correspondingly high fuel bill. Cost of operation is the most important factor in the home owners mind. The distribution of cold weather during the winter months is quite variable and sometimes the owner of a gas heating system is alarmed by what appear to be excessive bills for gas consumption. For example during the average winter in New York, generally will require 20 per cent of the total quantity of gas used for heating during the year while Galveston, Texas, will consume 34.3 per cent during the same month and Bismarck, N.D., will use 18.8 per cent during the same period.

To obtain economical operation of gas-fired heating plants, it is essential to have an appropriately proportioned installation to guard against over or under-heating, faulty thermostats and to have proper chimney proportions.

CHAPTER XIV

AUTOMATIC HEAT CONTROL

TEMPERATURE regulation is a vital function in the human body. Everyone carries about with him remarkably effective automatic heat control equipment. In the best functioning of many social and commercial services, automatic temperature regulation is proved to be necessary, not only to comfort and health, but also to the prevention of waste and to the perfection of manufacturing processes.

Temperature control is usually achieved by preventing over-heating. It follows that *automatic heat control* is a better term than automatic temperature regulation, and it is obvious that automatic heat control in itself must always effect economy.

Overheating is much more common than underheating, and the results of overheating are more harmful to health and efficiency.

All heating equipment must be sufficient in capacity to render acceptable service under the most arduous conditions. The most arduous conditions, especially as to extreme cold outside, are in effect only a small part of the heating season. It may surprise many people to realize that in Chicago, for instance, the most extreme cold prevails only on about six days per year.

During the balance of the heating season the heating apparatus must be operated at much less than full capacity—generally in colder climates at about 40 per cent of the maximum.

Hence there is ample ability and strong probability for overheating during the major part of each heating season unless automatic control of the heating apparatus is provided.

Ventilating systems without automatic heat control give trouble from drafts.

Rooms heated by radiators can be cooled more quickly by opening windows than by shutting radiator valves, so that it is found that great heat waste occurs through open windows and open radiator valves, unless automatic heat control is furnished.

Gas and oil heaters and similar devices using quickly responsive fuels become prohibitively expensive for fuel unless automatic heat control is used.

Service hot water heaters must have automatic heat control, not only for economy and satisfaction, but also to prevent scalding the bodies of users.

Automatic heat control is responsible for a goodly share in the increase in efficiency of modern manufacturing processes, especially in saving of

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Compiled especially for THE GUIDE by Samuel R. Lewis, consulting engineer, Chicago, Ill.

time. It has made possible the drying of lumber in months, where it formerly took years.

In the manufacture of prepared foods automatic heat control has shortened the time and has made the processes exact, saving much spoilage formerly wasted.

The introduction of automatic heat control in manufacturing plants almost always releases labor which would otherwise be kept occupied manipulating valves and dampers.

The installation of automatic heat control is a justifiable investment for many heating systems, inasmuch as it very positively contributes to:

1. Conservation of fuel.
2. Improvement in health.
3. Increase in comfort and efficiency.

Automatic heat control is a desirable addition to or rather a fundamental part of the heating and ventilating apparatus in:

1. All public buildings such as schools, theatres, etc.
2. All residences, particularly those using oil or gas fuel.
3. All offices, especially those having many employees.

Automatic heat control is vitally necessary in order to operate satisfactorily and economically:

1. All manufacturing processes in which heat is employed, and where varying temperatures affect the quality of the manufactured product.
2. All refrigerating systems, especially the ultramodern small automatic unit type.
3. All service hot water heating systems.

Thermostats

Thermostats are very simple mechanisms. Almost every physical thing expands or changes under the influence of heat and so can be made into a more or less effective thermostat. Liquids can be compounded which will become gases at any reasonable temperature desired. Metals having different rates of expansion can be harnessed together so as to give a greatly increased thermostatic movement. Common air is an excellent thermostatic medium, and is used extensively.

There are two general divisions into which devices for automatic heat control may be grouped, as follows:

1. The simpler class includes the type in which the thermostats and the valves and dampers which they operate are self-contained without any outside power, gaining sufficient energy from the thermostat itself (Fig. 1). This class of apparatus is especially adapted to single installations, as for service hot-water heaters, residence heating, and the like. It is suggested that this kind of thermostat be called the unit type. In present commercial practice most unit type thermostats use the expansive power of a liquid or gas, contained in a hermetically sealed receptacle.

2. The other and more elaborate class of thermostat, Fig. 2, includes the type of thermostat which controls air or liquid or electricity already under pressure, and which by controlling this outside power, operates the dampers or valves against springs or weights and similar opposition which will reverse conditions when the outside power is shut-off. There is practically no limit to the power which can be applied in this manner.

It is suggested that this kind of thermostat be called the pilot type. In present commercial practice, pilot type thermostats are used for large buildings, where many

thermostats are required, usually with air at about 15 lb. pressure, from an electric or steam compressor.

Compressed air is a very reliable agent, capable of great flexibility and elaboration of control, and is of considerable corollary use for remote operation manually of distant dampers and valves. Pilot type thermostats often are used to operate electric switches, the current then passing to electric motors or to magnets which move the dampers and valves. Electricity is so flexible and adaptable that very complicated and elaborate interlocked functions are possible.

Pilot type thermostats are also used to operate valves on pipes from water supply mains, thus using hydraulic power for moving valves and

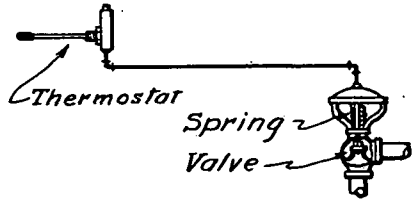

FIG. 1. EXAMPLE OF UNIT TYPE THERMOSTAT

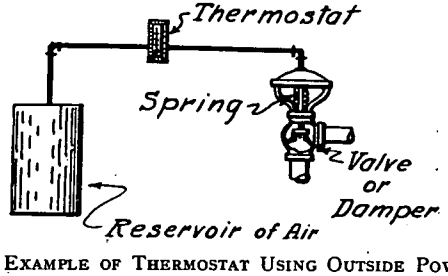

FIG. 2. EXAMPLE OF THERMOSTAT USING OUTSIDE POWER

Note.—The expansive material in the thermostat acts directly on the diaphragm of the valve, against the spring, which opens the valve when the thermostat contracts.

dampers. Owing to silting up of pipes which have sluggish currents and to corrosion, this method is not always to be advised.

APPLICATIONS OF AUTOMATIC HEAT CONTROL

New uses and styles are developed almost daily. Some of the applications will be listed which are believed to be approved methods of installation.

Tempering Heaters

The tempering heaters, particularly if they are of copper with extended surfaces, and if there is a two-pipe vacuum system of steam circulation having a vacuum pump, should be arranged with a separate outer layer of radiation capable of heating the air from the coldest temperature likely

to be encountered to a temperature above freezing. This outer layer should be controlled by a thermostat on the cold side set to shut off steam when the outside temperature gets warmer than around 34 deg., and set to keep steam turned on when the outside temperature becomes cooler than 34 deg. There should be an additional layer of tempering heater, controlled by an additional thermostat in the duct beyond the fan discharge after mixing of the strata of air shall have been accomplished by the fan. This thermostat should be set to control the temperature at the desired degree for cooling the building, such as will give an average temperature at the delivery opening of say 65 deg., or if this causes drafts, at a slightly higher temperature.

If there is no vacuum system of steam circulation, it is decidedly likely that any attempt to control the temperature by opening and closing

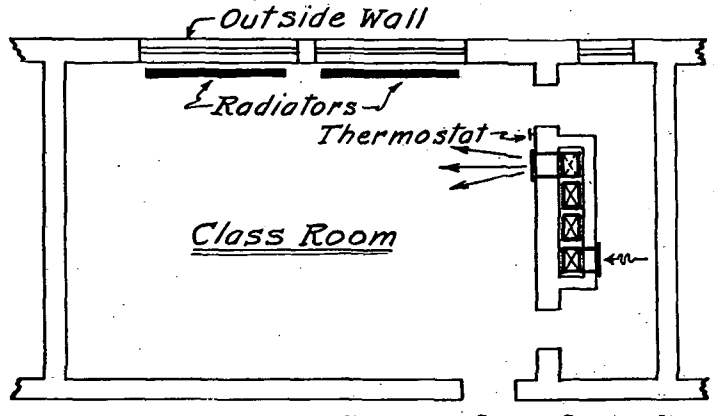

FIG. 3. PLAN OF CLASS-ROOM IN AN ELEMENTARY SCHOOL, SHOWING LOCATION OF THERMOSTAT

steam and return valves will result unfavorably, due to freezing of the radiation and sudden temperature fluctuations in the rooms, as tempering heaters are immediately responsive and flash hot or freeze solid with great rapidity. Where no vacuum system is available it will be wiser to control the tempering heaters by means of dampers, preferably of the interlocked double type operating in a slow or intermediate manner and reducing positively the air volume through the heaters as they increase the air volume through the by-pass around the heaters. Under this condition no diaphragm valves will be placed on the tempering heater supply and return connections.

Air Washers

The air washer should invariably be placed between an outer tempering heater capable of warming the air above a freezing temperature, preferably controlled by an outside thermostat, and an inner tempering heater capable of warming the conditioned air to the desired delivery temperature and controlled by a thermostat in the duct on the discharge side of the fan. It is never advisable to use a by-pass damper around a

tempering heater in front of an air washer, since the cold air might cause freezing.

Control of humidity is possible by adjustment of the temperature of the air as it meets the water, and in greater refinement, by control with an additional thermostat, of the water temperature, cooler for lower relative humidity, possibly from a refrigerated supply; and warmer for a higher relative humidity, possibly from a heated supply.

Room Temperatures

The room temperatures are controlled by individual thermostats, operating valves on the radiators, and mixing dampers in the flues, as

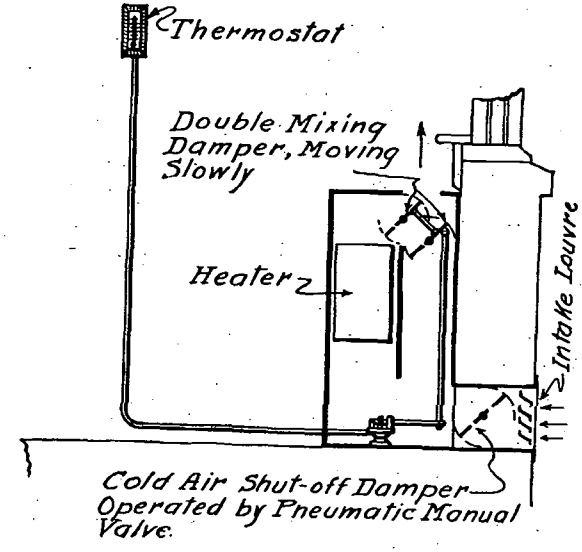

FIG. 4. DIAGRAM OF A METHOD OF CONTROL FOR A UNIT VENTILATOR

may be necessary. If a vacuum system of steam circulation is installed, the room thermostats should be intermediate or slow moving, while if steam circulation is by single-pipe or any kind of gravity system, the radiator valves should be operated quickly from full open to full closed. It is important that the mixing dampers in any case shall be moved slowly and held in intermediate positions.

If there is any room which has a separate supply fan and heating equipment, such as an auditorium or gymnasium heated by warm air and without radiation, as is often convenient and desirable, it is advisable to provide against cold drafts by a variation in the above arrangement, as follows:

Suppose that there is a fan drawing through a heater composed of five layers, and delivering air directly to an auditorium, or to a picture theatre. The thermostat in the room ordinarily will strive to keep the room cool. If there are many occupants and many

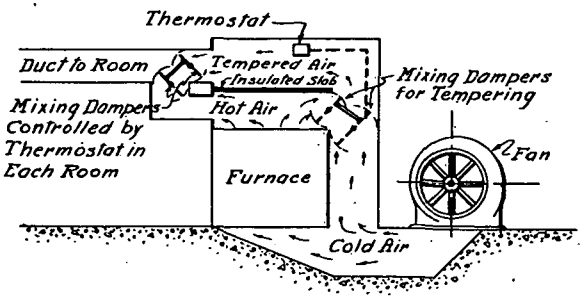

FIG. 5. AN ARRANGEMENT FOR TEMPERED AIR WITH WARM AIR FURNACES

artificial lights, the problem will be to keep cool rather than warm, and the room thermostat, in a temperature above that at which it is set to operate, will ordinarily shut off all heat, while the fan will deliver unheated air. In a room at 80 deg. the admission of air colder than about 70 deg. (depending on the point of entry) will cause discomfort from drafts.

The prevention of this unfortunate situation is achieved by installing two thermostats, one in the room and one in the air duct, the room thermostat serving merely to admit air to the duct thermostat. When the room is cool, both thermostats will be closed and warm air will enter. When the room temperature gets to the critical point of the room thermostat, the room thermostat opens, passing air to the duct thermostat. The duct thermostat may be set to permit this air to pass on by and to function at the heater to reduce the temperature, but will be set so that when the duct temperature lowers to the critical point of the duct thermostat, the latter takes control and prevents the entering air from getting so cool as to cause drafts.

Unit Ventilating Systems

These individual fan-radiator units are usually equipped with highly efficient radiators in one section, having one supply and one return valve, and depend on nicely adjusted dampers for mixing the heated air with unheated air to gain a desirable admission temperature. It is usually not wise to operate the steam supply valves with thermostats, since freezing may occur, and it is usually not practicable to install in these units separate tempering heaters with separate automatic control. The approved procedure is to use an intermediate or slow acting room thermostat for operating the mixing dampers in the unit. This thermostat

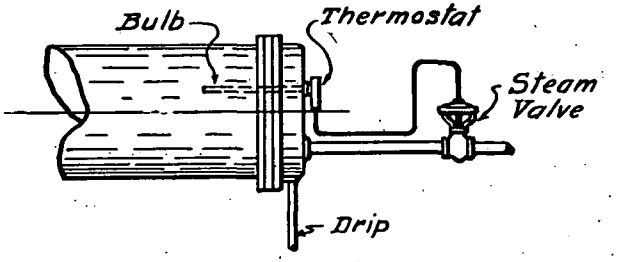

FIG. 6. THERMOSTAT ON STORAGE WATER HEATER

Note.—Connected to special heavy duty water heater and regulating temperature of water by flow of steam in coils. Flow of steam controlled by temperature of water to be heated.

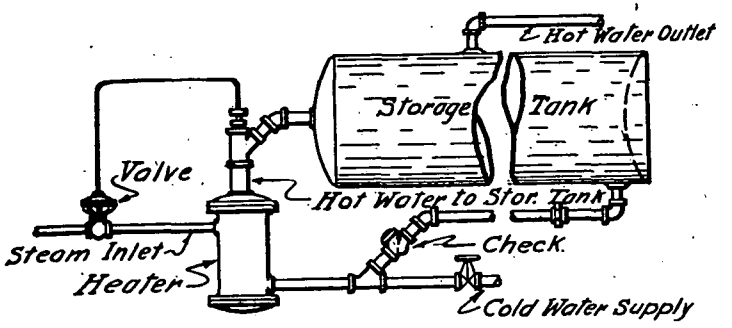

FIG. 7. THERMOSTAT ON AN INSTANTANEOUS WATER HEATER AND STORAGE TANK

Note.—Controlling supply of steam to an instantaneous water heater and storage tank. Control of steam to heater maintained by temperature of water in tank.

may also operate the radiator valves if a vacuum system of steam circulation is provided. If the steam circulation is single-pipe. or any kind of gravity type, the direct radiators should have positive thermostats.

The fresh air intakes to the units should be closed when the building is unoccupied, and the human operator cannot be trusted, especially in an installation comprising many units, to do this by manual means at each unit. An excellent recourse is to handle these cold air intake dampers by a compressed air line running from the control point, say in the boiler room, which by manual opening of a valve permits air to pass to all of the units and to open all of the inlet dampers, the arrangement being such

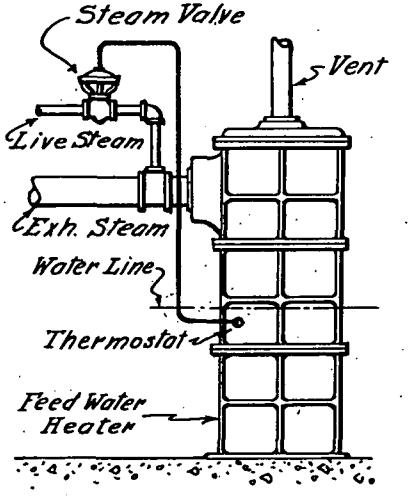

FIG. 8. THERMOSTAT ON AN OPEN FEED WATER HEATER

Note.—Regulating temperature of feed water by injection of live steam to supplement exhaust steam, controlled from temperature of feed water.

that the dampers will always be held shut by springs or weights when no air is permitted to pass or when the air compressor is shut down.

Direct-Indirect Radiators

Direct-indirect radiators are usually housed in, having cold air inlets at their bases, and give rather a make-shift type of ventilation. It is not practicable usually to install mixing dampers, such as are used with fan-units, in these, and since the heating surface is in a single radiator calculated for the coldest air inlet temperature, regulation is difficult. The best results are obtained, where the use of direct-indirect radiators is necessary, by installing slow acting thermostats on special brackets directly above the radiators where the thermostat will be exposed to the

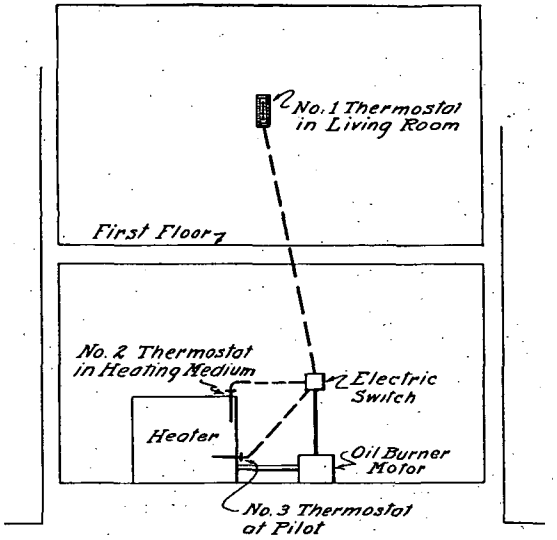

FIG. 9. TYPICAL ARRANGEMENT FOR OIL BURNER

air currents from the outside, and arranging for these to receive air only through additional thermostats placed in the room and controlling the direct radiators. There should be a vacuum system of steam circulation, and the thermostats should be of slow or intermediate acting type, operating on the supply valves to the radiators.

Hot-Water Radiators

Hot-water radiators lend themselves to automatic heat control, especially where the circulation of water is of the forced type, but as the radiators heat and cool rather slowly, there will be some temperature fluctuation or range at the thermostat, especially when the radiator surface is excessive in amount. It is wise to use supply valves which will close tightly and to place lock-shield valves on the return ends of radiators, to facilitate repairs, and the lock-shield valves may prove invaluable in equalizing with great nicety the circulation.

In residence heating with hot-water it often suffices to install a general thermostat in some representative room, which controls the draft, as with coal, or which controls the fire, as with gas or oil, but there should always be furnished in addition a thermostat in the water or circulating medium which will reinforce the general thermostat and which will prevent boiling over in case the general thermostat should be subjected to unfair exposure, such as an open window.

Warm-Air Heating

With warm-air heating from furnaces, with fans, as in public buildings, it is always necessary to provide a supply of tempered air for cooling after the rooms become warm. A duct thermostat and dampers easily and positively will accomplish this, either by mixing some cold air with heated air from the furnaces in an intermediate chamber, or by injecting some hot air from the furnaces into the cold air at the fan inlet, recirculating a measured and controlled part of the air around the furnaces. The room temperatures are controlled by intermediate thermostats and double mixing dampers the same as for a steam system.

Warm-air heating for residences may be controlled by a general thermostat in a representative room, and again, as with hot water, an additional thermostat at the furnace in the warm-air chamber is desirable to reinforce the general thermostat.

Service Hot-Water Heating

It is safe to say that no service hot-water heater should ever be installed without automatic heat control. Automatic heat control for this service not only saves fuel, but also prevents scalding and damage to materials. It also brings about a great reduction in maintenance of valves, pipes, and fixtures. A unit type thermostat is most desirable, since it will function whether or not the general mechanical apparatus is in service, and will control steam and return valves or draft dampers, oil or gas fires, or electric heaters.

In hotels, hospitals, and similar institutions, there should always be at least two independent water heaters, one having very hot water for kitchen uses, the other having water of medium temperature for bath and lavatory purposes, both controlled automatically. Thermostatic anti-scalding devices are available for showers and the like, but these will not prevent the great heat waste due to maintenance of scalding temperatures for bath water. No kitchen administration is satisfied without very hot water, but this demand is intermittent and small in volume as compared with usual bath and lavatory demands.

Oil Burner Control

No oil burning apparatus, unless provided with automatic heat control, can compete in operating cost with coal. An approved method for residence heating with oil is to install the following combination:

1. A general thermostat in a representative room, controlling the electric supply to the burner motor.
2. A second thermostat in the boiler or furnace which will take control should No. 1 thermostat fail to prevent improper or unsafe temperature being maintained inside the heater.
3. A third thermostat at the gas pilot which, unless kept warm by the pilot flame, will bring about the opening of the main switch to the burner motor, thus insuring that no fuel shall be injected unless a flame is in being surely to ignite it.

There are many other combinations for giving assured protection with oil burners other than thermostatic devices, such as pressure and weight-actuated mechanisms, but it is doubtful whether they are as reliable as the thermostatically controlled schemes.

Where electric ignition for the intermittent oil spray is used, it is safer to provide for a continuously operating spark, and to have a thermostat in the heater which will cut out the main switch if the temperature ever gets lower than the critical point which indicates failure to ignite the spray.

Gas Burner Control

The same high intensity as with oil fuel makes it necessary to depend on thermostats to prevent waste, and the intermittent operation and

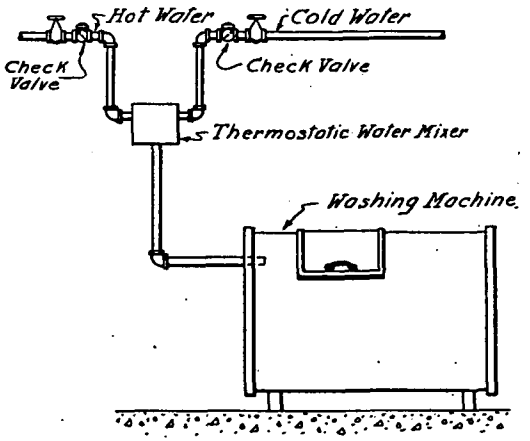

FIG. 10. WATER TEMPERATURE CONTROL FOR LAUNDRY MACHINERY

Note.—WASHING OF WOOLENS BY LAUNDRIES. A Thermostatic Water Mixer installed on the pipe line to a wash wheel will automatically deliver water of the exact temperature required properly to wash woolens. No matter how hot or how cold the water is admitted to the mixer, or whether the pressure of either varies, the temperature of the water delivered to the wash wheel will remain constant. Woolens should not be washed with water warmer than 80 deg. fahr.

necessity for a pilot flame makes it wise to install for gas the same combination of three thermostats as for oil burners, one on the general service, one in the heater, and one on the pilot flame.

Central Station Heating

Central plants should always be governed by thermostats as a measure of economy, and many public service companies require the installation of automatic heat control for this reason. Where economy is of greater consideration than comfort, it often suffices to install one unit type thermostat in a representative room, this controlling a main valve at the entrance to the building.

Where steam at appreciable pressure is furnished from a central station, a combination of pressure reducing valve and cut-off valve, controlled by a thermostat in a representative room, gives excellent results,

as it automatically varies the steam pressure in the radiating surface within a considerable range, giving excellent regulation as well as economy.

Laundry Automatic Heat Control

Many laundry machines, especially for washing woolens, are improved wonderfully in service by the installation of automatic heat control.

By using automatic water mixers on the water supply pipe lines, water at the exact temperatures desired will always be delivered, no matter how hot the warm water may be, thus preventing the aggravating and expensive shrinking of woolen goods so common when water over about 80 deg. is used.

There is also a tremendous fuel saving by preventing overheating of all laundry water, while still insuring, by use of thermostats, that the water always shall be hot enough for each specific condition.

Refrigeration Automatic Control

In most buildings where refrigeration is used, common practice until recently at least, has been to install a central system, where cold brine is produced, and which is pumped through insulated pipes to the various out-lying boxes.

Since the brine temperature is usually much lower than the desired temperature for many of these boxes, the automatic heat control of each unit is desirable and effects a considerable saving in operating cost.

Unit type thermostats are especially well adapted to this service and are available for control of such comparatively cool substances as drinking water, or storage compartments in ice boxes. The low temperature thermostats are placed in the water pipes or in the air chambers with balanced valves in the brine pipes, and automatic control, without attention and enduring for many years without adjustment, goes into effect forthwith.

DOUBLE THERMOSTATIC CONTROL

Nearly all buildings equipped with a large number of thermostats and using compressed air for power, are occupied only part of each 24 hours, and can without any prejudice be kept at a lower temperature during unoccupied periods, as over night or over a holiday. The conventional thermostats as ordinarily applied militate against this arbitrary reduction, and each instrument would have to be adjusted each time for the lower degree, and then each would have to be restored following the unoccupied period. Equipment is available which provides two temperature adjustments to each instrument, such that if the general air pressure leading from the central compressor to the thermostat is suddenly changed, the service is switched automatically from one control to the other, and if the pressure again shall be suddenly changed, the service will be switched back. Thus at 6 o'clock p. m., say, the engineer of an office building releases the air pressure for an instant and all of the thermostats are switched from the 68 deg. control to the 45 deg. control. Either control, of course, is set for any temperature desired. At say 7 o'clock the following morning, a repetition of the drop in air pressure will restore to service the 68 deg. temperature.

In a school building the compressed air supply mains may be grouped so that parts of the building used for night school only remain on the

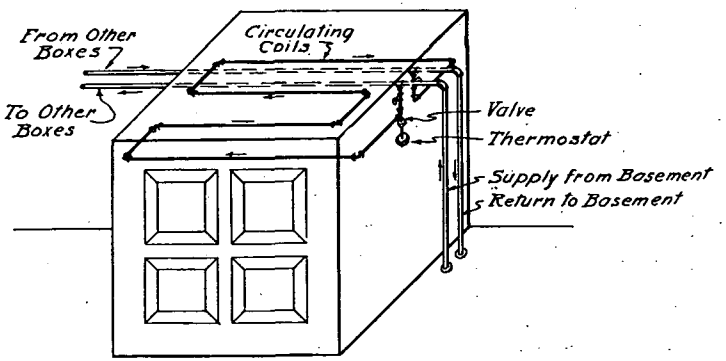

FIG. 11. UNIT THERMOSTAT

Note.—Unit Thermostat on brine refrigeration system automatically controlling flow of brine by temperature of air in box. This installation is also typical of rooms or driers heated by steam or hot water.

68 deg. service, while others can be thrown over to the alternate service and kept much cooler until again required for occupancy.

A familiar scheme similar to the foregoing, with a cooler temperature automatically maintained during the night and increased early in the morning is in use, with the switch operated by a clock, for residence work.

AUTOMATIC HEAT CONTROL IN INDUSTRY

Automatic control of heat in manufacturing processes is believed to be still in its infancy. The promotion and development of automatic heat control was hard pioneering for many years. The reward for this pioneering seems to be in process of realization in the fabulous uses of thermostats in industry.

Without automatic heat control in innumerable manufacturing processes, what now are sure and perfect reactions would be only occasional successes, and the cost of production would be much higher.

In beet sugar making there are at least eleven processes where exact thermostatic control is imperative. In tanning leather there are at least fourteen such stages.

Without exact temperature and humidity control, no fine printing is possible, and no good weaving or dyeing is assured.

In the preparation of most food products automatic heat control is vital.

Thermostats prevent scorching in clothes dryers. They reduce evaporation and are a safety device for oil storage tanks.

They are essential to control gelatine temperature in making photographic films. They are used to control paraffin vats in making waxed paper, milk containers, etc.

They control baking ovens, no matter how the ovens are heated.

They are in use to an enormous extent in the drying and hardening of paints and enamels.

CHAPTER XV

HEAT INSULATION FOR PIPES AND SURFACES

THE first consideration in determining whether or not the pipes and other heated surfaces should be insulated is the magnitude of these losses from such surfaces if they were allowed to remain bare. The losses under still air conditions in B.t.u. per square foot of bare pipe

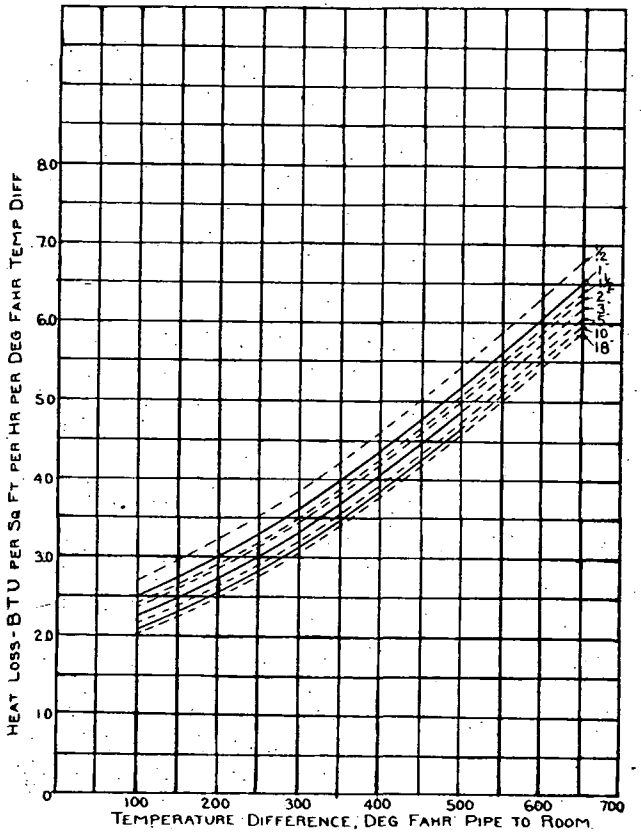

FIG. 1. BARE PIPE LOSS CURVES

surface per hour per deg. fahr. temperature difference for pipes of various diameters are given in Fig. 1.

In Table 1 the B.t.u. loss as well as the loss in dollars and cents and

Compiled from data submitted especially for THE GUIDE by L. B. McMillan, New York, N. Y., and R. H. Heilman, Pittsburgh, Pa.

Table 1. Losses from Horizontal Bare Iron Steam Pipes

From 100 lineal feet of pipe per month of 30 days with steam in pipes 24 hours per day. Coal at $4.00 per ton of 2000 lb.

Pipe Size	Gage Pressure Temperatures: Hot Water 120 Deg. Fahr. Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Hot Water 150 Deg. Fahr. Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Hot Water 180 Deg. Fahr. Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Hot Water 210 Deg. Fahr. Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	10 Lbs. 239.4 Deg. Fahr. Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	80 Lbs. 324 Deg. Fahr. Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	120 Lbs. 350 Deg. Fahr. Dols. Loss	Lbs. Coal	B t.u. per Lineal Ft per Deg. Fahr. Diff. per Hr.
½"	0.53	215	0.543	0.90	363	0.573	1.32	526	0.605	1.77	707	0.638	2.24	897	0.670	3.92	1566	0.779	4.51	1805	0.815
¾"	0.65	261	0.660	1.09	437	0.690	1.58	635	0.729	2.11	845	0.762	2.70	1083	0.809	4.74	1895	0.943	5.48	2190	0.990
1"	0.78	313	0.791	1.31	525	0.829	1.91	763	0.878	2.55	1020	0.920	3.26	1305	0.973	5.72	2290	1.14	6.25	2601	1.18
1¼"	0.97	388	0.979	1.61	646	1.02	2.36	947	1.087	3.19	1275	1.15	4.00	1610	1.20	7.14	2860	1.42	8.18	3280	1.48
1½"	1.08	432	1.09	1.82	728	1.15	2.65	1060	1.220	3.57	1430	1.29	4.54	1818	1.35	7.98	3190	1.58	9.28	3710	1.67
2"	1.32	530	1.34	2.21	886	1.40	3.24	1297	1.491	4.37	1750	1.58	5.36	2142	1.60	9.78	3910	1.94	11.37	4549	2.05
2½"	1.56	625	1.58	2.64	1056	1.67	3.86	1545	1.778	5.18	2075	1.87	6.65	2660	1.98	11.66	4660	2.32	13.66	5460	2.46
3"	1.86	744	1.88	3.15	1260	1.99	4.56	1824	2.100	6.12	2460	2.22	8.24	3292	2.46	13.88	5550	2.76	16.14	6450	2.91
3½"	2.11	843	2.13	3.54	1418	2.24	5.18	2070	2.380	6.95	2780	2.51	8.89	3554	2.65	15.82	6325	3.14	18.31	7322	3.30
4"	2.33	934	2.36	3.95	1580	2.50	5.78	2305	2.650	7.70	3080	2.78	9.87	3950	2.95	17.70	7075	3.52	25.50	8200	3.70
4½"	2.57	1030	2.60	4.35	1740	2.75	6.35	2540	2.920	8.53	3420	3.08	10.94	4370	3.26	19.48	7790	3.87	22.60	9025	4.07
5"	2.84	1135	2.87	4.77	1910	3.02	6.95	2780	3.200	9.36	3750	3.38	11.97	4790	3.57	21.25	8500	4.23	24.62	9850	4.45
6"	3.35	1342	3.39	5.62	2250	3.56	8.20	3280	3.775	11.10	4450	4.01	14.21	5680	4.24	25.30	10,110	5.02	29.30	11,720	5.29
7"	3.83	1533	3.87	6.40	2570	4.06	9.40	3760	4.325	12.70	5080	4.58	16.18	6470	4.82	29.10	11,640	5.78	33.70	13,480	6.09
8"	4.27	1710	4.32	7.20	2880	4.55	11.00	4398	5.050	14.24	5700	5.14	18.25	7300	5.45	32.60	13,030	6.45	37.65	15,050	6.84
9"	4.75	1900	4.80	8.00	3200	5.05	11.62	4650	5.350	15.80	6330	5.71	20.35	8130	6.07	36.25	14,500	7.21	42.10	16,840	7.60
10"	5.26	2100	5.32	8.86	3550	5.61	12.68	5065	5.925	17.55	7030	6.34	22.05	8820	6.58	40.20	16,100	8.01	46.70	18,690	8.44
12"	6.18	2475	6.25	10.46	4190	6.62	15.00	6000	6.995	20.65	8270	7.46	26.44	10,580	7.89	47.40	18,950	9.42	55.40	22,120	10.00
14"	6.74	2700	6.82	11.40	4570	7.22	16.60	6635	7.625	22.40	8980	8.10	28.90	11,560	8.62	52.00	20,800	10.34	60.50	24,200	10.9.
16"	7.66	3065	7.74	12.95	5190	8.20	18.82	7525	650	25.50	10,200	9.20	32.80	13,120	9.79	58.76	23,500	11.70	68.40	27,320	12.34
18"	8.58	3440	8.68	14.53	5820	9.20	21.00	8400	9.650	28.60	11,450	10.33	36.10	14,460	10.80	65.40	26,150	13.00	76.50	30,570	13.80

In these tables coal has been figured at $4.00 per ton of 2000 lb.—13,000 B t.u. per lb. of coal—labor, boiler room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70 per cent. Air temperature 70 deg. fahr. Experimental data obtained at the *Mellon Institute*.

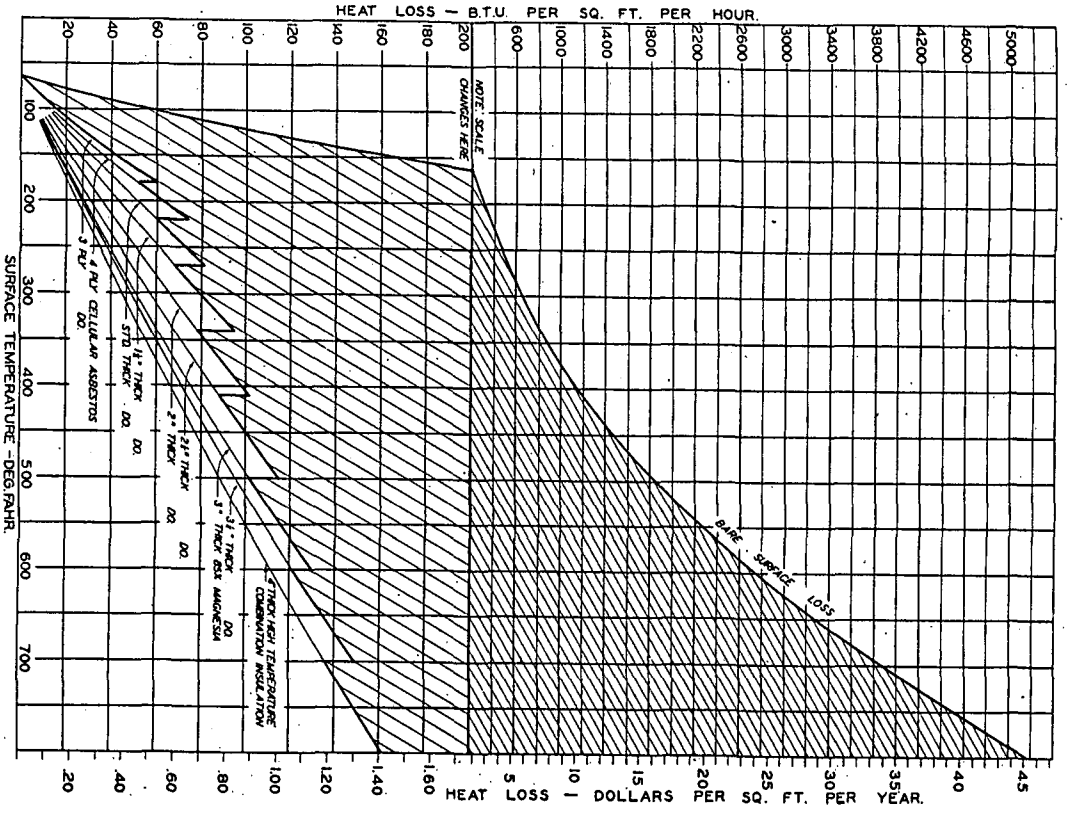

Fig. 2. Losses from Appropriately Insulated Surfaces as Compared with Losses from Bare Surfaces

Note.—The scale showing Dollars loss per sq. ft. per year is based on a unit cost of $1.00 per 1,000,000 B.t.u. *The actual cost is usually less than this* where heat is derived directly from burning coal or oil but may be greater where illuminating gas or electricity is the source of heat. However, the use of $1.00 as the unit greatly simplifies the use of the chart in connection with any cost per 1,000,000 available B.t.u. All that is necessary is to multiply the values from the chart by the ratio of the actual cost to $1.00. For example, if the cost of heat is $.50 per 1,000,000 B.t.u., multiply values from the chart in dollars by 0.5, etc.

in pounds of coal per 100 lineal feet of bare pipe is tabulated for temperatures up to 350 deg. fahr. Pounds of coal used are given per 100 lineal feet per month assuming continuous use of the apparatus, 70 per cent boiler efficiency, and 13,000 B.t.u. per lb. The "dollars" column represents the money value of the coal used per 100 lineal feet per month assuming coal at $4.00 per ton and boiler room expense at $1.00 per ton.

The loss of heat per unit area from flat surfaces varies greatly with the size and position of the body. The loss from the surface in a horizontal position is entirely different for the same surface in a vertical position. Also, the loss is different for the same flat surface facing downward than

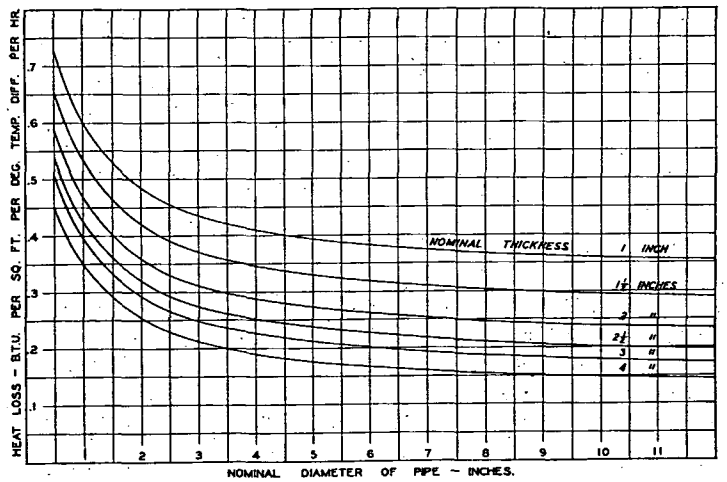

FIG. 3. VARIATION WITH PIPE SIZE OF RATE OF HEAT TRANSMISSION THROUGH A GIVEN THICKNESS OF INSULATION

for it facing upward. For these reasons a single equation or curve has not yet been obtained that will give accurately the heat loss from flat surfaces in various positions. However, until more experimental work has been conducted, it is suggested that the heat loss from flat bare iron surfaces be taken as equal to 95 per cent of the values given for the 18 in. pipe in Fig. 1.

HEAT LOSSES FROM INSULATED SURFACES

Fig. 2 shows the losses from appropriately insulated surfaces compared with losses from bare surfaces. It will be noted that it was necessary to plot the upper part of the bare surface curve to a greatly reduced scale in order to show it on the same sheet with the curves for losses through insulation. Therefore, for a true measure of the relative losses from bare and insulated surfaces, compare the numerical value of the ordinates of the curves rather than the apparent spaces between the curves on the chart.

The chart, Fig. 2, is based on still air conditions, room temperature of 70 deg. fahr., and 5 in. pipe size. The effect of pipe size on losses through insulations of various thicknesses is shown in Fig. 3. (TRANS. A. S. H. & V. E., Vol. 26, p. 375).

For equations by means of which heat losses may be calculated for any thickness of insulation on any pipe size see TRANS. A. S. H. & V. E., Vol. 26, p. 360. Refer also to manufacturers' data for heat losses and efficiencies of different insulations on various sizes of pipes.

CONDUCTIVITIES OF INSULATING MATERIALS

The conductivities in B.t.u. per square foot per hour per inch thick per deg. fahr. temperature difference between inner and outer surfaces of the insulation are given in Table 2 for various types of insulation. In this table the conductivities are shown as functions of the mean temperatures or the mean of the inner and outer surface temperatures of the insulation. This method of expressing conductivities permits their use in the calculation of either single or compound sections. It should be emphasized that in this table all variables due to differences in thickness, different pipe sizes and different air conditions are eliminated.

TABLE 2. CONDUCTIVITIES OF VARIOUS TYPES OF HEAT INSULATING MATERIALS

	Mean Temperature, Deg. Fahr.								
	100	150	200	250	300	350	400	450	500
Laminated Asbestos Type (Approx. 40 laminations per 1 in. thickness)	0.402	0.421	0.442	0.464	0.486	0.510	0.534	0.560	0.586
85 per cent Magnesia Type	0.468	0.480	0.492	0.505	0.518	0.532	0.547	.....	.....
Indented Asbestos Felt Type (Approx. 20 laminations per 1 in. thickness)	0.540	0.570	0.600	0.630	0.660	0.690	0.720	0.750	0.780
Air Cell Type (Four laminations per inch of nominal thickness)	0.529	0.590	0.653	0.712	0.773	.....	.....	.....	.....

RADIATING SURFACE OF PIPES

In order to determine heat losses per linear foot of pipe from known losses per square foot, it is necessary to know the number of square feet area per linear foot of pipe. Table 3 gives these areas for various standard pipe sizes.

TABLE 3. RADIATING SURFACE PER LINEAR FOOT OF PIPE

Pipe Size In.	Surface Sq. Ft.	Pipe Size In.	Surface Sq. Ft.	Pipe Size In.	Surface Sq. Ft.
½	0.22	2	0.622	5	1.456
¾	0.275	2½	0.753	6	1.734
1	0.344	3	0.917	8	2.257
1¼	0.435	3½	1.047	10	2.817
1½	0.498	4	1.178	12	3.338

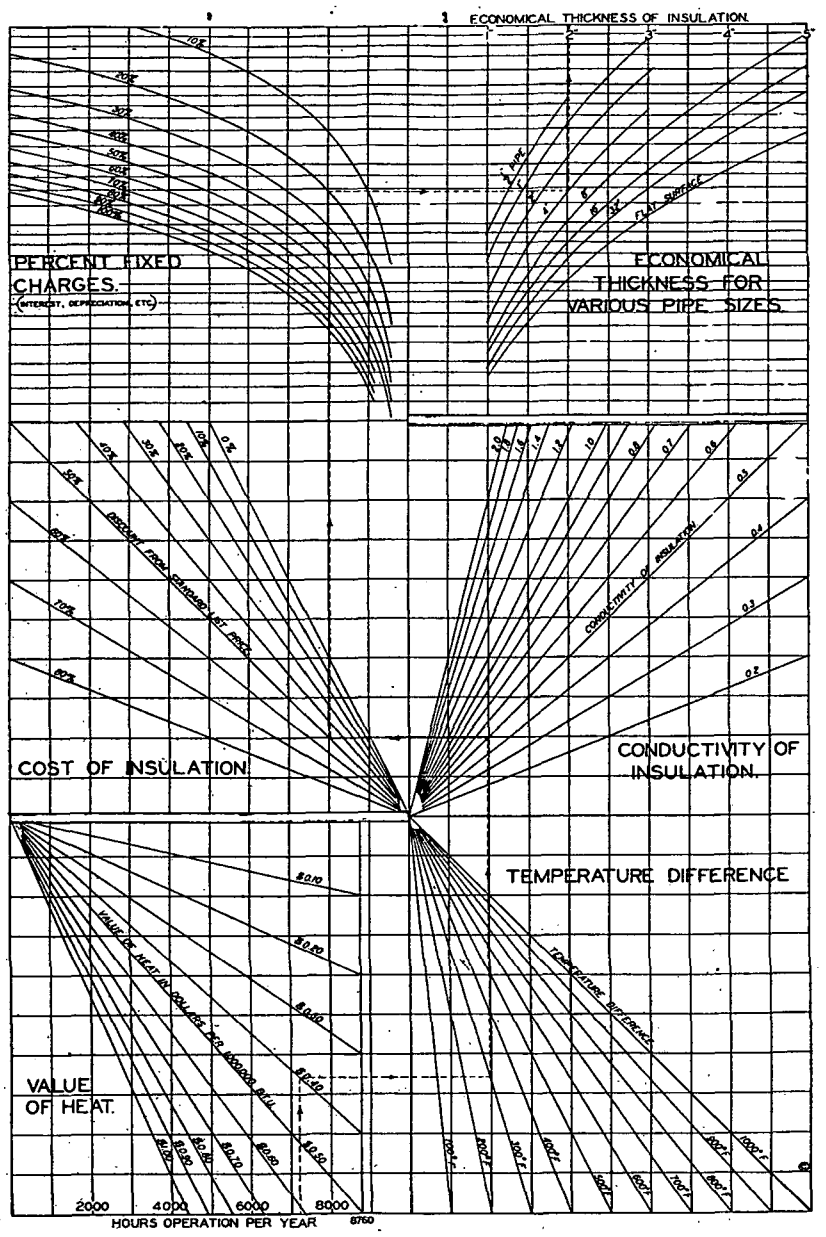

FIG. 4. CHART FOR DETERMINING ECONOMICAL THICKNESS OF INSULATION

TABLE 4. THICKNESSES OF INSULATION ORDINARILY USED

STEAM PRESSURES (LB. GAGE)	STEAM TEMPERATURES (DEG. FAHR.)	THICKNESS OF INSULATION		
		Pipe larger than 4 in.	Pipes 2 in. to 4 in.	Pipes ½ in to 1½ in.
0 to 25	212 to 267	1 in.	1 in.	1 in.
25 to 100	267 to 338	1½ in.	1 in.	1 in.
100 to 200	338 to 388	2 in.	1½ in.	1 in.
Higher Pressure or Superheat	388 to 500	2½ in.	2 in.	1½ in.
Higher Pressure or Superheat	500 to 600	3 in.	2½ in.	2 in.

ECONOMICAL THICKNESS OF INSULATION

Table 4 (TRANS., A. S. H. & V. E., Vol. 26, page 377) shows the thicknesses of insulation which are ordinarily used for various temperature conditions. Where a thorough analysis of economic thickness is desired, this may be accomplished through the use of the chart, Fig. 4.

In order to use the chart, start at the lower left hand corner and proceed to the right to a point representing the given number of hours of operation per year; then proceed vertically to the line representing the given value of heat; thence horizontally, to the right, to the line representing the given temperature difference; thence vertically to the line representing the conductivity of the given material; thence horizontally, to the left, to the line representing the given discount on that material; thence vertically to the curve representing the required per cent return on the investment; thence horizontally, to the left, to the curve representing the given pipe size; thence vertically to the scale at the top of the sheet where the economical thickness may be read off directly. The dotted line on the chart illustrates its use in solving a typical example.

EFFECT OF AIR VELOCITY ON SURFACE LOSSES

The rate of heat loss from a surface maintained at constant temperature is greatly increased by air circulation over the surface. Fig. 5 (*Iron & Steel Engineer*, July, 1925), is based on Langmuir's equations (*Trans. Am. Electro Chem. Soc.*, Vol. 23). Other investigators have shown even greater increases in rates of heat loss from bare surfaces due to air velocity.

In the case of well-insulated surfaces the increases in losses due to air velocity are very small as compared with increases shown above for bare surfaces, because of the fact that air flowing over the surface of the insulation can increase only the rate of heat transfer from surface to air, and cannot change the internal resistance to heat flow inherent in the insulation itself. The maximum increase in heat loss due to air velocity ranges from about 30 per cent in the case of 1 in. thick insulation, to about 10 per cent in the case of 3 in. thick insulation, provided that the insulation is thoroughly sealed so that air can flow only over the surface. If the conditions are such that the air may circulate through cracks and crevasses in the insulation, the increases may be far greater than those given above. Therefore, it is essential that insulation be sealed

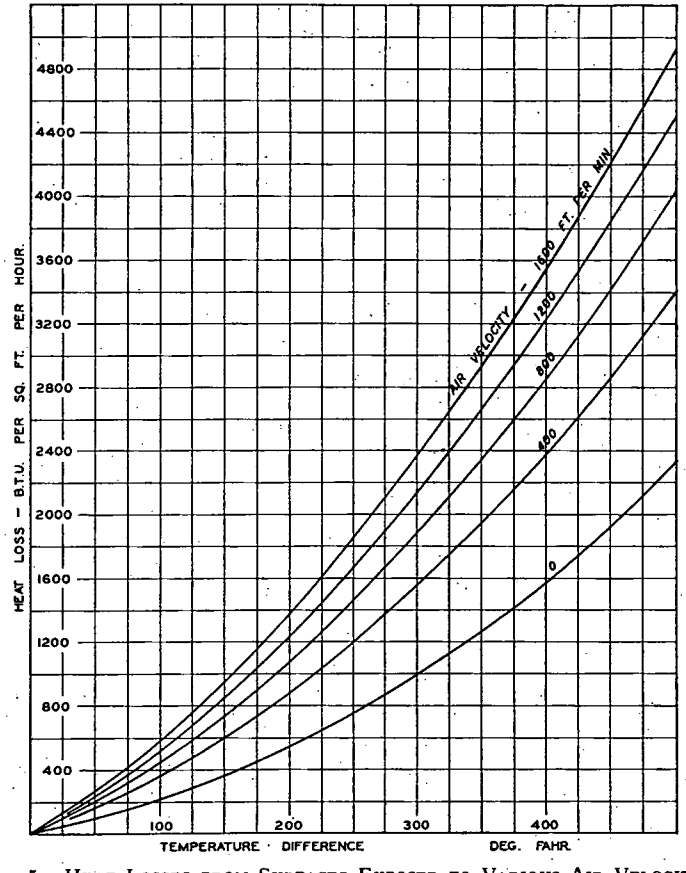

FIG. 5. HEAT LOSSES FROM SURFACES EXPOSED TO VARIOUS AIR VELOCITIES

as tightly as possible. Pipe insulation out of doors should be provided with a weatherproof jacket, and other outdoor insulation should be thoroughly weatherproofed.

HEATING CONDUITS

When steam pipes are run between buildings they should be placed in some form of waterproof conduit which will withstand earth loads and take care of the expansion and contraction of the piping without strain or stress on the couplings, and without affecting the insulation or conduit. Expansion of the piping must be carefully controlled by means of anchors and expansion joints or bends so that the pipes can never come in contact with the conduit. The anchors used are usually U-shaped steel straps

which partially encircle the pipes and are firmly bolted to a short length of structural steel set in concrete.

In laying out conduits of this type the following points should be borne in mind:

1. The conduit should be laid out in successive straight runs between manholes or anchor pits.
2. An anchor should be placed wherever the line changes direction.
3. An expansion joint or bend must be placed between each two anchors.
4. Manholes should be provided at each expansion joint. Where slip joints are used manholes should be vented.
5. Branches should be taken off at or near an anchor.
6. If the distance between buildings is less than 150 ft. and the steam line contains high pressure steam, it may be anchored in the basement of one building and allowed to expand into the basement of the second building. If the steam line contains low pressure steam (up to 4 lb. pressure), this method may be used if buildings are less than 250 ft. apart.
7. If the distance between buildings is between 150 ft. and 300 ft. and the steam line contains high-pressure steam, the lines should be anchored midway between the buildings and allowed to expand into the basements of both buildings. If the steam line contains low-pressure steam this method may be used if buildings are between 250 ft. and 500 ft. apart. No manhole is required at the anchor, and a blind pit is all that is necessary.
8. For longer lines manholes must be located according to judgment and depending upon the expansion value of the type of expansion joint or bend that is used. The minimum number of manholes will be required when an expansion bend or an anchor with double expansion joint is placed in each manhole, and the pipes are anchored midway between manholes.
9. Stabilizers to maintain alignment of pipes should be placed on each side of each expansion bend.
10. A proper hydrostatic test should be applied to the piping before top of conduit is applied and before application of insulation. The pressure used in this test should be greater than the pressure used in service, and should be not less than 100 lb. per square inch in any case.

STYLES OF CONDUITS

Filler Type.—The pipes are supported on rollers placed on a steel rod which rests on an iron frame. The frame is set on a concrete or mortar base. The pipes are protected by a split tile conduit, and the entire space between the pipes and the tile is filled with an insulating filler. Thus the pipes are nested and the insulation between them and the tile effectively prevents circulation of air. The conduit is placed on a bed of gravel or crushed rock from 4 to 6 in. thick, which is extended upward so as to come about 2 in. above the parting lines of the tile. A tile underdrain is placed beneath the conduit throughout the entire length and is connected to existing sewers led to some other point of free discharge.

Insulated Tile Type.—The insulating material, which is diatomaceous earth, is molded to the inside of a split tile conduit. The pipes are supported on rollers, which in turn are supported by an iron frame which extends through the conduit and rests on a tile base which also serves as an underdrain. The space between the pipes and the insulating conduit lining may also be filled with an insulating filler. The conduit, insulation, piping and earth load are supported by the base drain. A few inches of gravel or crushed rock are placed about the conduit and the base drain.

Sectional Insulation Type (Tile Conduit).—Each pipe is insulated in the usual way with any desired type of sectional pipe insulation over which is placed a jacket of standard asphalt waterproof roofing with cemented joints. The pipes are enclosed in a split tile conduit which is placed on a bed of crushed rock or gravel from 4 to 6 in. thick. This gravel bed is extended upward so as to come about 2 in. above the parting lines of the tile. Underdrains are sometimes omitted where this type is used, any water which seeps into the conduit being allowed to flow down the bottom of the conduit to the nearest manhole. Drains are laid from the floor of each manhole to some point of free discharge. The pipes are supported on roller frames and these, according to the type of conduit used, are either supported by the conduit itself or have their lower parts set in concrete thus supporting the pipes independent of the conduit.

Sectional Insulation Type (Tile or Concrete Trench).—In a type of construction frequently used in city streets, where service connections are required at frequent intervals, the pipes are insulated as described in the preceding paragraph, and are enclosed in a box or trench made either entirely of concrete, or with concrete bottom and specially constructed tile sides and tops. The pipes are supported on roll frames secured in the concrete.

Sectional Insulation Type (Bituminized Fibre Conduit).—Each pipe is individually insulated and encased in a bituminized fibre conduit. The insulating material is 85 per cent carbonate of magnesia sectional pipe covering, applied in the usual manner as on overhead pipes, except that bands are omitted. After every fifth section of magnesia covering there is applied a short, hollow section of very hard asbestos material in the bottom portion of which rests a grooved-iron plate carrying ball-bearings upon which the pipe rides when expanding or contracting. This short expansion section is of the same outside diameter as the adjacent 85 per cent magnesia covering. Over the pipe covering and expansion device there are placed two layers of bituminized fibre conduit with all joints staggered and the surface of each conduit finished with liquid cement. Conduits are placed on a bed of crushed rock or gravel, approximately 6 in. deep, and this is extended upward to about the center line of the conduit when trench is backfilled. Underdrains leading to points of free discharge are placed in the gravel or crushed rock beds.

Wooden Conduit.—Each pipe is enclosed in a tin-lined wooden casing. Sufficient space is allowed between the pipe and the casing to provide for the insertion of pipe guides or rollers which rest on the bottom of the casing. The casings are bedded in gravel or broken stone and one or more tile underdrains are laid beneath them.

PART II—VENTILATION

CHAPTER XVI

MODERN STANDARDS OF VENTILATION

GENERAL REQUIREMENTS

VENTILATION is the science that treats of the proper conditioning of air to make it satisfactory for the human system. A study of ventilation is a study of the best methods of conditioning and handling air, and a study of the effect of that air on the human system. The test of good ventilation is the measure of health and comfort derived from it. Health and comfort are the proper basis for measuring the quality of ventilation.

In the present status of the art of ventilation it is no longer felt that chemical composition of the air is the important factor, but that proper ventilation depends more largely upon a number of other factors which may be stated in the order of their importance as follows:

1. Air Supply.
2. Air Temperature
3. Relative humidity.
4. Air motion.

(1–4: These four factors, in combination, are the basis of what is termed "Effective Temperature.")

5. Air cleanliness, in reference to its freedom from dust, bacteria and other suspended matter.
6. Air Distribution, with reference to freedom from drafts.
7. Freedom from odors.
8. Freedom from injurious substances such as gases and fumes.
9. Psychological Reactions.

Air supply is put at the head of the list because, while this is no longer considered to be the all important factor in ventilation, the amount of air to be supplied per person or the number of air changes to be furnished for any particular space will always be the starting point, for without air supply there can be no effective ventilation.

Air Supply for Ventilation

A comparatively small quantity of air supply is required to take care of the needs of the lungs. A very much larger quantity is required to take care of the needs of the outside of the body and to provide the heat control necessary for the maintenance of body health and comfort. In order to provide the necessary air movement to maintain uniform temperature conditions, remove odors and provide comfort, the delivery by the ventilating plant of the following quantities of air, are usually found desirable and necessary:

Compiled and revised by John Howatt, E. P. Heckel, W. A. Rowe and Samuel R. Lewis.

Schools:	
Classrooms	2.0 cu. ft. per minute per square foot of floor area
Assembly rooms	1.5 cu. ft. per minute per square foot of floor area
Gymnasia	1.5 cu. ft. per minute per square foot of floor area
Picture Machine Booth	1.5 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Kitchens	2.0 cu. ft. per minute per square foot of floor area
Corridors	0.5 cu. ft. per minute per square foot of floor area
Wardrobes and lockers	2.0 cu. ft. per minute per square foot of floor area
Toilet, Bath, Etc.	2.0 cu. ft. per minute per square foot of floor area
Theatres:	
Seating spaces	2.0 cu. ft. per minute per square foot of floor area
Toilets, etc.	2.0 cu. ft. per minute per square foot of floor area
Hotels:	
Assembly rooms	2.0 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Kitchens	4.0 cu. ft. per minute per square foot of floor area
Hospitals:	
Wards	1.0 cu. ft. per minute per square foot of floor area
Dining-rooms	1.5 cu. ft. per minute per square foot of floor area
Toilets	2.0 cu. ft. per minute per square foot of floor area
Kitchens	4.0 cu. ft. per minute per square foot of floor area

Air temperature is second in the list for the reason that it has been proved by practically all of the accredited experimentors that over-heating is more detrimental to the quality of ventilation than any other one thing.

Some methods of controlling air temperature with ventilating plants are discussed in THE GUIDE Chapter on Automatic Heat Control and in Chapter XIV of this section, entitled Conditioning and Cooling Air.

Relative humidity bears an intimate relationship with Air Supply and Temperature. These relations are described in Chapter XVIII of this section.

Air Motion is also associated with the three preceding factors, and enters into the Comfort Zone term which has been designated "Effective Temperature." See Chapter XVIII.

Air Cleanliness has to do with human health both from the standpoint of freedom from dust and other suspended substances, which irritate and clog the air passages, and from the standpoint of freedom from bacteria and other infectious media carried along with these substances which constitute the dirt in air.

Methods of cleaning air are treated in Chapter XXII in this section.

Air Distribution is of the utmost importance, and is closely correlated with effective temperature. Chapter XIX, Systems of Ventilation, has much to do with the effectiveness of air distribution, as also does Chapter XXI, Air Duct Design and Construction.

Freedom from Odors is often accomplished by plentiful air supply and efficient distribution, but may be facilitated by other means, among which are Ozone, treated in Chapter XXIV.

Freedom from Injurious Substances such as gases and fumes may be of the utmost importance. These are handled usually by mechanical exhaust ventilation with effective distribution. This phase of ventilation is affected in one way or another by nearly all of the items, tabulated before.

Psychological Reactions

The engineer who disregards the psychological factor in ventilation is indeed short sighted. As in most human contacts and activities, the effect on the mind of air conditions is profound.

Consideration must always be given to objectionable noise from machinery or to air friction noises. It is usually helpful if the occupants of a ventilated room may visualize some indication that air is moving. It helps if they may, when they wish, place their bodies or portions thereof, in sensible air currents, to demonstrate that ventilation is in effect. Periodical or occasional temperature reductions or increases in air movement, possibly accompanied by muscular exercises, are of great value, psychologically as well as physically.

Ventilation Requirements

In the practical work of engineers who design ventilating systems and of architects and owners who have to pass upon these systems, the one item involving standards which is the basis of all calculations and layouts, is the quantity of air to be handled by the system to be used, for producing the results desired. The functions of the air handled in connection with ventilated spaces are: (1) to supply the necessary oxygen for respiration, (2) to keep the dilution of CO_2 and other objectionable substances down to the proper point, and (3) to maintain the proper effective air temperature. It has been estimated that an adult at rest will breathe 0.25 cu. ft. of air per minute and exhale 0.01 cu. ft. of CO_2 in the same period or at the rate of 0.6 cu. ft. per hour, thus removing about 5 per cent of the oxygen from the air breathed. The same air may be rebreathed for a limited time without apparent harmful effect, but discomfort is evident. However, air may be filtered, washed, cooled and recirculated with evident satisfaction.

The air handled may consist entirely of air taken in from the outside or it may consist partly of new air and partly of recirculated air.

Heat from Occupants, Lights, Equipment

In a crowded place of assemblage, the heat given off by the occupants together with that given off by the lighting and power equipment is usually more than the normal heat loss through the structure to the outside air, even in winter under cold climatic conditions. This means that in order to preserve an equilibrium of effective temperature the entering air must be cooler than the leaving air, so that the problem is usually one of cooling and ventilating rather than of heating and ventilating.

A typical case for winter might show about 300 B.t.u. of body heat plus 100 B.t.u. from light, etc., being given up to the building against 200 B.t.u. heat loss from the building, per person per hour. This would mean that 200 B.t.u. per person must be carried away by the air. (See page 52, Chapter I of THE GUIDE.)

If the flow of air is upward, or from the side, so as to bring the incoming air into direct contact with the occupants, the temperature of the incoming air should not be more than about 5 deg. below the temperature of the air leaving the occupant (for ceilings 10 ft. or less in height), otherwise the ventilation will be drafty and uncomfortable. This difference may be increased about 1 deg. for each 2 ft. of added ceiling height, providing

the rising air does not come into direct contact with another tier of occupants.

For ceiling heights 10 ft. and lower the quantity of air per person to dissipate this excess heat is $\frac{200}{60 \times .075 \times .24 \times 6} = 30$ cu. ft. per person per minute.

This amount may be reduced somewhat on the assumption that the component of heat from lights is usually introduced near the ceiling and may be allowed to heat the outgoing air to a greater difference.

Effect of High Temperature and Humidity

If a room is crowded in weather 85 deg. outside, with relative humidity 70 per cent, to give each occupant 30 cu. ft. of air per minute, it may be assumed that there will be an increase of temperature of at least 5 deg. due to body heat and heat from equipment.

A moisture increase from the bodies of the persons may be assumed as 10 grains per minute or 0.30 grains per cu. ft. of air handled. Under such a condition some method of air cooling will be needed to get satisfactory ventilation.

A good air washer can reduce the temperature of the air passing through it about 70 per cent of the difference between the wet and the dry bulb temperatures. Its operation would hardly be worth while without a cool water supply. It will be understood that the example cited is an extreme case of temperature and humidity. The beneficial effect of an air washer will increase in proportion as the relative humidity of the outside air is lower.

Experience, however, shows that a supply of fresh air which proves to be adequate for maintaining effective temperature in winter will usually prove inadequate for the same purpose in hot weather. While an increased volume of air supply is often of material benefit, the use of refrigeration brings the final hot weather solution, not so much in actual temperature drop as in humidity control.

Using as much as 30 cu. ft. per minute air supply per person especially with an upward system, as through floor mushrooms, drafts will be felt at introduction temperatures more than 5 or 10 deg. cooler than the average room temperature.

For this reason and for the additional reasons of sanitation and control, the downward system of ventilation is perhaps more efficacious in large and intensively occupied places of assemblage.

On account of transporting all of the heat from lights downward and of forcing the body-heated air back over the occupants it is usually necessary to do much more cooling of the air than can be done with the air washer alone, and it is necessary to employ refrigeration. The air is brought in at a point high enough to permit of its being diffused and brought to the proper condition before coming into contact with the occupants. It can be seen, therefore, that the air supply per person per minute for assembly rooms might be as low as 10 cu. ft. in winter, as high as 30 cu. ft. in summer, with air washers, and anywhere between these two figures for the entire year, with refrigeration.

Recirculation

Where recirculation of air in ventilation work is permitted, care should be taken that the recirculated air is thoroughly reconditioned by cleaning and deodorizing, and if necessary, dehumidifying. The saving in operating costs obtainable by recirculation of the air in ventilation systems must not be obtained at the expense of quality. A reduction in the quality of the ventilation when recirculation is used can be prevented by the installation and use of complete mechanical ventilation equipment for this purpose.

A reasonable arrangement is to provide apparatus for handling not less than 30 cu. ft. of fresh air per person per minute, with provisions for recirculating any amount up to as much as two-thirds of this.

The percentage of air recirculated may be varied to suit the seasonal changes so as to conserve heat in winter and refrigeration in summer.

Toilets and similar rooms in buildings using recirculation should be separately ventilated, employing mechanical supply and exhaust with the exhaust in excess of the supply in order to prevent objectionable odors from diffusing into other parts of the building.

Table 1. Amount of New Air to be Supplied per Person[1]

	Cubic Feet per Minute			Number of Air Changes per Hour
	Without Humidification or Recirculation	With Humidification but Without Recirculation	With Humidification and Recirculation	
Schools—				
Class Rooms	30	20	5 to 10	.....
Assembly Rooms	15 to 20	10 to 15	5 to 10	.....
Gymnasiums	30	25	15 to 20	.....
Toilets	.....	.....	.....	10 to 20
Locker Rooms	.....	.....	.....	5 to 10
Kitchens	.....	.....	.....	20 to 60
Lunch Rooms	.....	.....	.....	10 to 20
Theaters—				
Seating Space	30 to 50	20 to 30	10 to 15	.....
Hospitals—				
Wards	30 to 40	20 to 30	.....	.....
Kitchens	.....	.....	.....	20 to 60
Dining Rooms	.....	.....	.....	10 to 20
Toilets	.....	.....	.....	10 to 20
Hotels—				
Dining Rooms	.....	.....	.....	10 to 15
Kitchens	.....	.....	.....	20 to 60
Ball Rooms	.....	.....	.....	5 to 10
Work Space	.....	.....	.....	5 to 10
Assembly Rooms	20 to 30	15 to 20	10 to 15	.....

The Synthetic Air Chart

Long experience and elaborate experiments and tests have demonstrated that certain qualities of air, especially the qualities of temperature, humidity and motion, result in the greatest health and comfort. These

are described in Chapter XVII. These qualities along with dustiness, odor, bacteriological content and carbon dioxide content, have been considered and combined in the preparation of a Synthetic Air Chart as a means of measuring the percentage of perfection or the ideal quality of air. This chart is explained in Chapter XVII.

Control is the principal factor in deciding whether the ventilation in any space will be satisfactory or unsatisfactory; control of quantity, quality, temperature, dirt, humidity, odors and movement. Experience and experiments have shown all of these factors are important in ventilation work, and control of them is essential if a high rating of ventilation perfection is desired.

It is a familiar fact that a room may be comfortable at one temperature and yet decidedly uncomfortable at another time even though the same dry bulb temperature is recorded. This fact may be due either to change a relative humidity or air motion. On the other hand a room may feel equally comfortable with different dry bulb temperatures provided the relative humidity or air motion is varied to produce this effect.

Elaborate tests have been made to determine the effective temperature range most comfortable to the majority of people and this has been called the Comfort Zone. Reports of the cooperative tests on this work with the U. S. Bureau of Mines and the U. S. Public Health Service, appear in the A. S. H. & V. E. TRANSACTIONS, 1922 to 1927, and in many government bulletins.

The prolonged effect of temperature humidity and air motion upon health is not so well understood as the effect upon comfort. Strictly speaking good ventilation is merely a relative term and today ventilation is considered necessary for personal comfort and good health. The standards today are more exact than ever before and consequently adequate ventilation is considered a necessity.

After a good ventilating system is designed the engineer is only fairly well started on the road to good ventilation. A system is not a ventilating system until it ventilates. Here is where the operating man and proper supervision of operation come in.

It is recommended that the engineer who designs a ventilating plant shall supervise its installation, and that his interest and responsibility shall be maintained during the operation of the plant.

CHAPTER XVII

THE HILL SYNTHETIC AIR CHART

PERFECTION in ventilation depends upon the condition of the air in a room as it affects health and comfort rather than upon the quantity of outside air supplied. The known conditions of air which may affect human health and comfort are its temperature, humidity, motion, dustiness, odors, bacterialogical contents, and carbon dioxide contents.

The synthetic air chart, devised by Dr. E. Vernon Hill, and revised as a result of the investigations by the Society's Research Laboratory is the accepted standard for grading the perfection of ventilation in any room by the conditions of the air itself.

The chart is devised for recording test data of air conditions and obtaining, mathematically, a "percentage of perfect" for the test as a whole. It substitutes definite figures for personal opinion and guess work. The value of the chart encourages accurate testing of the specific factors that determine air conditions. Furthermore, the test data in the various columns reveal at a glance wherein conditions are followed and indicate what steps should be taken to correct the same.

The Synthetic Air Chart consists primarily of an arrangement of ventilating factors in seven vertical columns, arranged in five groups. The first group contains one factor; namely, the effective temperature condition, and is often referred to as the physical group. It includes the temperature, humidity and air motion.

The second group contains three factors—dust, bacteria and odors. This group may be considered the chemical group.

The third group is carbon dioxide; the fourth, distribution; and the fifth, the "percentage of perfect" for the test as a whole. The chart contains all the known factors that influence or determine air conditions in an occupied room.

It is unnecessary to describe the theory of the chart and its development, the relative and absolute weights of the various factors, etc., in this article, as a complete description of the same may be found in the TRANSACTIONS of the Society in volumes 23 and 26, namely, for the years 1917 and 1920. It may be well, however, to mention in this connection that the chart, as illustrated (see Fig. 1), has been somewhat modified from the one illustrated and described in the previous GUIDE and in the TRANSACTIONS. None of the values have been changed, but the plus percentage which appears to the left of each column has been omitted The plus percentage columns in the previous chart were for the purpose of determining the relative values on a percentage basis of each individual factor, but as these percentages were not used in arriving at a final

This chapter revised by O. W. Armspach, Chicago, Ill.

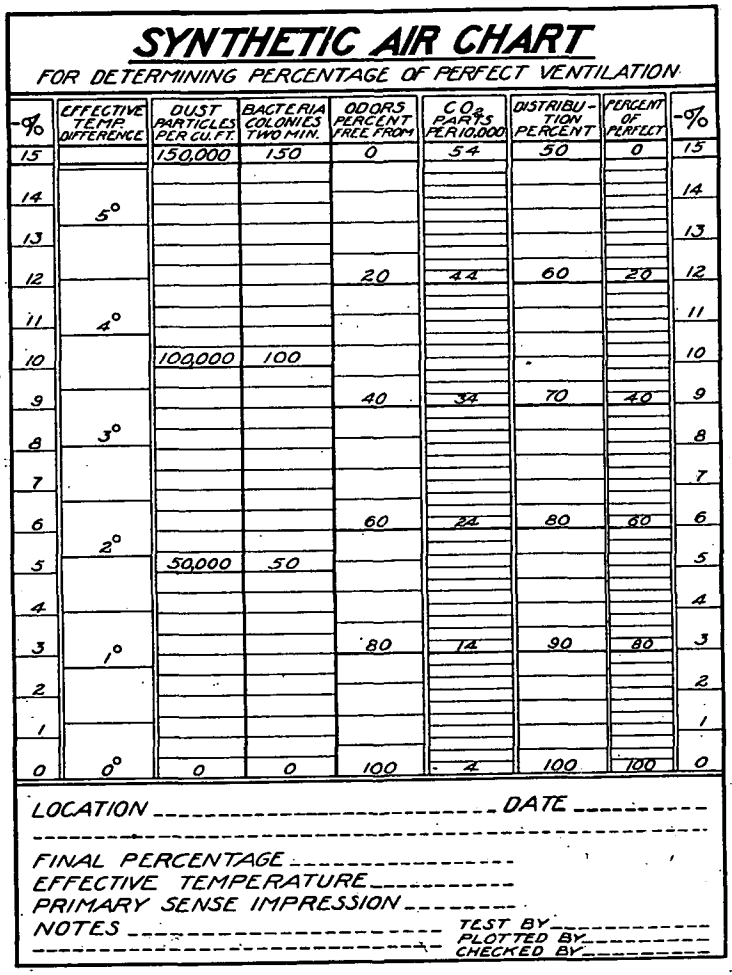

FIG. 1. THE SYNTHETIC AIR CHART

percentage of test as a whole, it was thought desirable to omit them.

The minus percentage columns in the old chart which appear at the right of each factor column, have been also omitted from the body of the chart and placed in duplicate on the right and left borders. This leaves the chart proper free from all figures, except those relating to the specific factor.

The scales have also been reversed in the present chart so that penalization for undesirable conditions as apply to the percentage of perfection for ventilation is directly proportional to the height of the shaded areas

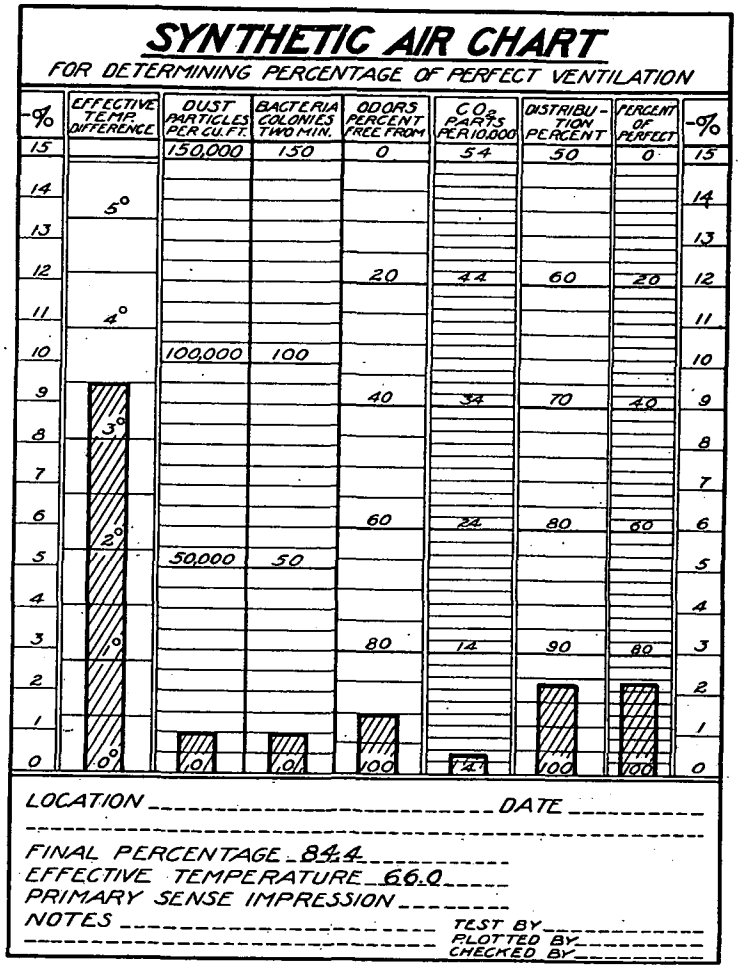

FIG. 2. METHOD OF CHARTING TEST RESULTS

in each column, as the chart in this form visualizes much better the defects in the air conditions represented by the test.

METHOD OF USING THE CHART

In using the Synthetic Air Chart, the floor area of the room to be tested is divided into a certain number of equal areas and tests made at the center of each area. In the standard school classroom, for example, the room is divided into four equal areas by two imaginary lines from the center of contiguous side walls, crossing at right angles in the center.

The tests are made at the center of each area so determined and the results plotted in the proper columns on the chart. Wet and dry bulb readings are first taken and air motion determinations made to determine the effective temperature. The difference between the effective temperature, so determined, and the ideal effective temperature, as shown by the comfort chart, is plotted in the first column.

Dust determinations are next made and the results plotted in the second column, and so on until all the observations have been made. When all the factors have been plotted as a shaded area in each column, a straight edge is laid across the chart and the penalization for each factor as determined by the height of the column on the shaded area is read from the scales on the border. The sum of all penalization factors is subtracted from 100 to obtain the final percentage of perfection of the ventilation as it appears in the last column.

CONDITIONS OF MAXIMUM COMFORT

Temperature Humidity and Air Motion.—A person's feeling of warmth is determined, by the temperature, humidity and motion of the air. A single index of a person's feeling of warmth is given by a scale of effective temperature, which takes into consideration these three factors. This scale of effective temperature (abbreviated E. T.) has been determined by the Society's Research Laboratory and is discussed in Chapter XVIII. For the average human being at rest an effective temperature of 64 deg. gives maximum comfort. Persons working at various rates are most comfortable at effective temperatures below 64 deg. The exact effective temperatures giving maximum comfort for persons working at various rates have not yet been determined by the Research Laboratory but from the best data available, they are as follows:—

At rest	64 deg. E. T.
Light Work	62.5 deg. E. T.
Moderate Work	62 deg. E. T.
Hard Work	59.5 deg. E. T.

One hundred per cent perfection in ventilation, for people at rest exists when the effective temperature is 64 deg. Life is impossible for any considerable length of time in an effective temperature of 97⅓ deg. and a condition having this effective temperature is therefore, rated zero per cent perfect, is penalized 100 per cent as regards this factor and 90 per cent for imperfection in ventilation. The penalization for variation in temperature from the ideal is therefore 3 per cent per deg. E. T. It will be noticed that this will give zero per cent perfection for 31 deg.—a condition nearly impossible for life for a person normally clothed and at rest.

Dust.—Dust is inimical to health and comfort. It is, however, more difficult to arrive at a basis of penalization since it is hard to say that any degree of dustiness is impossible for life. Dust-free air is 100 per cent perfect and 250,000 particles per cu. ft. of air as determined by the Hill counter is considered zero per cent perfect, or is penalized 100 per cent as regards the dust factor and 25 per cent for imperfection of ventilation. The percentage of perfection is reduced by 1 per cent for each 2500 particles.

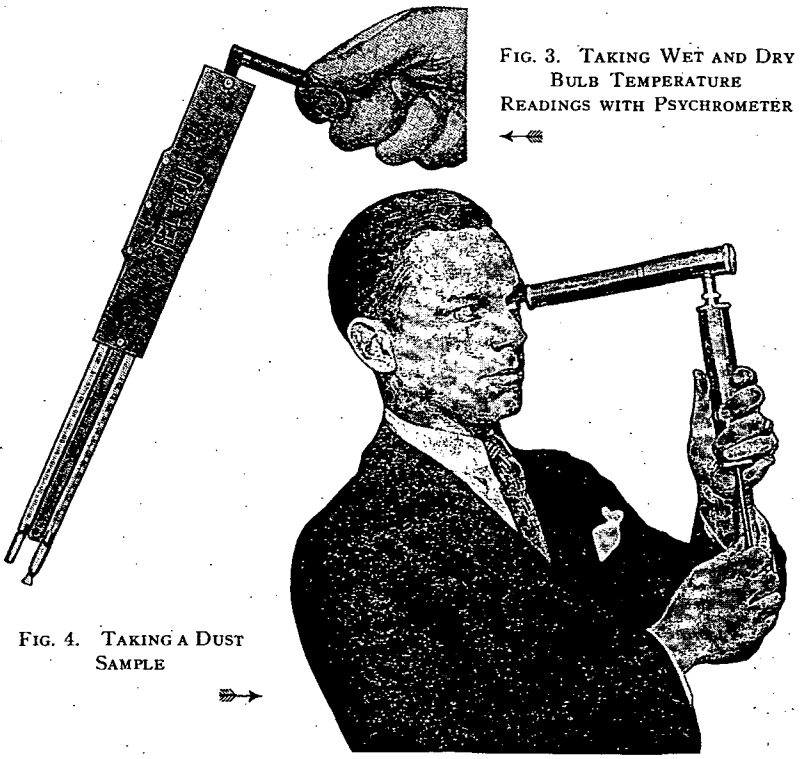

FIG. 3. TAKING WET AND DRY BULB TEMPERATURE READINGS WITH PSYCHROMETER

FIG. 4. TAKING A DUST SAMPLE

Odors.—In the case of odors it is even more difficult to arrive at a basis for penalization. The following scale has been adopted:—

Free from odor	100 per cent perfect
Very faint odor	95 " " "
Faint odor	90 " " "
Noticeable odor	85 " " "
Distinct odor	80 " " "
Decided odor	75 " " "
Strong odor	70 " " "

Penalization for imperfection of ventilation is 0.15 of that for the odor factor.

Bacteria.—All bacteria are not harmful and some may be desirable, the number of bacteria in the air generally indicates the surrounding sanitary condition. According to the synthetic air chart, the percentage of perfection depends upon the number of bacteria in the air as determined by the number of colonies that develop on a culture plate which has been exposed for two minutes. A standard 4 in. Petrie dish, with agar-agar for a media, is used for this purpose. The plates are incubated from 24 to 48 hours at a temperature of 98 deg. fahr. At the end of this time the separate colonies have developed to a size which are easily

counted. If an incubator is not available, cultures may be grown at room temperatures (70 deg.) for a period of five days. If no colonies appear, the condition is read at 100 per cent, and if 500 colonies appear, it is read at zero per cent perfect. The percentage of perfection is reduced by one for each five colonies, for this factor. Penalization for poor ventilation is one-half as great.

Carbon Dioxide.—Carbon dioxide determinations are made, not to determine the purity of the air, but to determine the percentage of distribution and sometimes the quantity of outside air that is introduced into a room. The percentage of perfection on the quantity basis is 100 per cent if the carbon dioxide is the same inside and outside; namely, four parts in 10,000 parts of air. The percentage of perfection is reduced by 1 per cent for every three parts per 10,000 over that found in the outside air. This gives 100 per cent penalization for 300 parts of CO_2. Penalization for imperfect ventilation is 0.9 for the CO_2 factor.

Distribution.—The distribution of the air throughout the room is an important factor in ventilation. Imperfection in this factor is determined by the variation in percentage of carbon dioxide in various parts of the room. The percentage of variation of the various samples from the average CO_2 content of the room is the percentage penalization for poor distribution. Penalization for imperfect ventilation is 0.3 that for the distribution factor.

EXAMPLE IN THE USE OF THE CHART

Determine the percentage of perfection of ventilation in a room where the following conditions are observed. The room to be occupied by persons normally clothed and doing light work.

Dry Bulb Temperature	72 deg.
Wet Bulb Temperature	54 deg.
Air Velocity	Still air.
Dust Count by Hill Counter	10,000 particles per cu. ft.

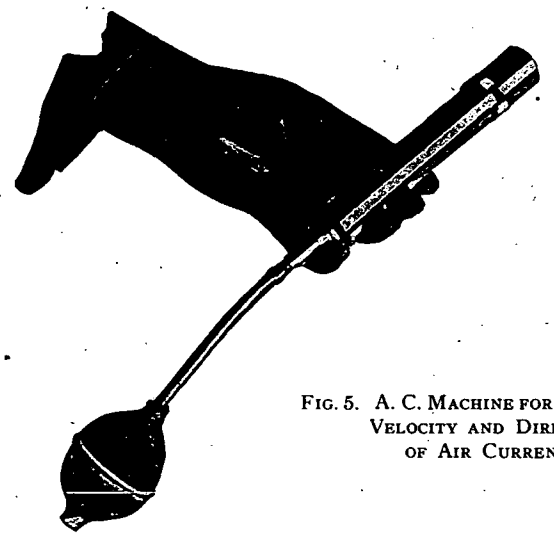

FIG. 5. A. C. MACHINE FOR DETERMINING VELOCITY AND DIRECTION OF AIR CURRENTS

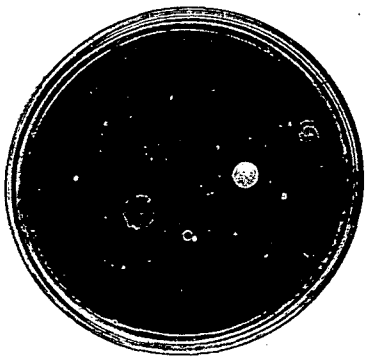

FIG. 6. CULTURE PLATE SHOWING COLONIES OF BACTERIA

FIG. 8. APPARATUS FOR OBTAINING AIR SAMPLES

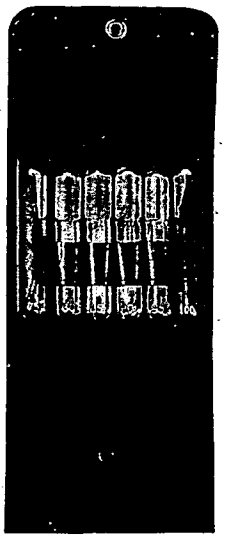

FIG. 7. ODOROMETER CONTAINING STANDARD ODOR SOLUTIONS

Bacteria colonies developed in a 2 min. plate	10
CO_2 analysis inside Station No. 1	6 parts in 10,000
CO_2 analysis inside Station No. 2	6.3 parts in 10,000
CO_2 analysis inside Station No. 3	5.5 parts in 10,000
CO_2 analysis inside Station No. 4	5.0 parts in 10,000
CO_2 analysis outside	4.0 parts in 10,000
Other objectionable substances	None

The effective temperature for the observed wet and dry bulb temperature and air motion is determined from Tables 1 to 7 in Chapter XVIII. From Table 2 (See Chapter XVIII) for still air, the intersection of the line for 72 deg. dry bulb and the column for 54 deg. wet bulb gives 66.0 deg. as the E. T. of the condition. For 100 per cent perfection 62.5 deg. E. T. is required for persons doing light work whereas the existing condition is 66.0 deg. E. T. or 3.5 deg. too high, which gives according to the chart, 89.5 per cent perfection and 10.5 per cent penalization for this factor and a penalization of 9.5 per cent for imperfect ventilation. This is indicated in the chart, Fig. 2.

Ten thousand dust particles per cu. ft. of air gives according to the chart 96 per cent perfection and 4 per cent penalization for this factor and 1 per cent penalization for imperfect ventilation.

10 bacterial colonies on a 2 min. plate gives 98 per cent perfection for this factor and a penalization of 1 per cent for imperfect ventilation.

A faint odor or 90 per cent free from odors calls for a 10 per cent penalization for this factor and 1.5 per cent penalization for imperfection of ventilation.

The average carbon dioxide content of the 4 samples taken in the room is 5.7 or 1.7 parts more than the outside sample, which, according to the chart, is 99.5 per cent perfect for this factor and calls for 0.4 per cent penalization for imperfection of ventilation.

There are no other injurious substances indicated hence no penalization is given for such factors.

The variations of the carbon dioxide content of the four stations from their average are as follows:—

Station No. 1	6.3 − 5.7	= 0.6	parts per	10,000
" " 2	6.0 − 5.7	= 0.3	" "	10,000
" " 3	5.7 − 5.6	= 0.1	" "	10,000
" " 4	5.7 − 5.0	= 0.7	" "	10,000
		4 | 1.7		

The average variation is 0.42, and the percentage of variation is $\frac{0.42}{5.7} \times 100 = 7.4$ per cent. Therefore the percentage distribution is 100 − 7.4 = 92.6, and the percentage penalization for imperfect ventilation is 2.2.

The percentage of perfection for each factor is indicated in the chart, Fig. 2 and are summed up in Table 1. The sum of all the penalizations for imperfection in ventilation is 15.6 and the percentage of perfection of ventilation is 100 minus 15.6 or 84.4 which is shown in the last column of the chart.

TABLE 1. TYPICAL RESULTS OF ANALYSIS BY HILL SYNTHETIC AIR CHART

FACTOR	PERCENTAGE OF PERFECTION FOR FACTOR	PERCENTAGE OF PENALIZATION FOR FACTOR	PERCENTAGE OF PENALIZATION FOR IMPERFECT VENTILATION	PERCENTAGE OF PERFECTION FOR VENTILATION
Effective Temperature	89.5	10.5	9.5	.....
Dust	96.0	4.0	1.0	.....
Bacteria	98.0	2.0	1.0	.....
Odor	90.0	10.0	1.5	.....
Carbon Dioxide	99.5	0.5	0.4	.....
Distribution	92.6	7.4	2.2	.....
Total			15.6	84.4

The above observations are made as follows: The wet and dry bulb temperatures are determined with a sling psychrometer, the air velocity is determined by observing the speed of a smoke cloud with the aid of a stop watch. The smoke cloud may be caused by means of an ammonium cloud apparatus, or by exploding a smoke bomb, or by other means.

The dust count is made by means of the Hill dust counter. In this instrument a given volume of air is made to impinge against a glass microscope cover slip coated with an adhesive. The particles are counted under a microscope of definite magnification and the number corrected per cu. ft. of air.

Carbon dioxide samples are taken in 120 cc. rubber stoppered bottles by exhausting air from the bottles with an atomizing bulb, Fig. 8. The bottle should be held at arms length while sampling so as not to be contaminated with the observer's breath and then tightly stopped until the sample can be analysed on a Peterson-Palmquist apparatus for carbon dioxide.

CHAPTER XVIII

HOW TEMPERATURE, HUMIDITY AND AIR MOTION AFFECT HUMAN COMFORT

AN ordinary thermometer is only of relative value for indicating a person's feeling of comfort as the sense of warmth experienced by the human body is not due alone to the temperature registered by the dry bulb thermometer, neither does it depend solely upon the wet bulb temperature. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with high moisture content.

This is according to the conclusions determined through a series of investigations conducted by the Society in conjunction with the U. S. Public Health Service and the U. S. Bureau of Mines at Pittsburgh, Pa.

Human comfort or discomfort depend largely on body temperature and therefore on the relation between the rate of heat production and dissipation. By the process of metabolism heat is constantly generated within the body, while on the other hand, loss of heat is constantly occurring from the surface of the body by radiation, convection and evaporation. To maintain a constant body temperature the loss of heat must equal the heat produced. It is therefore apparent that any interference with the elimination of heat from the body is accompanied by a rise in temperature and a feeling of discomfort.

There are three principal factors affecting loss of body heat:

1. Temperature. 2. Humidity. 3. Air motion.

As the temperature of the air and surrounding objects rises, the loss of heat by convection and radiation decreases. When the air temperature reaches that of the body, the loss by radiation and convection ceases. Finally as the air temperature exceeds that of the body, heat passes from the air to the body.

If on the other hand, the relative humidity is increased the heat loss by evaporation decreases. If while the dry bulb temperature increases, the wet bulb temperature decreases sufficiently, the increase in loss of heat by evaporation may be made equal to the decrease in loss of heat by radiation and convection, resulting in no change in body temperature or comfort.

From the above, it is concluded that there must necessarily exist certain combinations of temperatures and humidities, which produce the same total body heat loss by radiation, convection and evaporation and therefore the same feeling of comfort or discomfort. Lines passing through such air conditions plotted as a psychrometric chart may be called

Prepared especially for THE GUIDE by F. C. Houghten, director of the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

equal comfort lines. The fact is further substantiated by the general experience of heating engineers in observing that the lower the humidity the higher the dry bulb temperature required for the same degree of comfort.

A series of tests have been made in the two psychrometric rooms of the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, in order to locate these lines on the psychrometric chart, both for still and moving air and the detailed data obtained is to be found in the Society's TRANSACTIONS, Vol. 27-32 inclusive, and in the JOURNALS for 1926 and 1927.

The relation of temperature and humidity to comfort, in still air, for persons normally clothed, is given in Fig. 1 while the effect of air motion upon comfort or effective temperatures for persons normally clothed are given in the Tables 1 to 7, which cover still and various moving air conditions.

HOW TO USE THE COMFORT CHART AND TABLES

In the Psychrometric Chart, dry bulb temperature is plotted as abscissae and grains of moisture per pound of dry air as ordinates. The maximum moisture which the air can hold at any temperature gives the saturation or 100 per cent relative humidity curve. Relative humidities between 0 and 100 per cent are given by a series of curved lines similar to the saturation curve. The wet bulb temperatures for all atmospheric conditions are given by a series of nearly parallel oblique lines. Effective temperature is given by a series of oblique but not parallel lines which approach being parallel to the wet bulb lines at high temperatures and humidities, and dry bulb lines at low temperatures. The numerical value of the wet and effective temperature lines is given by the dry bulb temperature of their intersection with the saturation curve.

Dry bulb temperature is the true temperature of the air as determined by an ordinary thermometer. It does not, however, accurately indicate a person's feeling of warmth. If the humidity is high a person will feel warmer at the same dry bulb temperature than he will if the humidity is low.

Wet bulb temperature is not the temperature of the air but that which a thoroughly wet body will attain if the air passes over it for a sufficient length of time and with a high enough velocity. A person is not thoroughly wet and hence does not react entirely in accordance with the wet bulb temperature. At high temperatures when the body is wet with perspiration, it reacts more nearly to wet bulb temperature while at low temperatures the body is comparatively dry and reacts more nearly in accordance with the dry bulb temperature.

Effective temperature is an experimentally determined scale which unlike the dry bulb and wet bulb scales is a true measure or index of a person's feeling of warmth in all combinations of temperature and humidity. In other words with any given effective temperature a person will feel the same degree of warmth or coldness regardless of the dry bulb or wet bulb temperature.

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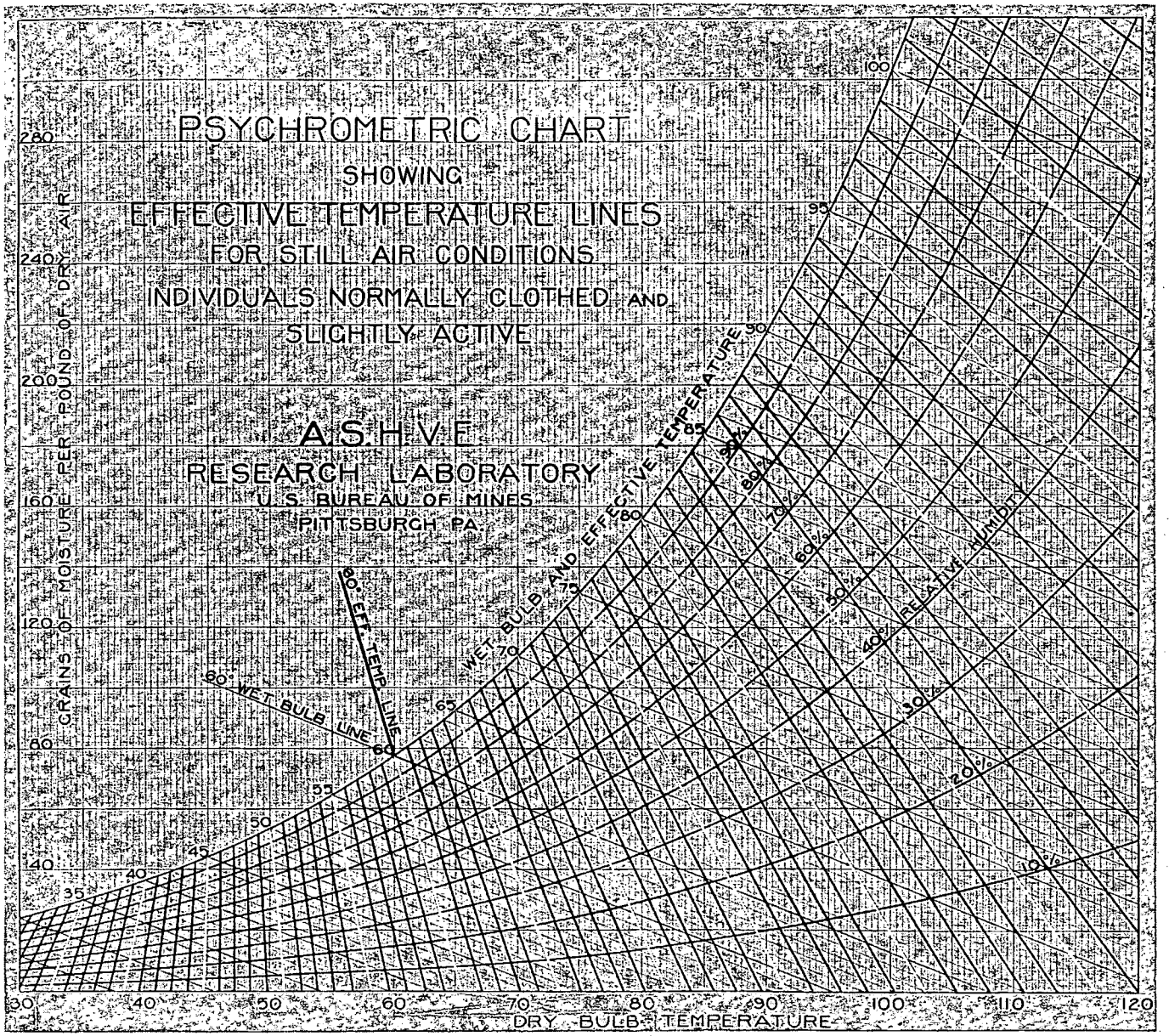


FIG. 1. STANDARD PSYCHROMETRIC CHART WITH EQUAL COMFORT LINES SUPERIMPOSED

THE COMFORT ZONE

That range of effective temperatures over which 50 per cent of people feel comfortable, namely 62 deg. effective temperature to 69 deg. effective temperature, is called the Comfort Zone.

That particular effective temperature at which a maximum number of people feel comfortable is 64 deg. effective temperature and is called the comfort line. While at rest in still air, 97 per cent of all people are comfortable at this temperature.

Tables 1 to 7 give the relation between dry and wet bulb temperatures, and effective temperature for still air, and various air velocities up to 700 ft. per min. for persons normally clothed.

The data given in the chart, Fig. 1, and Tables 1 to 7, are for persons normally clothed and differ somewhat from the data contained in previous editions of the Guide for person's stripped to the waist. The tables are divided into zones with correction factors in black face at the side which subtracted from the "normally clothed effective temperatures" will give the "stripped to the waist effective temperatures" with sufficient accuracy for all practical purposes.

There are four fundamental ways of producing effective cooling: (1) The dry bulb temperature may be lowered by direct cooling or removal of heat. (2) The moisture content of the air may be reduced. (3) Air motion will produce effective cooling except for extremely severe conditions. (4) Evaporation of water without addition or subtraction of heat is accompanied by an increase in moisture content and a fall in dry bulb temperature along the wet bulb line resulting in effective cooling.

Take as an example a condition of 95 deg. dry bulb and 40 per cent relative humidity having a wet bulb temperature of 75.2 deg. and effective temperature of 83.1 deg. This condition can be made equivalent to 80 deg. effective temperature or it can be made to feel 3.1 deg. cooler by any one of the four fundamental changes mentioned.

(1) By the removal of heat the dry bulb may be made to fall to 88.2 deg. (see Fig. 1) along the "100 grain moisture per pound of dry air" line when the effective temperature will be 80 deg.

(2) Without removal of sensible heat or lowering of the dry bulb the moisture content may be reduced from 100 to 54 grains per pound of dry air, when the effective temperature will be 80 deg.

(3) Upon inspection of Tables 6 and 7, it will be found that 95 deg. dry bulb and 75.2 deg. wet bulb will give 80.2 deg. effective temperature with 500 ft. air velocity and 79.6 deg. effective temperature with 700 ft. air velocity. Interpolation between these two velocities will give 567 as the velocity necessary to make this condition equivalent to 80 deg. effective temperature.

(4) Evaporation of water at room temperature without addition or removal of heat will cause the point on the chart Fig. 1, indicated by our condition, to move along the wet bulb line to the left thereby lowering the dry bulb temperature and increasing the moisture content. The wet bulb temperature will remain the same but the effective temperature will be lowered. By adding 14 grains of moisture without heat, the dry bulb will fall to 86.2 deg. and the effective temperature will fall to 80 deg.

Table 1. Effective Temperature for Various Wet Bulb and Dry Bulb Temperatures for Still Air

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30	32.0	30.0																						
35	37.0	36.2	35.0																					
40		41.0	40.6	40.0																				
45		45.1	45.1	45.0	45.0																			
50			49.1	49.3	49.7	50.0																		
54			52.1	52.4	52.9	53.3	53.8	54.0																
57				54.5	55.0	55.6	56.0	56.3	56.8															
60				56.4	57.0	57.7	58.2	58.6	59.0	59.5	60.0													
62				57.7	58.3	59.0	59.6	60.0	60.4	60.9	61.3	62.0												
64					59.6	60.3	60.9	61.2	61.8	62.2	62.8	63.3	64.0											
66					60.8	61.5	62.1	62.5	63.0	63.5	64.0	64.7	65.3	66.0										
68					62.0	62.7	63.3	63.8	64.3	64.8	65.3	65.9	66.5	67.2	68.0									
70					63.0	63.9	64.5	65.0	65.4	65.9	66.4	67.0	67.8	68.4	69.2	70.0								
72					64.2	65.0	65.6	66.0	66.5	67.0	67.6	68.2	68.9	69.6	70.3	71.1	72.0							
74						66.0	66.6	67.0	67.6	68.1	68.7	69.2	70.0	70.6	71.4	72.2	73.1	74.0						
76						67.0	67.7	68.1	68.7	69.1	69.8	70.3	71.0	71.7	72.4	73.2	74.1	75.0						
78						68.0	68.7	69.1	69.7	70.2	70.8	71.3	72.0	72.7	73.4	74.2	75.0	76.0	77.4					
80						69.0	69.7	70.1	70.6	71.1	71.7	72.3	73.0	73.7	74.4	75.2	76.0	76.9	78.3	80.0				
83							71.0	71.4	72.0	72.5	73.1	73.7	74.3	75.0	75.8	76.5	77.2	78.2	79.7	81.2				
86							72.3	72.8	73.3	73.9	74.4	75.0	75.7	76.2	77.0	77.8	78.6	79.4	80.8	82.4	85.4			
90								74.5	75.0	75.5	76.0	76.6	77.2	77.9	78.6	79.3	80.1	80.9	82.3	83.8	86.6	90.0		
95									76.8	77.3	77.9	78.5	79.1	79.8	80.3	81.1	81.8	82.6	84.0	85.4	88.0	91.2	95.0	
100										79.1	79.6	80.2	80.8	81.3	82.0	82.7	83.4	84.2	85.4	86.7	89.3	92.3	95.8	100.0
105											81.1	81.7	82.2	82.8	83.4	84.1	84.8	85.5	86.7	88.0	90.4	93.2	96.7	100.6
110												83.0	83.6	84.2	84.8	85.4	86.0	86.7	87.7	89.0	91.3	94.0	97.3	101.2
120														86.4	86.9	87.5	88.2	88.8	89.8	90.9	93.0	95.6	98.5	102.2
												3.0		2.0					1		0			

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading; subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table

Table 2. Effective Temperature for Various Wet Bulb and Dry Bulb Temperatures with an Air Velocity of 50 Ft. per Minute

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35	34.1	33.2	31.9			5																		
40	7	38.6	38.0	37.3																				
45		43.2	43.0	42.9	42.6			4																
50			47.6	47.7	47.9	48.0																		
54			50.9	51.0	51.3	51.7	51.9	52.1				3												
57		6		53.3	53.7	54.1	54.5	54.8	55.1															
60				55.2	55.9	56.4	57.0	57.2	57.7	58.0	58.6													
62				56.7	57.3	57.9	58.4	58.8	59.2	59.7	60.1	60.7												
64					58.7	59.2	59.8	60.2	60.6	61.1	61.6	62.1	62.7			2								
66					59.9	60.6	61.1	61.6	62.0	62.4	63.0	63.5	64.1	64.8										
68					61.1	61.9	62.4	62.9	63.3	63.8	64.2	64.9	65.5	66.1	66.8									
70					62.3	63.1	63.6	64.0	64.5	65.0	65.6	66.2	66.7	67.4	68.1	69.0								
72					63.6	64.2	64.9	65.3	65.8	66.2	66.8	67.3	68.0	68.7	69.3	70.2	71.0							
74						65.4	66.1	66.5	67.0	67.4	68.0	68.5	69.1	69.9	70 5	71.3	72.1	73.1		1				
76						66.6	67.1	67.5	68.0	68.5	69.0	69.7	70.3	70.9	71.6	72.4	73.2	74.1						
78						67.6	68.2	68.6	69.0	69.6	70.1	70.7	71.3	72.0	72.8	73.4	74.2	75.2	76.7					
80						68.6	69.1	69.6	70.1	70.6	71.1	71.8	72.3	73.0	73.7	74.4	75.3	76.2	77.6	79.2				
83							70.6	71.0	71.5	72.0	72.6	73.2	73.8	74.4	75.1	75.9	76:7	77.6	79.0	80.6				
86							72.0	72.5	73.0	73.4	74.0	74.5	75.1	75.8	76.4	77.2	78.0	78.8	80 2	81.8	84.7			0
90								74.2	74.6	75.1	75.7	76.2	76.8	77.4	78.0	78.8	79.6	80.4	81.8	83.2	86.2	89.6		
95									76.6	77.1	77.6	78.2	78.7	79.3	80.0	80.7	81.4	82.2	83.4	84.9	87.7	90.9	94.7	
100										78.9	79.3	79.8	80.3	81.0	81.6	82.3	83.0	83.8	85.0	86.3	88.9	92.0	95.6	100.0
105											80.9	81.4	81.9	82.6	83.2	83.8	84.5	85.2	86.3	87.6	90.1	93.0	96.4	100.6
110												82.9	83.4	83.9	84.5	85.1	85.8	86.4	87.5	88.8	91.1	93.9	97.2	101.2
120														86.2	86.8	87.3	87.9	88.6	89.7	90.8	92.9	95.3	98.4	102.3

Note.—To obtain the effective temperatures for any wet and dry bulb reading for a person stripped to the waist; subtract from the normally clothed effective temperature as found in the chart, the factor at the edge of the Table for the particular belt or zone.

TABLE 3. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 100 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

DRY BULB TEMP.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30			**9.0**			**8.0**																		
35	31.5	30.2																						
40		36.3	35.5	34.5				**7.0**																
45		41.3	41.0	40.6	40.0																			
50			46.0	45.9	45.9	45.8				**6.0**														
54			49.4	49.5	49.7	49.9	50.0	50.2				**5.0**												
57				52.0	52.3	52.7	53 0	53 1	53.4															
60				54.3	54.8	55.2	55.6	55.8	56.1	56.5	56.9				**4.0**									
62				55.8	56.2	56.7	57.2	57.5	57.9	58.2	58.6	59.0												
64					57.7	58.2	58.7	59.0	59.4	59.9	60.2	60.8	61.3											
66					59 1	59.7	60.1	60.5	60.9	61.3	61.9	62.3	63 0	63.6										
68					60.4	61.0	61.6	62.0	62.3	62.9	63.3	63.8	64.3	65.0	65.7		**3.0**							
70					61.8	62.3	62.9	63.3	63.7	64.1	64.7	65.2	65.8	66.4	67.0	68.0								
72					63.0	63.6	64.1	64.5	65.0	65.4	66.0	66.5	67.0	67.7	68.4	69.2	70.0							
74						64.7	65.3	65.8	66.2	66.7	67.1	67.8	68.3	69.0	69.8	70.5	71.2	72.2	**2.0**					
76						66.0	66.5	67.0	67.3	67.8	68.3	69.0	69.6	70.2	70.9	71.6	72.4	73.3						
78						67.0	67.6	68.0	68.4	69.0	69.5	70.0	70.6	71.3	72.0	72.8	73.5	74.4	75.9		**1.0**			
80						68.0	68.7	69.1	69.5	70.0	70.5	71.1	71.8	72.4	73.1	73.8	74.7	75.4	77.0	78.6				
83							70.1	70.6	71.0	71 5	72.1	72.7	73.2	73.9	74.6	75.3	76.1	76.9	78.3	80.0			**0.0**	
86							71.6	72 0	72.5	73.0	73 5	74.0	74.7	75.3	76.0	76.7	77.4	78.2	79.7	81.2	84.1			
90								73.8	74.2	74.8	75.3	75 8	76.3	77.0	77.7	78.3	79.1	80.0	81.2	82.8	85.6	89.0		
95									76.2	76.7	77.2	77.8	78.3	78.9	79.6	80.3	81.0	81.8	83.0	84.5	87.2	90.4	94.5	
100										78.5	79.0	79.5	80.1	80.7	81.3	82.0	82.6	83.4	84.7	86.0	88.5	91.6	95.4	100.0
105											80.7	81.2	81.7	82.2	82.8	83.5	84.2	84.9	86.0	87.3	89.8	92.7	96.2	100.6
110												82.6	83.1	83.7	84.2	84.8	85.5	86.2	87.3	88.6	90.8	93.7	97.0	101.1
120														86.2	86.7	87.3	87.8	88.4	89.4	90.6	92.7	95.2	98.3	102.1

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading; subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 4. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 200 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

DRY BULB TEMP.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40		31.9	30.8			**13.0**																		
45		38.0	37.2	36.4	35.6																			
50			42.7	42.5	42.0	41.8		**10.5**																
54			46.8	46.8	46.8	46.8	46.7	46.7		**9.0**														
57				49.5	49.8	49.9	50.0	50.1	50.2			**8.0**												
60				52.0	52.4	52.8	53.0	53.2	53.4	53.7	54.0			**7.0**										
62				53.7	54.0	54.5	54.8	55.0	55.3	55.6	56.0	56.5				**6.0**								
64					55.7	56.1	56.5	56.9	57.1	57.5	57.9	58.3	58.9				**5.0**							
66					57.2	57.8	58.2	58.6	59.0	59.2	59.6	60.0	60.5	61.0										
68					58.8	59.3	59.8	60.0	60.4	60.9	61.3	61.8	62.2	62.9	63.5									
70					60.1	60.8	61.2	61.6	62.0	62.4	62.9	63.3	63.9	64.5	65.1	65.9								
72					61.5	62.2	62.6	63.0	63.4	63.9	64.3	64.9	65.4	66.0	66.7	67.3	68.0		**4.0**					
74						63.5	64.0	64.4	64.9	65.3	65.8	66.3	66.9	67.4	68.0	68.8	69.5	70.3						
76						64.9	65.4	65.8	66.2	66.7	67.1	67.7	68.1	68.8	69.3	70.0	70.9	71.7		**3.0**				
78						66.0	66.7	67.0	67.5	67.9	68.3	68.9	69.4	70.0	70.6	71.3	72.0	72.9	74.3					
80						67.3	67.8	68.2	68.6	69.1	69.5	70.0	70.6	71.2	71.8	72.5	73.2	74.1	75.5	77.0	**2.0**			
83							69.4	69.8	70.2	70.7	71.2	71.7	72.2	72.9	73.5	74.2	75.0	75.8	77.1	78.7				
86							71.0	71.4	71.8	72.2	72.7	73.2	73.8	74.4	75.1	75.8	76.5	77.3	78.7	80.1	83.1		**0.0**	
90								73.3	73.8	74.2	74.7	75.2	75.8	76.3	76.9	77.7	78.3	79.1	80.4	81.9	84.7	88.1		
95									75.9	76.3	76.8	77.3	77.9	78.5	79.0	79.7	80.3	81.1	82.4	83.8	86.4	89.7	94.0	
100										73.3	78.8	79.2	79.8	80.3	80.9	81.5	82.2	83.0	84.2	85 4	88.0	91.0	94 9	100.0
105											80.4	80.9	81.4	82.0	82.5	83.2	83.8	84.6	85.7	86.9	89.3	92.2	95.8	100.7
110												82.5	83.0	83.5	84.1	84.7	85.2	85.9	87.0	88.3	90.4	93.2	96.7	101.3
120										1.0				86.1	86.6	87.2	87.8	88.3	89.3	90.3	92.3	94.9	98.0	102.4

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading; subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 5. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 300 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40																								
45		35.0	34.1	33.1	31.9		**13.0**																	
50			40.0	39.8	39.2	38.7																		
54				44.0	44.0	43.9	43.8	43.7			**11.0**		**9.0**											
57				47.1	47.2	47.2	47.3	47.3	47.4					**8.0**										
60				50.0	50.2	50.4	50.7	50.9	51.0	51.1	51.3													
62				51.9	52.1	52.4	52.7	52.9	53.0	53.2	53.6	53.9												
64					54.0	54.3	54.6	54.9	55.0	55.3	55.7	55.9	56.3											
66					55.7	56.1	56.4	56.7	57.0	57.2	57.6	57.9	58.3	58.9		**7.0**	**6.0**							
68					57.2	57.8	58.1	58.4	58.8	59.1	59.4	59.8	60.2	60.7	61.2									
70					58.9	59.3	59.8	60.1	60.4	60.8	61.2	61.6	62.0	62.6	63.1	63.8		**5.0**						
72					60.4	61.0	61.3	61.7	62.0	62.3	62.8	63.2	63.8	64.3	65.0	65.6	66.3							
74						62.3	62.8	63.2	63.6	64.0	64.4	64.9	65.3	66.0	66.5	67.1	67.9	68.7	**4.0**	**3.0**				
76						63.8	64.2	64.7	65.0	65.4	65.9	66.3	66.9	67.4	68.0	68.7	69.3	70.1						
78						65.2	65.6	66.0	66.3	66.8	67.2	67.8	68.2	68.8	69.4	70.1	70.8	71.6	73.0					
80						66.3	66.8	67.2	67.7	68.1	68.6	69.0	69.6	70.1	70.8	71.3	72.1	73.0	74.2	75.7	**2.0**			
83							68.7	69.1	69.5	69.9	70.3	70.9	71.4	72.0	72.7	73.3	74.0	74.8	76.0	77.4		**1.0**		
86							70.4	70.8	71.2	71.6	72.1	72.6	73.1	73.7	74.3	75.0	75.6	76.3	77.7	79.0	82.0			
90								72.9	73.3	73.8	74.2	74.8	75.2	75.7	76.3	77.0	77.7	78.3	79.6	81.0	83.8	87.2		**0.0**
95									75.6	76.0	76.4	76.9	77.4	78.0	78.6	79.2	79.9	80.6	81.8	83.1	85.7	89.0	93.3	
100										78.0	78.4	79.0	79.5	80.0	80.6	81.2	81.8	82.4	83.6	84.9	87.3	90.5	94.6	100.0
105											80.3	80.7	81.2	81.7	82.3	82.8	83.4	84.2	85.2	86.4	88.8	91.8	95.6	100.7
110												82.3	82.8	83.3	83.8	84.3	85.0	85.6	86.6	87.8	90.0	92.9	96.6	101.3
120														85.9	86.4	86.9	87.4	88.0	89.0	90.1	92.2	94.7	98.0	102.3

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading; subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 6. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 500 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
Effective Temperature																								
30																								
35																								
40																								
45	**13.0**	31.5	30.3																					
50			36.9	36.1	35.2	34.3																		
54		**10.5**		41.0	40.7	40.2	39.8	39.6																
57				44.4	44.3	44.1	44.0	44.0	43.8															
60				47.6	47.6	47.7	47.6	47.6	47.7	47.8	47.8													
62			**9.0**	49.6	49.8	49.8	50.0	50.0	50.0	50.1	50.3	50.5												
64					51.7	51.9	52.0	52.1	52.2	52.5	52.6	52.9	53.1											
66			**8.0**		53.5	53.8	54.0	54.2	54.4	54.7	55.0	55.2	55.5	55.9										
68					55.2	55.8	56.0	56.2	56.5	56.8	57.0	57.3	57.7	58.0	58.3									
70					57.1	57.6	57.9	58.1	58.4	58.6	58.9	59.2	59.7	60.0	60.5	61.0								
72				**7.0**	58.8	59.2	59.6	59.9	60.1	60.4	60.8	61.1	61.5	62.0	62.3	63.0	63.5							
74						60.8	61.2	61.5	61.9	62.2	62.5	62.9	63.3	63.8	64.2	64.8	65.3	66.0						
76						62.4	62.9	63.1	63.5	63.8	64.2	64.6	65.0	65.4	66.0	66.5	67.1	67.8						
78					**6.0**	64.0	64.4	64.8	65.0	65.3	65.8	66.2	66.6	67.0	67.6	68.1	68.8	69.4	70.5					
80						65.4	65.9	66.2	66.5	66.8	67.2	67.7	68.0	68.6	69.1	69.8	70.3	71.0	72.1	73.4				
83						**5.0**	67.7	68.2	68.6	69.0	69.3	69.8	70.2	70.7	71.2	71.9	72.4	73.1	74.2	75.4				
86							69.8	70.2	70.4	70.8	71.2	71.7	72.1	72.6	73.1	73.7	74.3	75.0	76.2	77.4	80.1			
90						**4.0**		72.4	72.8	73.2	73.6	74.0	74.4	74.9	75.4	76.0	76.7	77.3	78.4	79.8	82.2	85.6		
95							**3.0**		75.3	75.7	76.1	76.5	77.0	77.4	78.0	78.6	79.2	79.8	80.9	82.0	84.6	87.8	92.3	
100								**2.0**		77.9	78.3	78.8	79.2	79.6	80.1	80.7	81.2	81.8	82.9	84.1	86.5	89.5	93.8	100.0
105											80.2	80.6	81.0	81.4	82.0	82.5	83.0	83.7	84.7	85.8	88.2	91.0	95.0	100.7
110										**1.0**		82.2	82.7	83.1	83.6	84.1	84.7	85.3	86.2	87.3	89.5	92.3	96.0	101.3
120												**0.0**		85.8	86.3	86.8	87.3	87.9	88.8	89.8	91.8	94.3	97.6	102.5

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading; subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

TABLE 7. EFFECTIVE TEMPERATURE FOR VARIOUS WET BULB AND DRY BULB TEMPERATURES WITH AN AIR VELOCITY OF 700 FT. PER MINUTE

Persons Normally Clothed and Slightly Active

Wet Bulb Temperature

Effective Temperature

Dry Bulb Temp.	25	30	35	40	45	49	52	54	56	58	60	62	64	66	68	70	72	74	77	80	85	90	95	100
30																								
35																								
40																								
45			35.0	34.0	32.8	31.1																		
50				39.4	38.8	38.0	37.2	35.8																
54				43.0	42.7	42.2	42.0	41.8	41.4															
57				46.3	46.1	46.0	46.0	45.9	45.7	45.6														
60				48.3	48.3	48.3	48.2	48.2	48.2	48.2	48.2													
62					50.3	50.5	50.6	50.7	50.7	50.8	50.9	51.0	51.1											
64					52.3	52.6	52.8	52.9	53.0	53.0	53.2	53.4	53.6	53.9										
66					54.3	54.5	54.8	54.9	55.0	55.2	55.4	55.7	56.0	56.2	56.5									
68					56.0	56.3	56.6	56.8	57.0	57.2	57.4	57.8	58.0	58.3	58.8	59.1								
70					57.8	58.1	58.3	58.6	58.9	59.1	59.4	59.8	60.0	60.4	60.8	61.2	61.8							
72						59.9	60.1	60.4	60.7	60.9	61.2	61.6	62.0	62.4	62.8	63.2	63.7	64.2						
74						61.4	61.9	62.1	62.4	62.8	63.1	63.3	63.8	64.1	64.6	65.1	65.6	66.1						
76						63.1	63.5	63.8	64.0	64.3	64.7	65.0	65.4	65.8	66.3	66.8	67.3	68.0	68.9					
78						64.6	65.0	65.2	65.6	65.8	66.2	66.6	67.0	67.4	68.0	68.4	69.0	69.6	70.6	71.8				
80							67.1	67.4	67.8	68.0	68.5	68.9	69.3	69.8	70.2	70.8	71.3	71.9	73.0	74.1				
83							69.2	69.5	69.8	70.2	70.6	71.0	71.3	71.8	72.3	72.8	73.4	74.0	75.0	76.2	78.6			
86								71.9	72.2	72.6	73.0	73.4	73.9	74.3	74.8	75.3	75.9	76.5	77.5	78.7	81.2	84.7		
90									75.0	75.3	75.7	76.0	76.5	76.9	77.4	77.9	78.5	79.2	80.2	81.3	83.8	87.1	91.6	
100										77.6	77.9	78.3	78.8	79.3	79.8	80.2	80.8	81.4	82.4	83.6	85.8	89.0	93.3	100.0
105											80.0	80.3	80.8	81.2	81.8	82.2	82.8	83.3	84.3	85.3	87.7	90.6	94.8	100.9
110												82.1	82.5	82.9	83.3	83.8	84.3	84.9	85.8	87.0	89.2	92.0	95.8	101.5
120														85.6	86.1	86.6	87.0	87.6	88.5	89.6	91.5	94.1	97.6	102.4

17.0 | 14.0 | 12.0 | 9.5 | 7.5 | 5.5 | 3.5 | 1.5 | 0.0

Note.—To obtain the effective temperatures for a person stripped to the waist, for any wet and dry bulb reading, subtract from the normally clothed effective temperature, the factor for the particular belt or zone found at the edge of the Table.

The best method of producing effective cooling to be employed in any particular case will depend upon accompanying circumstances and should be determined by a competent engineer. Generally removal of heat or water vapor or both, are most effective. However excepting under unusually favorable circumstances direct cooling or dehumidifying is an expensive process and can only be resorted to where the results will justify the cost. Effective cooling by air motion or evaporation of water is relatively much less expensive. Unfortunately however these methods of cooling are limited to certain conditions of temperature and humidity. Cooling by evaportaion of water is effective when the air is dry or when there is considerable difference between the wet and dry bulb temperature. Cooling by air motion is most effective at low temperatures. When the effective temperature approaches that of the body little or no cooling results and for certain higher temperatures air motion will make an uncomfortable condition even less bearable.

For moderately high temperatures greater effective cooling is experienced as the result of air motion at high humidities than at low humidities. This suggests a valuable method of cooling by a combination of evaporation and air motion. Take, for example, a summer condition of 96 deg. dry bulb and 80 deg. wet bulb having an effective temperature of 85.7 deg. A 300 ft. air velocity will improve this condition by only 2.2 deg. Saturation with water vapor will give a condition of 80 deg. dry bulb, 80 deg. wet bulb and 80 deg. effective temperature or 5.7 deg. effective temperature improvement. A 300 ft. air velocity with this new wet and dry bulb will give an effective temperature of 75.7 deg. or a total improvement of 10.0 deg.

Example 1.—Given dry bulb and wet bulb temperatures of 75 and 68 deg. *First:* what is the effective temperature? *Second:* is this condition warmer or cooler than 80 deg. dry bulb and 60 deg. wet bulb?

Answer.—The first condition is given by the intersection of the 75 deg. dry bulb line and the 68 deg. wet bulb line. The effective temperature is given by the numerical value of the effective temperature line, passing through this point and indicated by the scale along the saturation curve, and is 71.9 deg. effective temperature. The second condition is given by the intersection of 80 deg. dry bulb and 60 deg. wet bulb and is 71.7 deg. effective temperature. It is therefore 0.2 deg. effective temperature cooler than the first condition.

Example 2.—Given 76 deg. dry bulb and 61 deg. wet bulb how many degrees difference between this condition and the comfort line or 65 deg. effective temperature?

Answer.—The effective temperature of this condition is given by the intersection of the 76 deg. dry bulb and 61 deg. wet bulb lines and is 70 deg. effective temperature or 5 deg. effective temperature warmer than the comfort line.

Example 3.—Given the dry and wet bulb temperatures in a room of 76 and 54 deg. respectively, what air velocity will be necessary to make this condition ideally comfortable, that is, 65 deg. effective temperature?

Answer.—From Table 1 for still air it will be seen that this condition has an effective temperature of 68.1 deg. in still air. Looking through the various Tables 2 to 7 for moving air it will be found that with a 300 ft. velocity this condition will have an effective temperature of 64.7 deg., and with a velocity of 200 ft. (Table 4) it will have an effective temperature of 65.8 deg. Interpolating between these two velocities the desired velocity is found to be 273 ft. per min.

Example 4.—Given a condition having dry and wet bulb temperatures of 90 and 85 deg. respectively, how much cooler will this condition feel if 300 ft. air velocity is supplied instead of still air?

Answer.—From Table 1 it will be found that this condition in still air has an effective temperature of 86.6 deg., while if the air has 300 ft. velocity it will be found from Table 5 that it will have an effective temperature of 83.8 deg. Cooling of 2.8 deg. will be produced by the 300 ft. air velocity.

In practice these theoretical values will not be fully achieved. Therefore an allowance should be made for an increase in temperature and a decrease in humidity of the diffusing air before it strikes the occupants. The clothing worn and the kind of work done will also have a retarding effect. The experimental evidence now available, of the laws governing the cooling of the human body is of great value in predicting just what may be expected of a definite air velocity at a given temperature and moisture content when directed upon the body of lightly clothed individuals. Complete reports with other detailed examples of the use of Laboratory Human Comfort Data are to be found in the A. S. H. V. E. TRANSACTIONS, Vol. 27-32 for 1921 to 1926 inclusive.

There are many applications for these data. In warm weather it is especially desirable to have greater comfort in school rooms, theaters, auditoriums, also factories, foundries, iron, steel and glass works, mines and other places where workers are subjected to extreme temperature conditions. Maintaining comfortable conditions indoors in summer when the thermometer registers about 95 deg. is a more complicated problem than maintaining the proper condition in winter.

Effective cooling, using cold water or refrigeration, frequently is resorted to in theaters and other public buildings and this practice may be expected to increase. While increased comfort due to cooling is expensive and while it may generally be considered a luxury there are few other luxuries which offer as much real comfort for the money expended. The fact that provision for cooling in hot weather is not found in more homes, clubs and places of assembly is largely due to the fact that possible comfort to be attained, from this source has not been clearly demonstrated to the building public by the air conditioning engineer.

CHAPTER XIX

SYSTEMS OF VENTILATION

VENTILATION, whether natural or mechanical, means the displacement of vitiated air from any enclosure and its replacement with fresh air. The systems may be classified as follows:—

Method of Supply	Method of Exhaust
Window	Gravity
Gravity	Fan
Fan	Gravity
Fan	Fan (with or without recirculation)

In addition to the above, there is also employed a method requiring fan supply without any exhaust fans or gravity exhaust duct work, the exhaust depending entirely on natural leakage around doors and windows and through open entrance doors. This system is utilized in theatres and auditoriums where air cooling and refrigeration is employed in which a large percentage in varying quantities is recirculated. The air forced outward by interior excess air pressure is equivalent in volume to the percentage of outside air taken in by the supply fans.

The movement of air in natural ventilation systems is produced by the difference between the density of the column of air in the ducts and the density of the outside air. The greater the difference in temperature between the two columns of air the more rapid the air movement.

In mechanical systems the circulation of air is maintained positively and uniformly regardless of outside air conditions and when properly designed and operated they will furnish any required temperature or humidity under automatic control.

Five methods of fan application in heating and ventilating are common, as follows:

1. Fan system supplies both heating and ventilation.
2. Fan provides air for ventilation, direct radiation supplies heat.
3. Fan provides air for ventilation and portion of heating, remainder supplied by direct radiation.
4. Fan system does entire heating (no ventilation supplied).
5. Fan system provides ventilation exclusively.

Typical installations of the first type of system will be found in churches, theatres, auditoriums and other places of assembly requiring a relatively large amount of ventilation and little heating. The second type of system is usually provided in hotels and office buildings where only certain rooms need ventilation. Experience has shown that the third type is economical for schools, manufacturing plants doing special work, hotels and other places where a properly controlled air volume is essential.

Compiled and revised by John Howatt, E. P. Heckel, W. A. Rowe and Samuel R. Lewis.

System four is especially adapted to industrial plants and shops to convey heat to the points desired and to create an effective air motion and uniform temperature with minimum heat loss. When the fan is required to do both heating and ventilating it is necessary to keep the fans in operation. Great success has been reported in school work with systems of this kind, particularly because of its flexibility, easy temperature and humidity control, and economy of operation.[1]

The Fan System for Heating and Ventilating consists of a combination of a fan operating in conjunction with a blast heater, with or without a system of air distributing ducts. An air washer or humidifier may be added when required without otherwise changing the type of system. For heating purposes only, the fan system may or may not be used, depending on circumstances and the requirements to be met. The fan system may be used to supply both heat and fresh air for ventilation, or it may be used in conjunction with some form of direct radiation which is to care for the heat losses. When used for ventilating purposes, the fan will be required to supply whatever amount of air is specified to meet the ventilation requirements. The system may be arranged so that the fan may blow the air through the heaters, or may draw the air through the heaters. Each arrangement possesses its own peculiar advantages, but the selection depends largely upon the individual requirements of the installation.

The draw-through apparatus is usually employed in factory buildings on account of its compactness as well as on account of the advantage gained by connecting directly to the piping system. In this case the temperature of the air delivered will be the same for all parts of the building. The blow-through apparatus is used in public buildings, or wherever different temperatures and independent temperature regulation are required for different rooms of the building. The use of a by-pass around the heating coils permits the mixture of hot and cold air in any desired proportions, by the use of a mixing damper at the point where the two ducts, one from the heater, and one from the by-pass, joint to form one duct leading to the room. In the case of public buildings, the fan frequently blows the warm air into a space termed a plenum chamber, from which the air ducts radiate to the various rooms of the building; this arrangement is sometimes called the plenum system of heating and ventilating.

Air supply systems may be distinguished as upward and downward systems; the former being used frequently in such buildings as theaters and auditoriums where people are associated closely. Air is supplied near the floor and exhausted through grilles in or near the ceiling.

The downward plan is used in schoolrooms, hospitals, and other public buildings, air being introduced about 8 ft. above the floor and drawn out near the floor. The selection of either system depends upon conditions confronting the engineer.

The amount of heat to be supplied is governed by the losses from transmission plus those from infiltration, with proper allowances for heat

[1]AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS TRANSACTIONS, Vol. 25, 1919. Comparative Study of Natural and Mechanical Ventilation for School Rooms, Legg & Walker; Vol. 28, 1922, Intermediate and Junior High Schools in Detroit, H. W. Anderson; Vol. 29, 1923, Heating and Ventilating Chicago Schools, John Howatt.

supplied by persons or processes. Temperatures usually specified for various types of buildings are to be found in Table 1.

The amount of air to be supplied depends largely upon the type of service required, the amount of heat needed, the perfection of ventilation demanded, etc.

The total quantity of air to be circulated in an indirect heating system, either mechanical or gravity type, is demonstrated in the seven cases set forth in the Fig. 1, Cases 1 to 6, page 294 as follows:

H = heat loss of room or building as determined by formulae and data given under Chapter I (B.t.u. per hour)
M = weight of air passing into room per hour in pounds from the heating system
M_r = weight of air recirculated per hour, pounds
M_o = weight of air drawn into the system from the outside for the ventilation requirements per hour lb. and passed through the indirect radiation system
M_b = weight of tempered air by-passed around the reheater per hour, pounds
M_h = weight of air passed through heater or reheater per hour, pounds
t = mean air temperature of the room of building
t_o = mean outside air temperature
t_1 = mean temperature of the air entering the heater
t_2 = mean temperature of the air leaving the indirect radiator
t_x = temperature loss assumed in the air duct system
t_y = temperature of the air entering the room or building
0.24 = specific heat air of constant pressure. (B.t.u. required to raise 1 lb. of air 1 deg. fahr.)

The mean temperature t_2 of the air leaving the indirect radiator (blast heater, tempering coil, reheater, unit heater or gravity indirect radiator) should be learned from the makers, tables for the heater or indirect radiator or heater it is proposed to use.

Case 1—When all of the air passing through indirect heater is recirculated air:

$M_o = 0$; $M_h = M_r = M$; Temperature of air entering heater, $t_1 = t$; $M = \dfrac{H}{0.24\,(t_y - t)}$ ....(1)

Case 2—When all of the air passing through the indirect heater is drawn from the outside:

$M_r = 0$; $M_h = M = M_o$ Temperature of air entering heater, $t_1 = t_o$ $M = \dfrac{H}{0.24\,(t_y - t)}$ ....(2)

Case 3—When a portion of the air passing through the indirect heater is outside air and the remainder recirculated air:

$$M_h = M = M_r + M_o = \frac{H}{0.24\,(t_y - t)} \quad \text{.....(3)}$$

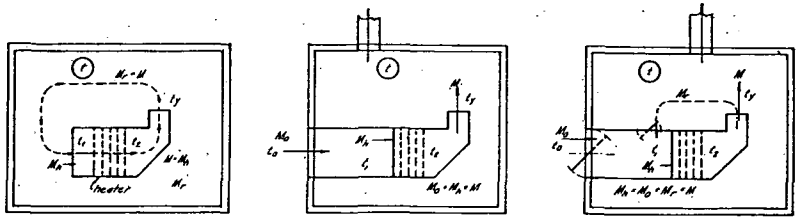
In this case M_o is known from the ventilating requirements and the amount of air to be recirculated is ascertained by the following formula: $M_r = M - M_o$ or $M_r = \dfrac{H}{0.24\,(t_y - t)} - M_o$ .....(4)

The mean temperature of the air entering the indirect heater is ascertained by the following formula:

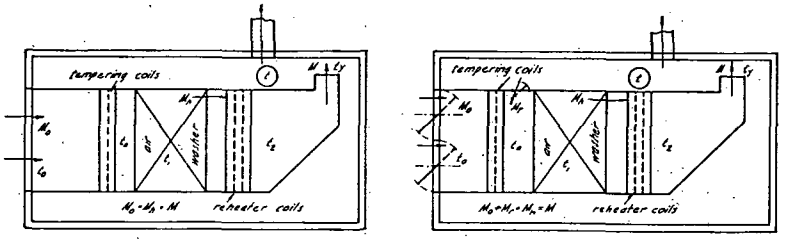
$$t_1 = \frac{M_o\,(t_o + 460) + M_r\,(t + 460)}{M_o + M_r} - 460 \quad \text{.....(5)}$$

Case 4—When all of the air circulated is drawn from the outside and passed through a tempering coil, air washer or humidifier and reheater.

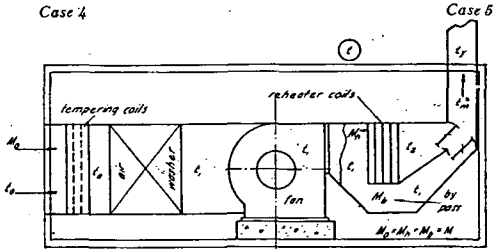
The temperature of the air t_1 entering the reheater will have the same dewpoint temperature as the air in the room or building to which the air is delivered, having temperature t and relative humidity as specified. If the relative humidity is not specified it shall be assumed as 35 per cent. If the room temperature is not specified it shall be assumed as 70 deg. fahr.



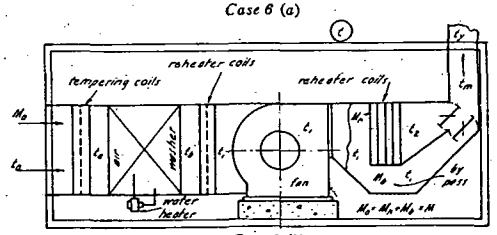
Case 1 Case 2 Case 3



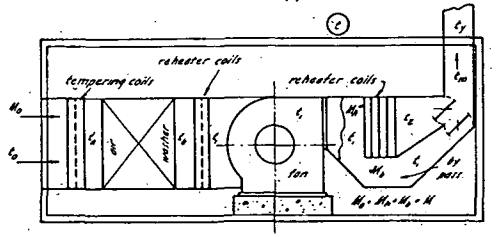
Case 4 Case 5



Case 6 (a)



Case 6 (b)



Case 6 (c)

A relative humidity of 35 per cent for a room temperature of 70 deg. has been selected because this is the highest percentage of moisture which the air can hold without producing dripping on single-thickness windows in cold weather.

In this case: $M = M_o = M_h = \frac{H}{0.24\ (t_y - t)}$ .....(6)

If it is desired to maintain a room temperature of 70 deg. with 35 per cent relative humidity from an outside temperature of zero and with simply an air washer without any water heater in connection, the tempering coil must be of sufficient capacity to heat the entering air from the outside temperature to 88 deg. dry bulb temperature and 52 deg. wet bulb temperature, and this will be represented by t_a in the diagram. In this case the difference is 36 deg. between the wet bulb temperature and the dry bulb temperature and assuming the washer to be 67 per cent efficient, moisture will be evaporated into the air in sufficient quantity to bring the temperature down to 24 deg. which is 67 per cent of 36 deg. Subtracting 24 deg. drop in temperature through the air washer from 88 deg. dry bulb temperature of the air entering the air washer, gives 64 deg. as the final temperature of the air leaving the air washer, the wet bulb temperature remaining at 52 deg. The reheater will heat the air to any temperature necessary to take care of the heat losses since room heating is desired.

The dewpoint temperature of the air leaving the air washer and in the room itself will be 41 deg.

Using the same illustration and assuming that a humidifying air washer is used with a water heater, the tempering coil will simply have one stack, section or tube row deep to raise the air temperature to about 35 deg. from zero outside temperature. The hot water sprays in the air washer will saturate this air at a tempearture of 41 deg. and the reheater will simply raise this temperature to any point required to maintain a room temperature of 70 deg. and a relative humidity of 35 per cent.

The amount of heat to be furnished by the water heater in connection with the humidifying air washer is made up of the sum of two factors—*First:* to heat the specified air volume from the temperature leaving the tempering coil to the saturated air temperature leaving the washer, and *Second:* to evaporate sufficient moisture into this air to saturate it at the temperature required.

If only 23 per cent relative humidity is desired in the room in connection with 70 deg. dry bulb temperature, the temperature entering the air washer, without water heater will be 64 deg. dry bulb, and the temperature leaving the air washer will be 48 deg. dry bulb, which is a drop of 16 deg. through the washer or 67 per cent of 23½ deg. difference between 64 deg. dry bulb and the corresponding 40½ deg. wet bulb temperature.

The illustration in connection with Case 4 indicates that this arrangement is used entirely for heating the room by the fan system. In many cases the heat losses in a room or building are taken care of entirely by direct radiation, and in such cases the final temperature of the air leaving the heater will probably be in the neighborhood of 80 deg. In such a case the same arrangements of tempering coils and reheaters will be used. The arrangement shown in the diagram contemplates the same air temperature being delivered to all rooms on this system, and will not be applicable to the heating of several rooms where individual control of each room is desired.

Case 5—When a portion M_o of the air circulated is drawn from the outside and the remaining M_r recirculated air, the air drawn from the outside is passed through a tempering coil and the mixture of air, from the outside and recirculated air, being passed through an air washer or humidifider and a reheater.

Similar conditions will apply to this Case 5 as have been outlined for Case 4 except that a percentage of recirculated air at a different dry and wet bulb temperature and a different percentage of relative humidity will be mixed with the fresh air after it has been warmed by the tempering coil.

In this Case 5, M_o is known from the ventilation requirements as specified, and the amount of air permitted to be recirculated is, therefore:

$$M_r = \frac{H}{0.24\ (t_y - t)} - M_o \quad \text{.....(7)}$$

Case 6 (a, b, c)—When all of the air circulated is drawn from the outside, passed through a tempering coil and air washer or humidifier, a portion of the tempered and

conditioned air passed through an indirect heater or reheater and a portion of the tempered and conditioned air by-passed around the reheater and the mixture passed into the room or building for heating and ventilating.

The weight of air to be circulated per hour equals (M_o) as determined by the ventilation requirements. The dry bulb temperature of the mixture of tempered and reheated air entering the room or building is to be ascertained by the following formula:

$$M_o \times 0.24\ (t_y - t) = H \quad \text{.....(8)}$$

$$t_y = \frac{H + 0.24\ M_o t}{0.24\ M_o} \quad \text{.....(9)}$$

This case illustrates the arrangement of apparatus when the heating of several rooms is required with individual control of temperature for each room. The arrangement of apparatus, including tempering coil, air washer or humidifier, retempering coil and reheater coil, will be the same as has been outlined in Case 4.

The air leaving the reheater and the air by-passed around the reheater, although having different dry bulb temperatures, will have the same dewpoint temperature as the air t in the room or building to which the air is delivered and with relative humidity as specified; if no relative humidity is specified it can be assumed as 35 per cent. If no room temperature is specified it should be assumed as 70 deg. The relative weights of air passed through the reheater and by-passed around the reheater shall be ascertained by the following method:

X = Parts of reheated air in mixture
$(1 - X)$ = Parts of tempered air in mixture
t_y = Mean dry-bulb temperature of the mixture entering room or building
t_x = Loss of temperature in the duct system
t_1 = Mean dry bulb temperature of the air entering reheater and by-pass
t_2 = Mean temperature of the air leaving the reheater

$$(X)\ (t_2 + 460) + (1 - x)\ (t_1 + 460) = (t_m + 460) \quad \text{.....(10)}$$

t_m = Mean tempearture of air entering the duct system = $(t_y + t_x)$.
SOLVE: for X. Then $M_h = X$

M_h is the weight of air in pounds per hour to be passed through the reheater. The temperature t_y will ordinarily be different for each room of the building. The *total weight* of air passed through the reheater will be the sum of the requirements for all the rooms.

Case 7—Indirect system for warming the air drawn in from the outside for ventilating purposes only. (When an indirect system is employed to warm the air drawn into the system from the outside for ventilating purposes only, the heat loss is provided for by direct radiation or by some other means).

The weight of air to be circulated per hour is M_o as may be determined from the specified ventilation requirement $M_h = M = M_o$. The temperature of the air delivered to the room t_y shall be assumed 5 deg. higher than room temperature t specified.

a. If no air-conditioning apparatus is to be employed the arrangement is similar to *Case 2* where $t_1 = t_o$ and $t_y = t + 5$.

b. If air-conditioning apparatus is to be employed the arrangement is similar to *Case 4*; $M_h = M = M_o$.

Loss of Temperature in Duct Systems (t_x):

a. When the indirect heater and duct system, are located in the enclosure to which the air is to be delivered, it may be assumed that there is no loss of temperature between the indirect heater and the point or points of discharge into the enclosure. $t_x = 0$.

b. For gravity indirect heating, a loss in air temperature of 5 deg. for the first floor, 8 deg. for the second floor, and 10 deg. for the third floor between the indirect radiator and room register can be assumed.

c. For ducts run underground an allowance must be made based on the estimated heat loss of the duct, assuming an average temperature of the ground of 55 deg. fahr.

d. For ducts run in outside walls to the second floor and above, a loss of not less than 10 deg. shall be used in the calculations.

When the heating and ventilation requirements have been found the size of the heater and fan are calculated for a given friction, temperature range, pressure loss in ducts, etc. Pressure losses build up rapidly as velocities are increased and generally vary approximately as the square of the velocity. The allowable pressure loss through the heater should in general not exceed 50 per cent of the total static pressure of the system. In public building practice allowable pressure loss through tempering coils and reheaters should be under ½ in. of water and when an air washer is used the friction through the tempering coil and reheater should not exceed 40 per cent of the total resistance as a rule.

Factory work permits greater friction allowance for the heaters where duct runs are comparatively short and the resistance of the heater is a large part of the entire pressure loss in the system.

The fan can be selected when the following facts are known:

1. Quantity of air required in cubic feet per minute.
2. Static pressure of system (ducts, heaters, air washers, filter, entrance connections, etc).

The kind of fan will depend upon the service required, disc and propeller fans being used generally where no resistance is built up. In ventilation work centrifugal fans are used largely and these come under two classifications—those with straight radial blades and those with curved blades. Each type of fan has its special applications and there is a definite relation between its pressure characteristics, power requirements, and the service rendered. Where noise is not objectionable, fan efficiency is the governing factor. In places where quiet operation is essential proportionate outlet velocities should be chosen.

The quantity, velocity and pressure of air delivered by the fan should be determined by the A. S. H. V. E. Standard Code for Testing Centrifugal and Disc Fans (See TRANSACTIONS, 1923, Vol. 29, p. 407).

It is well to remember that good practice requires that:

1. The mechanical efficiency of a centrifugal fan should exceed 55 per cent.
2. Air velocity passing through the fan outlet should not cause excessive noise.
3. The fan should operate silently and not transmit noise to ducts.
4. The use of variable speed motors is advisable to meet changes in frictional resistance, when ventilation demands vary, while constant speed motors are less expensive when ventilation requirements remain uniform.

A fan installation rightly designed and operated will be quiet and efficient, but every precaution should be taken to prevent vibration or sound transmission to the rooms.

It is usually more effective to float on cork the entire mechanical apparatus, including its foundations, than to attempt to isolate each separate apparatus. There are several systems for the sound-proofing of machinery available, and contracts may be made covering guaranteed and assured results.

UNIT SYSTEMS*

Unit systems consist of an individual unit incorporating all the apparatus necessary for providing, directing and controlling the necessary volume of air heated to the proper temperature for the purpose. Two types are in common use, one for public building work and the other for factory and industrial installations.

All unit heating and ventilating devices consist essentially of small fans connected closely with heat radiating surfaces. Steam or hot water usually is used for heating, and electric motors usually are used for power.

Public Building Work

A unit heating and ventilating machine intended for public building work consists usually of a small rectangular steel cabinet, enclosing the following essential parts:—

1. A fresh air inlet.
2. An air filter.
3. A motor and fan assembly.
4. A radiator or heating element.
5. A cold air or by-pass chamber.
6. Mixing chamber.
7. Air discharge outlet.
8. Fresh air and recirculating control damper.
9. A by-pass or temperature control damper.

Note.—Both the recirculating control damper and the by-pass damper can be manually operated, or the recirculating control damper may be pneumatically controlled from some remote point. The by-pass or temperature control damper can be automatically operated on room temperature by means of thermostatic motor in connection with the use of any pneumatic automatic temperature control system. (See also Chapter XIII.)

When the fresh air inlet damper is open the fresh air is drawn immediately from out of doors, having the dust and dirt removed by means of the air filters. From this point the air is driven by means of the motor and fan assembly and forced up through the machine, using either polyphase, alternating current or direct current motor.

All of the air may be driven through the radiator to be heated and thence to the room, or all of the air may be driven through the cold air or by-pass chamber and thence to the room, or part of the air may be driven through the radiator and part through the cold air chamber in any desired proportion, depending upon the position of the by-pass damper.

The closing of the fresh air damper simultaneously opens the recirculating grille at the floor line, so that there is a free path for the air to circulate by gravity through the radiator. Thus, when the motor is not operating and the fresh air damper is closed, the radiator of the unit becomes an enclosed direct radiator, functioning in the same manner, as any other enclosed direct radiator. By starting the motor during heating-up period in the morning, the air may be drawn from the room at the floor line, heated, discharged, recirculated, reheated and redischarged, this process continuing until the room has reached the desired temperature, thus effecting a tremendous saving in time and fuel in preparation of the room for occupancy.

With this system of ventilation, the air outlets for the room serve strictly in the capacity of vents to permit of displacement and they

*Data on Unit Systems contributed by H. B. Hedges, New York, N. Y., G. E. Otis, Moline, Ill., and A. J. Nesbitt, Atlantic City, N. J.

should be small, with as little exhausting effect as possible. Under such conditions their location is unimportant further than that they be placed at or very near the floor. In the typical layout they are usually placed in the wall opposite the fan unit.

In school work where it is desired to circulate air through adjoining wardrobes, room outlets should be in low panels of doors or near floor in partitions. Wardrobe outlets may be either at floor or ceiling. The latter arrangement is usually preferable from a purely ventilation standpoint but the former provides a better heating effect. By such a plan direct radiation may usually be omitted from such rooms. When half doors or no doors are used between class-rooms and wardrobes, outlets from the latter must be at the floor.

With the mechanical unit ventilation system exhaust fans or aspirating coils in vent flues are neither necessary nor desirable, it being the idea to force the air out of the rooms under back pressure. Where the outlets are properly proportioned this has an inflation effect that retards infiltration and assists in diffusion. One vent for each machine is sufficient and both the grille and flue should have a net free area of about 18 sq. in. for each 100 cu. ft. of air delivered per minute by the ventilator.

In order to carry out the principle of diffusion and get proper results from the unit system of ventilation, consideration must be given to the number, size, location and general application of the mechanical ventilators. With a correctly designed system and proper equipment, good diffusion will be effected if the frequency of air change in the room ventilated is equivalent to five or more volumes per hour but the extent to which the desirable effect of air motion is present will be governed both by the frequency of air change and the ceiling height.

On the same principle that underlies the necessary distribution of direct radiation there is a limit to the amount of air which can be distributed from a single point in ventilation work if good results are to be expected. Practical experiments seem to indicate that this limit is about 1500 cu. ft. per min. with this type of apparatus. In a practical way this determines the number of unit machines to be used in a given case. Where the very best results are desired it is recommended that the capacity of any single machine be limited to 100 cu. ft. per min. per foot of ceiling height.

Mechanical unit ventilators should be located centrally on the outside wall of the room which they serve. Corner locations are liable to result in inefficient and unbalanced distribution. In fact, under adverse conditions, drafts may result from such a location.

Unit ventilators may be recessed but they should never be enclosed or concealed. Not only are enclosures liable to affect the perfection of diffusion, but from a practical standpoint they interfere with proper care and attention by rendering the machine inaccessible. Moreover, there is a certain psychological value to an exposed machine. The occupants quickly learn its purpose and operation with the result that they appreciate its value and see that it is operated and properly cared for.

No single mechanical unit ventilator should be made to serve more than one room by the extension of ducts from the outlet, since this is contrary to all the basic principles of the system. Adjacent rooms, if

not sufficient in size and importance to be equipped with individual ventilating systems probably do not require any ventilation.

Where the total heat required is in excess of the rated capacity of the unit, the unit must be supplemented by direct radiation. Otherwise, the unit can be used for both heating and ventilating without direct radiation.

No special treatment of vent flues is required by this system, the vitiated air being discharged from the building in the same manner, as all other mechanical systems. It has been found that the best results have been obtained where the cross sectional area of the vent flue does not exceed 20 sq. in. per 100 cu. ft. of air per minute.

Industrial Service

Unit heaters for industrial work consist of a heating element over which air is forced or drawn by means of a power driven fan which also distributes this heated air to the space to be heated. The area that can be served by one unit varies according to the type of unit and the location of the unit within the building.

Industrial units are available in capacities from that of the smallest disc or propellor type fan up to that of gangs of centrifugal fans, and in ranges, expressed in heating output, from perhaps one hundred square feet of radiation up to several thousand square feet of radiation.

They may be placed on the floor, or may be suspended from overhead construction, and may be heated by steam or water or other fluid, or may be direct fired, with coal, oil or gas.

There has been a remarkable recent expansion in the demand and in the production of all sorts of industrial heaters, and their use no longer is confined, by any means, to industrial buildings alone.

The tendency is apparent to return after some digression, toward a location for the units as near the floor as is practicable, especially with suction ducts or high velocity outlets arranged to move the cold heavy stratum of air which is likely otherwise to lie close to floors.

The service of industrial unit heaters is essentially that of heating, and recirculation is usual, with dependence on windows and doors for ventilation. Since the fans can be operated without heating the radiators there is some advantage from them in warm weather.

Due to the very high heat transmission rates from radiators over which air is driven at high speed by fans, industrial unit heaters usually effect material space economies.

CHAPTER XX

MOTIVE POWER FOR FANS

THE selection of motors for heating, ventilating and air conditioning systems is an important consideration for the architect and engineer in producing a plant that is efficient and economical. Points to be discussed briefly are fan characteristics, motor selection, methods of drive and general requirements of control as well as other power sources and sound deadening methods.

FAN MOTIVE POWER

Motive power for fans should be determined in accordance with the Standard Code of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, TRANSACTIONS, Vol. 29, 1923; p. 442.

Fans divide themselves into two general classes; the disc or propellor type, and the centrifugal type.

Disc and Propellor Fans

The disc or propellor type of fan is available for conditions of low air resistance, with very short ducts, or no ducts at all. The low speed of the blades near the hub of such fans, compared with the peripheral speed renders this entire class of fans of low efficiency when overcoming heavy resistance. The air driven by the effective blade areas near the rim can pass back through the less effective blade areas at the hub more easily than it can pass the duct-resistance. The power required for such fans increases with the cube of the speed as the speed is increased, and the static efficiency curve falls rapidly at any given speed when the resistance to air flow is increased.

Disc and propellor fans lend themselves to direct-connected motive power, especially as the speeds may be high enough for economical electric motor speeds.

In specifying direct connected electric motors for these fans it should always be remembered that the motor will be subject to the dust and possible high temperature of the material handled by the fan.

Enclosed and especially cooled electric motors are available for this service, and in many types the fan is suspended on the motor shaft and seems to be incidental to the motor.

Centrifugal Fans

The centrifugal, housed, type of fan is available for conditions of high air resistance, with heaters, ducts, etc., and is used for systems requiring

Material for this section prepared by S. R. Lewis, Chicago.

from one-fourth to two inches or more of water pressure to overcome the air friction.

The power required for such fans is proportional to the volume of the air moved, and to the pressure overcome. Centrifugal fans with radial or forward-curved blades require power proportional to the volume at constant speed and have a power increase as the cube of the speed. If the resistance is increased the air volume is reduced, and the power at constant speed is reduced. If the resistance is reduced the air volume is increased at constant speed, and the power demand will be increased.

Centrifugal fans with backward-curved blades and those with compound curves while following the same general laws as the fans with the forward-curved blades, have been developed to the extent that they have a self-limiting power demand at a certain peripheral velocity even though the resistance at that speed may be decreased.

It is no easy matter to pre-determine the exact resistance to be encountered by a fan, or having determined this resistance, to insure that no changes in construction or operation shall ensue which may increase air resistance, thus requiring more fan speed and power to deliver the required volume, or which may reduce air resistance, thus causing delivery of more air and a consequent increase of power even at constant speed.

It is recommended therefore for centrifugal type fans that the rated power to be supplied shall exceed the rated fan power by a liberal margin, depending on the type of blade, of from 10 per cent minimum, to about 50 per cent maximum.

Justification for liberal power provision exists also in the possibility of varying demand due to changes in ventilation requirements, intensity of occupation, weather conditions, etc.

Speed Control

Some method of volume control of fans usually is desirable. This may be done by varying the peripheral velocity, or by interposing resistance, as by throttling-dampers. Both methods since they reduce the volume of air, reduce the power required. In many installations adjustments of volume are desirable during varying hours of the day. In others an increased supply of air in summer over that needed for winter, is demanded. There is room for judgment in deciding whether speed-control or damper-control shall be used for specific cases. Where noise is a factor, it may be exceedingly desirable to reduce the speed at times, while on the other hand a centrifugal fan which has its normal speed reduced as much as 50 per cent without change in resistance will move so small a volume of air that operating the fan will be hardly worth while.

Electric Motors

Electric power is the almost universal solution for fan operation, and each type of motor and current has its advantages and disadvantages.

Direct-connected electric motors are usually very efficient for fan driving because there is no slippage due to belts, and no wear or noise due to chains or gears.

Unless the fan speeds are high enough to permit comparatively high

rotative speeds, however, direct connected motors must be unduly large and heavy and will be costly. If anything goes wrong with a direct-connected motor there may be a considerable delay in replacing or repairing it, and changes in speed are not always made easily with full efficiency. On the other hand, the non-direct connected motors have transmission subject to wear and slippage, and chains and gears may be noisy. With the latter type, however, changes in speed-ratio are easily made, and in case of a break-down a standard stock-motor may be substituted quickly.

There is no advantage as to mechanical or induction-noise, in the direct-connected slower speed motors over belted higher speed motors. In either case noise seems to result from obscure manufacturing causes, and generally can be controlled by proper sound-insulation in the foundations.

Kinds of Electric Current

In general if direct current is available, it is most satisfactory for fan operation because of the inexpensive and flexible speed-control which is inherent. Where motors are inaccessible or subject to dust, however, direct current motors with their commutators and brushes will generally cause undue up-keep expense, and polyphase induction motors are to be preferred.

Single phase electric motors are reasonably satisfactory for small sizes, say 10 horsepower and smaller. They require special starting devices, which are noisy and troublesome as compared with electric motors for direct current or polyphase current.

Polyphase electric motors are satisfactory from all standpoints except that of low speed and variable speed, these arrangements being rather expensive and difficult to secure.

Controllers for Electric Motors

Electric motors of 5 horsepower and smaller for constant speed, generally may be thrown directly on to the line. Larger sizes than these require starters, of which there is a wide choice, with a multitude of variations in service and a great range in price.

Arrangements can be made for remote control of fan motors, or for automatic control by influence of temperature. Remote control may be by pneumatic or by hydraulic manipulation as well as by electrical means.

It is easy to provide tell-tales to show the setting of remote electric controllers, as by miniature electric lamps.

Other Power Sources for Fans

In many large ventilating systems which have heating plants in connection, steam engines are used to operate fans. A medium-speed steam engine, exhausting at low pressure into the radiators which heat the building or which warm the air, is a very economical source of power, is nearly noiseless, and has a wide range of speed variation. The steam-economy of such an engine usually is of little importance, since the engine serves as an auxiliary to the pressure-reducing valve interposed in such cases between the boiler and the radiators.

Internal combustion engines and line shafting are often used for fan driving, requiring clutches or shift-belts with loose pulleys in order to secure proper starting and control.

Control of Noise from Fan Motive Power

Experience seems to indicate that this control is largely to be gained by isolation of foundations. The best practice is to bolt the fan and motor rigidly to substantial foundations of concrete or wood, to go in inertia and solidity, and to float this foundation above a yielding, inert non-resonant buffer of cork or dry sand, with arrangements to prevent any side motion by interposing similar side-buffers.

It is sometimes necessary to sound-insulate the walls of the machinery room. The best practice for this purpose is cork, felt or other sound absorbing material against the walls, faced with sheet steel, the steel being isolated from direct contact with the building structure.

CHAPTER XXI

AIR DUCT DESIGN AND CONSTRUCTION

THE successful operation of a mechanical or plenum heating installation, an exhaust system or a dust collecting plant is largely dependent upon the correct design of the duct system. Materials, proportions, friction, location and innumerable other items are factors in the correct operation of a duct system.

In the design of ducts and flues for the mechanical circulation of air, or by gravity, losses due to friction are the basis for figuring and these losses must be kept within the available pressure difference. This pressure difference in mechanical ventilation is that derived from the fan, while in gravity ventilation it is the asperating effect due to the temperature and height of the column of heated air.

When attempting the design of a duct system the general rules to remember are:

1. The air should be conveyed as directly as possible at reasonable velocities to obtain the result desired with greatest economy of power, material, and space.
2. Sharp elbows and bends are to be avoided.
3. All ducts or flues shall have sides as nearly equal in size as possible. (In no case shall the ratio between long and short sides be greater than 10 to 1.)

The piping systems for various operations must be of different design as the principal consideration for industrial work is for heating while in public buildings the air required for ventilation greatly exceeds the volume needed for heating. For instance, the ducts for a school, theatre or other public buildings, where freedom from noise and elimination of drafts is essential and where branch ducts serve individual rooms, is a much different problem in design than that involved in proportioning ducts intended for heating a factory, where a main duct of decreasing dimensions extends lengthwise of the building and gives a uniform distribution of air. For public buildings air velocities must, therefore, be kept low between 900 and 1200 ft. per min. while in industrial buildings they can range from 1500 to 2000 ft. per min. or even more with no other disadvantage than the difference in operating expense.

Standard velocities of air in public buildings are as follows:

1. Through the outside air intakes 1,000 ft. per min.
2. Through connections to and from heater 1,000 to 1,200 ft. per min.
3. Through the main discharge duct from 900 to 1,200 ft. per min.
4. In branch ducts 700 to 900 and vertical flues 400 to 600 ft. per min.
5. In registers or grilles 200 to 400 ft. per min. depending upon the size and location.
6. If diffusers of proper design are used, 25 per cent higher air velocities may be permitted.

Material for this section was prepared by F. R. Still, New York.

TABLE 1. CORRESPONDING PRESSURES AND VELOCITIES OF DRY AIR AT 70 DEG. AND 29.92 IN. BAROMETER

INCHES OF WATER	OUNCES PER SQ. IN.	VELOCITY FT. PER MIN.	INCHES OF WATER	OUNCES PER SQ. IN.	VELOCITY FT. PER MIN.
0.05	0.0289	896	4.77	2.750	8745
0.10	0.577	1266	5.00	2.884	8943
0.20	0.1154	1791	5.20	3.000	9134
0.25	0.1443	2003	5.50	3.172	9392
0.30	0.1730	2193	6.00	3.460	9810
0.40	0.2308	2533	6.07	3.500	9864
0.43	0.2500	2637	6.50	3.749	10210
0.50	0.2884	2832	6.94	4.000	10545
0.60	0.3460	3102	7.00	4.037	10595
0.70	0.4037	3351	7.50	4.326	10968
0.75	0.4326	3468	7.80	4.500	11187
0.80	0.4614	3582	8.00	4.614	11328
0.87	0.5000	3729	8.67	5.000	11792
0.90	0.5190	3800	9.00	5.190	12015
1.00	0.5768	4005	9.54	5.500	12367
1.25	0.7209	4478	10.00	5.768	12665
1.30	0.7500	4566	10.40	6.000	12915
1.50	0.8650	4905	11.00	6.344	13282
1.73	1.0000	5273	11.27	6.500	13445
1.75	1.0092	5298	12.00	6.921	13875
2.00	1.1535	5664	12.14	7.000	13950
2.17	1.2500	5895	13.00	7.497	14440
2.25	1.2975	6007	13.87	8.000	14913
2.50	1.4418	6332	14.00	8.074	14985
2.60	1.5000	6457	15.00	8.650	15510
2.75	1.5860	6641	15.61	9.000	15820
3.00	1.7300	6937	16.00	9.227	16020
3.03	1.7500	6976	17.00	9.805	16513
3.25	1.8740	7220	17.34	10.000	16675
3.47	2.0000	7457	18.00	10.380	16990
3.50	2.0185	7492	19.00	10.960	17456
3.75	2.1630	7756	19.07	11.000	17488
3.90	2.2500	7910	20.00	11.535	17910
4.00	2.3070	8010	20.81	12.000	18265
4.25	2.4510	8256	22.54	13.000	19012
4.34	2.5000	8337	24.28	14.000	19730
4.50	2.5950	8496	26.01	15.000	20420
4.75	2.7395	8729	27.74	16.000	21090

CORRESPONDING VELOCITY FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES AND 29.92 IN. BAROMETER

PRESSURE		50°	60°	70°	100°	150°	300°	500°	550°
Inches	Ounces								
0.25	0.1443	1965	1986	2003	2059	2149	2399	2696	2895
0.5	0.2884	2778	2808	2832	2911	3038	3391	3812	4095
0.75	0.4326	3402	3439	3468	3565	3720	4153	4668	5020
1.00	0.5768	3929	3971	4005	4117	4296	4796	5390	5795
1.25	0.7209	4393	4440	4478	4602	4804	5362	6027	6470
1.50	0.8650	4812	4864	4905	5042	5262	5874	6602	7100
1.75	1.0092	5197	5254	5298	5446	5683	6344	7131	7655
2.00	1.1535	5556	5616	5664	5822	6076	6783	7624	8195
2.25	1.2975	5892	5956	6007	6174	6443	7193	8085	8690

It is customary in proportioning ducts for heating and ventilating work to follow either of two methods:

1. Arbitrarily select sizes from assumed velocities, depending upon velocity of air at fan outlet.
2. Determine the velocity which will give an assumed resistance within fan capacity at noiseless operating speed.

By decreasing the velocity in main duct as air is delivered through branch outlets: (1) uniform air delivery through outlets is accomplished, (2) friction in smaller pipes is reduced, (3) portion of velocity head is converted into static pressure.

The two greatest losses in duct systems are dynamic losses and friction losses. The former are chiefly caused by changes in direction or in velocity of air flow and are expressed in pressure in inches of water gage as per Table 1.

Friction losses due to friction of air against sides of ducts, vary directly as the length of the pipe, directly as the square of the velocity, and inversely as the diameter. Friction is commonly expressed as equivalent pressure in inches water gage or in terms of velocity heads, (the ratio of friction loss to the theoretical pressure corresponding to the velocity in the duct). One velocity head is the pressure corresponding to the velocity of air in the duct.

For smooth round pipes the friction loss is:

$$F = \frac{L}{50\,D}\left(\frac{V}{4005}\right)^2$$

where

F = loss of pressure in inches of water
V = velocity in feet per minute
L = length of pipe
D = diameter of pipe in feet; $\frac{L}{D}$ = length of pipe in diameters.

If a factor of safety is thought desirable the length 45 may be used though experiments show that the friction loss is equal to one velocity head in a length varying from 40 to 60 diameters depending upon the smoothness of the duct. The engineer's judgment and experience should prevail in this matter. For example, correction should be made for pipes with rough or uneven surfaces and in the case of brick or concrete ducts the friction loss should be increased 25 per cent or more.

A formula for rectangular ducts is derived in a similar manner but it will be found very convenient to use the accompanying chart, Fig. 1.

Other losses of pressure are at the entrance to the duct, through heater, air washer, etc. In ordinary practice it is usual to keep the sum of the piping losses $\frac{1}{3}$ to $\frac{1}{2}$ and the loss through heater at less than $\frac{1}{2}$ of the static pressure. The remainder is then available for producing velocity.

The ideal duct system will take all factors into consideration and proportion air velocities so that the resistance will be practically equal in all ducts regardless of length.

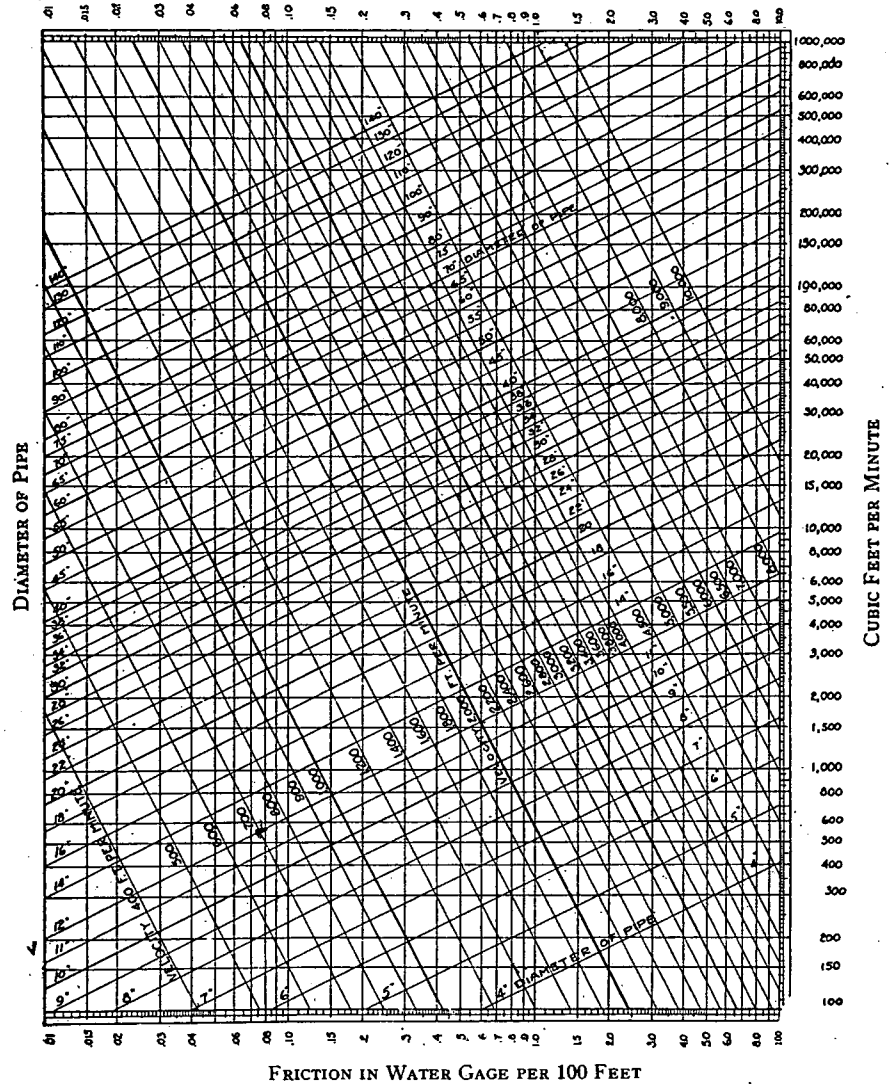


FIG. 1. FRICTION CHART

HOW TO USE THE FRICTION CHART

While this chart can be used to determine the friction of air which is flowing through ducts, it also can be used for determining the size of a pipe to handle a specified volume or the velocity that will be necessary. For example:

1. Assume that a volume of 20,000 cu. ft. per min. is to be discharged through a 36 in. duct. The volume is given on the right hand margin; follow along the horizontal line opposite 20,000 cu. ft. per min. until it intersects with the diagonal line sloping upward to the right which is marked 36 in. diameter of pipe. The velocity will be found to be 2,800 ft. per min., this being the other diagonal line sloping downward to the right. At this point of intersection is a vertical line giving the friction, which is indicated at the bottom of the chart as being 0.4 in. water gage per hundred feet of length. Thus if the duct is only 40 ft. long, the friction will amount to $\frac{40 \times 0.4}{100} = 0.16$ in. W. G.
2. The friction of elbows varies with the radius; an elbow having a radius in the throat that is half the diameter of the pipe, will present a frictional resistance that is equivalent to a straight pipe that is 30 times its diameter. For instance, a 36 in. diameter elbow having a radius of 18 in. in the throat would present as much friction as $\frac{30 \times 36}{12} = 90$ ft. of straight 36 in. pipe.

   If the radius in the throat is equal to the diameter then the friction would only be equal to 10 diameters. If the radius is twice the diameter, the friction is only 4.3 diameters.

   The friction of a rectangular pipe for a given velocity (not for volume) can be converted to an equivalent round pipe as follows: $D = \frac{4\,W\,H}{2\,W + 2\,H}$, in which W is the width, H is the height and D is the diameter, all in inches.

   To find an equivalent diameter for a given volume and the same friction as a rectangular duct, proceed as follows:

$$D = \frac{W}{0.79 \sqrt[5]{\left(\frac{W}{H}\right)^2 + \left(\frac{W}{H}\right)^3}}$$

SOME GENERAL INSTALLATION AND CONSTRUCTION HINTS

1. Ducts should be not less than 6 x 6 in. in size and made of galvanized iron or steel.
2. Angular turns should be made with elbows having a radius not less than the width or diameter of the duct.
3. Offsets should be at an angle of 30 to 45 deg.
4. Branch ducts should make curved connection with main duct and should have accessible dampers.

GAGES OF GALVANIZED IRON OR STEEL TO BE USED FOR DUCTS, FOR OUTSIDE AIR INTAKE

Heating and Ventilating

ROUND DUCTS, DIAM., IN.	GAGE	RECTANGULAR DUCTS WIDTH, IN.	GAGE
6 to 19	26	4 to 18	26
20 to 29	24	19 to 30	24
30 to 39	22	31 to 60	22
40 to 49	20	61 to 118	20
50 and above	18	118 and above	18

5. Rectangular ducts should have metal strap or rod supports and when over 36 in. in width should be stiffened with angle iron at 4 ft. intervals.
6. Longitudinal seams and transverse joints should be flat and smooth inside; slip joints should be in direction of air flow.
7. Access doors to ducts should be hinged and fire dampers in supply and vent ducts should be of ⅛ in. steel plate, held by fusible link for release at 160 deg. fahr.
8. Air intake should be screened with 1 in. mesh or less and protected from weather.
9. Final exit for exhaust ducts should be protected from weather and placed so as not to contaminate air supply.
10. Underground ducts should be waterproofed, drained, and provided with means of access for inspection and cleaning.

MEASUREMENT OF AIR FLOW

The quantity, velocity, and pressure of air discharged by a fan or flowing through a pipe may be determined by various methods. An anemometer is used where accuracy is not required and where air velocities not over 600 ft. per min. are to be measured, as at registers. For the greatest measure of reliability the anemometer shall have been newly calibrated, and correction shall be made for the error as shown by the calibration.

The standard method for measuring air velocity and pressure shall be the Pitot Tube as described in the A. S. H. & V. E. Standard Code for the Testing of Centrifugal and Disc Fans (TRANS., A. S. H. & V. E., Vol. 29, 1923, p. 407.) Installation tests for determination of fan capacity and efficiency shall be under laboratory conditions, in accordance with this Code.

CHAPTER XXII

AIR CLEANERS

THE desirability of air free from objectionable dirt and dust has long been recognized. This was especially true in certain industrial processes, but it is only recently that people have come to the realization of the economic importance of dust free air for use in general ventilation.

The first attempts at cleaning air probably were by the use of dry screens.

Since ordinary Portland cement all passes through a screen having 100 meshes to the inch, it is apparent that much dust may pass the finest mesh dry screen. When a screen as fine as this is moistened, not only the dirt ceases to pass, but also the air passages clog, so that the filter becomes ineffective.

Fine cloth filters are effective, except that they clog up rapidly and soon become impervious to air.

These considerations led many years ago to the development of the water using-air washer.

TYPES OF AIR WASHERS

Air washers are arranged to pass the air over a large surface area of water: (1) by passing it through a fine spray; (2) by passing it over wet surfaces; (3) by passing it both through a spray and over wet surfaces. After the air is washed it is freed from entrained water.

When air is cleansed by washing its humidity or moisture content is usually changed. In passing through the water spray or over the wet surfaces both the dry and wet bulb temperature of the air approaches that of the water at which temperature the air tends to become saturated. The moisture content of the air may, therefore, be controlled by controlling the water temperature. By using water at a very low temperature the washer becomes a dehumidifier or by heating the water the air may be humidified. By raising the dry bulb temperature of the air after leaving the washer its relative humidity may also be controlled. The humidifying efficiency of any air washer may be given as

$$E = 1 - \frac{\text{Final wet bulb depression}}{\text{Initial wet bulb depression}}$$

for example: With an initial wet bulb depression of 20 deg. and the final wet bulb depression of 6 deg., the humidfying efficiency is

$$E = 1 - \frac{6 \text{ deg.}}{20 \text{ deg.}} = 0.70$$

Material prepared especially for THE GUIDE by W. H. Carrier, Newark, N.J., S. R. Lewis, Chicago, and H. C. Murphy, Louisville, Ky.

TEMPERATURE AND HUMIDITY CONTROL

Air washers require method of control of temperature to prevent freezing by too low temperature and of over-humidification by too high temperatures of the air entering and leaving the washer. There is available one method of hand control and five methods of automatic or semi-automatic control. The method of hand control is by tempering coils divided into two or more sections in series; the outer coil being turned on by hand whenever the outside temperature approaches freezing; the successive coils being turned on as the temperature drops below freezing. Where two sections are available it is usual to turn on the second section when the outside temperature goes below zero, and the third section, where provided, at temperatures below zero. The first, or outside section, must always be turned on full for all temperatures to prevent freezing of the coils. The steam supply to the second, or inside section, may be hand regulated at all temperatures above 10 deg. above zero.

The five systems of automatic regulation are:

1. Substitution of automatic regulation for hand regulation and operated in a similar manner; the coils being controlled both by variations in the outside temperature conditions and also by an auxiliary control for one inside coil from a thermostat located on the discharge side of the air washer. (It is not possible to control the temperature of the air entering the washer except where there is an unusually long tunnel or duct for the thorough mixture of the air leaving the tempering coils before coming in contact with the thermostat.)

2. By heating the spray water so as to maintain a temperature or dewpoint (as the air is then saturated), between 35 and 40 deg. of the air leaving the washer. This method does not necessarily require a tempering coil, it is preferable, however, to use one tempering coil for the purpose of tempering the air should the washer be shut down and prevent freezing of the water when the apparatus is not in operation. More than one tempering coil should never be used except where temperatures may go considerably below zero, then the tempering coils may be turned on, one at 20 deg. fahr. and the second at 0 deg. fahr. The tempering coil may be operated manually or by a thermostat connected with the outside air. The steam supply for water heating should be sufficient to heat and saturate the air from 10 to 35 deg. fahr., when water heating is used in conjunction with a tempering coil. This is to allow for sufficient margin for safety of operation. The steam requirements for this are given later.

3. By regulating the heat supplied either through tempering coils or through the spray water so that the water in the tank shall be kept well above the freezing point. Inasmuch as the wet bulb temperature of the air and the water in the tank are but few degrees apart when the water in the tank is not heated directly, it is a fairly effective and simple to control. One permissible variation of this method is to use a thermostat in the air leaving the washer controlling the dry bulb temperatures at this point through regulation of the steam supply to the inside tempering coil. The wet bulb temperature of the air is controlled by means of water leaving the eliminator plates and is held at the desired point by means of adding heat to the spray water. This will control exactly the temperature and relative humidity of the leaving air. Two or more tempering coils are required for this method.

4. The fourth method is desirable where recirculation is used and consists in maintaining the temperature leaving the washer at about 40 deg. by means of a thermostat located at this point and controlling the admixture of fresh and return air through automatically operated dampers. This effectively prevents over-humidification and also danger of freezing and prevents the highest economy in cost in ventilation as no steam is required for either tempering or humidifying except after the air has passed the washer.

5. The fifth method of automatic control is to reheat the air leaving the air washer to a definite thermostatic controlled temperature and to control the relative humidity of the air by means of a hygrostat which operates either on the tempering coils to heat the air or to heat the spray water through a water heater.

STEAM REQUIREMENTS FOR AIR WASHERS AND FOR HUMIDIFICATION

Where the spray water is not heated it is necessary that the wet bulb temperature of the incoming air be above the freezing point otherwise the eliminator plates will coat with ice and stop up even if the dry bulb temperature of the leaving air is above freezing point. It is necessary to heat zero air to 48 deg. in order that the wet bulb temperature may be 35 deg. The temperature of the leaving air may then be expected to be approximately 39 deg. dry bulb and 35 deg. wet bulb with a dew point of 31 deg. The additional heat required due to humidification is that indicated by the temperature drop of 9 deg. or 162 B.t.u. per 100 cu. ft. of air, or 1 b.h.p., for every 3400 cu. ft. of air per min. These are the minimum requirements for humidication above that required for heating the air. The following Table 1 gives the heat required from various outside entering wet bulb temperatures to various dew points temperatures corresponding to a relative humidity of 70 deg.

Table 1. Heat Required from Various Outside Entering Wet Bulb Temperatures to Various Dew Point Temperatures Corresponding to a Relative Humidity of 70 Deg.

See Mark's Engineers Handbook.

Wet Bulb Temperature of Entering Air, Deg. Fahr.	Relative Humidity, Per Cent at 70 Deg. Fahr. (and Dew Point, Deg. Fahr.)					
	30% (37.25)	40% (44.5)	50% (50.5)	60% (55.3)	70% (59.6)	80% (63.5)
−10	1194	1452	1653	1860	2044	2245
0	984	1246	1447	1663	1840	2039
10	750	1025	1228	1445	1621	1822
20	510	779	983	1200	1377	1581
30	300	496	700	920	1097	1300
40	.....	178	384	603	783	987
50	.....	.....	.....	220	394	619
60	.....	.....	.....	.....	.....	181

These values are for the total heat required for both heating and humidifying the air. The amount of heat required for humidfying only may be found by subtracting from the values given the heat required to raise the temperature of 1000 cu. ft. of air per min. between the limits specified. The heat required for heating the air is given by the formula

$$H = 1000\,\frac{t_2 - t_1}{55.5}$$

AIR FILTERS

Air filters are distinguished from air washers in that they clean the air without the use of water or the addition of water vapor. They are of two types (1) the viscous filter depending upon the dirt impinging on

surface covered with a viscous fluid or oil; (2) the true dry filter which removes the dirt from the air by passing it through cloth or felt screens, the openings in which are too small to allow the passage of dirt, or by passing the air through tortous passages.

VISCOUS AIR FILTERS

Investigation has shown that the dirt and dust in air including the soot, carbons, etc., are trapped and retained by adhesive impingement on oil coated surfaces. This is not a new idea—as for years roads and floors have been oiled to keep the dust from flying about. Considerable originality has been shown by various arrangements of ferrules, rods, plates, etc., which were formed into filter units and made available for air cleaning work.

While the arrangement of filtering media and the kind of material used are almost unlimited, there are certain rather definite requirements for a practical commercial filter, and these have limited the possible constructions.

To fulfill the essential requirements of the engineer an air filter must:

1. Be efficient in dirt removal.
2. Interpose low resistance to air flow.
3. Have a large dust holding capacity.
4. Be easy to clean and to handle.

There are other factors of importance of course, among them weight, strength, and permanency.

In order to secure maximum efficiency, it is necessary to divide the air into innumerable fine streams; the more intimately and frequently the air is brought into contact with the viscous coated media the better the cleaning will be. Theoretically seven impingements are sufficient; more will give better service.

As the dirt and dust are leached out of the air and collected on the adhesive coated surfaces, additional supplies of the binding liquid are required in order to bind additional layers of dirt.

UNIT VISCOUS FILTERS

Some of these filters are made up of a number of separate units, each easily removed for cleaning.

If the unit air filters are cleaned "progressively" the resistance and volume of air delivered need never vary. By cleaning a pre-determined number of filters every week—or every month—as the case may be, the resistance and consequent air volume can be held at any desired figure.

To make sure of proper periodic cleaning of the units the installation of a simple air vane switch such as is used on air blast transformers is sometimes recommended. The switch is usually placed back of the filter and is so adjusted that if the air flow is cut down due to dirt accumulation in the filter, it rings a bell or lights a light. There are several makes of these air switches on the market at the present and they are not unduly high in price.

It is desirable also to install, on the suction side of the filter, an inclined draft gage giving constant visual indication of the resistance due to dirt-clogging.

AUTOMATIC VISCOUS FILTERS

Unit air filters have certain distinct limitations in the amount of dirt which can be handled. If the dirt reaches the filter too rapidly, or in such quantities that the adhesive liquid does not have sufficient oppotunity to soak through and wet the successive layers, the cleaning efficiency drops off. Removals for filter cleansing become so frequent as to be objectionable or impracticable.

This fact, and perhaps the age-old effort to eliminate where possible the human element, brought forth the self-cleaning or automatic viscous filters, several distinct types of which are now available.

DRY AIR FILTERS

These are of no great commercial importance except as used to some extent on the intakes of internal combustion engines, air compressors, etc. There are some successful dry impingement-type filters reported from abroad.

Changes and advances are so rapid and so unexpected in this industry that no safe prediction can be made.

DUST REMOVAL

The comparative efficiency of various air cleaning devices, on the basis of dust removal, can be determined by means of standardized tests operated at rated capacities and when handling air at a definite standard with respect to quantity and quality of dirt content. The determination of the cleaning efficiency may be made according to some standard method such as that described by A. M. Goodloe, member, A. S. H. & V. E. in the February 1924, JOURNAL. The percentage of dust removal as determined by the method of testing for all commercial air cleaning devices should lie between 80 and 95 per cent and the minimum removal under such conditions should be specified and guaranteed by the manufacturer.

The efficiency of dust removal may be expressed by the following formula:

$$E = 1 - \frac{\text{Weight any sample leaving}}{\text{Weight any sample entering}}$$

In case the resistance method is used in accordance with the Anderson-Armspach method of dust determination, the formula will become

$$E = \frac{\text{Time required to give a definite resistance increment with entering sample}}{\text{Time required to give the same increment with leaving sample}}$$

or, if the same time be used in obtaining both samples, which is preferable then

$$E = 1 - \frac{\text{The resistance increment of outgoing sample}}{\text{The resistance increment of ingoing sample}}$$

RATING OF AIR WASHERS AND FILTERS

Air washers and filters are rated as follows:

1.—Capacity in cubic feet of air handled per minute.

2.—Resistance in inches of water which the washer or filter offers to the flow of air at its rated capacity.

3.—Percentage of dust removal at its rated capacity.

4.—Percentage of entrained moisture remaining in the air after passing through the washer while operated at its rated capacity.

5.—If considered as a humidifying agent, the humidfying efficiency, or the percentage of reduction in the initial wet bulb depression without external alteration of heating the circulating water.

CHAPTER XXIII

CONDITIONING AND COOLING AIR

THE temperature and humidity of the air that surrounds people has an important bearing on their comfort and general efficiency while in the industrial field hundreds of manufacturing operations are dependent for their success upon the atmospheric conditions maintained.

Geographical location has a bearing on climatic conditions and a study of temperature and humidity variations in different localities tends to show that the places having an average wet bulb temperature in the neighborhood of 56 deg. fahr. with corresponding dry bulb temperatures to give effective comfort temperatures of 63 to 71 deg. are favored with best health conditions.

Scientists have always been seeking a way to produce the same ideal conditions indoors that prevail outside at certain seasons of the year. Many studies have been made, numerous theories have been advanced and discarded. From the latest studies of human comfort (see Chapter XVIII) it has been concluded that there is a definite relation between a person's feelings and the degrees of heat, humidity and air motion.

Air conditioning as it is practiced today means to obtain predetermined effects upon material or persons within an enclosure by controlling the air purity, temperature, humidity, distribution and movement.

The development of effective devices for producing and maintaining the ideal atmospheric conditions desired, has made tremendous strides in the workroom and factory, school, theatre and hotel while but little effort has been made to reproduce these conditions in dwellings.

The manufacturer has adopted air conditioning as it has become an exact science with results measurable in dollars and cents, in a more perfect product, in increased production, in elimination of waste or in some equally important factor. Varying degrees of moisture are required in manufacturing processes and the nature of the product will indicate whether a high or low relative humidity is to be maintained. Heating as well as cooling must be considered in air conditioning work and textile mills, printing plants, bakeries, candy kitchens, laundries, etc., all present definite problems. For example, in spinning rooms 75 deg. fahr. and 65 per cent humidity have been found best for the operations; in match factories 68 deg. dry bulb and 55 deg. wet bulb permit continuous operation and reduce fire hazards; in candy dipping rooms 66 deg. dry bulb and 50 per cent relative humidity give a high quality product. In some cases humidity must be supplied; in others dehumidifying is necessary.

Air has certain definite properties and obeys certain well known laws, therefore to handle problems in air conditioning the relation between the wet and dry bulb temperature and the dewpoint should be thoroughly understood by the engineer. Briefly, the dewpoint is the temperature at which saturation is obtained for a given amount of water vapor. With

Revised by E. P. Heckel, Chicago, Ill.

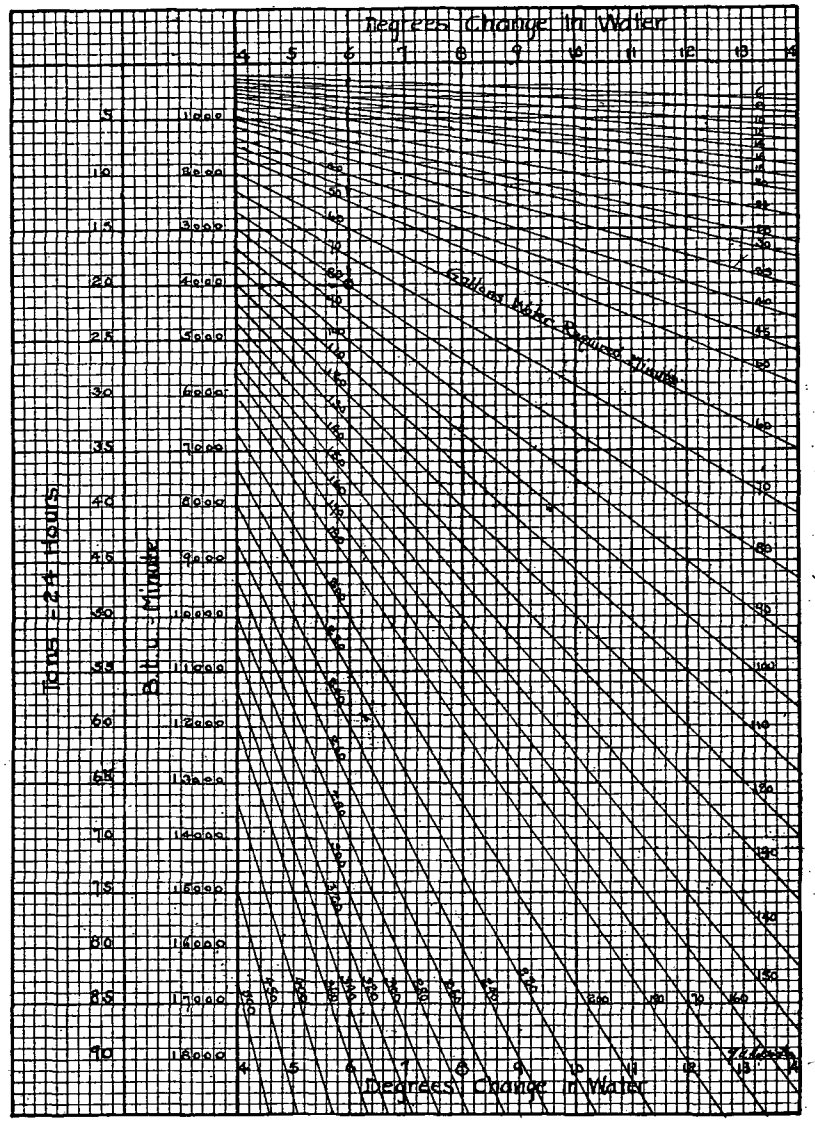


FIG. 1. GALLONS WATER REQUIRED PER MINUTE

air at the dew point the wet and dry bulb temperatures are the same. If heat is applied to air saturated at 50 deg. both thermometers will rise, the wet bulb more slowly and the relative humidity will be reduced. At ordinary temperatures the absorption of 1 grain of moisture per cu. ft. reduces the dry bulb temperature 8½ deg.

The usual way of adding moisture to air in large plants is with the use of an air washer while in homes and offices water pans in furnaces, or devices used in connection with radiators tend to better prevailing indoor conditions. While with air washers the degree of humidity as well as the temperature can be definitely controlled, in the average dwelling little attention is paid to these items as contrasted with factories, theatres, schools and other large buildings.

USE OF REFRIGERATION IN AIR CONDITIONING*

The advantages of one method of cooling air over another and the general factors governing the proportioning and design of air conditioning units are of interest to all whose work may bring them in contact with systems using refrigeration. It is the purpose of this section to give those not familiar with this important branch of air conditioning a better understanding of how refrigeration is applied in this work.

The producing of the refrigeration for an air conditioning installation is a problem for the engineer, and is the same as any other refrigerating problem with a varying load. The method of treatment of the air, and its distribution is a separate study involving the entire subject of air conditioning.

The remaining problem, then, in connection with the use of refrigeration in air conditioning is the actual application of refrigeration in a unit or apparatus for cooling the air.

The transfer of heat in air conditioning apparatus is usually accomplished by one of three methods:

1. Passing air through cold water or cold brine sprays
2. Passing air directly over cold coils
3. Combination of the above two methods

COLD SPRAYS VS. COLD COILS

A liquid spray which absorbs the heat from the air and transfers it to cooling coils is more frequently used than cooling coils in direct contact with the air, for the following reasons:

1. Fewer coils required, therefore lower first cost, less space and weight
2. Low power for driving compressor
3. Ease of keeping unit clean
4. Ease of controlling effect on air
5. Securing of air cleaning
6. Humidity control in winter

*Section on Cooling with Refrigeration compiled especially for THE GUIDE by N. A. Hollister, New York, N. Y.

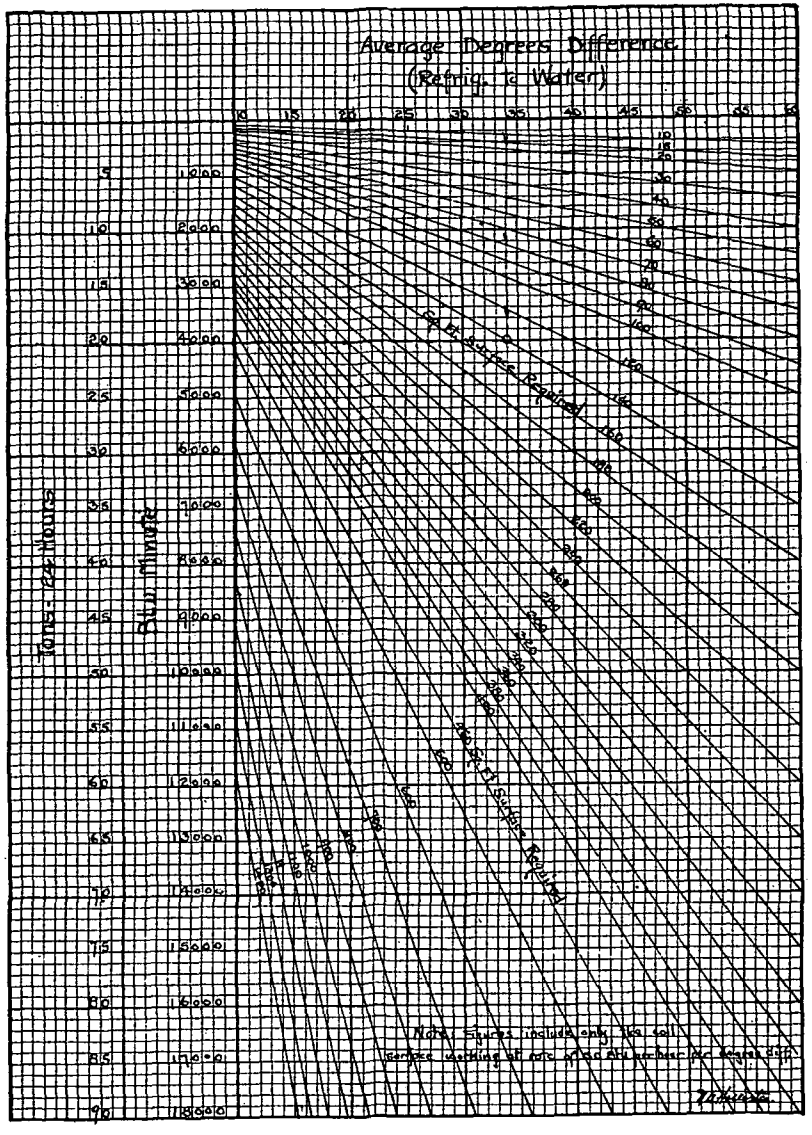


FIG. 2. SQUARE FEET WET COIL SURFACE

LESS COIL REQUIRED

Water is generally used for spraying when the lowest liquid temperature is not too close to freezing. For lower temperature calcium or brine solutions of varying strengths, according to the requirements, are used. A liquid spray has the following marked advantages:

1. Cheap method of securing an enormous radiating surface for heat transfer from the air
2. Continuous cleaning radiating surface
3. Elimination of all frosting of the coils with the accompanying lowering of heat transfer from coil surface
4. High heat transfer from liquid to coil surface

With the comparatively small temperature differences encountered in such work, as 40 deg. water and 55 deg. air, the need of considerable heat absorbing surface is apparent. When water is sprayed the heat transfer must take place on the surface of the drops and the square feet of surface will depend upon how finely the water is divided. Ten gallons of water sprayed and divided into spheres of 0.25 in. diameter gives about 380 sq. ft. of drop surface. If divided into drops of 0.10 in. diameter spheres, the surface increases to about 1000 sq. ft. The water is divided into almost invisible drops and the square feet of radiating surface secured will make a heat transference which would require a large and expensive coil.

With water flowing over the cooling coils the rate of heat transfer is many times that secured with air passing over or through the coils even when the coils are dry and not frosted. With the correct design and proportioning 40, 50, or even 60 B.t.u. per hour per sq. ft. per deg. difference may be obtained in practical commercial units as compared to the 2 B.t.u. or 6 B.t.u. from dry coils to air. The high transmission from water to coil, frosting disadvantages and other factors all combine to necessitate much less water-to-coil surface than coil-to-air surface with an accompanying saving of cost, space, and weight.

Many air conditioning installations are operated 24 hrs. per day and on every installation power used for operation is important. It should be understood that with the higher refrigerant temperatures operating at the higher refrigeration plane, the power used by the compressors will be lower per ton of refrigeration effect, than when operated at lower temperatures of refrigerant and at a lower refrigeration plane. This is true regardless of whether ammonia, carbon dioxide, or dielene or any of the other refrigerants are used.

CLEANING UNIT

When using the coil-to-air bunker room designs in order to get contact between the coils and air, the coils must be close together, arranged in some staggered form or with deflectors and baffles. Such arrangements make it almost impossible to allow for proper cleaning.

Dirt collects on the wet surfaces as on the wet eliminator or scrubber plate surfaces in the dehumidifying unit but in the bunker room there is

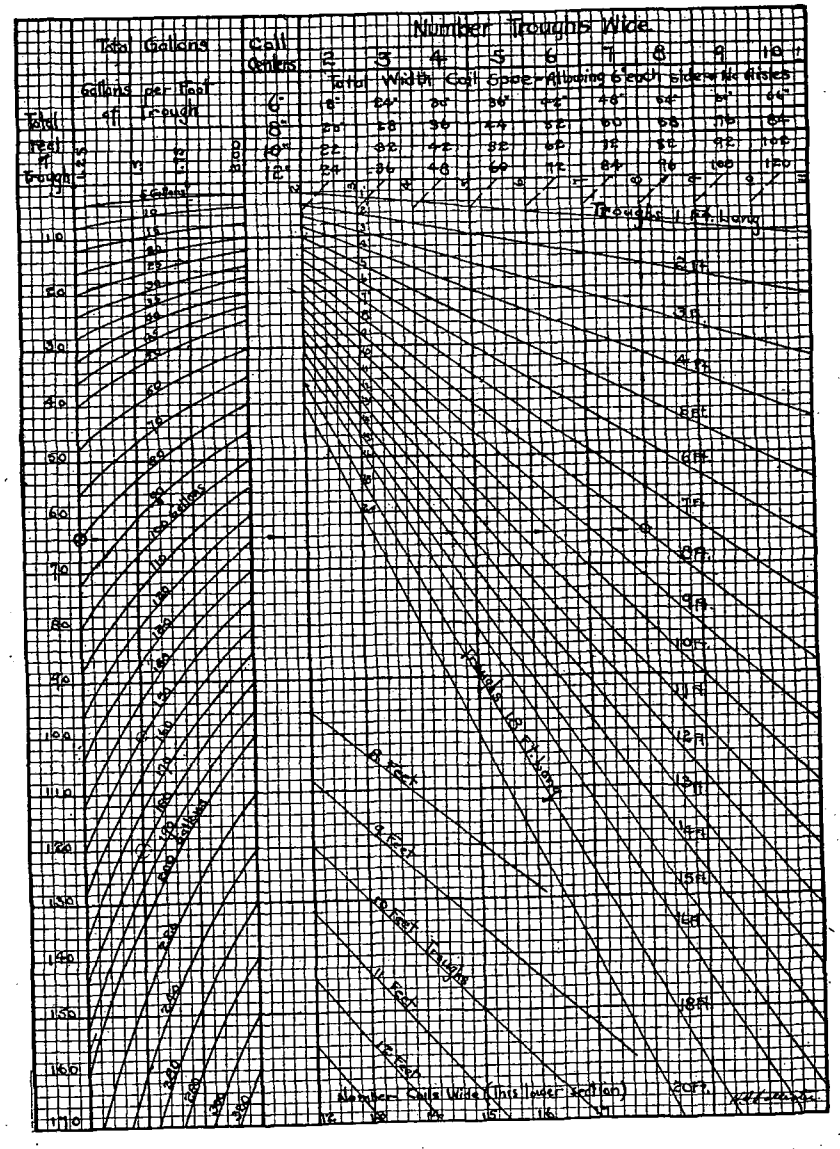


Fig. 3. Troughs

no flow of water to clean the surface. Fungus slime frequently collects which, together with rust and dirt and matter carried in by the air, makes cleaning desirable, if not an absolute necessity.

With the spray method the flowing water keeps all surfaces cleaner and the draining of the tanks gives a ready means of carrying away all matter collected.

CONTROLLING EFFECT ON AIR

The control of outgoing air conditions, whether by hand or by automatic devices, is more rapidly changed in the spraying method than in the coil-to-air method. If an operator is cooling the air with coils covered with frost (and they are practically always covered with frost and ice) and he desires to remove the cooling effect he may shut off the refrigerant but the bunker room will continue to treat the air until the frost and ice are melted which may take quite a while. The alternative method of changing the air temperature is to use more space and increase the cost by providing a by-pass duct around the bunker room.

By using a small tank capacity in relation to the volume being pumped it is possible quickly to cool or heat the water and thus have quick effect on the air.

Cleaning of Air

Where dirt or gases carried by the outdoor air which would harm a product or be undesirable for persons, the coil-to-air bunker room does no cleaning and may even add unsatisfactory bacteria due to the unit not being easily kept clean. The spray unit is in itself an efficient air cleaning apparatus.

Humidifying of Air

When refrigeration is used in air conditioning work, whether primarily for lowering the dry bulb or for lowering the humidity, the resulting moisture in the air is seldom as low as in the outdoor air during our many winter months. For many uses too low a humidity is as undesirable as too high a humidity and many times a constant humidity is desired all year to control yearly manufacturing conditions. The coil-to-air method offers no humidifying whatever while the spray type unit changes from a dehumidifier to a humidifier as soon as the water is not cooled. By air re-circulation or by heating the water or by both, even an excessive humidity may be readily produced by the spray type unit and the humidity controlled all year.

Coil and Spray Combined

Without study it might appear that placing the coils in the spray chamber would be the practical solution. It is seldom that this is advisable.

On light duty units, that is, where not much refrigeration is being used in comparison with the air being handled and in some small units, coils may be placed in the spray chamber thus doing away with the lower coil chamber, tank, and troughs, but more coil surface and a large spray chamber must be used.

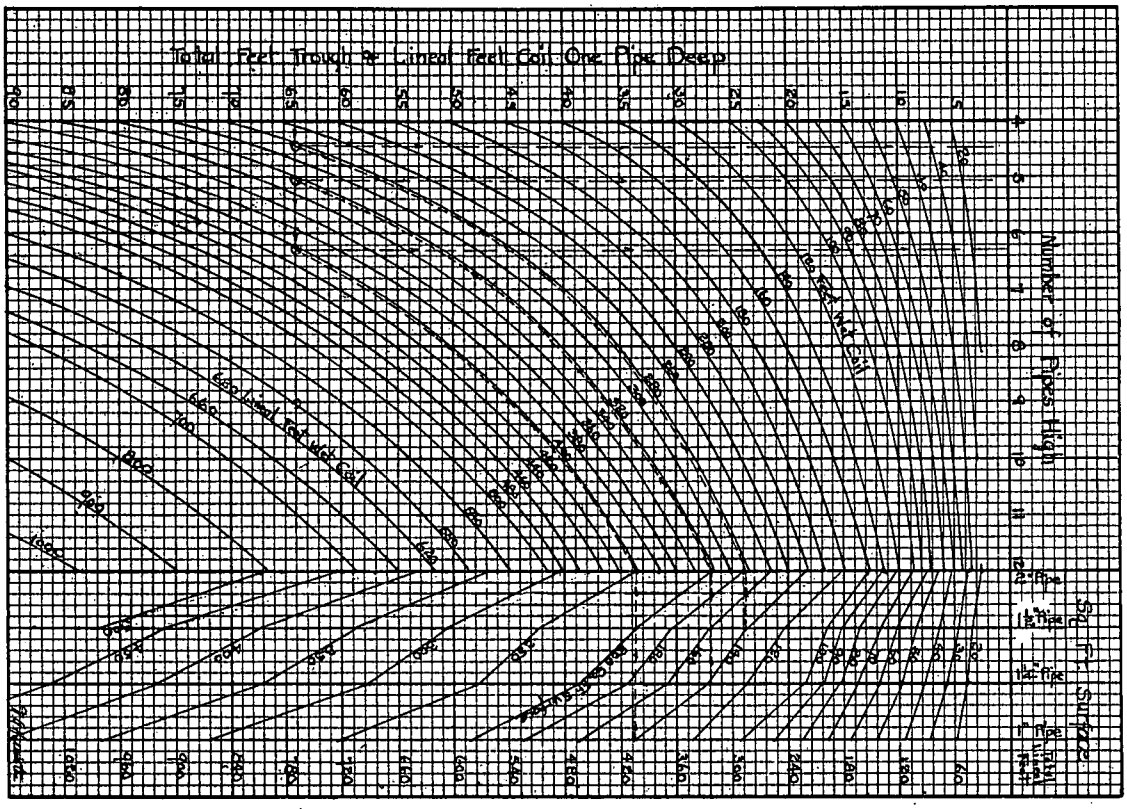


FIG. 4. SIZE OF PIPES AND NUMBER OF PIPES HIGH

TABLE 1. CUBIC INCHES OF AMMONIA VAPOR TO BE CIRCULATED TO PRODUCE ONE TON OF REFRIGERATION IN TWENTY-FOUR HOURS

CONDENSER PRESSURE	Gage	95	110	125	140	155	170	185	200	215	230	245
	Abs.	109.7	124.7	139.7	154.7	169.7	184.7	199.7	214.7	229.7	244.7	259.7
Temperature of Liquid		61°F.	68°	74.4°	80.3°	85.8°	91°	95.8°	100.3°	104.6°	108.7°	112.6°

SUCTION PRESSURE		TEMP. OF SUCTION	AMMONIA VAPOR IN CUBIC FEET PER MINUTE										
Gage	Abs.												
5"V.	12.2#	−33.6°F	14,880	15,100	15,310	15,525	15,750	15,975	16,175	16,375	16,575	16,775	16,975
4"	12.7	−32.3°	14,320	14,550	14,750	14,950	15,170	15,375	15,560	15,750	15,940	16,120	16,310
3"	13.2	−30.9°	13,820	14,040	14,240	14,440	14,630	14,825	15,010	15,190	15,375	15,560	15,740
2"	13.7	−29.6°	13,340	13,540	13,720	13,920	14,110	14,300	14,480	14,660	14,840	15,010	15,190
1"	14.2	−28.4°	12,885	13,075	13,250	13,445	13,640	13,820	13,990	14,150	14,320	14,490	14,660
0#	14.7	−27.1°	12,460	12,650	12,840	13,020	13,200	13,375	13,540	13,700	13,860	14,025	14,190
1#	15.7	−24.8°	11,700	11,855	12,020	12,210	12,380	12,545	12,720	12,875	13,010	13,150	13,305
2	16.7	−22.6°	11,005	11,160	11,340	11,500	11,660	11,810	11,950	12,100	12,240	12,400	12,540
3	17.7	−20.4°	10,410	10,575	10,710	10,850	11,020	11,175	11,310	11,450	11,590	11,730	11,860
4	18.7	−18.4°	9885	10,020	10,180	10,310	10,450	10,595	10,720	10,850	10,990	11,110	11,225
5	19.7	−16.5°	9400	9540	9690	9820	9960	10,090	10,210	10,340	10,450	10,580	10,700
8	22.7	−11.0°	8200	8310	8425	8550	8675	8790	8895	9000	9100	9200	9305
10	24.7	−7.7°	7550	7670	7770	7880	7990	8090	8190	8290	8390	8480	8580
12	26.7	−4.7°	7010	7110	7210	7320	7420	7520	7610	7700	7795	7880	7980
15	29.7	−0.3°	6320	6420	6510	6610	6695	6790	6860	6940	7025	7110	7190
20	34.7	+6.1°	5445	5530	5605	5690	5750	5825	5905	5990	6040	6110	6190
25	39.7	+11.9°	4780	4850	4910	4990	5050	5110	5190	5240	5300	5380	5420
30	44.7	+17.0°	4250	4310	4380	4440	4500	4560	4620	4680	4725	4790	4840
35	49.7	+21.8°	3850	3910	3970	4020	4070	4120	4170	4220	4270	4320	4370
40	54.7	+26.2°	3510	3560	3610	3655	3705	3760	3810	3855	3905	3940	3980
45	59.7	+30.3°	3220	3280	3320	3360	3410	3450	3500	3540	3590	3630	3680
50	64.7	+34.1°	2980	3020	3070	3110	3150	3190	3225	3275	3310	3350	3390

Unless the resistance of the unit is to be increased the spray chamber must be increased to allow for the space occupied by the coil in the air path. If much refrigeration is being used it will be found that the horizontal projected area of the coil is considerable.

Only a small fraction of the water sprayed hits or comes in contact with the coil surface. Some of the water is therefore not cooled during each cycle and to maintain a certain average water temperature some of the water must be cooled considerably lower. As it is not advisable to operate too close to the freezing point, either brine must be sprayed or a low temperature cannot be carried without submerged coil surface as well as extra coils in the spray chamber.

When the sprayed water hits the cooling coil it does not have a tendency to stick to the coil. The result is that a lower total volume of water will be flowing over the total coil surface and less total cooling will be secured per foot of surface used.

If the cost of a larger spray chamber, extra coil surface in the spray chamber, and the submerged coils required and the other factors are favorable, the coils may be used in the upper spray chamber with satisfactory results in some installations.

For some duties a return bend arrangement may be used passing the air through the upper chamber and then down and back through the lower coil chamber. The coils are covered by a film of running water at a lower temperature than the air and as some air will come in contact with the cold water and other cooled surfaces a limited amount of extra cooling may be secured.

There is one important point which is a problem for the refrigerating engineer, but which has sometimes been overlooked. This is the matter of control of the refrigeration. Almost all air conditioning installations, whether with automatic or hand control, give a varying refrigerating load. Systems have been operated using many tons of refrigeration and this load has suddenly been removed owing to changing requirements. Meanwhile the ammonia compressor may be operating, and freezing of the system with accompanying damages results if carried far enough. Ammonia lines in a plant cannot be tapped and valves turned on and off quite as readily as in a steam line. The refrigerating engineer should be fully advised regarding the varying of the air conditioning refrigerating load.

With the accompanying charts no one should have difficulty in checking a layout or making preliminary approximate estimates of the part of an air conditioning unit using ammonia as the refrigerant. It is impossible to give here all the factors governing the use of refrigeration and the allowance to make for different conditions such as coils that are dirty or oily on the inside, coils with poor outside surfaces, the element of time in changing conditions of air treatment, structural considerations, and particularly the action of the water when it is sprayed in the coil chamber in contact with the air. It is not suggested by the author that those unfamiliar with the details of such work use these charts except as a source of general information as to the factors governing the design of such equipment.

Estimates as shown by the dotted lines on the charts are made as follows:

1. Total heat load—4,000 B.t.u. per minute
   20 tons refrigeration
2. Design and conditions allow 6 deg. rise in water temperature
3. Average water temperature 44 deg.
4. Average ammonia temperature 10 deg.
5. Difference ammonia and water 34 deg.
6. Gallons handled per ft. of trough 1¼
7. Standard unit available allows 8 ft. long troughs

Fig. 1 shows that 80 gallons water per minute are required.

Fig. 2 shows that 140 sq. ft. of cooling coil surface are required when working at the rate of 50 B.t.u. per hour per square foot per degree difference.

Fig. 3 shows 64 lineal feet trough required.

Also shows 8 troughs and coils wide and space required as follows:

6 in. coil centers require space 54 in. wide
8 in. coil centers require space 68 in. wide
10 in. coil centers require space 82 in. wide
12 in. coil centers require space 96 in. wide

From Figs. 2 and 3 it was found that 140 sq. ft. of surface and 64 lineal feet of troughs were required. Fig. 4 shows the following:

Pipe diameter.....	1½ in.	1¼ in.	1 in.
Lineal Feet.....	225	283	404
Pipes High.....	5	6	7

Pipes High have been increased to eliminate fractions and in designing a unit the lineal feet of coil required would have to be increased in proportion. Allowance must be made for dirty coils, uneven water distribution, quick control of temperatures, and other factors, all of which might double the coil surface shown mathematically by the charts.

The heat transfer which may be obtained in the upper chamber and the maximum rise in the water temperature, and therefore the use of Fig. 1, will vary with each change in nozzle, pump pressure, time element, pounds of water used per pound of air, water to air temperature differences, and other such factors as might be expected, but once the volume of water and the temperature through which it must be cooled are determined, the design of that part of the apparatus using refrigeration will be a comparatively simple problem to those familiar with such work.

In this work the problems are many and varied, for cooling is used in many industries as well as for the conditioning of air in hotel dining-rooms, theater auditoriums, and many other rooms where it is desirable to maintain a temperature under that prevailing out of doors.

With modern refrigerating and dehumidifying apparatus properly designed and applied it is possible to obtain most any percentage of ventilation perfection. Unless artificial cooling is resorted to it is hardly possible to obtain better than 75 per cent perfection in hot sultry summer

weather. In hotel, theater, etc., cooling work recirculation will conserve heat in winter and refrigeration in summer.

The development of the science of air conditioning has been rapid and the textile industry has derived great benefit from the adoption of adequate systems. Its applications are wide entering somewhere into every process in making of articles used every day, such as clothing, candy, meat products, and a host of others. Mass production of uniform quality products has been made possible and has placed manufacturing schedules on a year round basis for many industries. It has also improved conditions of comfort and permitted the operation of theaters and other assembly places every day of the year contributing greatly to the health comfort and wealth of the nation.

CHAPTER XXIV

OZONE IN VENTILATION

OZONE is a normal constituent of pure, natural air and its quantity varies with the topography of the country, particularly with regard to the altitude, the presence of bodies of water, and certain plant life.

Ozone is produced, photo-chemically, by ultra-violet light of short wave length (120-180 μμ), while light of greater amplitude (300-330 μμ) exerts a decomposing effect. At high altitudes, where short wave radiations are more intense, ozone naturally occurs in greater quantities. It is continuously under the destructive effect of longer waves, however, but a dynamic equilibrium is finally reached between the rate of formation and the rate of decay, which shifts with the altitude. Since light of longer wave length penetrates closer to the earth than does that of shorter amplitude, the equilibrium becomes favorable to ozone directly as the altitude.

In summing up the evidence at hand it may be concluded that ozone, while mostly absent from city air, is normally present in pure country air, but in amounts that are difficult to estimate accurately. In nature the air is continuously under ionizing influences, and the enclosing of air, as in buildings, excludes these influences, in addition to destroying the original ionization of the air. Ionization is involved in chemical activity.

The process of ozonizing, in addition to supplying ozone, ordinarily absent from city air, further provides considerable ionized oxygen, producing a fresh, chemically active air, comparable with fresh, pure air of nature.

Physical Properties

Density—Observed Values; 1.657 (Otto, Direct weight method).
1.717 (Soret, by diffusion).
Calculated Value; 1.66

The foregoing values refer to air as unity. Its rate of diffusion, with respect to oxygen is 0.75.

Heat of Formation—The production of ozone is an endothermic reaction, the heat of formation being 34,000 calories per gram molecule (Jahn, Zeit. Anorg. Chem. 68, 250; 1910).

Boiling Point −112 deg. cent. (International Critical Tables, 1926).

At a temperature of 270 deg. Cent. (518 deg. fahr.), Ozone is instantly decomposed.

Odor—Strong, penetrating and characteristic. Perceptible to the sense of smell in concentrations above 0.01 p.p.m. by volume (Hill & Aeberly, *Heating and Ventilating Magazine*, December, 1921).

Olfacty (minimum perceptible concentration expressed in molecules per c.c.) 2.705×10^9 at 0 deg. cent. and 760.

Solubility—Soluble in water and dilute acids, quite soluble in carbon tetrachloride and many vegetable oils.

Its solubility in water, like all gases, is dependent upon the temperature and partial pressure. Nernst (Festschrift, 391; 1912) gives the solubility coefficient for water, at

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0 deg. cent. and 760 m.m. Hg., as 0.494; or about ten times as great as oxygen. However, high concentrations of ozone, in solution, in water, are not easily obtained in practice, due to the low concentrations at which ozone is available commercially. Of the two factors, temperature appears to have the greatest bearing, as evinced by the following tabulation wherein the experiments are listed in order of decreasing pressure, with only small variations in temperature. The experiments listed here are typical of many hundred of the kind, made by the author.

EXPERIMENT NO.	GAGE PRESSURE ABOVE AN ATMOSPHERE mm *Hg*	PARTIAL PRESSURE OF O_3	TEMPERATURE DEG. CENT.	SOLUTION OF O_3 IN H_2O ppm BY WEIGHT	CONCENTRATION mgs. O_3 PER LITRE OF AIR
19	300	5.83	21.5	1.7	11.0
82	240	5.75	17.5	3.0	11.5
22	300	5.72	20.5	1.5	10.8
151	150	4.87	17.7	1.98	10.7
4	500	3.19	21.5	1.0	4.7
10	500	3.19	18.9	1.7	4.7

Chemical Properties

Ozone is one of the strongest oxidizing agents known. It is capable of oxidizing all of the elements, with the exception of gold and some of the metals of the platinum group.

In the dry state its activity towards metals is not so marked, and in very low concentrations, such as used in ventilation, it may be considered as being practically inert towards the common metals.

It exerts a depolymerising action on the rubber molecule, its destructive effect being quite characteristic even at comparatively low concentrations (ca. 3 to 4 ppm). However, unless the rubber is under stress, fairly high concentrations (ca. 50 to 100 ppm), fail to effect it appreciably. The low concentrations used in ventilation have no noticeable effect on ordinary rubber goods.

Iodine is liberated from potassium iodide by ozone. Many of the low oxidation salts (ous salts) are carried to a higher degree of oxidation (ic salts) by ozone.

Generally, ozone reacts to liberate molecular oxygen, only the third atom entering into combination. This may be expressed by the equation:

$$M + O_3 = MO + O_2 \quad \text{(a)}$$

which is typical of the inorganic reactions of ozone. In many cases, however, ozone reacts as follows:

$$M + O_3 = MO_3 \quad \text{(b)}$$

This reaction is examplified in the oxidation of sulphur dioxide:

$$3SO_2 + O_3 = 3SO_3$$

Reaction (b) is more typical of the organic, than the inorganic, reactions of ozone, as illustrated by the oxidation of urea:

$$CO(NH_2)_2 + O_3 = N_2 + CO_2 + 2H_2O \quad \text{(c)}$$

In the oxidation of odoriferous substances, commonly met with in ventilation, such as skatole, indole, amine compounds, and the like,

reaction (c) may be said to hold throughout. Where an amino group is present, molecular nitrogen will be produced, in addition to the carbon dioxide and water produced from hydrocarbons.

Germicidal Properties

Ozone compared with other gaseous germicides, generally used for fumigation, rightfully holds first place, as is revealed by the following table:

Agent	Per cent necessary in moisted air to be germicidal
Ozone	0.1
Formaldehyde	1.0
Sulphur Dioxide	4.5

One-tenth percent by weight, of ozone in air is equivalent to approximately 560 parts per million. Such a concentration of ozone could never be used in ventilating work. Rideal (Ozone, D. Van Nostrand) cites 0.05 per cent concentration as germicidal in air. Hill and Aeberly (Heating & Ventilating Mazagine, February, 1922), report noticeable bacteriacidal effects in concentrations ranging from 300 to 450 ppm by volume. Ozone, even in respirable concentrations, is effective in inhibiting the development of fungi in cold storage; however, its action is inhibitory and not destructive.

Deodorizing

T. Graham has pointed out that odoriferous substances are susceptible to oxidation. It is further known that most odoriferous substances contain unsaturated valencies, which render them particularly susceptible to attack by ozone.

The so-called odors of animal effluvia, frequently encountered in crowded places, and where a large percentage of the air is re-circulated, consists of low oxidation gases, and whilst present only in vanishingly small quantities, are highly odoriferous. These gases are completely and rapidly oxidized to odorless and innocuous products by ozone.

Hydrogen sulphide is thrown off in small quantities by man, and is frequently present in the air in relatively large quantities, as the result of many industrial operations. Ozone oxidizes hydrogen sulphide very rapidly; under some conditions to sulphuric acid and under other conditions to free sulphur and water.

Products of putrefaction, such as trimethylamine, indole, skatole, the mercaptans, etc., are readily oxidized by ozone; as are the odors arising from foods, especially during cooking. Many of the odors resulting from the combustion of organic matter are destroyed. Sulphurous gases produced by the combustion of coal are completely oxidized, whilst many of the unsaturated gases resulting from the incomplete combustion of natural gases, oil and spirit fuels, are deodorized by ozone.

Carbon monoxide is but slowly oxidized to the dioxide, the reaction being accelerated by the presence of a catalyst and also at elevated temperatures. However, the molecular concentrations of ozone must be comparable, and preferably in excess of, that of the CO, in order to obtain reaction velocities of sufficient value for practical purposes.

In garages and testing rooms the air is frequently contaminated with gasoline vapors and unsaturated gases, resulting from incomplete combustion, which cause headaches and feelings of lassitude. Ozone is valuable in oxidizing these gases and freeing the air from odor. However, CO must always be taken into consideration. It is an odorless and very insidious poison, since the victim has no warning of his condition until coma is induced. Four parts of CO per ten thousand of air is the maximum concentration which may be respired continuously without noticeable effect. (Henderson, Yandell, et al—*Journal. Ind. Hyg.* Vol. 3, 1921). Carbon monoxide frequently has been found present in quantities much greater than four parts per ten thousand in the atmosphere of garages and the like, and so far, adequate ventilation is the only remedy known. It is obvious that, chemically, ozone has nothing to offer for carbon monoxide correction, since the reaction is, at best, slow in the absence of a catalyst, and a molecular concentration of ozone comparable with a lethal concentration of CO, would produce quite as much physical distress as the carbon monoxide. Carbon monoxide is the index of good garage ventilation; this factor may be favorable and still an odoriferous condition, causing minor distress, may attain. Here ozone is of value, but is must be used with judgment, and does not permit of a curtailment of any of the ordinary CO precautions. Ozone and ionized air may possibly have some physiological effect on the haemoglobin, which may cause a shift, in selectivity, in favor of oxygen, but to date knowledge on this subject is not available.

The Production of Ozone

The air actually passed through an ozone generator should be free from water vapor, dust and gases normally foreign to the atmosphere. Rideal (Ozone, D. Van Nostrand) states that a RH of 25 per cent, at a dry bulb temperature of 20 deg. Cent., limits the yield of ozone 60 to 70 per cent of that which would be produced with dry air, other conditions being equal. The vapor content of air to be ozonized should not exceed 0.1 grains per cubic foot, for the best results.

The presence of sulphur dioxide, nitrogen dioxide, chlorine, etc., appreciably reduces the efficiency of an ozonizer. Ammonia gas, should it be admitted to the ozone generator in appreciable quantities, may cause an explosion.

The presence of dust favors the passage of sparks, which cause thermal decomposition of the ozone, and adds to the formation of oxides of nitrogen. Ozone generators are now generally supplied with an air filter.

Sparking and "creeping discharges," which frequently form at the edges of the electrodes, should be prevented by the proper design of the electrode members.

The rate of decomposition of ozone is greatly accelerated at high temperatures, therefore, ozonizers should be operated with a minimum temperature rise. At room temperatures the rate of decomposition is negligible.

Due to the catalytic effects on the decomposition of ozone, inherent in commercial ozonizers, there is a decided limiting concentration at which ozone may be produced. As a rough approximation, it may be stated

that the rate of decomposition is proportional to the concentration of ozone. Thus, the energy necessary to produce high concentrations is much greater than that required to produce the same weight of ozone in a more dilute state. The rate of air flow, to energy input, determines the concentration; therefore, air flow is a very important factor in ozonizer design. However, it must be pointed out that the yield does not increase indefinitely, with increasing air flow; and since the power required to dry the air is considerable, in relation to the power required to produce the quantities of ozone used in ventilation, it becomes necessary to strike a compromise between these two costs, in order to obtain the lowest gross cost of production.

Hill and Aeberly (*Heating and Ventilating Magazine*, December, 1921) have published graphs showing the relation between yield of ozone and air flow, while Hartman (*Ice & Refrigeration*, November and December, 1924) has given a detailed analysis of this factor, in the terms of dollars and cents.

Analysis of Ozone-Air Mixtures

Ozone, in air, is best determined quantitatively by iodimetric titration. Of the numerous methods, for the quantitative determination of ozone, that have been advanced from time to time, none combine as high an order of accuracy with simplicity of technique, as does this standard method, the technique of which is familiar to all chemists or may be found in any text book of volumetric analysis. A few precautions, not ordinarily described in standard text books, should be observed when applying this method to ozone determinations, (See Hartman, F. E., Analysis of Ozone-Air Mixtures, *Aerologist*, August, 1926.)

As the out-put of an ozonizer can be very closely controlled by the manufacturer, it is recommended that the out-put be checked, when desired, by an analysis of the ozonized air coming directly from the ozonizer, thus eliminating the errors inherent in fan deliveries, leakage, etc., which may be addative, and of sufficient magnitude to give quite an erroneous idea of the performance of the ozonizer.

It is frequently desirable to determine the concentration of ozone actually produced in the spaces for which the ventilation is intended. Such concentrations are generally of the order of 0.01 ppm minimum, to about 0.5 ppm maximum, and are without the range of accuracy of the standard iodimetric method. A fairly accurate, and comparatively simple, method for determination of concentrations of this order has been devised by Yant, Jones & Houghten, which is described in detail in the Transactions, A. S. H. & V. E., Vol. 29, p. 331 et seq., 1923.

Periodical checks of the actual out-put of the ozonizer, together with a check of the concentration established in the ventilated spaces should be fruitful of exceedingly interesting and suggestive data.

Determining Proper Concentration

The concentration of ozone in the air of ventilated spaces, should not be allowed to rise appreciably above 0.01 ppm. However, this does not mean that this is the proper concentration to introduce. The quantity of ozone necessary to maintain this concentration will depend upon what has been aptly termed "respiratory load," or cubic feet of air, per person,

per unit of time; together with a consideration of such odoriferous operations as may exist in the ventilated spaces, and the purity of the source of air supply. Thus air drawn from near the level of the city streets will require more ozone to maintain the proper concentration, than will air drawn from purer sources. This applies equally to air drawn from the vicinity of stock yards and the like.

Likewise restaurants, smoking rooms, dance halls. and theatres will require a greater quantity of ozone than will schools, offices, etc. Department stores, particularly the basements, due to odors arising from fabrics and other wares, require special consideration. There is also what may be called the "building co-efficient," which includes the length of the duct system, the heigths of the ceilings, and the condition of the ventilating system, whether old and dusty or new and clean, together with the rate of air change, and whether humidity control is provided or not.

In industrial ventilation, where specific contaminants are to be contended with, a knowledge of the concentration and character of the contaminating substances is essential for best results. Ozone is not a cure-all for industrial odors in general, for instance, allyl alcohol vapors, which possess an annoying odor, when subjected to action with ozone, produce the aldehyde acrolein, which is exceedingly irritating, even in very small concentrations. Here harm rather than good will be done. It is best to submit problems of this character to engineers experienced in the use of ozone for definite recommendations.

It has been recommended (Hill & Aeberly, *Heating and Ventilating Magazine*, March, 1922) that sufficient ozone capacity be provided to permit of building up comparatively high concentrations when the building is not occupied. In schools, for example, the ozone equipment should be operated at a capacity to give perhaps 0.01 ppm of ozone when the building is occupied, and after the pupils have left the building, the full capacity of the machine should be used, closing all openings, recirculating the entire amount of air, and building up a sufficient concentration to exert the maximum deodorizing effect throughout the building, the duct work and mechanical equipment.

For general ventilation, under average conditions (85 per cent ventilation), the ozonizer should be of sufficient capacity to provide a concentration of 0.05 ppm of ozone in the fan volume. For 100 per cent ventilating systems a lesser quantity can be made to suffice. A generalization cannot be made broad enough to cover the many special conditions, particularly problems of specific deodorization.

Determining Required Capacity

Having chosen the maximum required concentration of ozone, for the purpose in hand, it becomes necessary to calculate the capacity of the ozonizer. There seems to be no agreement, among makers of ozone equipment, regarding the unit of rating for ventilating ozonizers. There are three methods in common use, as follows:

Parts per Million: wherein the ozonizer is rated in parts per million (generally by volume) in some specific air volume. At first this may seem a very desirable method for rating ozonizers, as it is simply necessary to state the ppm of ozone, required for the specific CFM of air. Ozonizers so rated, have their ozone meter calibrated in ppm for the specified CFM, and should the fan volume be varied, the meter is liable to become

misleading, as the original CFM may not always be considered when reading it. Consideration of the original CFM, and proportioning to any new CFM, is essential with an ozonier so rated, if accurate knowledge of the concentration employed at any other CFM is desired.

Ozone is generally applied on the basis of ppm by volume, and as there is no existing agreement concerning a standard temperature and pressure at which the ozonizer should be calibrated, this method of rating leaves the actual capacity of the unit open to question, unless the temperature and pressure employed for calibrating is stated. Since weight is unaffected by temperature and pressure, and as ozone is determined chemically, directly in the terms of weight, weight forms a better basis for the rating of ozonizers, and eliminates a number of qualifying factors, together with tedious calculations in ozonizer design.

Milligrams per Minute: Ozonizers so rated have their ozone meter calibrated directly in the terms of milligrams per minute, and leave no questions concerning the actual capacity of the unit. Errors of omission are further circumvented by forcing a consideration of all factors, when determining the concentration of ozone in the air of the ventilating system.

The expression ppm, generally means parts per million by volume at room temperature and average barometric pressure, when referred to ozone in ventilation. One litre of ozone at 25 deg. Cent. and 740 mm Hg, weighs 1.9127 grams. Taking these conditions as a basis, the weight of 1 cc. of ozone may be taken as 2 milligrams, yielding a very convenient figure for use, easily remembered, and sufficiently accurate for all practical purposes. The metric system is best employed here, for convenience of analysis and calculations of design, with final conversion into English units for purpose of application. It is on this basis that the following formulae have been derived:

Formulae for Application:

CFM = Fan Capacity, cubic feet per minute of air.
mpm = Milligrams of ozone per minute.
ppm = Parts of ozone per million parts of air, by volume, at 25 deg. cent. and 740 mm. Hg.
28,320 = cc per cubic foot.
2 = weight of 1 cc of O_3 at 25 deg. cent. and 740 mm. Hg.

Given: CFM and ppm; Find: mpm

$$\frac{\text{CFM} \times \text{ppm}}{10^6} \times 28{,}320 \times 2 = \text{mpm}$$

which reduces to:

$$\frac{\text{CFM} \times \text{ppm}}{10^3} \times 56.64 = \text{mpm} \quad (1)$$

Given: mpm and ppm; Find: CFM

$$\frac{\text{mpm} \times 10^3}{56.64} \times \frac{1}{\text{ppm}} = \text{CFM} \quad (2)$$

Given: mpm and CFM; Find: ppm

$$\frac{\text{mpm}}{56.64} \times \frac{10^3}{\text{CFM}} = \text{ppm} \quad (3)$$

Ventilating Unit—The Ventilating Unit (VU) has been created by the author, for the purpose of simplifying the calculations for applying ozone to ventilating systems. It is a compound unit, taking into consideration quantity and time. It is analagous to the horsepower, wherein 33,000 pounds are lifted one foot in one minute. It represents that quantity of ozone necessary to produce a concentration of 0.1 ppm in 1,000 CFM, at 25 deg. cent. and 740 mm Hg.

1 VU = 5.7 milligram of O_3 per minute
340 milligrams of O_3 per hour

The formulae for its application are very simple:

Given CFM and ppm; Find VU

$$\frac{\text{CFM}}{100} \times \text{ppm} = \text{VU} \quad (4)$$

which reduces to pointing off two places in the CFM and multiplying by the ppm.

Given: VU and CFM; Find: ppm

$$\frac{0.1 \times VU}{CFM} \times 1{,}000 = ppm \quad (5)$$

which reduces to pointing off three places in the CFM, one place in the VU, and dividing the former into the latter.

Given: VU and ppm; Find: CFM

$$\frac{1{,}000}{ppm \times 10} \times VU = CFM \quad (6)$$

As the VU represents a definite weight of ozone, in a definite period of time, ozonizers so rated leave no question as to their actual capacity. The decimal character of the unit admits of much facility in calculations.

WATER PURIFICATION

Ozone finds a very important application in the purification of water. Operating costs rarely exceed an energy expenditure of 500 watt hours per thousand gallons.

Ozone successfully eliminates odors and tastes of organic origin, particularly the tastes and odors due to excessive chlorination, and the presence of chlorinated phenols and tarry substances. Organic colors are bleached, and the effluent of a properly designed ozonizer is practically sterile.

The essentials of a good water ozonizer are an adequate and constant supply of ozone, in sufficiently high concentrations to effect high solubility at normal temperatures, adequate mixing of the ozonized air and water, under conditions which produce maximum diffusion and absorption, and over a sufficient period of time to effect sterilization. The control should provide under and over voltage release, together with a release for water pressures too low to efficiently operate the mixing device.

INDUSTRIAL USES

Ozone finds a number of applications as an oxidizing agent, in industrial operations, many of which are of little interest in ventilation. However, ozone may be used to accelerate the drying of paints and varnishes, the "oxidation" of drying oils, and many other drying operations involving oxidation. Such problems are generally specific, and it is advisable to consult the manufacturers of ozone equipment concerning them.

COLD STORAGE

Ozone is of value in cold storage for the prevention of mould development, deodorizing of storage spaces, after removal of odoriferous products, to prepare for other commodities. The preservation of flavor, particularly in eggs, and the general freshening and vitalizing of the air, the advantage of which is reflected by the superior condition of products stored in "fresh" air over those stored in "dead" air.

CHAPTER XXV

METHODS OF DRYING

DRYING is an extraordinarily interesting problem in engineering, and thousands of the products that we use every day go through some sort of drying process during their manufacture. Wood when dried becomes a workable and dependable material, the leather used in our shoes must submit to the drying operation, and the manner of its drying determines its value in the finished product. Clay when dried becomes ceramic ware, flour mixed with water when dried becomes macaroni, wood pulp dried becomes paper and gelatine dried and sensatized becomes photographic film. All textiles require the drying process at some time during their manufacture.

The term drying is often used to cover dehydration, distillation, oxidation, evaporation or any chemical action due to each of these conditions. Drying in its broader sense is not confined to the removal of moisture alone, but may refer to the evaporation or removal of substances other than water and to such operations as paint and varnish drying, linoleum manufacture and many other materials which require special treatment with respect to temperature, relative humidity and rates of moisture removal.

METHODS OF DRYING

In general, drying processes may be divided into three classes: vacuum drying, drying with radiant heat, and drying with air currents.

The vacuum method is particularly adapted to material which must be dried quickly at low temperatures and is generally used in the drying of milk, sugar, vegetables and similar products.

In drying with radiant heat the temperature of the material being dried is above that of the air surrounding it. The uniform distribution of radiant heat is important in the proper drying of materials, and the radiator used should have relatively large radiating surface and be well distributed in the drying area. About one-third to one-half of the heat given off by the radiating surface passes through the air to the object which is to be dried without materially raising the air temperature, the remaining portion of the heat emitted by the radiator warms the air by convection and produces air currents which assist in the removal of the moisture from the material being dried.

Drying with currents of air or air processing as this method is usually termed, depends for its success upon the proper circulation in the drying chamber so that it will come into direct contact with the substance to be dried. In ordinary work air temperatures carried are from 70–200 deg. fahr. with a relative humidity of 90–50 per cent. When temperatures exceed 200 deg. the process is referred to as high temperature

drying. Low temperature dryers are heated either by steam or hot water directly or indirectly and the temperatures are below the boiling point. In high temperature dryers the range is above the boiling point and the heat is maintained directly or indirectly by electricity or heated oil, direct introduction of flue gases, by high pressure steam or special air heaters. Dryers are usually termed intermittent or continuous, depending on whether they are charged for the complete drying period of whether the material to be dried is continuously admitted and removed. As compartment dryers consist of an enclosure to direct the air movement and control the heat, the current of heated air flowing through the drying cabinet is under accurate and uniform control of temperature and humidity. The selection of the compartment or continuous type of dryer depends upon the most practical method of handling the material rather than upon the drying process. The use of the continuous dryer is customary whenever the drying period is less than 6 hours or where the continuous drying process is required for 24 hours at a time. The efficient operation of the continuous dryer requires that it function at full capacity. The continuous dryer will be found in a variety of forms those principally used being the tunnel, drum, rotary and spray types. In a tunnel dryer the product being kept in trays or loaded on cars moves along by gravity or by means of an endless belt conveyor and the air usually moves in the opposite direction from the material in order to get the maximum drying efficiency. Drum dryers are used for liquids or solids such as paper, cloth and materials that will pass over the drum in a continuous sheet.

A rotary type of dryer consists of revolving drums through which material and air intermingle, the drum being inclined to facilitate the movement of the material and is generally used where the product to be dried is in a moist or semi-moist condition. Spray drying consists of sending a fine solution of the material into a current of warm air and is limited to products which can be handled in liquid form.

The relative advantages of the different types of dryers are dependent on the nature of the material, the space available and the capacity of the apparatus.

The variety of products to be dried include many of animal or vegetable origin and many possess exceptional hydroscopic or absorptive properties. When they are of colloidal nature, successful processing is more difficult. Frequently it is necessary to expose the material to a series of different conditions beginning with a minimum temperature and maximum humidity, the temperature being increased and the relative humidity decreased as the work progresses. Where material contains both free and hydroscopic moisture, humidity conditions must be carefully adjusted so that during the period when the free moisture is being removed case hardening or surface drying does not occur. The air circulation is another important factor and the velocity which is used should be high enough to constantly remove the heavy film of saturated air which surrounds the material as soon as it begins to dry.

The temperature in which a product is to be dried should be as high as can be used without injury to the material. The accompanying tabulation will give the conditions that are usually found satisfactory.

Material	Temp. Deg. F.	Time
Apples	140–180	6 hours
Cocoanut	175–200	4–6 hours
Sugar	150–200	20–30 minutes
Coffee	160–180	24 hours
Mixed Stock Feed	220	20–30 minutes
Starch	180–200	12 hours
Glue	70–90	2–4 days
Thin Leather Hides	90	2–3 days
Thick Sole Leather	90	4–6 days
Shade Cloth	240	1–2 minutes
Rubber	80–90	1–2 weeks
Soap	100	2 days
Wall Board	200–250	12–24 hours
Gypsum Board	180–280	24–48 hours

In any system where there are no critical temperatures the permissible maximum working temperature is that above which the actual gain in speed or output due to the increase temperature is less in proportion than the increase speed of operation due to the increased temperature. In the case of some fruits and vegetables a relatively low temperature and high velocity is better than too high temperature, but, a too low temperature and too long drying period result in a tough product.

The evolution of the compartment and tunnel dryer design is very interesting and innumerable means have been used to secure the proper heating effect, air distribution and moisture removal. In dryer design it should be noted that there are three important objectives to be attained: to secure an adequate supply of air so distributed that it circulates evenly over the radiators and trays; to secure a rapid air movement so that moisture is absorbed from the material to be dried, and to effectively remove the moisture from the saturated air. The quantity of air that should be supplied by the fan and the number of air changes in the drying compartment will vary with the type of installation and is affected by the rate at which moisture is given up by the material to be dried.

The theoretical amount of moisture which the air will remove is directly proportional to the difference between the wet-bulb and dry-bulb temperature of the entering air, while the actual amount absorbed by a given quantity of air is measured by the drop in dry-bulb temperature between the air entering and leaving the dryer, less a slight correction for radiation. For the same reason the higher the temperature of the entering air (for a given initial moisture content) the greater will be the amount of moisture removed per given quantity of air and the greater the economy of the dryer.

The temperature of the air will drop approximately 8½ deg. for each grain of moisture absorbed per cu. ft. of air measured at 70 deg., or 0.64 of a deg. for each grain of moisture absorbed per pound of air. Approximate calculations may be based on air volume, but for exact determinations the weight of air handled should be used, on account of it being a fixed quantity at all temperatures. Knowing the rate of drying desired and the amount of moisture to be removed, it is a simple matter to determine the quantity of air required.

It is generally found that about 2 lb. of steam are required to evaporate

1 lb. of water, under the most favorable conditions, while the more usual figure for steam consumption is 2½ lb. of steam to 1 lb. of water evaporated. The principal losses in air drying are radiation and escape of unsaturated air, either through the usual vent ducts or by leakage through the kiln walls.

Practically every problem in air processing and drying presents its individual considerations which affect the over-all efficiency of the final installation. The peculiarities of the material to be dried, the allowable temperature and humidities, the most efficient means of handling the material, the speed with which the process must be effected, and the mechanical or physical limitations imposed by the plant conditions themselves are all factors which must be carefully considered in the design of air processing and drying equipment.

It is customary for engineers who specialize in the design of such equipment to treat each problem individually and develop the most efficient for the specific requirements of the client.

REFERENCES

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS, Vol. 22, p. 479; Commercial Drying Apparatus, L. P. Dwyer, Vol. 23, p. 255; Drying by Evaporation, F. R. Still, p. 265; Drying in Industrial Plants, J. O. Ross, p. 339, 511, 529, 537, 545; Food Drying, Vol. 24, p. 7; High Temperature Drying, Burt S. Harrison, p. 25; The Temperature of Evaporation, W. H. Carrier, p. 352; Bibliograph on Food Drying and Dryers, Vol. 26, p. 551; Commercial Dehydration, J. E. Whiteley, Vol. 27, p. 251; Drying as an Air Conditioning Problem, A. W. Lissauer, JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, October, 1921, p. 715; A Chronological Survey of Drying and Dryers, J. E. Bolling.

CHAPTER XXVI

DUST, EXHAUST AND COLLECTING SYSTEMS

PNEUMATIC exhaust and collecting systems may be classified in various ways. They may be classified by the economic purpose to be accomplished by the industries served, or by the type of system used.

Classifying exhaust systems by industries served, they fall in subdivisions such as, metal working, woodworking, leather and shoe manufacturing, rubber industry, flint grinding, pottery works, pulverizing works, celluloid manufacturing, printing establishments, felt hatting and fur manufacturing, textile mills, grain and cereal industry, etc.

TYPES OF SYSTEMS

The type of exhaust system to be used is determined by the industry served, kind of material handled, and the work to be accomplished. There are two general arrangements; the central and the group systems. In the central system a single or double fan is located near the center of the shop with a piping system radiating to the various machines to be served. In the group system, which is sometimes employed where the machines to be served are widely scattered, small individual exhaust fans are located at the center of the machine groups.

The group arrangement has the advantage of flexibility. It is, however, more difficult to balance than the central, and also the large number of small diameter trunk lines required show a much higher friction loss per foot of length than with the central system where one large main pipe serves a considerable number of machines.

Exhaust systems are also characterized by the means employed to collect the dust or other material handled. The dust or refuse may be collected and controlled by enclosing hoods, open hoods, inward air leakage or general room exhaustion.

With some classes of machinery it is not feasible to closely hood the machines and in these cases open hoods over or adjacent to the machines are provided to collect as much of dust and fumes arising as possible. In this class come such machines as rubber mills, package filling machinery, sand blast, crushers, forges, pickling tanks, melting furnaces, and the unloading points of various types of conveyors.

The open hoods should be placed as close to the source of dust or fumes as possible with due regard to the movements of the operator.

When the hood has to be placed at some distance above the machine it should be large enough to encompass an area of considerable extent as diffusion is usually quite rapid.

Material for this section originally prepared for THE GUIDE by H. M. Nichols, revised by R. E. Shaw, Boston, Mass.

Consideration must also be given to the natural movement of the fumes. For those that are lighter than air the hood should be over or above the machine and where a heavy vapor or dust-laden air at ordinary temperature is to be removed, horizontal or floor connections are required. If it is attempted to remove heavy dust such as lead oxides by an overhead hood the conditions may be worse than if no exhaust were used at all, owing to the rising air current carrying the dust up through the breathing zones. The principle to keep in mind in all cases is to take advantage of the natural tendency of the material to move upward or downward.

In another class of operation the main object is to prevent the escape of dust into the surrounding atmosphere, the removal of some dust from the machine or enclosure being merely incidental. The dust creating apparatus is enclosed within a housing which is made as tight as practicable, and sufficient suction is applied to the enclosure to maintain an inward air leakage, thus preventing escape of the dust. While the exhaust system is only required to handle the air which leaks in through the crevices and openings in the enclosure, yet in many installations leakages are very high and great care is required to obtain satisfactory results with a system of this kind. The inward leakage principle is utilized for controlling dust in the operating of tumbling barrels, grinding, screening, elevating and similar processes.

Certain dust and fume producing operations are best carried on by isolating the process in a separate compartment or room and then applying general ventilation to this space. The compartment or room in which the work is performed should be as small as is consistent with convenience in handling the work. The ventilating system should be designed so that a strong current of clean air is drawn across the operator, and away from him toward the work, where the dust is picked up and carried from the room.

IMPORTANT REQUIREMENTS OF AN EFFICIENT EXHAUST AND COLLECTING SYSTEM

It is impracticable to enumerate all of the requirements for an efficient exhaust and collecting system, however, among the more important there are the following:

1. Fans, collectors, hoods, and ducts should be of adequate size.
2. Air volume and velocities should be adequate for the work to be accomplished.
3. The exhaust hoods should not interfere with the operation of the machine or access to its working parts.
4. The system should not increase the fire hazard.
5. The system should not increase the dust explosion hazard.
6. Where power is expensive, it should do the required work with a minimum power consumption.
7. In cold climates, it should not remove any more air than necessary from the building.
8. Where power is comparatively cheap, first cost should be low, even if the power required to operate is slightly higher.

In designing an exhaust system certain quantities must be chosen arbitrarily by the engineer, and the success of the installation depends to a large degree upon his experience and the skill with which he chooses these arbitrary quantities. It is quite possible for an inexperienced designer to lay out a system which may figure out theoretically correct, but the general results may be unsatisfactory.

The first step in designing systems employing hoods to trap the material is to determine the number and size of the connections for each individual machine. At this point the designer's past experience is of great value, as, while it is possible to set certain general standards, yet in actual practice the sizes are considerably affected by the local conditions which the layout man finds in the field, and he bases the pipe sizes and hoods on his judgment, being guided by his experience and the general practice.

The size of hoods and connections are determined by the size and type of machines or apparatus to be handled by the exhaust system, by the kind of material worked, by the duty of the machines and other local conditions. It is impracticable to lay down any general rules for determining size connections for the various types of machines and Tables 1 to 3, giving sizes as used in some of the common industries are only intended to serve as a general guide. Under certain favorable conditions smaller connections may be supplied.

Open bottom exhaust hoods of the canopy type, where it is impractical to enclose completely the point of origin of the dust or fumes, should extend over the machine or operation at least 6 in. in every direction if the hood is not elevated more than 2 ft. For each additional 2 ft. of elevation, the size of the hood should be increased 6 in. in all directions.

It is desirable to make the area of the connecting pipe not less than $\frac{1}{15}$ of the total hood area.

In systems employing inward air leakages the area of connections must be proportional to total leakage area in the enclosing housing.

Tumbling barrels have connections ranging from 4 to 8 in., bucket conveyors 6 to 12 in., and screening machines 6 to 10 in.

In general room exhaust large connections should be provided so that the air may be handled at low velocity and with a minimum power consumption.

After having determined on the proportions of the exhaust system as regards hoods and connections it is then necessary to choose the air velocity or suction at the hood connections, suction at the hood connections being a measure of the air velocity at that point.

AIR VELOCITY

The air velocity required is dependent upon the specific gravity of the material, the fineness of the particles, and their physical characteristics. Certain materials such as grease wools, silk waste, salt, and other hydroscopic substances are difficult to handle due to the tendency to deposit in the conveyor pipes.

While the velocity in the system should be sufficiently high to insure the removal of the material it should be kept as low as practicable since any higher velocity requires the use of unnecessary power. With a fixed system or orifice the power increases as the cube of the increase in velocity.

Table 1. Size of Connections for Wood-Working Machinery

Type of Machine	Diameter of Connections in Inches
Circular Saws, 12-in. diam.	4
Circular Saws, 12-24-in. diam.	5
Circular Saws, 24-40-in. diam.	6
Band Saws, Blade under 2 in. wide	4
Band Saws, Blade 2-3 in. wide	5
Band Saws, Blade 3-4 in. wide	6
Band Saws, Blade 4-5 in. wide	7
Band Saws, Blade 5-6 in. wide	8
Small Mortisers	6
Single End Tenoners	6
Double End Tenoners	7
Double End, Double Head Tenoners	10
Planers, Matchers, Moulders, Stickers, Jointers, etc.—	
With Knives, 6-10 in.	5–6
With Knives, 10-20 in.	6–8
With Knives, 20-30 in.	6–10
Shapers, Light Work	4–5
Shapers, Heavy Work	8
Belt Sander, Belt less than 6 in. wide	5
Belt Sander, Belt 6-10 in. wide	6
Belt Sander, Belt 10-14 in. wide	7
Drum Sander, 24 in.	5
Drum Sander, 30 in.	6
Drum Sander, 36 in.	7
Drum Sander, 48 in.	8
Drum Sander, over 48 in.	10
Disc Sander, 24 in. diam.	5
Disc Sander, 26-36 in. diam.	6
Disc Sander, 36-48 in. diam.	7
Arm Sander	4

Table 2. Size of Connections for Grinding and Buffing Wheels

Diameter of Wheels	Max. Grinding Surface Sq. In.	Min. Diam. of Branch Pipes in Inches
Grinding—		
6 in. or less, not over 1 in. thick	19	3
7 in. to 9 in., inclusive, not over 1½ in. thick	43	3½
10 in. to 16 in., " " " 2 in. "	101	4
17 in. to 19 in., " " " 3 in. "	180	4½
20 in. to 24 in., " " " 4 in. "	302	5
25 in. to 30 in., " " " 5 in. "	472	6
Buffing—		
6 in. or less, not over 1 in. thick	19	3½
7 in. to 12 in., inclusive, not over 1½ in. thick	57	4
13 in. to 16 in., " " " 2 in. "	101	4½
17 in. to 20 in., " " " 3 in. "	189	5
21 in. to 27 in., " " " 4 in. "	338	6
27 in. to 33 in., " " " 5 in. "	518	7

Table 3. Suctions Required at Hoods For Connections of Usual Proportions

Work	Static Suction in In. of Water
Exhausting from grinding and buffing wheels	1–2
Exhausting from tumbling barrels	1–2
Exhausting from wood-working machinery—light duty	1–2
Exhausting from wood-working machinery—heavy duty	2–4
Shoe machinery exhaust	2–3
Exhausting from rubber manufacturing processes	1–2
Flint grinding exhaust	1–2
Exhausting from pottery processes	1–2
Lead dust and fume exhaust	1–4
Fur and felt machinery exhaust	2–3
Exhausting from textile machinery	1–3
Exhausting from elevating and crushing machinery	1–2
Conveying bulky and heavy materials	3–5

Velocities commonly employed are: 2,500 to 3,000 ft. per min. for light dusts, cotton, shavings and sawdust from dry wood, and similar substances. Heavy dusts, wool, shavings and sawdust from wet wood, rags, waste paper and similar materials 3,000 to 4,000 ft. per min. Lead dust, hog waste, pulp chips, etc., 4,000 to 6,000 ft. per min.

In choosing the pipe sizes consideration must be given to the way and manner in which the machines will be operated, as in case a considerable number of machines, all discharging into one main, should be shut off at the same time, the velocity in the main might easily be lowered to the point where it would not be sufficient to carry the material from the machines still in operation, and thus result in clogging the pipes. Accordingly, it is sometimes desirable to use velocities higher than the minimum to allow a factor of safety to cover this contingency.

The resistance of a round pipe to the flow of air is inversely proportional to the fifth power of the diameter of the pipe. Therefore, handling a given quantity of air through a larger pipe at a lower velocity decreases the frictional resistance very materially and correspondingly decreases the horse-power required at the fan, and thus it is very desirable to keep the air velocities throughout the system as low as possible, consistent with the major requirement that the material must be taken away as fast as made, without clogging the pipes, under the varying operating conditions met with from day to day in the plant.

The static suction required at the hood connections varies from 1 to 5 in. of water. The suction required depends upon many factors such as the relative size of the hoods and connections, kind and quantity of material handled, as well as its physical condition. In some states codes have been issued specifying suctions to be maintained for the more common dusts.

A suction standard should always be considered in conjunction with the shape of hood, and size connection, as these factors together determine the volume of air exhausted and its velocity which in turn are a measure of the effectiveness of the exhaust system.

The cubic feet of air of standard density taken into the system at each connection is given by the formula:

$$Q = 4000\, A\, f \sqrt{i}$$

where

Q = Cubic feet of air per minute;
A = Area of connection in square feet;
f = Orifice or restriction coefficient;
i = Static suction measured in inches of water.

The orifice coefficient f is dependent upon the shape and construction of the hood and will range from 60 to 90 per cent. An average value is 70 per cent.

Knowing the suction at each hood and the diameter of each connection, the volume of air passing up each branch can be taken from the accompanying Table 4. The sum of all these volumes gives the total volume to be handled by the exhaust fan.

TABLE 4. CUBIC FEET OF AIR HANDLED PER MINUTE THROUGH AVERAGE COLLECTING HOODS

Based on Coefficient of Orifice of 0.71 with 10 Per Cent Added for Leakage

DIAMETER OF CONNECTION PIPE IN.	MAINTAINED SUCTION—IN. WATER GAGE						
	1	1½	2	2½	3	4	5
1½	38	47	54	61	67	76	86
2	68	84	97	108	118	136	153
2½	107	131	161	168	185	214	238
3	153	188	217	243	266	306	343
3½	209	256	296	330	362	418	466
4	273	334	386	431	473	546	609
4½	345	423	488	546	598	690	775
5	427	523	605	676	741	854	955
6	614	751	867	970	1062	1228	1373
7	835	1023	1181	1322	1448	1670	1870
8	1092	1337	1546	1727	1892	2184	2440
9	1381	1694	1953	2184	2387	2762	3091
10	1705	2090	2409	2695	2959	3410	3806

Common practice is to provide a main suction pipe having an area 20 to 25 per cent in excess of the sum of the areas of the branches entering it between the point in question and the dead end of the main. Similarly the discharge pipe leading from the fan outlet to collector is frequently made the same diameter as the large end of the main suction pipe. The reason for this increase in size is that a considerable power saving results from the lower air velocity. However, there is no technical reason why mains should be a certain percentage greater area than the sum of the connections, and still lower power consumption can be obtained by using larger branches and mains of equal area. While the rule

of thumb method of determining size of mains works very well in many cases, yet it is always desirable to figure the mains and branches of the proper size to give the velocity which has been found best suited to the work to be done.

In certain special cases where explosive or poisonous dusts such as aluminum buffings, grain dust, powdered sugar, or lead dust are handled, increasing the size of the mains unduly would introduce a serious hazard.

An exhaust system to be effective must remove a certain amount of air from each hood or other connection, and in addition must maintain sufficient velocity throughout the piping system to convey the dust or refuse material to the separator. Any system which is mechanically well constructed and handles the requisite air at the connections and maintains sufficiently high velocities, is an effective system from the standpoint of the work done. However, to keep the operating cost low it is advantageous to do the work with as low velocities as the characteristics of the material will permit. The skilled designer will keep both of these requirements in mind and produce a system which is both effective and economical of power.

The maintained resistance of the exhaust system is composed of three factors: (1) Loss through the hoods; (2) Collector drop; and (3) Friction drop in the pipes.

A. Suction at the various hoods must be chosen from experience. Loss through the hoods can be calculated by an experienced engineer but may be taken very roughly at one-half the suction.

B. Collector drop in inches of water is given by the following formula:

$$\text{Drop} = C\left(\frac{V}{1000}\right)^2$$

where

C = a constant which depends upon the type of collector and is found to range from 0.25 to 0.75;
V = velocity in feet per minute of air entering the collector.

C. Friction drop in the pipes must be computed for each section where there is a change in area or in velocity. Find the velocities in each section of pipe starting with the branch furtherest from the fan. The friction drop for these sections can be determined by reference to Table 108. Total friction loss in the piping system is the friction drop in furthest branch plus the drop in the various sections of the main, plus the drop in the discharge pipe.

The total maintained resistance of the system—or static head required at the fan $= A + B + C$.

SELECTING THE FAN

Having determined the volume of air and static head required, the size of exhaust fan, speed and horse-power can be found by reference to the manufacturers performance tables or charts covering the type of exhaust fan selected.

TABLE 5. FRICTIONAL RESISTANCE OF STRAIGHT CONVEYOR PIPE

To Flow of Air Per 100 Feet of Pipe

VEL. OF AIR IN FT. PER MIN.	LOSS OF PRESSURE IN INCHES FOR GIVEN DIAMETER PIPE						
	4"	5"	6"	7"	8"	10"	12"
2000	1.92	1.53	1.28	1.09	0.962	0.770	0.640
2200	2.32	1.85	1.55	1.32	1.16	0.932	0.778
2400	2.77	2.22	1.84	1.58	1.39	1.01	0.924
2600	3.26	2.60	2.17	1.86	1.63	1.30	1.08
2800	3.76	3.01	2.52	2.15	1.89	1.51	1.26
3000	4.33	3.46	2.88	2.47	2.08	1.73	1.44
3200	4.93	3.94	3.28	2.82	2.47	1.97	1.64
3400	5.56	4.45	3.71	3.18	2.78	2.22	1.85
3600	6.23	4.98	4.15	3.56	3.12	2.49	2.08
3800	6.95	5.55	4.62	3.97	3.48	2.78	2.32
4000	7.69	6.15	5.13	4.40	3.85	3.08	2.57
4200	8.48	6.78	5.65	4.85	4.25	3.49	2.83
4400	9.26	7.41	6.18	5.30	4.63	3.71	3.09
4800	11.05	8.85	7.38	6.32	5.55	4.43	3.69
5200	13.00	10.50	8.66	7.44	6.50	5.21	4.34
5600	15.25	12.05	10.05	8.61	7.55	6.03	5.05
6000	17.30	13.85	11.52	9.89	8.66	6.92	5.76
	14"	16"	18"	20"	22"	24"	30"
2000	0.550	0.482	0.428	0.385	0.350	0.320	0.257
2200	0.655	0.582	0.578	0.465	0.423	0.388	0.310
2400	0.790	0.693	0.617	0.553	0.504	0.462	0.369
2600	0.930	0.810	0.722	0.650	0.590	0.542	0.434
2800	1.07	0.932	0.838	0.754	0.685	0.628	0.503
3000	1.24	1.08	0.961	0.865	0.788	0.722	0.577
3200	1.41	1.23	1.09	0.985	0.895	0.820	0.657
3400	1.59	1.43	1.24	1.11	1.01	0.925	0.742
3600	1.78	1.56	1.38	1.25	1.13	1.04	0.832
3800	1.99	1.74	1.54	1.39	1.26	1.16	0.926
4000	2.20	1.92	1.71	1.54	1.40	1.28	1.03
4200	2.43	2.12	1.88	1.70	1.54	1.42	1.13
4400	2.66	2.33	2.06	1.85	1.68	1.54	1.24
4800	3.17	2.77	2.46	2.22	2.02	1.85	1.48
5200	3.72	3.25	2.89	2.61	2.36	2.16	1.75
5600	4.32	3.78	3.35	3.02	2.74	2.52	2.01
6000	4.95	4.33	3.85	3.46	3.14	2.89	2.31

FRICTIONAL RESISTANCE OF ELBOWS

Elbows having a throat radius equal to the pipe diameter set up a resistance equivalent to a section of straight pipe approximately 10 diameters long. With a throat radius of 1½ times the diameter the resistance is about the same as seven diameters of straight pipe.

The usual types of ventilating fans are unsuitable for exhaust systems which are required to handle materials such as shavings, sawdust, emery dust, etc. Higher pressures are required than in ventilating work and in addition housings and blast wheel must be so constructed that the materials handled do not deposit in same. While the fans used in different exhaust systems are more or less of the same general type, modifications are frequently necessary to fit them for handling such materials as long shavings, strips of paper, cotton, pulverized coal, etc.

The most common method of separating the dust and other materials from the air is to pass the mixture through a centrifugal or "cyclone"

collector. In this type of collector the mixture of the air and material is introduced on a tangent, near the cylindrical top of the collector, and the whirling motion sets up a centrifugal action causing the comparatively heavy materials suspended in the air to be thrown against the side of the separator, from which position it spirals down to the tail piece, while the air escapes through the stack at the center of the collector.

COLLECTORS

For most systems, the nominal size and number of the collector will be the same as the diameter in inches of the main pipe leading to it. The nominal sizes of the different makes of collectors vary greatly, and it

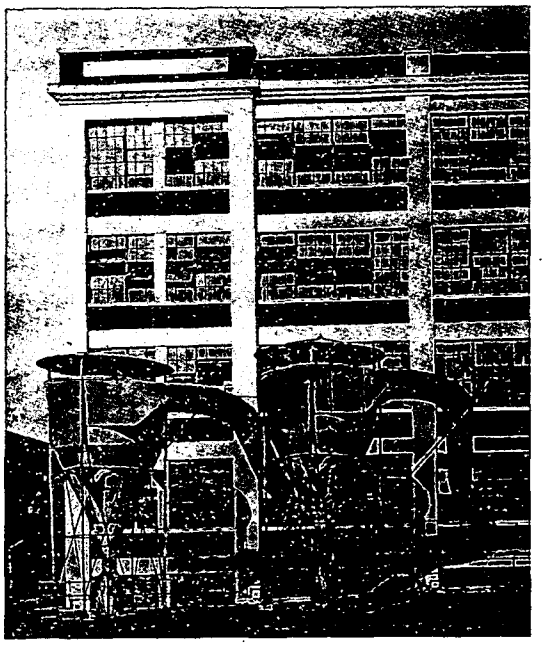

FIG. 1. COLLECTORS ON ROOF PIANO FACTORY

is advisable to make sure that a collector is large enough to do the work without excessive pressure drop, irrespective of nominal number or size. The larger the collector within certain limits the better will be the separation, and the less will be the back pressure on the fan and power consumed.

Special construction is sometimes required for fine dust, also some blow pipe manufacturers use a special type of collector for furnace feed, the object being to deliver the material to furnaces as uniformly as possibly.

When more than one fan delivers into a single collector a back pressure

valve is required to prevent one fan blowing back through the other in case the second fan should stop for any reason.

In most plants, where wood refuse is used for fuel, it is delivered by gravity directly from the collector to the furnace. The discharge pipe leading from the bottom of the collector is divided and the junction furnished with a switch or valve so arranged that when the material comes too fast for the fires it can be diverted into a reserve bin.

The furnace feeder should be hinged where it is attached to the lower end of the discharge pipe, in order that it may be disconnected from the furnace when the fan is shut down. Also great care must be taken to provide an absolutely tight switch. Otherwise, when discharging refuse to the storage bin, fine sawdust will sift through this valve and settle in the furnace feed pipe, and, in case the fireman has neglected to disconnect the feeder from the furnace, the flame may flash back, following this train of fine sawdust, into the collector.

Other forms of collectors or separators, are: settling chambers, cloth screen and bag collectors, bag houses, air washers and electric precipitators.

DESIGN OF HOODS

The mechanical design as regards shape and construction of the hoods is extremely important. Probably more systems fail from improper hood construction than from any other one cause.

If the material to be moved is already in motion, as are the chips thrown off from wood-working machines, the hoods should be arranged in the path of the particles so that the velocity of the particles assists the air in carrying the material to the throat of the hood.

Hoods should be arranged to draw dust and fumes away from the face of the operator. They should be placed as close as possible to the source of dust or waste material and wherever practical, the hoods should entirely enclose the dust producing operation.

Hoods are usually constructed of galvanized sheet iron or other equally substantial and durable material. The material should be heavy enough to stand the abrasive action of the dust and refuse. The hoods should be of sufficient mechanical strength to keep their shape and should be well braced and substantially supported. Galvanized iron used should never be lighter than No. 22 gage.

If acid or corrosive fumes are present heavy material painted with acid resisting paint should be used, or the hoods may be made of non-corrosive material.

The exposed edges of all sheet metal hoods should be bound with wire or band iron, not only to give the necessary stiffness, but also to prevent the operator from being cut by the raw edges of the sheets.

CONVEYOR PIPES

The conveyor pipes leading from the hoods to the fan and thence to the collector are commonly made of galvanized iron, the gage of which varies from No. 24 to 14, depending upon the diameter. The piping should

be free from dents, fins and projections of all kinds on which refuse material might catch.

All permanent circular joints should be lap-jointed, riveted and soldered, and all longitudinal joints either grooved and locked or riveted and soldered. Circular laps should be in the direction of the flow, and piping installed out-of-doors should have the longitudinal laps at the bottom. Every change in pipe size should be made on a taper not by an abrupt change.

All pipes passing through roofs should be equipped with collars so arranged as to prevent water leaking into the building.

The main trunks and branch pipes should be as short and straight as possible, strongly supported, and have the dead ends capped to permit inspection and cleaning. All branch pipes should join the main at an acute angle, the junction being at the side or top and never at the bottom of the main. Branch pipes should not join the main pipes at points such that the material from one branch tends to enter the branch on opposite side of main.

Cleanout openings having suitable covers should be so placed in the main and branch pipes that every part of the system can be easily reached in case the system clogs. Either a large cleanout door should be placed in the main suction pipe near the fan inlet or a detachable section of pipe, held in place by lug bands, may be provided.

Elbows should be made at least two gages heavier than straight pipe of the same diameter, the better to enable them to withstand the additional wear caused by changing the direction of flow. They should preferably have a throat radius of at least one and one-half times the diameter of the pipe.

Every pipe should be kept open and unobstructed throughout its entire length, and no fixed screen should be placed in it, although the use of a trap at the junction of the hood and branch pipe is permissible, provided it is not allowed to fill up completely.

The passing of pipes through fire-walls should be avoided wherever possible, and sweep-up connections should be so arranged that foreign material cannot be easily introduced into them.

Where considerable quantities of explosive dust or inflammable materials pass through the exhaust fan, the blast wheel should be constructed of brass composition, copper or other soft metal and in all cases ample clearance should be provided between blast wheels and housings.

Where stringy or fibrous material is to be handled through the fan be sure to employ a fan wheel especially designed for that purpose.

MAINTENANCE OF SYSTEM

Because of its simplicity the exhaust system usually receives but little attention once it is installed; however, to obtain the best results, it should be inspected at suitable intervals and necessary adjustments made.

The exhaust fan should be given proper attention the same as any other high-speed machine. It should be kept in proper alignment and tightly bolted to its foundation.

Suction hoods, which have been removed to adjust the machines, should be replaced as soon as the adjustments are completed.

Never start a machine with the blast gate closed, as the slight air leakage past the blast gate may draw material into the pipe and clog it.

Disconnect furnace feeders from the furnaces when not in operation, and do not overload the system by ill-advised additions.

CHAPTER XXVII

MECHANICAL DRAFT

THERE is a certain draft which will give the best results for every kind of fuel and rate of combustion. The amount of fuel that can be burned per hour per square foot of grate surface is governed by the quality and the type of fuel as well as by the draft obtainable. Mechanical draft is used to obtain economy of operation, increased capacity or both and may be accomplished by either the forced or induced method. The two common methods of producing mechanical draft are by means of fans or steam jets. Each method has its advantages and design conditions will govern the choice of apparatus. Steam jets are reliable, have nothing to break or wear out and are more economical to install. On the other hand fans usually take more power to operate and in cases where fan engines or turbines are used steam can be recovered in the water heater or condensers.

Mechanical draft fans are usually either disc or centrifugal type and because of the severe service to which they are subjected they must be of rugged construction, well balanced, must be able to operate continuously, withstand high stresses, maintain the proper pressure and horse power characteristics and show a good efficiency over a wide range of operative conditions.

The amount of coal that can be burned per hour per square foot of grate surface is governed by the quality and type of coal as well as the amount of draft available. Mechanical draft fans should be of such capacity that they will be able to handle the quantity of gases produced. If it is assumed that 5 lb. of coal per boiler horse power at 24 lb. of flue gases per pound of coal there would be 120 lb. of flue gases per hour to handle.

The volume of flue gases may be easily computed from the density of gases at the flue temperature and the size of fan to be provided may be obtained from the maker's table. No attempt should be made to put more air through existing boilers by speeding up the fans as the power consumption will be increased too rapidly. With the fuel bed at constant thickness, doubling the weight of air requires about 3½ times the draft pressure difference, and trebling the weight of air about 6 times. Under the first condition the fan would require 6½ times the weight of steam, so it can be seen that the most efficient fan must be selected for boilers to be driven at a high rating.

The effects of running a fan under conditions other than those for which it is designed are graphically shown by the performance curves of any given fan.

Where the size of the openings and the length of the pipe remain constant the volume of air handled by any fan increases almost directly,

as the speed, the pressure increases as the square of the speed and the power consumed increases as the cube of the speed. It is evident therefore that if more air is required, but at an increased pressure, it would be better to install a larger or additional fan rather than increase the speed of the present fan.

FORCED DRAFT

In forced draft work the air enters directly to the ash-pit so that the fuel bed is under pressure. Pressure maintained is sufficient to force the air through the duct system, stoker setting and fuel bed, otherwise there would be an objectionable leakage of gasses whenever the fire doors were opened. Losses through the boilers, breechings, etc. are cared for by the stack.

Forced draft equipment requires a higher stack than when the induced draft system is used. As the fan handles comparatively cool air the

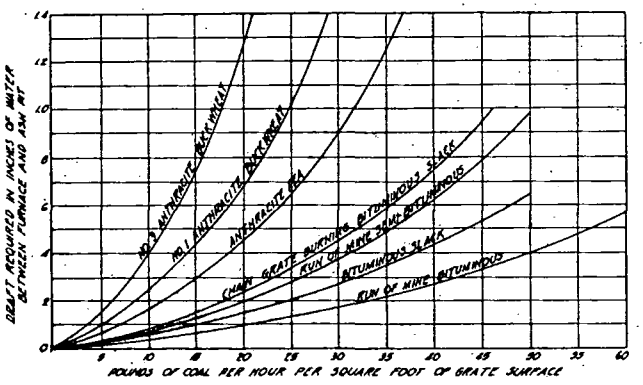

FIG. 1. DRAFT REQUIRED TO BURN VARIOUS KINDS OF COAL

equipment required is smaller and uses less power than an induced draft system of similar capacity.

Forced draft is used in under feed stokers and with chain grate stokers when high peak loads, beyond the capacity available with the natural draft, are required.

INDUCED DRAFT

Fans for induced draft are placed near the base of the stack and handle the smoke and hot gasses leaving the furnace. It is desirable to use this system when an even draft is required and the chimney available is of limited height.

With the practice of providing economizers, air heaters, etc. in the modern boiler plant and operating up to 400 per cent rating an excessive load is placed upon the chimney and induced draft equipment is necessary.

A good idea of the draft needed to burn various kinds of coal at the rate indicated under normal conditions is shown in Fig. 1. Draft for

various loads varies with the combustion rate and with the kind of fuel used. The principal losses which the draft will have to overcome will be through the boiler, fuel bed, the stokers, brick work, breechings and economizers.

The amount of air required with the forced draft system will depend upon the size of the plant and will necessitate the assumption of the combustion rate and the evaporation. There are theoretically 12 lb. of air required for the combustion of 1 lb. of coal, actually the requirements are from 20 to 25 lb. per pound of fuel.

It is customary in mechanical draft work to allow for 100 per cent excess air for hand-fired installations and 50 per cent excess where a stoker is used. This, however, is affected by the kind of stoker used, the size of the installation and the rating it carries. As there is a definite relation between the analysis of flue gases leaving the boiler and the quantity of air supplied, the results of an analysis will give the amount of air or gases being handled by a forced or induced fan. The method used is usually the Orsat apparatus. The amount of air being used may be determined by taking CO_2 readings in the breeching or forced draft connections, or by weighing the coal and ash and taking a flue gas analysis.

MECHANICAL STOKERS

Three types of stokers are commonly used, namely chain-grate, under-feed and over-feed type. Their use permits a uniform fuel supply, efficient combustion, boiler operation at higher rating and the effectual meeting of peak loads. Either forced or induced draft is successful with chain grate stokers which are designed primarily for the use of bituminous coal particularly the free burning and clinkering types. Where forced draft is used, air is delivered at different pressures under the grate, the control being accomplished by dampers, to suit the grade of fuel and the firing rate. At the front the pressure will not exceed 2 in. water gauge and will decrease toward the rear as the fuel bed gets thinner.

Over-feed stokers are adapted for all kinds of fuel and the angle of the grate bars will indicate whether bituminous, semi-bituminous coking coal or the non-coking types are to be used.

Under-feed stokers are made in single or multiple units and will burn coking or non-coking varieties of coal equally well. In both cases either forced or induced draft may be used.

The important points to be observed in recommending and using stoker installations are:

1. Stokers in large plants used in conjunction with modern methods of coal storage and handling at their disposal show a considerable labor saving.
2. In small plants stokers are only advisable where the saving in fuel will be large or where the smoke question is a factor.
3. The upkeep cost of stokers generally exceeds that for hand fired furnaces.
4. The use of different fuels and a better efficiency is obtainable with mechanical stokers.

No stoker will handle every class of fuel satisfactorily so that in selecting a stoker the engineer should take into consideration the type best suited for the fuel and operating conditions. Relative to efficiency of combustion, other conditions being similar, there will be no appreciable difference with the different types of stokers provided that the proper type is used for the fuel to be burned and the operating conditions are fulfilled.

The duct for forced draft work should be as short and straight as possible and designed so that the maximum velocity pressure under load conditions should not exceed 10 per cent of the static pressure. The air velocity should generally not exceed 2500 cu. ft. per min. Air ducts are made of heavy steel but concrete ducts are commonly used. Duct sizes are determined in accordance with the general laws of frictional resistance.

RECOMMENDATIONS FOR THE INSTALLATION OF STOKER FANS

By the

STOKER AND FAN MANUFACTURERS' ASSOCIATIONS

as reported by the Joint Committee, April, 1923

DUCTS

Velocities and Duct Proportions

The area of the main air ducts shall be determined by using a velocity in the ducts based on a velocity pressure of from 5 per cent to a maximum of 10 per cent of the static pressure. The area of the branch air ducts leading to boilers should be such that the velocity will not be more than two-thirds of that in the main ducts.

The following table shows the relation between velocities and static pressures on the above basis:

Static Pressures	Velocity in Main Air Duct 5 Per Cent S. P.	Velocity in Main Air Duct 10 Per Cent S. P.
2	1300	1800
2½	1400	2000
3	1550	2200
3½	1700	2400
4	1800	2550
4½	1900	2700
5	2000	2850
5½	2100	3000
6	2200	3100
6½	2300	3250
7	2400	3350

The above table is based on a weight of air of .075 lb. per cu. ft. which corresponds to a temperature of 68 deg. fahr., a barometric pressure 29.92 in. (sea level) and 50 per cent relative humidity. (For higher elevations or temperatures, the above velocities may be increased 1 per cent for each 500 ft. increase in elevation, and 1 per cent for each 10 deg. fahr. increase in temperature.)

Any change in the direction of the air flow should be accomplished by means of bends having a radius of throat not less than one-half the diameter of a round duct or one-half the width of a rectangular duct.

With rectangular ducts, the ratio of one side to the other should preferably be not greater than two to one.

For rectangular ducts having a ratio of one side to the other greater than 2/1 lower velocities are recommended, the reduction being 5 per cent for a ratio of sides of 3/1; 10 per cent for ratio of sides of 4/1; 15 per cent for ratio of sides 5/1; etc.

Dampers in air ducts should be located at points where the air velocity does not exceed the velocities specified above.

Construction

Air ducts shall be constructed so as to be smooth and air tight.

Where concrete or masonry ducts are used, the interior surface shall be coated with cements, paints, or other materials that will prevent air leakage. If the ducts are of metal construction, particular attention shall be given to making the joints air tight.

Where ducts are located under ground, sewer drainage shall be provided at the lowest point and manholes or doors provided for access to the ducts.

Design of Fan Discharge Connections and Main Ducts

If the fan outlet velocity exceeds the velocity in the main air duct, the connection between the fan discharge and the main air duct shall be straight and of such length that the slope of any side relative to the axis of the duct will not exceed 1 to 8.

If the discharge connection expands on one side only the slope relative to the axis of the duct may be 1 to 5.

Changes in section of the main air duct shall be made to conform with the above recommendations.

If the fan outlet velocity is not greater than the velocity in the main duct, the fan may discharge directly into the duct, unless the proportions of the fan outlet and duct are sufficiently different as to require a transformation piece, in which case the above recommendations shall apply.

Branch Air Ducts

Branch ducts shall not be taken from the connection between the fan discharge and the main duct.

Where the direction of air flow in the main duct is constant, branch ducts shall be taken off the main duct at an angle of 45 deg.

Where the air flow in the main duct may be in two directions, the branch ducts shall be taken off at right angles to the main duct with a radius of throat not less than one-half the diameter of a round branch duct or one-half the width of a rectangular branch duct.

Parallel Operation of Fans

Only fans with rising pressure characteristics shall be used for parallel operation. A fan is of rising pressure characteristic type when the pressure curve rises continuously from free delivery to no delivery condition.

If two or more fans discharge into the same duct, the connections from the fan discharges to the duct shall be designed so that the frictional loss in each case between the fan discharge and the duct will be equal.

If two or more fans discharge into the same duct with the same and constant direction of air flow, the connections from the fan discharges to the duct shall be designed so that the air streams at the point where they merge will be flowing in a parallel direction.

DATA

Fan performance is a statement of the capacities, pressures, speeds and horsepower inputs of a fan.

Performance Tables

Fan performance tables shall be based upon uniform increments of outlet velocities and give volume, speed, static pressure and horsepower.

Performance tables shall be based upon the use of inlet screens, guards, or other devices serving a similar purpose. Factors shall be given for the proper correction of performance for fans equipped with outlet dampers.

Characteristic Curves

A characteristic curve is a graphical presentation of fan performance of the relation between capacity, static and horsepower at a fixed speed. On all characteristic curves the capacities should be abscissae and static pressures and horsepowers ordinates.

Data Sheet Size

A standard size sheet, 8½ by 11 in., shall be adopted for the compilation of performance tables and characteristic curves.

Drawings

Proposal drawings shall show only limiting dimensions and shall not be used for construction purposes.

GUARANTEE

How Interpreted

The guarantee of a fan duty should be understood to cover the performance based on the capacity and pressure developed at the fan discharge.

How Demonstrated

If the conditions of the installation do not permit of an accurate field test, a laboratory test shall be made on a fan of similar type and proportions but not of a larger size.

The expense of tests to demonstrate a guarantee shall be paid by the party requesting the test unless the test demonstrates that the guarantee has not been met.

Rules Governing Fan Tested

Fan tests and the determination of the results of tests shall be governed by, and be in accordance with, the code proposed by the joint committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association of Fan Manufacturers*, and as later adopted by the *American Society of Mechanical Engineers*.

CHAPTER XXVIII

VENTILATORS AND NATURAL VENTILATION

OF the two methods of ventilating available, namely by mechanical means, and by the so-called natural forces, the later is often favored, because it is not dependent upon fans, blowers and motive power apparatus, any of which may get out of order; it requires no supervision, and it costs nothing for power to operate. It is dependent upon the operation of natural laws and is not subject to the requirements of control possible with mechanical ventilation.

Natural ventilation utilizes two separate agencies, (1) the buoyancy of the air caused by temperature difference between inside and outside of the building, and (2) the energy of the wind. The former is the same action that produces draft in a chimney. The two forces are entirely distinct and separate, and may either co-operate or oppose each other, depending upon the design of the ventilator.

A ventilator is an opening in the roof, properly protected against rain, snow and down draft; and surrounded by a hood or cowl intended to utilize the force of even the slightest breeze from any direction whatsoever, in such a manner as to assist and increase air movement within an enclosure. Occasionally a damper is required to prevent over-ventilation in cold, stormy weather. In any event, openings near the floor of the building which is to be ventilated are necessary to allow the ventilators to act.

Ventilators may be classified in general as stationary and rotary, and each of these may be divided into siphoning and non-siphoning, the rotary ventilator being one which always presents the same face to the wind, and the siphoning ventilator being one which is so constructed as to use the force of the wind to siphon the air out of the ventilator, usually allowing some of the external air to pass through the head.

Engineers, architects and contractors who must make a selection should be guided by the following four general points, (1) quality of material, (2) design, (3) construction and (4) capacity (conditions should be stated, otherwise a fair comparison of this item is impossible).

What is generally desired more specifically is, the greatest amount of reliable ventilation for a given cost of equipment. The following facts affect ventilation and ventilator capacity:

1. Temperature difference between inside and outside of building.
2. Height of ventilator above air inlet openings.
3. Wind velocity.
4. Design, shape and proportions of ventilator.

Material for this section furnished especially for THE GUIDE by Frank Kelley, Pittsburgh, Pa., C. T. Palmer, Akron, Ohio and Thornton Lewis, Philadelphia, Pa.

5. Air admission below the ventilator, (resistance to flow of air *into* building).
6. Resistance to air flow *through* the building.
7. Resistance to air flow in the ventilators themselves.
8. Location of the ventilator with respect to surrounding objects.

Of the factors mentioned, only items 4 and 7 depend upon the ventilator itself; the other items depend upon circumstances wholly outside of ventilator size and design.

While ventilators may be divided into certain classes or groups and the average efficiency of one class will be higher or lower than the average efficiency of another class, this does not in any way determine the capacity of individual ventilators, as ventilators of the same class and, which from a casual observation appear to be the same, will have entirely different characteristics, due to the fact that some of the fundamentals have been overlooked or changed in one or the other.

The principles which should be followed are:

A—Stationary Ventilators.

1. A head sufficiently large to produce a large low-pressure area on the side opposite the wind, and to give an area of outlet for the air leaving the head large enough to obviate undue resistance to flow. At the same time the head should not be so large as to be unwieldy handling or to be structurely weak when erected.
2. A storm band on stationary non-siphoning ventilators sufficiently wide and so placed as to prevent the entrance of external air into the ventilator head.
3. If the ventilator is a siphoning type additional outlet air space must be provided in the head in order not to restrict the air passage from the exhaust pipe.

B—Rotary Ventilators.

1. A flaring outlet from a rotary ventilator will give a better exhaust than a straight outlet.
2. Practically frictionless and noiseless turning of the ventilator head, when the wind direction changes. The head should turn at very low wind velocities.
3. Smallest possible change of direction of the air ascending from the building and least possible resistance to its egress by louvres or other obstructions at the outlet opening.

C—All Ventilators.

1. Freest possible outlet for the air from the building, with large areas and smallest possible change of direction of the air flow.
2. Freedom from down drafts and from entrance of rain or snow.
3. Freedom from being rendered inoperative by collection of snow or formation of ice on ventilator.

The simplest form of ventilator, shown in Fig. 1, consists of an outlet pipe with a conical hood above it. The addition of a storm band, as

shown in Figs. 2, 3 and 4, gives an increased protection against the entrance of rain or snow. The storm band, if placed so close to the cones as to restrict the outflow of air, interferes with ventilation. On the other hand, if the openings are made large enough to permit free egress of the inside air, the storm band increases the ventilation by utilizing the wind velocity to produce suction.

A further development of the later principle is the siphon ventilator, as illustrated in Fig. 5, in which siphons or ducts are introduced for the particular purpose of producing suction.

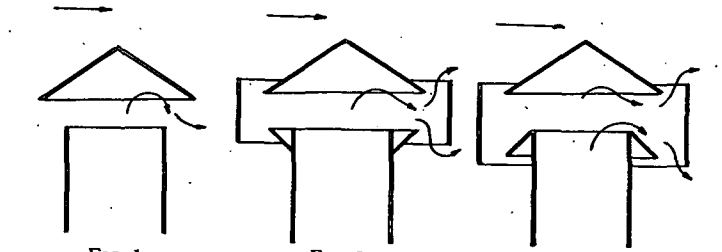

FIG. 1 FIG. 2 FIG. 3

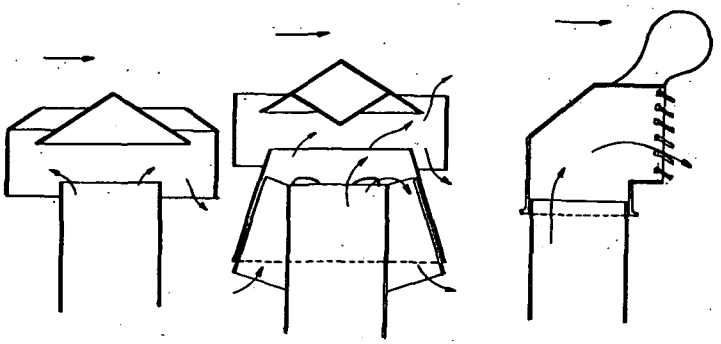

FIG. 4 FIG. 5 FIG. 6

VARIOUS STYLES OF ROOF VENTILATORS

In the swiveling or rotary ventilators, typified by Figs. 6 and 7, a freely rotating cowl is used. A wind vane is provided for keeping the opening facing away from the direction of the wind. This type allows free egress of the inside air (unless the outlet is made unduly small). For producing suction, it depends upon the viscous drag of the wind passing along the outside of the cowl.

In the induction or ejector type of ventilator, which is also of the swiveling or rotary type Fig. 8, the kinetic energy of the wind is used to a large extent by creating suction, due to the viscous drag both inside and outside the cowl. This device is effective for ventilation even with very low wind velocities. In some stationary ventilators of the siphon type, or of

the swiveling cowl type, low wind velocities have the effect of reducing the air discharge produced by the temperature difference, apparently because the laws of fluid flow are not the same at high and low velocities, which is an established fact.

All comparisons of capacity must be referred to a given dimension, namely the throat area, corresponding to the nominal size of the ventilator.

Resistance to flow of air is caused by; (1) restricted outlet openings, or (2) many turns or changes of the direction of the air flow. As regards the first item, this depends entirely upon the proportions, and not upon the type; some of the stationary ventilators have smaller, and others have larger outlet area than some cowl ventilators of the same nominal size. Regarding the second item, the swiveling cowl ventilators offer less resistance than the stationary type, in that the direction of air flow is changed as little as possible.

Unless swiveling ventilators move very freely, the opening, at times, faces towards the wind so that ventilation produced by temperature difference is much reduced, or wholly counteracted. In that case, snow and rain may blow in. The rumbling or creaking noise caused by a hard turning swivel ventilator is also very unpleasant. These troubles are, of course, eliminated in well designed ventilators, but must be kept in mind.

In Fig. 9, is shown a rotary or air-turbine ventilator, which rotates continously under the action of the wind, the motion being produced by the difference of wind pressure on the convex and concave sides of the vanes. The air-exhausting action is due to centrifugal force. This type of ventilator must be very carefully designed if it is to be leak-proof, and if the noises and impact forces, due to ice accumulating on the vanes in the winter are to be eliminated.

CAPACITIES

The variety of factors affecting capacity makes it essential for the user of ventilators to exercise great care in respect to this item of capacity.

The draft in a ventilator head, due to the velocity of the wind, is primarily caused by the low pressure area or partial vacuum on the leeward side of the ventilator head. A draft in certain designs may also be caused by the siphoning action of the wind passing through the ventilator head, but any air which is allowed to enter the head to create a siphoning action must get out and in so doing will diminish the effective area of the head for exhausting air, and it is also very likely to reduce the effectiveness of the low pressure area.

Naturally the ventilator which makes the best use of the available forces for creating a draft and which at the same time provides the freest path for the flow of exhaust through the ventilators should be the best ventilator. It does not follow, however, that a ventilator of one class is better or poorer than one of any other class. It may be good or poor not because it belongs to a certain class, but depending upon whether the proper basic principles have been observed in its design.

The theoretical velocity of the gases due to temperature difference may be obtained from the following well-known formula:

$$V = \sqrt{2gH} = \sqrt{2gH\left(\frac{T^1}{T^0} - 1\right)}$$

in which

V = Velocity in feet per second
g = Gravity 32.2
H = Effective height of ventilator
T^1 = Temperature absolute of air in ventilator
T^0 = Temperature absolute of air outside

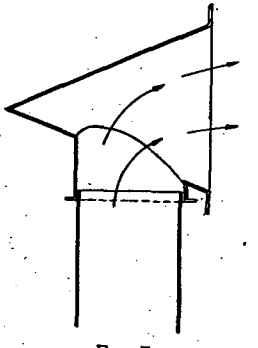

FIG. 7

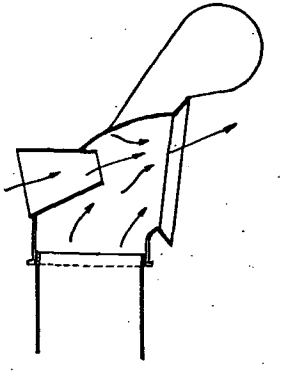

FIG. 8

ROTARY VENTILATORS

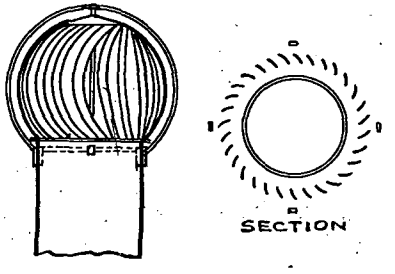

FIG. 9

AIR-TURBINE VENTILATOR

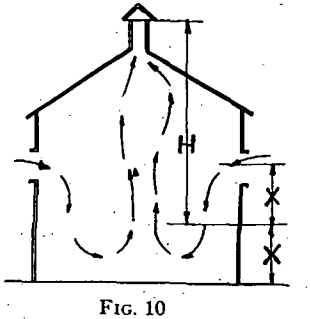

FIG. 10

DETERMINING THE EFFECTIVE HEIGHT

This gives the theoretical velocity which will be reduced in the practical case by the resistance in the pipe and the ventilator head. It is impossible to state an exact ratio between the velocity obtainable and the theoretical as every case will be different, but a reasonable assumption would be 50 per cent providing there is free admission of fresh air into the room or space ventilated.

Many exaggerated claims have been made in the marketing of ventilators and it was only recently that very careful tests were made by the U. S. Bureau of Standards (TRANS. A. S. H. V. E., Vol. 27, 1921, p. 67. See also TRANS., Vol. 28, 1922, p. 189 and Vol. 29, 1923, p. 39) and by other reliable investigators, with the result that ventilator capacities are now quite accurately known under specified test conditions.

Conservative figures for the best types of ventilators now on the market, under conditions of unrestricted flow of air to the ventilator, are given by the equation:

$$Q = A \times \left[\frac{36 \times \sqrt{H \times (t_i - t_o)}}{6 + V} + 20 \times V \right]$$

where

Q = cubic feet of air exhausted per hour through a ventilator having a free area at the throat of A square inches, mounted on a roof at a height of H feet from the center of the ventilator outlet to the floor, and with a wind velocity of V miles per hour, and average temperature t_i inside t_o outside.

The height H has been given as the height above the floor; strictly speaking, it is the height of the column of warm air in the building, which is approximately equal to the height above the location of the air inlet to the building. This location is usually near the floor. If, however, the inlet is much higher, as shown for instance in Fig. 10, the height H is indeterminate, but may, in general, be taken as halfway between the center of the air inlet and the floor.

High class ventilators, for instance those of the ejector type, will, under favorable conditions, discharge continuously 25 per cent more air than these conservative figures indicate. Capacities are lower, on the other hand, if ventilators of lower efficiency are used, or if the flow of air into or through the building is restricted, or if the ventilator is not exposed to the free sweep of the wind. Tests occasionally show considerably higher discharge rates over short periods of time. These abnormally high results are produced by the action of the wind upon certain openings of the building; they are not due to the ventilator itself, and cannot be depended upon for continuous ventilation if the direction of the wind changes. In the smaller sizes of ventilators (12 in. or less in throat diameter) the air discharge per square inch of cross-sectional area is reduced, on account of the frictional resistance and, in the rotary types, on account of reduction of free area by the supports, bearings, etc.

Example.—What is the capacity of an 18 in. ventilator, located 35 ft. above the floor, with 6 miles per hour wind velocity, 50 deg. fahr. outside temperature, 68 deg. fahr. inside temperature?

Answer.—$A = 0.7854 \times (18)^2 = 255$ sq. in.

$$Q = 255 \times \left[\frac{36 \times \sqrt{35 \times (68 - 50)}}{6 + 6} + 20 \times 6 \right] = 50{,}000 \text{ cu. ft. per hr.,}$$

average capacity under these conditions.

VENTILATION REQUIREMENTS

The air supply per person and per hour, or the number of the renewals of air contents per hour is given in Chapter I. (See also Chapter XVI.

To obtain effective, uniform ventilation and avoid local drafts, the ventilators should not be placed more than 30 ft. apart; 20 ft. apart is a good average. It is best, although not absolutely necessary, to locate the ventilator at the ridge of the roof, unless the building exceeds 40 ft. in width, in which case two rows of smaller ventilators should be used. Where the building to be ventilated is surrounded by higher buildings which obstruct air currents, it is desirable to extend the ventilators above the buildings by mounting them on stacks.

Example.—A foundry building is 40 ft. wide, 200 ft. long, with an average height of 40 ft.; the ventilators are to be mounted at the ridge of the roof, at a height of 55 ft. above the floor. What number and size of ventilators are required?

Answer.—In this case, ventilation is especially necessary in summer. The air in the building should not be over 10 deg. fahr. warmer than the outside air. The wind velocity may be as low as 4 miles per hour. Spacing the ventilators, tentatively, 25 ft. apart, 8 ventilators would be required. Under average conditions, 10 air renewals per hour are sufficient. If the foundry is small and cramped, and pouring takes place over a large section of the floor space, 15 or more air renewals per hour may be needed. On the basis of 10 renewals per hour, the capacity of each ventilator must be:

$$Q = \frac{10 \times (200 \text{ ft.} \times 40 \text{ ft.} \times 40 \text{ ft.})}{8} = 400{,}000 \text{ cu. ft. per hour}$$

The discharge per square inch of throat area under these conditions is;

$$\left[\frac{36 \times \sqrt{55 \times 10 \text{ deg.}}}{6 + 4 \text{ mi./hr.}} + 20 \times 4 \text{ mi./hr.} \right] = 165 \text{ cu. ft. of air per hr.}$$

The required throat area per ventilator is

$$\frac{400{,}000}{165} = 2420 \text{ sq. in.}$$

if there is no resistance and no wind pressure.

The diameter is $\sqrt{\frac{2420}{0.7854}} = 55.5$ in. Standard sizes are 54 in. and 60 in. Either eight—54 in. or else seven—60 in. ventilators could be used, spaced respectively 25 ft. or 28 ft. apart.

The foregoing is based on the use of high class ventilators. If ventilators of lower efficiency are used, or if the air flow into the building is restricted (as in winter) larger ventilators may be required.

CONTROL OF VENTILATION

The ideal ventilator would be one which utilized to the very best advantage even the very lowest wind velocities; attained full capacity at a wind velocity of 4 or 5 miles per hour; and then automatically controlled the air flow so that the discharge remained constant at all higher wind velocities. Such an ideal ventilator does not exist.

The best types now on the market do, however, fulfill very well the

first two requirements; for the last one, hand regulation is depended upon. For this purpose either a butterfly damper is provided in the throat of the ventilator, or, in some of the rotary types, louvres are sometimes arranged at the discharge opening of the ventilator. The damper or louvres may be operated by chains from the floor of the building, or the butterfly damper electrically controlled by push button. The louvres with their operating device have the disadvantage of restricting the free area of discharge, even when open wide. In some designs, this results in a serious reduction of capacity. Ice can interfere with their operation. The dampers may be made to close automatically in case of fire, by use of a weight and fusible link arrangement. The dampers should be so located that ice cannot freeze them tight so that adjustment is impossible.

Regulation may also be accomplished, just as effectively, by restricting the flow of air into the building (closing the windows or doors), although this is quite inconvenient in many cases.

It is generally considered best practice to have the area to be ventilated between the intake and the exhaust. Also to have the intake 15 per cent greater in area than the exhaust.

The efficient ventilator uses every bit of wind energy striking it, to the fullest possible extent.

The ideal ventilator is then the one using all the forces at hand, to the greatest possible advantage. Such a ventilator must first be correctly designed to use all these forces—proportioned to use them efficiently—be strongly and practically built to last—needing no care or attention—as they are usually placed in inaccesible places.

APPLICATION OF VENTILATORS

The use of ventilators on factory and mill buildings is too well known to require comment. For pickling rooms, etc., where noxious fumes are produced, they are practically indispensable.

Ventilators for houses are becoming quite common, especially for the ventilation of bathrooms, which has been much neglected in the past. A frequent use for ventilators is on the top of chimneys, to prevent down drafts and to increase the updraft by means of wind action.

For use on houses, several requirements must be kept in mind. Good appearance and noiseless operation are very important. The motion of the ventilator, if of the revolving type, must not shake the building or cause knocks or thumps; and the construction must be such that in the winter the movable part does not freeze to the fixed portion of the ventilator and thus stop the rotation.

On account of the increasing danger of carbon monoxide poisoning, it is becoming regular practice to equip garages with ventilators to carry off the waste gases coming from motor exhausts.

Another application of ventilators is found in connection with power ventilating systems on the outlet or discharge opening.

A very important application for ventilators is on schools, where recirculation of air is used.

Farm buildings use ventilators to a large extent and the duty required, necessitates careful selection.

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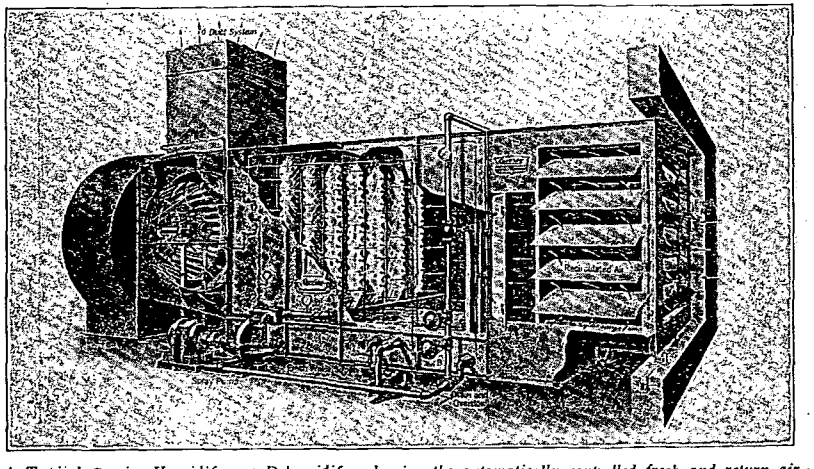
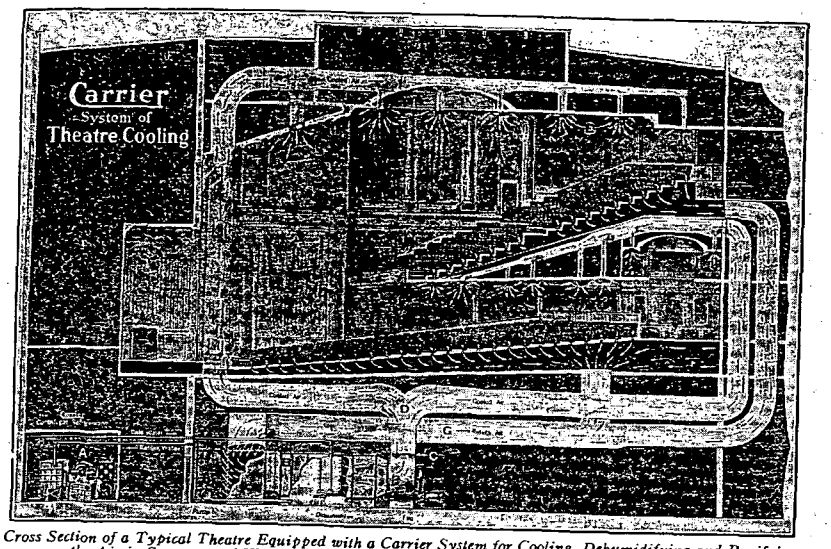


A Typical Carrier Humidifier or Dehumidifier showing the automatically controlled fresh and return air dampers, the spray chamber with pumping and water heating equipment and, on the left, the fan which delivers the air to the duct system



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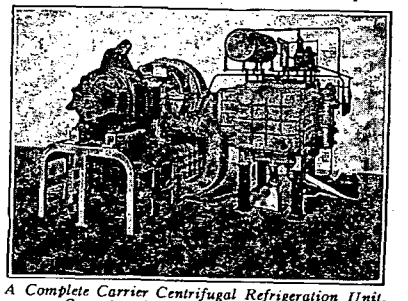

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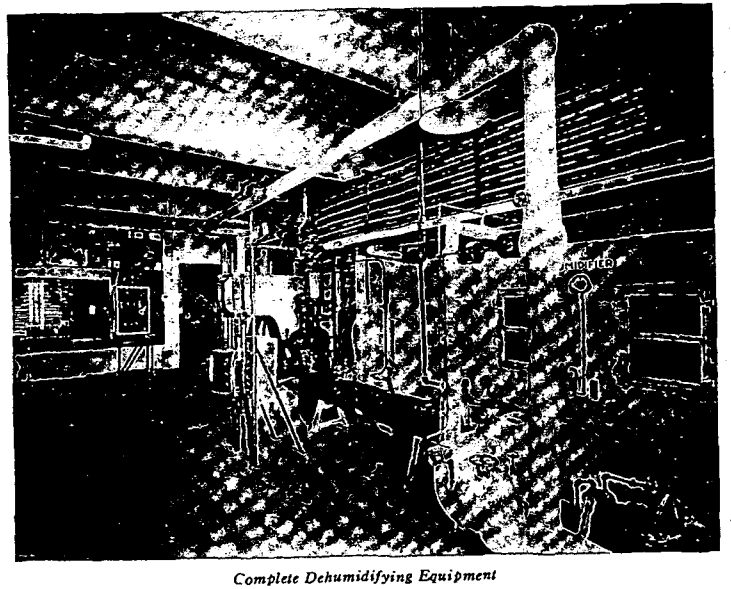

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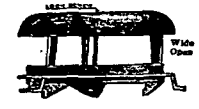
202-204 Franklin Street, New York

Knowles Air Diffusers for Auditoriums of Theatres, Churches, Schools

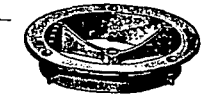
Knowles *Nu-Notch* Mushroom Ventilators are rigid because head has three outer bearings. Ten recessed notches give close regulation of air. Head is positively locked in position by tightening the head screw. Inside of cap is free from obstructions which retard the easy flow of air.

Three screwholes in floor flange are provided for fastening to wood floor or three steel L-lugs for setting in concrete. These lugs are fastened to the floor flange with bolts, permitting replacing of floor casting without disturbing concrete, or by 3 set-screws in floor collar to secure to sleeve.

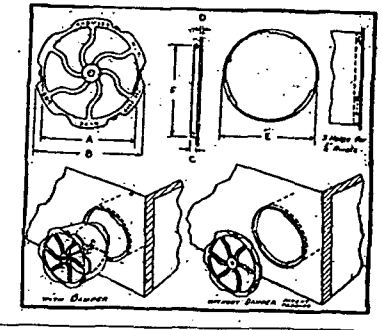
Supplied with dome or flat tops.



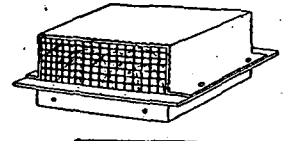
Size	C. f. m. at 300 Vel.	Area, Sq. Ft.	Weight, Lbs.
4" diam.	27	0.0873	2.75
5" "	42	0.1364	3.50
6" "	60	0.1964	4.25
7" "	81	0.2673	5.75
8" "	105	0.3491	8.00
10" "	165	0.5454	11.75

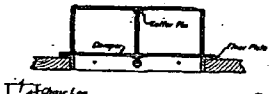


Knowles *Disc-Loc* Gallery Riser Ventilators are designed to insure better control of air. Round holes in the gallery risers do not weaken the construction but, on the contrary, with the cast iron rings it is actually strengthened. The sleeve is a plain galvanized iron cylinder, with a ½ in. turnover flange, and with a special cast iron ring, riveted flush to the inside front end. Sleeves are grouted in when concrete is poured. The cast iron grill is quickly inserted and locked by a simple twist motion—no bolts, screws or springs. Furnished with or without damper to fit same rings.



***Tu-Way* Air Deflectors** are designed to give maximum area of discharge of air with minimum fixed height. The air is discharged at both ends along the row of seats. Do not interefere with the back of chair seats when they are raised. Made of heavy cast iron with heavy wire screens locked into grooves at each end. Damper easily adjusted with screwdriver.

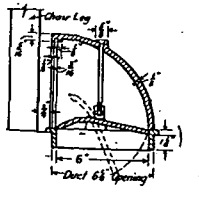




Size No.	Dimensions, Inches, Disc-Loc						Net Area Sq. Ft.	C.f.m. at 300 Velocity
	A	B	C	D	E	F		
4	3¾	5⅛	3/16	⅛	4¾	4	0.08	24
5	4¾	6¼	½	⅛	5⅝	5	0.13	39
6	5¾	7⅜	5/16	⅛	6⅞	6	0.19	57
7	6⅞	7⅞	1¼	⅛	7⅝	6⅞	0.24†	72

Size *No.	Dimensions, Inches			Area, Sq. Ft.	C.f.m. at 300 Velocity
	High	Wide	Long		
2	2	8	4	0.223	67
3	3	8	6	0.333	100
4	4	8	8	0.45	134
5	5	8	10	0.56	167
6	6	8	12	0.67	200

*With or without regulating damper. †Square grill.



Standard Aisle Hood Air Deflectors are used to throw the fresh air out into the aisles in one direction. They provide the engineer with an inexpensive method of introducing a large volume of air wherever needed without causing annoying drafts. A curved damper reduces friction loss.

	Long	Wide	High	Lbs.	C. F. M. at 300 Vel.	Area Sq. Ft.
Small Size	8"	4½"	4½"	9½	75	0.25
Large Size	8"	6"	6"	13	100	0.333

May also be made in any size to suit conditions.

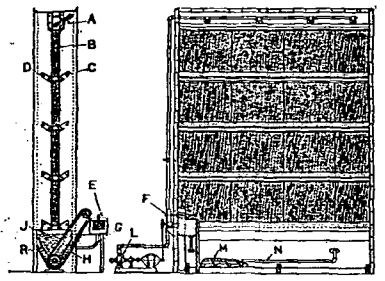
Send for NEW BOOKLET *of Complete Engineering Data*

General Air Filters Corporation

365 Lexington Avenue, **New York City**

PRODUCTS:—Manufacturers of Air Purification Equipment, Air Filters, Air Washers, Spray Nozzles

Ace Automatic Self-Cleaning Air Filters



A—Primary oil distributor. B—Filter section. C—Front flashing—removable. D—Rear, combined flashing and filter support. E—Mud basket. F—Reduction gear on mud conveyor and mud ejector mechanism. G—Drain from mud basket "S". H—Mud ejector and combined mud conveyor drive. J—Oil level. L—Filter flush pump. M—Mud conveyor. N—Pump suction from reservoir. R—Oil reservoir.

The filter media consists of overlapping baffle plates made of a finely slitted steel sheet arranged in vertical position, perfectly aligned and admirably satisfying from every standpoint the requirements of a practical self-cleaning air filtering apparatus.

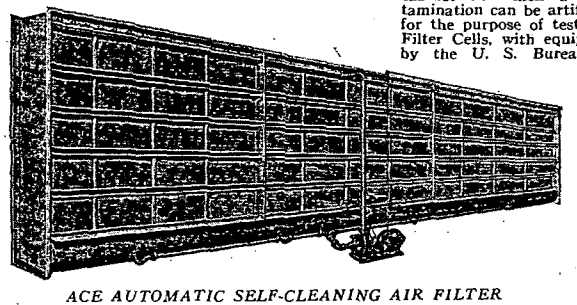
Each cell handles 1500 c.f.m. Length of installation 2 ft. multiplied by number of cells. For height multiply 21½ in. by number of cells to which add 27 in. for the reservoir and oil distributor. The depth of the filter casing is 20 in.

Operation.—For a period of only from five to seven minutes daily the flush pump is operated, pumping a special oil from the reservoir to the oil distributor on the top tier of cells. This oil flushes uniformly the entire filter surfaces and carries down the day's accumulation of dust to the settling tank and simultaneously charges the filter surfaces with oil for the next interval of operation. The conveyor and mud ejector work in conjunction with the flush pump, conveying the sediment to the mud basket located in plain view of the attendant. The basket is reversible and can be dumped very conveniently when loaded without soiling the hands; no washing is necessary. The excess oil carried up by the ejector drains back to the reservoir. Under ordinary operating conditions the day's accumulation of dust does not measurably increase the filter resistance. Accordingly there is no building up of resistance with this type.

For ventilating systems which do not operate continuously it is found most convenient to operate the flush pump when the fan unit is shut down.

For continuous service, however, such as ventilation of electrical apparatus, a dry filter section is positioned in the rear portion of the casing which permits flushing at any time during the operation of the filter.

We maintain a special test laboratory cabinet in which any dust contamination can be artifically created for the purpose of testing ACE Air Filter Cells, with equipment loaned by the U. S. Bureau of Mines.



ACE AUTOMATIC SELF-CLEANING AIR FILTER

A typical installation, Indianapolis, Ind. Length 24 ft., height 11 ft. 2 in., depth of casing 20 in. Number of cells 60–12 wide by 5 deep. Each cell occupies a space of 24 in. wide by 21⅛ in. high and has a nominal rating of 1500 c.f.m., with a resistance of 0.26 w. g.

MIDWEST AIR FILTERS

INCORPORATED

BRADFORD PENNSYLVANIA

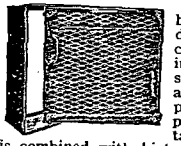
Midwest Canada, Ltd. Montreal, Canada

Branches in Principal Cities

Construction

All types of Midwest Filters are based upon the unit principle of construction, each cell being a complete and interchangeable unit. The filter cell proper consists of a heavy, welded, box like frame with expanded metal front and back, containing a series of strong, specially shaped and perforated filter sheets which are coated with a viscous non-inflammable fluid called Viscosine. Progressive increase in density of this medium provides for scientific distribution of dust from front to rear of the cell. *Note in the illustration* how dust accumulates but does not obstruct.

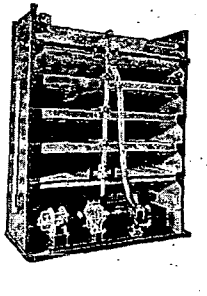
Unit Filters



Unit installations are built in wall type set-ups to deliver the required air capacity and are assembled in angle iron frames designed to fit the space available. Air tight joints provide absolutely *leak proof installations.* Resistance is unusually low and is combined with high efficiency and great dust holding capacity. Midwest cells have 19 per cent larger filter area than units with wider panels and *their cleaning efficiency* is rated between 97 and 98 per cent. Fireproof all metal construction insures maximum durability and safety. Size of unit (outside of frame)—20 by 20 by 6½ in. Size of cell—19½ by 19½ by 4 in. Net weight of cell—28 lb. Weight of cell and frame—40 lb. Air capacity per cell—800 to 1000 cu. ft. per minute. Dust holding capacity per cell 1½ lb.

Automatic Filters

Two highly efficient and dependable types of automatic self-cleaning filters are manufactured for installations where manual cleaning is not desired.



Model H. S. F. Automatic Filter

Automatic Horizontal Filters

The Midwest Horizontal filter consists of standard unit cells laid horizontally as shown in the illustration. This model possesses unusual advantages in that much of the heavy dust is eliminated by diagonal baffle aprons which catch and hold the heavier particles before the filter medium proper is reached. Cleaning is accomplished by flooding with Viscosine supplied by a Viscosine pump. Settling tank is located at the bottom of the filter. Motor and time switch provide for *regulating* cleaning intervals.

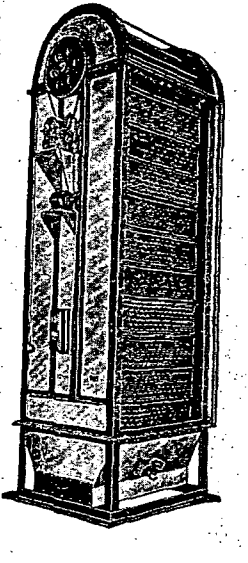
Rotary Self-Cleaning Filter

This filter is made for installation singly and in batteries for air capacity ranging from 9000 c.f.m. and up. High cleaning efficiency at low and constant operating resistance is offered. It provides great capacity per unit of space occupied, due to the fact that air enters through both sides and top. Efficiency is rated at 97 to 99 per cent.

Pressure drop ⅜ in. water gauge, constant. Capacity 1000 c.f.m. per cell.

Both the Rotary and Horizontal automatic filters possess the advantage of replaceable cells, built upon the time tested Midwest principle of construction.

Our Engineering Department will gladly furnish data, sketches and recommendations entirely without obligation to yourself.



Model SF Rotary Self-Cleaning Filter

NATIONAL AIR FILTER CO.

A DIVISION OF DRYING SYSTEMS, INC.

5130 Ravenswood Avenue

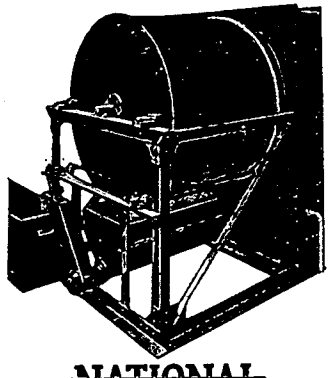
CHICAGO

National Air Filters provide a dependable and effective means of securing clean air—both for general ventilating systems and exacting industrial problems.

The NATIONAL ROTARY NATIONAL and the NATIONAL PHOENIX NATIONAL are the same in principle, but distinctive in design. They are furnished either as completely automatic or semi-automatic units.

PRINCIPLE.—The NATIONAL ROTARY NATIONAL and the NATIONAL PHOENIX NATIONAL both employ the proved principle of impingement of the dust against viscous coated surfaces, which are arranged to form a maze of tortuous passages thru which the air to be cleaned is drawn.

DESIGN.—Both filters are of the movable medium type, the cleaning element in either case, travelling intermittently by means of a fractional horse power motor, controlled by an automatic time clock.

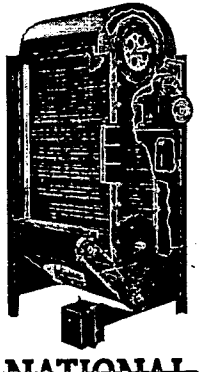


NATIONAL ROTARY NATIONAL

The medium in the NATIONAL ROTARY NATIONAL consists of innumerable strands of copper ribbon, ingeniously woven into a pad of uniform texture and wound around a hollow cylindrical drum. The medium in the NATIONAL PHOENIX NATIONAL consists of a number of special die stamped steel plates which are fabricated into an endless screen.

OPERATION.—The medium of the NATIONAL PHOENIX NATIONAL is cleaned by means of flushing the copper mesh with oil. The dust laden oil discharges into a reservoir located beneath the drum and the dust precipitates to the bottom of the receptacle. In the NATIONAL PHOENIX NATIONAL the screen revolves through the reservoir, so that a section of screen is always at rest for a sufficient length of time to permit the impinged dust to settle in the bottom of the reservoir through sedimentation.

In either type of filter, the dust accumulated in the bottom of the oil reservoir may be removed manually or by means of an automatic sludge ejector, depending on whether the user prefers a semi-automatic or an entirely automatic device.



NATIONAL PHOENIX NATIONAL

FLEXIBILITY.—Through reason of their design, these filters are flexible enough to cope with the most severe conditions. The rate of speed, as well as the density of the cleaning medium, can be regulated to best handle the individual problem.

ADVANTAGES

1. UNVARYING CLEANING EFFICIENCY.
2. CONSTANT RESISTANCE.
3. SELF CLEANING.
4. MINIMUM OPERATING COST.

Specifications

Inasmuch as both the **Rotary** and the **Phoenix** filters are furnished to meet individual requirements, floor space dimensions and headroom clearance offer an unlimited range of selection. Detail catalogs and layouts will be gladly furnished upon request and without cost or obligation.

"The Pioneers in Automatic Air Filtration"

Reed Air Filter Co.

Incorporated

Factory and General Offices:

202 Central Avenue, **Louisville, Ky.**

NEW YORK OFFICE
50 CHURCH STREET

Reed Air filters

DISTRICT REPRESENTATIVES
IN PRINCIPAL CITIES

Reed Air Filters—Streamline Self-Cleaning and Standard Unit Types— provide a simple, efficient, economical method of supplying clean air for general ventilation purposes and industrial processes.

The Reed Streamline (Self-Cleaning) Air Filter represents the most recent development in automatic air filtration. It is self-operating and requires no personal attention. The filtering media is stationary, thus eliminating moving parts. There is nothing to wear out—nothing to get out of order. Nothing moves but the charging liquid. Once a day the filter is automatically flushed or flooded with Adhesine for a period of less than two minutes, thoroughly cleaning the filtering media and leaving it freshly charged. The filtering media consists of staggered rows of streamline forms similar to the low-wind-resistance shapes developed in airplane service. (See Figure 2). These forms offer the minimum resistance to air flow.

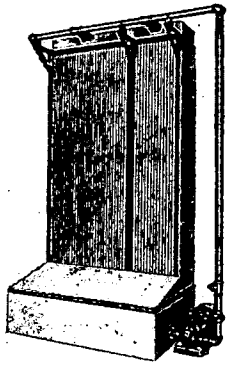


Fig. 1. An 18,000 c.f.m. Reed Streamline Filter Composed of 1½ No. 62 Sections. Note Simplicity of Installation

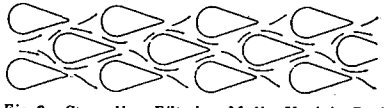


Fig. 2. Streamline Filtering Media Used in Reed Self-Cleaning Filter for Low Air Resistance and High Efficiency

The air is cleaned by a series of impingements against the Adhesine-coated forms, the impurities being gradually removed with each contact. With the Reed Streamline a constantly high cleaning efficiency is obtained with a resistance to air flow of only .25 in. of water. By adhering to the unit principle of construction and by building the filter in standard unit sizes, the laying out and installing of filters of various capacities has been greatly simplified.

The Reed Standard Unit Air Filter consists of a durable metal cell progressively packed with lead-dipped, split-wire filtering media thoroughly coated with Adhesine. This patented feature—exclusive with Reed Air Filters—separates the air into innumerable fine streams, provides the maximum number of baffles, insures the greatest number of impingements and makes possible the highest cleaning efficiency—97 to 99 per cent guaranteed.

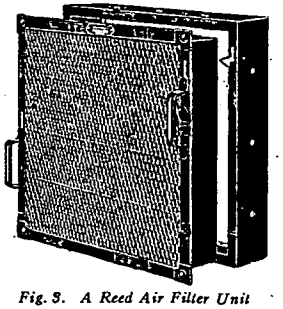


Fig. 3. A Reed Air Filter Unit

By progressively packing the media and gradually increasing its density toward the rear of the filter, greater capacity and minimum air resistance are assured. Periods between cleanings are also correspondingly increased. The new automatic latch facilitates the handling of cells in restricted areas and the felt gasket between cell and frame prevents leakage and insures full efficiency. The new Reed Steam Cleaning Tank eliminates the manual labor of washing and gives the assurance of uniformly clean filters at all times.

Our Engineering Department will gladly furnish complete data and drawings without cost or obligation to you.

Spray Engineering Company

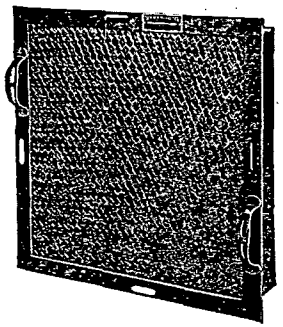
60 High Street, **Boston, Massachusetts**

Engineers and Manufacturers of Air Filters, Air Washers, Air Coolers, Spray Cooling Ponds, Nozzles, Strainers, Flow Meters, Lawn Sprinklers

SPRACO AIR FILTERS

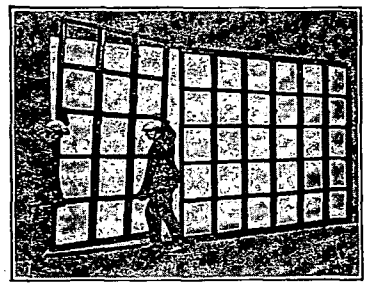
Spraco Air Filters efficiently remove from the ventilating air, dust, dirt and other foreign matter. Their design incorporates decided improvement in both the automatic and the unit cell type air filter, which results in low air resistance combined with exceptionally high air cleaning efficiency.

The filter media is arranged to give the greatest possible dust collecting surface within a given space and is comprised of diversiform expanded metal sheets and knitted copper mats. All parts are factory welded and exceptionally rugged.



Spraco Filter Cell (Front View)

Spraco Automatic Air Filter—The SPRACO Automatic Air Filter is not only exceptionally efficient (the air being filtered twice due to the double-pass feature) but is absolutely self-cleaning. The design incorporates a number of removable filter boxes made up as an endless filter belt, a portion of which extends down into a tank of "Dustix" Charging Solution. The dirt is settled out in this tank and removed automatically by the sediment ejector. The ¼ hp. motor which drives both the filter belt and sediment ejector operates for a period of only 10 to 20 minutes per day, consequently the power consumption is negligible. SPRACO Automatic Air Filters are furnished in single, two and three section units, to conform with the capacity required. *Further particulars on request.*



Spraco Sectional Framework minimizes erection costs

Spraco Cell Type Filters—(See Illustrations). The SPRACO Cell Type Filters, which are in universal use, have very distinctive features, some of which are mentioned below. Although not self-cleaning, they are generally preferred, owing to their low first cost.

Spraco Sectional Framework—The framework for holding the cells is made up in sections of all welded construction, to insure maximum strength and perfect alignment. The sectional framework also eliminates air leakage and reduces the cost of installation to a minimum.

Two-Point Seal—The cells make a two-point contact with the sectional framework which is provided with a felt sealing strip at the rear. All air must therefore pass through the filter media. Quick-acting spring latches, *four* to each cell hold the cell firmly against the two-point seal.

Spraco Washing Tank—All Spraco Washing Tanks are equipped with steam water heater, overflow, drain, and water connection. They can be furnished with steam cleaning device and mechanical lift, which reduces the labor required to clean the cells to an absolute minimum.

SEND FOR BULLETIN F-47

***Specifications for* Cell Type Filters**

Space occupied by Cell	20 x 20 x 4 in.
Standard air capacity of Cell	800 c.f.m.
Average Resistance	¼ in. w.g. when clean ⅓ in. w.g. with 1 lb. dirt per cell
Cleaning efficiency	Under normal conditions will remove 97 per cent of dust a nd dirt
Net weight of Cell	30 lbs.
Net weight of Sectional Framework	per Cell—15 lbs.
Net weight of Washing Tank (Standard)	100 lbs.
Net weight of Charging Tank	80 lbs.
Net weight of Dustix Charging Solution	per Gallon— 8 lbs.

Engineering Service

The Spray Engineering Company maintains a corps of engineers experienced in all phases of air conditioning, including the filtering, washing, cooling, humidifying, and dehumidifying of air for all classes of work. These engineers are available for consultation regarding the best solution of such problems.

American Radiator Company

IDEAL GAS BOILERS

Distributor

American Gas Products Corporation

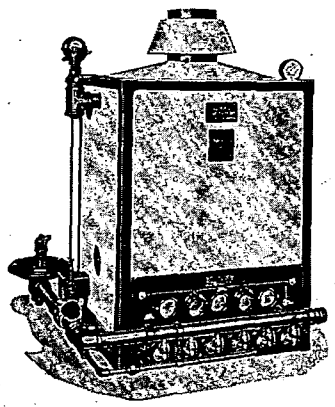
376 Lafayette Street, New York

Ideal Gas Boilers

for house-heating and industrial hot water supply

A full line of specially designed gas boilers, completely equipped for automatic operation (steam, water or vapor), with all accessories and furnished with handsome Ideal insulated jackets.

In use by leading gas companies; accepted as standard by architects, heating contractors and engineers. Will heat anything from a three-room cottage to the largest building.



Ideal Type 4G Gas Boiler

Boiler No.	RATINGS: Steam Boilers A. G. A. Rating	Steam Boilers Available B.t.u.	Steam Boilers Hp. Rating	Water Boilers A. G. A. Rating	Water Boilers Available B.t.u.	DIMENSIONS: No. of Burners	Width Inches	No. and Size of Flue Connec. Diameter Inches	Height Including Diverters Inches	No. and Size of Tappings: Supply Inches	Return Inches
1-G-4	525	126,000	3.8	900	135,000	3	18½	1-6	52½	2-4	2-4
1-G-5	700	168,000	5.0	1200	180,000	4	22½	1-7	52½	2-4	2-4
1-G-6	875	210,000	6.3	1500	225,000	5	26½	1-8	53	2-4	2-4
1-G-7	1050	252,000	7.5	1800	270,000	6	30½	1-8	53¾	2-4	2-4
1-G-8	1225	294,000	8.8	2100	315,000	7	34½	1-8	54½	2-4	2-4
1-G-9	1400	336,000	10.0	2400	360,000	8	38½	1-9	57½	2-4	2-4
1-G-10	1575	378,000	11.3	2700	405,000	9	42½	1-9	58¼	2-4	2-4
1-G-11	1750	420,000	12.5	3000	450,000	10	46½	1-10	58¾	2-4	2-4
1-G-13	2100	504,000	15.0	3600	540,000	12	54½	1-11	60¼	2-4	2-4
1-G-15	2450	588,000	17.5	4200	630,000	14	62½	1-12	61½	2-4	2-4
4-G-6	2000	480,000	14.3	3250	487,500	5	27	1-11	69	1-6	2-5
4-G-7	2400	576,000	17.2	3900	585,000	6	31	1-11	69¾	1-6	2-5
4-G-8	2800	672,000	20.0	4550	682,500	7	35	1-12	70¼	1-6	2-5
4-G-9	3200	768,000	22.9	5200	780,000	8	39	1-12	71	1-6	2-5
4-G-10	3600	864,000	25.8	5850	877,500	9	43	1-13	73	1-6	2-5
4-G-11	4000	960,000	28.6	6500	975,000	10	47	1-14	73½	1-6	2-5
4-G-12	4400	1,056,000	31.5	7150	1,072,500	11	51	1-14	74¼	1-6	2-5
4-G-14	4800	1,152,000	34.4	7800	1,170,000	12	61	2-11	69¾	2-6	2-5
4-G-16	5600	1,344,000	40.0	9100	1,365,000	14	69	2-12	70¼	2-6	2-5
4-G-18	6400	1,536,000	45.8	10,400	1,560,000	16	77	2-12	71	2-6	2-5
4-G-20	7200	1,728,000	51.6	11,700	1,755,000	18	85	2-13	73	2-6	2-5
4-G-22	8000	1,920,000	57.2	13,000	1,950,000	20	93	2-14	73½	2-6	2-5
4-G-24	8800	2,112,000	63.0	14,300	2,145,000	22	101	2-14	74¼	2-6	2-5

Ideal Gas Boilers are rated according to the specifications contained in the Code of the *American Gas Association* for testing and rating gas-fired boilers.

Ideal Gas Boilers will deliver 240 B.t.u. per hour per sq. ft. of STEAM rating and 150 B.t.u. per hour per sq. ft. of WATER rating at boiler outlets.

Pop Safety Valves conform in size to the requirements of the Code of the *American Society of Mechanical Engineers.*

The Bigelow Company

Main Office and Works

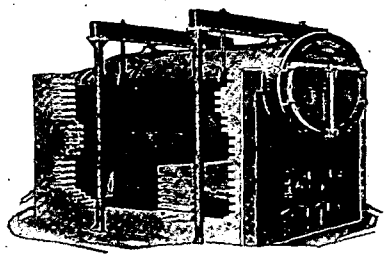
NEW HAVEN : CONNECTICUT

NEW YORK, N. Y.
149 BROADWAY

BOSTON, MASS.
141 MILK STREET

Manufacturers of

Bigelow-Hornsby Water Tube Boilers
Bigelow Horizontal Return Tubular Boilers
Bigelow Two-Pass Boilers
Bigelow-Manning Boilers
Bigelow Upright Boilers

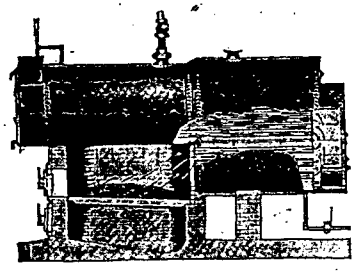


Bigelow H. R. T. Boiler

Investigation of the Bigelow H. R. T. boiler will convince you of its true value. Economical service has been the big feature of Bigelow products during a period of boiler building extending over 50 years. With a shop containing the most modern approved equipment for boiler construction a product is assured representing the highest quality in workmanship.

For Central Power Stations and large industrial plants the Bigelow Hornsby water tube boiler is unexcelled. High continuous economy, large overload capacity, large furnace volume and straight tubes are a few of the features contained in this type of boiler. The Hornsby is built in units of 375 H. P. to 3,000 H. P.

The Bigelow Two-Pass Boiler is the latest development of this company. After careful investigation of the existing types of steel heating boilers an effort was made to eliminate the objectionable features of many; the result being the Bigelow Two-Pass Boiler. This boiler will meet heating and power requirements especially where space limitations prevail. Elimination of staybolts and special brick shapes in furnace reduces maintenance to a minimum. Large furnace volume; long gas travel, uniform velocity of gas over heating surface and low exit temperature assures maximum efficiency.



Bigelow Two-Pass Boiler

Built in units from 25 H. P. to 150 H. P.

Burnham Boiler Corporation

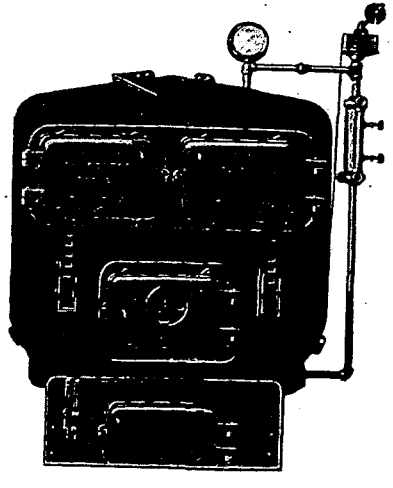
IRVINGTON, N. Y.

FACTORIES: IRVINGTON, N. Y. ELIZABETH, N. J. LANCASTER, PA.
Offices: Boston, Mass., Chicago, Ill., Baltimore, Md., Philadelphia, Pa., New York City, N.Y., San Francisco, Calif.

Makers of Low Pressure and High Pressure Cast Iron Boilers

Only One Kind of Intermediate Section in this New Burnham Smokeless

AS you will agree, a great, perhaps even the greatest handicap that smokeless boilers have had to overcome, was the complicated arrangement and various shapes of their intermediate sections.



Here is a thoroughly practical, fully tested and approved smoke-consuming boiler, with all intermediate sections of the same identical shape.

Put them in any order, and any which way about, and they will fit and function correctly.

Just three kinds of sections in all, including front and back and one kind of intermediate section.

Consequently any good steamfitter can set up the Burnham Smokeless, as easily as he does an ordinary sectional. No special training or skill is required in the firing.

RATINGS

STEAM

Size	No. of Sections	Rating	Sq. Ft. Grate Area	Tappings		Chimney Size	Overall Length
				Supply	Return		
638-S	6	5625	11.9	3-5″	3-5″	16″x16″x50′	74″
738-S	7	6875	14.3	3-5″	3-5″	16″x16″x55′	83″
838-S	8	7875	16.6	3-5″	3-5″	16″x16″x60′	92″
938-S	9	9000	19.1	4-5″	4-5″	20″x20″x60′	101″
1038-S	10	10,125	21.5	4-5″	4-5″	20″x20″x65′	110″
1138-S	11	11,250	23.9	4-5″	4-5″	24″x24″x65′	120″
1238-S	12	12,500	26.3	5-5″	5-5″	24″x24″x70′	129″

WATER

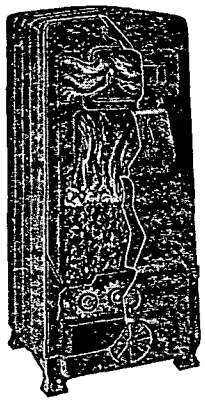
638-W	6	9,000	11.9	3-5″	3-5″	16″x16″x50′	74″
738-W	7	11,000	14.3	3-5″	3-5″	16″x16″x55′	83″
838-W	8	12,600	16.6	3-5″	3-5″	16″x16″x60′	92″
938-W	9	14,400	19.1	4-5″	4-5″	20″x20″x60′	101″
1038-W	10	16,200	21.5	4-5″	4-5″	20″x20″x65′	110″
1138-W	11	18,000	23.9	4-5″	4-5″	24″x24″x65′	120″
1238-W	12	20,000	26.3	5-5″	5-5″	24″x24″x70′	129″

Width Overall—60 in. Height Water Line—63 in. Height to Supply Tapping—75 in.
Size Smoke Pipe—18 in. 6, 7, 8 Section Boilers; 20 in. 9, 10, 11, 12 Section Boilers.

Continental Heater Corporation

Dunkirk, N. Y.

MANUFACTURERS OF CAST IRON BOILERS AND RADIATORS



Contento
For installation on same floor with radiators or in basement

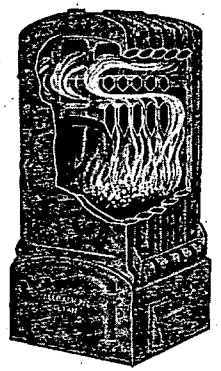
CONTENTO BOILERS

Boiler No.	Steam Rating Sq. Ft.	Water Rating Sq. Ft.	Overall Length Inches	Grate Area Sq. Ft.
4	240	400	20	.94
5	320	535	23¾	1.22
6	400	670	27	1.55
7	500	825	30¾	1.92
8	600	990	34	2.25

CONTINENTAL SQUARE BOILERS

Boiler No.	Steam Rating Sq. Ft.	Water Rating Sq. Ft.	Overall Length Inches	Grate Area Sq. Ft.
74	450	750	24	1.5
75	650	1075	28	2.0
76	825	1375	32	2.5
77	1000	1600	37	3.0
78	1175	1925	41	3.5
79	1300	2150	46	4.0

Water line 46 in. Flow tapping 56 in. Four, five, six and seven section have 2–2½ in. flow and returns; eight and nine section have 3–2½ in. flow and returns.

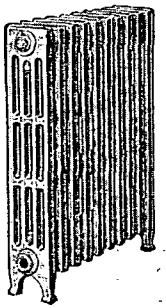


Continental Square. Water tube design. Burns any kind of fuel

CONTINENTAL RADIATORS

Each individual section is rigidly tested and inspected. After assembly each radiator receives a second test and inspection.

Continental radiators are dependable.



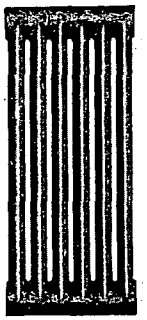
Classic in Name
Classic in Appearance

CONTINENTAL CLASSIC RADIATORS

	Width					
Four Tube	5⅞″	38″	32″	26″	20″	...
Sq. Ft. per Section	.....	4¼	3½	2¾	2¼	...
Six Tube	9″	38″	32″	26″	23″	20″
Sq. Ft. per Section	.....	6	5	4	3½	3
Eight Tube	12″	20″	17″	14″	....	...
Sq. Ft. per Section	.....	4½	3¾	3	...	...

CONTINENTAL PLAIN RADIATION

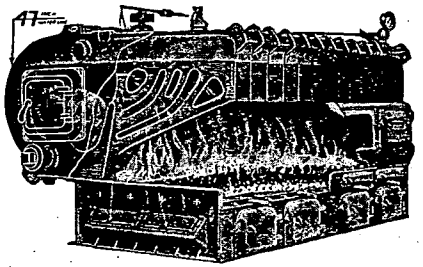
	Width					
One Column	5″	38″	32″	26″	23″	20″
Two Column	7⅛″	38″	32″	26″	23″	20″
Three Column	9″	38″	32″	26″	22″	18″
Four Column	11⅜″	38″	32″	26″	22″	18″
Five Column	13⅛″	22″	18″	14″	...	...



Wall Radiators are assembled with screw nipples

Continental Low Water Line Boilers

Smokeless and Regular Types



Interior View

Superior Features

Extremely low water line, that of largest boiler being only 47 inches. Fired short way of grates, making firing easy. Water tubes in fire box come in direct contact with flames. Good circulation within boiler and large volume of water insures steady water line on fan systems. Made in regular and smokeless types. Will burn any kind of fuel including oil. **Every boiler set up and rigidly tested before shipment.**

CONTINENTAL LOW WATER LINE BOILER DATA

(Ratings have never been changed)

Smokeless Boiler Number	Regular Series Boiler Number	Steam Rating	Water Rating	Grate Area	Flow and Return 2 Each Inches	Front Length of Boiler Inches	Extreme Overall Depth Inches	Chimney Area Inches	Chimney Height Feet
20 Series Water Line 38 Inches—Height of Flow 43 Inches									
....	25	700	1,150	3.88	3	35	39½	8x12	40
....	26	900	1,500	4.85	3	42	39½	12x12	40
....	27	1,100	1,850	5.82	3	49	39½	12x12	40
....	28	1,300	2,200	6.80	3	56	39½	12x12	40
30 Series Water Line 43 Inches—Height of Flow 48 Inches									
530	35	1,200	2,000	5.83	4	35	54½	12x12	40
630	36	1,600	2,650	7.29	4	42	54½	12x12	40
730	37	2,000	3,300	8.75	4	49	54½	12x12	40
830	38	2,400	4,000	10.21	4	56	54½	12x12	40
930	39	2,800	4,650	11.67	4	63	54½	12x16	40
1030	310	3,200	5,300	13.13	4	70	54½	12x16	45
1130	311	3,600	6,000	14.59	4	77	54½	12x16	45
1230	312	4,000	6,650	16.05	4	84	54½	16x16	45
40 Series Water Line 47 Inches—Height of Flow 54 Inches									
640	46	2,500	4,150	9.72	5	42	79	12x16	50
740	47	3,200	5,300	11.66	5	49	79	12x16	50
840	48	3,900	6,450	13.60	5	56	79	16x16	50
940	49	4,600	7,600	15.54	5	63	79	16x20	55
1040	410	5,300	8,750	17.48	5	70	79	16x20	55
1140	411	6,000	9,900	19.43	5	77	79	20x20	55
1240	412	6,700	11,100	21.35	*5	84	79	20x20	60
1340	413	7,400	12,250	23.32	*5	91	79	24x24	65
1440	414	8,100	13,400	25.27	*5	98	79	24x24	65
1540	415	8,800	14,550	27.22	*5	105	79	24x28	65
1640	416	9,500	15,700	29.17	**5	112	79	28x28	70
1740	417	10,200	16,850	31.12	**5	119	79	28x28	70
1840	418	10,900	18,000	33.07	**5	126	79	28x32	70

*One additional 4-in. flow. **Two additional 4-in. flows. Double series boilers 2,600 to 22,300 sq. ft.

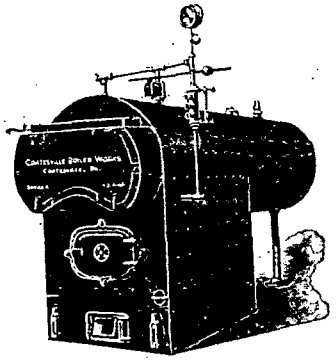
Coatesville Boiler Works

Coatesville, Pa.

NEW YORK, N.Y., 30 Church St.
BOSTON, MASS., 141 Milk St.
PITTSBURGH, PA., Union Trust Bldg.
PHILADELPHIA, PA., Packard Bldg.
BALTIMORE, MD., Lexington Bldg.
COATESVILLE, PA., 400 S. First Ave.

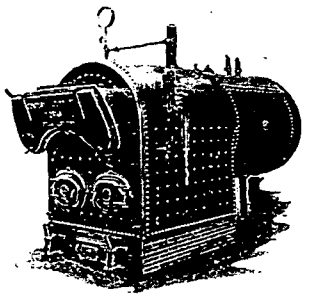
Manufacturers of Boilers, Steel Tanks and Heavy Steel Plate Work

Coatesville Boilers

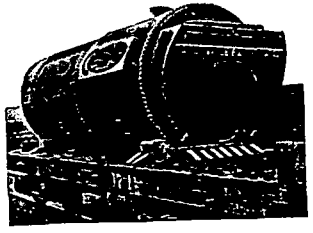


Coatesville "Series A" Welded Heating Boiler 15 lb. Working Pressure

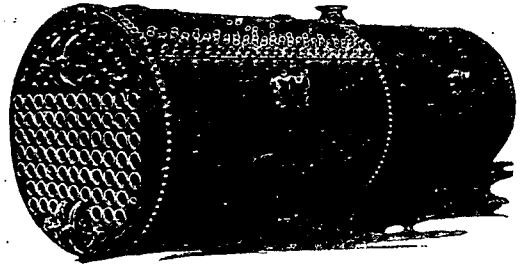
Coatesville Vertical Boiler, 100 and 125 lb. Working Pressure



Coatesville Riveted Fire Box Boiler Heating and Power



Coatesville Scotch Marine Type Boiler Power and Heating



Coatesville Horisontal Return Tubular Boiler, Power and Heating

Heating and Power Boilers.—We manufacture a complete line of steel heating and power boilers, suitable for Anthracite and Bituminous coal, Oil or Gas fuel. Note illustrations above.

Steel Tanks.—We carry storage tanks in stock to meet quick delivery requirements. We manufacture tanks for all purposes—House tanks, Storage tanks, Sump tanks, Sprinkler tanks, Blow-off tanks, Water tanks, Tanks for fuel oil, Pressure tanks, Storage tanks.

Miscellaneous Steel Plate Construction.—Steel smoke stacks, Breechings, Chutes, Hoppers, Air ducts, Bins and all special lines of steel plate work.

Electric Welding.—This department is well equipped with modern welding machines and experienced operators. Many orders for storage tanks and miscellaneous steel plate work can be economically fabricated of welded construction.

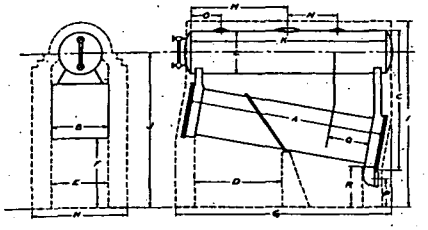
Foundry.—We have our grey iron foundry department with pattern shop and machine shop facilities. We manufacture all lines of grey iron castings required in connection with the usual building operations.

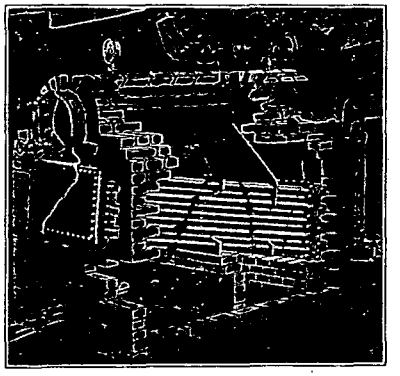
Efficient Heating Boiler Company

4116 S. Halsted Street, **Chicago, Ill.**

Steel Water Tube Boilers Adapted For Either Gas Or Oil Burning

Built to *A.S.M.E.* Standards for 15 lb. Working Pressure.





TYPES A AND B DIMENSIONS OF BOILER AND SETTING

	NUMBER OF BOILER		A-4	A-5	A-6	A-425	A-525	A-625	B-525	B-625	B-725
A	LENGTH OF BOILER	FT.	60	72	84	60	72	84	72	84	96
B	WIDTH OF BOILER	IN.	23½	23½	23½	23½	23½	23½	26½	26½	26½
C	HEIGHT OF BOILER	IN.	55	55	55	55	55	55	66	66	66
D	LENGTH OF COMBUSTION CHAMBER	IN.	24	30	36	24	30	36	36	42	48
E	WIDTH OF COMBUSTION CHAMBER	IN.	23½	23½	23½	23½	23½	23½	26½	26½	26½
F	HEIGHT OF COMBUSTION CHAMBER	IN.	24	24	24	30	30	30	36	36	36
G	OVER-ALL LENGTH OF BOILER	IN.	62	74	86	62	74	86	75	87	99
H	OVER-ALL WIDTH OF BOILER	IN.	40	40	40	46	46	46	53	53	53
I	OVER-ALL HEIGHT OF BOILER	IN.	62	62	62	72	72	72	86	86	86
J	HEIGHT OF WATER LINE	IN.	51	51	51	61	61	61	76	76	76
K	LENGTH OF TANK	IN.	56	68	80	56	68	80	69	80	92
L	DIAMETER OF TANK	IN.	18	18	18	18	18	18	24	24	24
M	LOCATION OF STEAM SUPPLY	IN.	24	30	36	24	30	36	24	30	36
N	LOCATION OF SAFETY VALVE	IN.	12	15	18	12	15	18	12	15	18
O	LOCATION OF STEAM GAGE	IN.	12	15	18	12	18	18	12	15	18
P	HEIGHT OF RETURN	IN.	7½	9½	4	13½	13½	11½	19½	17½	15½
Q	LOCATION OF REAR BAFFLE	IN.	12	15	18	12	15	18	12	18	18
R	HEIGHT OF REAR PIER	IN.	12	10	8	21	19	17	25	23	21
	AREA OF STACK	SQ.IN.	56	72	72	100	121	169	169	196	196
	MINIMUM HEIGHT OF STACK	FT.	40	40	40	43	45	45	45	45	45
	SIZE OF STEAM SUPPLY	IN.	4	5	6	6	6	6	6	6	6
	SIZE OF SAFETY VALVE	IN.	1	1¼	1½	2	2	2	2	2	2½
	SIZE OF RETURN	IN.	2½	3	3	4	4	4	4	4	4
	NO. OF FIRE BRICK		150	170	190	200	220	240	260	280	300
	NO. OF COMMON BRICK		550	625	700	760	635	910	985	1060	1135
	CAPACITY- STEAM	SQ.FT.	900	1100	1400	1800	2300	2800	3300	4000	4700
	CAPACITY- WATER	SQ.FT.	1400	1800	2200	3100	3900	4700	5600	6800	7900
	SHIPPING WEIGHT	LBS.	1067	1150	1275	1325	1500	1670	1875	2125	2350

THE TRIMMINGS FOR EACH STEAM BOILER CONSIST OF WATER COLUMN WITH WATER GAUGE, THREE COMPRESSION COCKS, STEAM GAUGE AND SAFETY VALVE.

Special Constructional Features

Water Tubes—Seamless steel tubing, ⅛ in. thick and small diameter. The tubes are sloped 10 deg.—positive and rapid circulation—can't become steam bound. The tubes are numerous as well as small—large heating surface contacts small water volume—quick steaming—less time—less fuel.

Two Baffle Plates—Hot gases pass 3 times over tubes (see illustration)—great heat removal—low chimney temperature.

Steel Headers—Removable cover plates—easy access for tube cleaning.

Steel Drum—Ample storage for steam and water.

Setting—Either brick or special designed insulated sheet iron setting—furnished in sections—easily bolted assembly, 3 cleaning doors—full access to all parts.

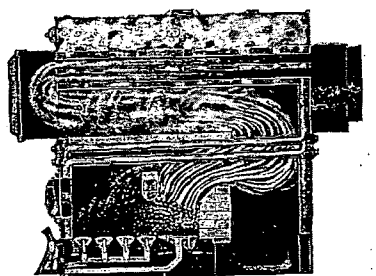
Easy Installation—Small, can be carried through ordinary door—light weight—strength through efficient design. No heavy castings.

The Frost Manufacturing Co.

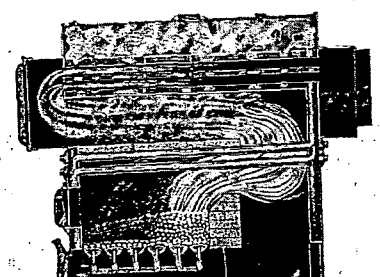
Ross Steel Heating Boilers

1530 Henderson Street

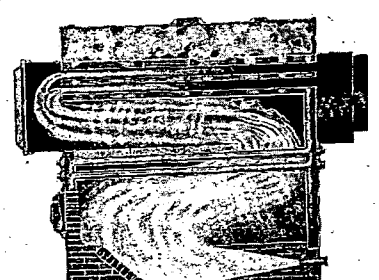
Galesburg, Ill.



Equipped for Burning soft coal smokelessly



Equipped with special grates for burning hard coal, soft coal, wood or sawdust



An Oil Burning Boiler for any type of Burner which can be installed in either front or rear of boiler

ROSS STEEL BOILERS

Steam or Hot Water

Designed for use with Bituminous, Anthracite, Buckwheat Coal, Gas, Oil, Wood or Sawdust.

Ross Boilers are quality Boilers built of steel to comply with the *A. S. M. E.* Code for heating boilers. All seams are electrically welded. Ross Boilers have unusual strength as they have no seams in tension.

Some points of advantage in Ross Boilers:

1. Spacious fire box and combustion chamber.
2. Long three pass travel of fire.
3. Fire box surfaces with crown sheet and bank of water tubes present unusually large amount of radiant heating surface in high temperature zone.
4. Complete, rapid and unrestricted circulation of water accelerated by water tubes.
5. Ample heating surface and grate surface in proper ratios.
6. Large central flue to allow complete combustion.
7. Liberal steam space and releasing area.
8. Unrestricted draft areas, correctly proportioned.
9. Large water content for hold-over.
10. Indestructible smokeless arch.
11. Full length self-cleaning crown sheet.
12. Every water space easily accessible for cleaning and inspection.
13. All tubes cleaned from outside of boiler at front.
14. Standardization of parts.
15. Perforated angle on base for securely lacing on covering.

Ross Boilers are quick, economical steamers, built for heavy duty and to outlast the building. They occupy but limited floor space, but are made big enough to carry a large body of water with broad steam disengaging areas and large combustion spaces.

Specifications.—ROSS SMOKELESS STEEL HEATING BOILERS

Steam Boiler No.	Steam Rating Sq. Ft.	Boiler Dimensions			Height Water Line In.	Heating Surface Sq. Ft.	Grate Surface Sq. Ft.	Diameter Smoke Breeching		Smoke Stacks				Steam Openings		Covering Required Sq. Ft.	Size of Base		Water Rating	Water Boiler No.
		Diam. In.	Length In.	Height In.				One Boiler In.	Two Boilers In	One Boiler Diam. In.	One Boiler Height Ft.	Two Boilers Diam. In.	Two Boilers Height Ft.	Main In.	Return In.		Width In.	Length In.		
S-101	400	24	38	59	51	43	2.34	10	...	12	35	...	...	2½	2	32	27	24	640	W-101
S-102	550	24	44	59	51	52	3.13	10	...	12	35	...	...	2½	2½	34	27	30	880	W-102
S-103	650	24	50	59	51	61	3.92	10	...	12	35	...	...	3	2½	42	27	36	1040	W-103
S-104	800	30	45	67	56	77	3.96	12	...	12	40	...	...	3½	2½	45	33	30	1280	W-104
S-105	950	30	51	67	56	90	4.98	12	...	12	40	...	...	4	2½	55	33	36	1500	W-105
S-106	1100	30	57	67	56	105	5.98	12	...	12	40	...	...	4	3	57	33	42	1750	W-106
S-107	1300	30	63	67	56	117	6.10	14	...	12	40	...	...	5	3	63	33	48	2080	W-107
S-108	1700	30	69	69	58	149	7.11	14	...	12	50	...	...	5	3	65	33	54	2700	W-108
S-109	2000	30	75	69	58	161	8.13	14	...	12	50	...	...	5	3	75	33	60	3200	W-109
S-110	2500	34	81	72	62	197	9.25	16	24	14	60	22	65	5	3	85	37	66	4000	W-110
S-111	3000	34	93	72	62	235	9.25	16	24	14	60	22	65	5	3½	95	37	78	4800	W-111
S-112	3600	34	105	72	62	275	10.40	16	24	14	60	22	65	6	3½	106	37	90	5750	W-112
S-113	4300	44	93	78	67	326	11.08	22	30	20	60	26	65	6	3½	107	47	72	6900	W-113
S-114	5000	44	105	78	67	376	12.68	22	30	20	60	26	65	6	3½	120	47	84	8000	W-114
S-115	5700	44	117	78	67	427	14.25	22	30	20	60	26	65	6	3½	133	47	96	9000	W-115
S-116	6400	48	109	86	72½	461	15.70	24	34	22	65	32	70	6	3½	127	51	84	10,200	W-116
S-117	7200	48	121	86	72½	523	17.44	24	34	22	65	32	70	6	3½	139	51	96	11,500	W-117
S-118	8000	54	112	98	80	563	17.87	26	38	24	65	34	70	8	5	140	57	84	12,800	W-118
S-119	9000	54	124	98	80	639	19.95	26	38	24	65	34	70	8	5	156	57	96	14,400	W-119
S-120	10,000	64	118	102	84½	723	21.65	28	40	26	70	36	75	8	5	172	67	90	.....	.....
S-121	11,000	64	130	102	84½	814	24.30	28	40	26	70	36	75	8	5	192	67	102	.....	.....
S-122	12,500	64	142	102	84½	904	26.46	28	40	26	70	36	75	8	5	212	67	114	.....	.....
S-123	14,500	68	138	109	91½	1033	28.30	32	46	30	70	42	75	8	5	230	71	108	.....	.....
S-124	16,000	68	150	109	91½	1144	30.60	32	46	30	75	42	80	8	5	248	71	120	.....	.....
S-125	17,500	68	162	109	91½	1253	30.60	32	46	30	75	42	80	8	5	265	71	132	.....	.....
S-126	20,000	78	154	122	97½	1383	33.00	36	50	32	80	44	90	8	5	258	81	120	.....	.....
S-127	22,000	78	166	122	97½	1515	36.00	36	52	34	90	46	100	8	5	283	81	132	.....	.....
S-128	24,500	78	160	125	104½	1660	39.00	36	52	34	90	46	100	8	5	268	81	126	.....	.....
S-129	27,500	78	172	125	104½	1812	39.00	36	52	34	90	46	100	10	5	294	81	138	.....	.....
S-130	30,000	84	160	132	111	1986	42.66	40	56	38	100	48	110	10	5	304	87	126	.....	.....
S-131	32,000	84	166	132	111	2107	42.66	40	56	38	100	48	110	10	5	316	87	132	.....	.....
S-132	35,000	84	176	132	111	2261	45.32	40	56	38	100	54	110	10	5	340	87	144	.....	.....

Built in Accordance with A. S. M. E. Code for Heating Boilers.

Every Boiler Inspected by Hartford Insurance Co. Certificate of Inspection furnished.

Catalogue sent on request.

Fitzgibbons Boiler Co., Inc.

ESTABLISHED 1886

General Offices: 570 Seventh Avenue, New York City

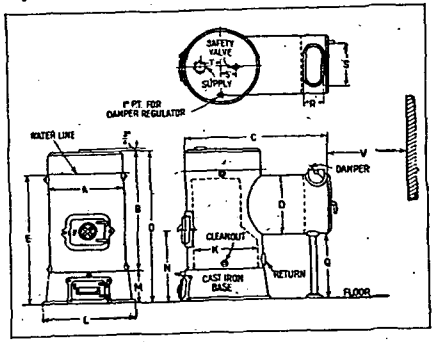
PRODUCTS

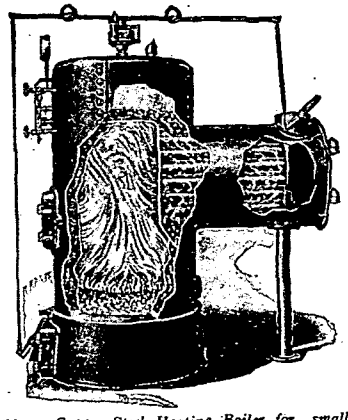
Fitzgibbons Copper Steel Boilers for Steam or Hot Water Heating. Table 1.

Fitzgibbons (Intermediate Sized) Steel Boilers for Steam or Hot Water Heating. Table 2.

Fitzgibbons All Riveted Steel Boilers for Heating and for Power. Table 3.

Reputation and Performance: For forty years Fitzgibbons Boilers have been recognized for their economy in coal consumption, quick steaming ability, and high evaporative power. Equally well known have been their performance records for low cost operation and absence of maintenance cost.





Fitzgibbons Copper-Steel Heating Boiler for small-sized installations, homes, churches, garages, etc.

Fitzgibbons (Small-Sized) Steel Boilers: These boilers embody all the economical and efficient features of the larger sized Fitzgibbons Boilers and are made in sizes ranging from 300 to 3200 sq. ft., steam rating or from 500 to 5100 sq. ft. water rating. The smallest size is 4 ft. 2 in. high, 3 ft. 3 in. long and 24 in. wide, and is particularly suited for use in small residences where space is limited. Designed for oil or coal.

They are built entirely of rust-resisting copper-steel, assuring durability and a life-time of service.

FITZGIBBONS COPPER-STEEL HEATING BOILERS—Ratings and Specifications—Table 1

Double-Electric-Welded Furnaces

Sizes 300 to 3200 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler	J-6	J-8	H-8	J-10	J-12	H-16	H-20	H-24	H-28	H-32	H-36	H-44	H-50	H-58	H-64
Steam Rating.....sq. ft.	300	400	400	500	600	800	1000	1200	1400	1600	1800	2200	2500	2900	3200
Hot Water Rating....sq. ft.	500	700	700	800	1000	1300	1600	1900	2200	2600	2900	3500	4000	4600	5100
A-Diam. Vertical Shell. in.	23	23	26	26	26	29	29	33	33	37	37	40	40	43	43
B-Height Bare Boiler, ft. in.	3-3	3-3	3-4	3-4	3-4	3-8	3-8	4-0	4-0	4-4	4-4	4-8	4-8	5	5
C-Length Bare Boiler, ft. in.	3-3	3-3	3-9	4-1	4-5	4-9	5-3	5-8	6-2	6-9	7-9	7-7	8-7	8-4	9-4
D-Diam. Horiz. Shell....in.	18	18	18	18	18	21	21	23	23	27	27	31	31	33	33
E-Water Line.....ft. in.	3-5	3-5	3-7	3-7	3-7	4-0	4-0	4-4	4-4	4-7	4-7	4-11	4-11	5-2	5-2
K-Diam. Fire Box.....in.	19	19	22	22	22	25	25	29	29	32	32	35	35	38	38
L-Diam. Base.....in.	26½	26½	30	30	30	33½	33½	37½	37½	40½	40½	42¾	42¾	45¾	45¾
M-Height Base.....in.	10½	10½	10½	10½	10½	13	13	13	13	13	13	13	13	13	13
N-Fire Door Center....in.	25½	25½	27	27	27	31	31	31	31	31	31	31	31	31	31
O-Height.....ft. in.	4-2	4-2	4-3	4-3	4-3	4-8	4-8	5-0	5-0	5-5	5-5	5-9	5-9	6-1	6-1
Q-Height of Stand.....in.				20	21	22	22	25	25	28	28	28	28	28	28
R-Width of Uptake....in.	5½	5½	5½	5½	5½	6½	6½	7½	7½	8½	8½	9½	9½	10	10
S-Length of Uptake....in.	12½	12½	12½	12½	12½	15½	15½	17½	17½	20½	20½	22	22	25	25
T-Supply Location....in.	7	7	8	8	8	8½	8½	10½	10½	11¼	11¼	13	13	12½	12½
V-Tube Space.....in.	18	18	18	18	22	24	30	27	32	31	43	35	47	40	52
Supply Outlet.....in.	3	3	4	4	4	4	4	5	5	5	5	5	5	6	6
Return.....in.	3	3	4	4	4	4	4	5	5	5	5	5	5	6	6
Safety Valve.....in.	1	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
Diam. Smoke Pipe.....in.	8	8	8	8	8	10	10	12	12	14	14	16	16	18	18
Stack Height.....ft.	35	40	40	45	45	40	45	45	45	50	50	50	60	60	60
Approx. Covering....sq. ft.	29	29	33	35	37	52	58	60	66	72	80	86	94	102	110
Shipping Weight.....lbs.	900	920	1250	1300	1350	1600	1700	2000	2100	2500	2600	3100	3400	3700	4000

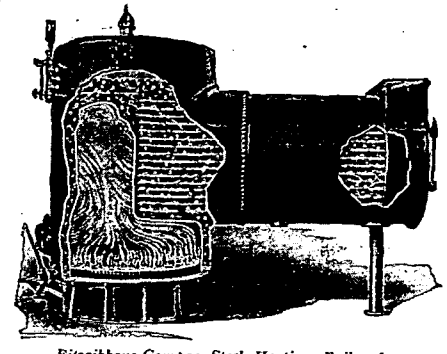
Fitzgibbons (Intermediate Sized) Steel Heating Boilers: This series is identical in general design with the large Fitzgibbons Boiler and is made in sizes from 3800 to 19,000 sq. ft. steam radiation. A most compact boiler specially adaptable to limited space conditions.

Construction: FITZGIBBONS Steel Heating Boilers are built completely of steel without a single cast-iron part holding water. Tested under pressure before shipment, and ready for immediate installation upon arrival at job. No assembling of parts at the building; no packed joints, unions, bolts, etc.

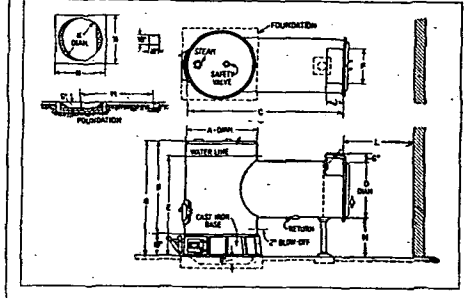
Fuel Economy: The furnace with its gas diverting arch is so large, and the heating surfaces so ample, that the direct fire and major portion of flue surface is exposed to the hottest gases, utilizing all the heat available from the fuel. This results in a saving of upwards of 40 per cent in amount of fuel required in comparison with ordinary types of heating boilers.

Burn Coal, Oil or Gas: The fuel-saving results whether semi-bituminous, egg, stove, chestnut, pea or buckwheat size of coal, or oil or gas is used as fuel. Unusually efficient when burning oil owing to large furnace and rapid water circulation.

Net Ratings: Ratings are net and indicate the amount of equivalent cast iron radiation that boilers will heat on the basis of 0.25 lb. steam sq. ft. of equivalent cast iron radiation with the pressure at boiler two pounds, or 180 deg. fahr. temperature of water. Cast iron radiation equivalent is cast iron radiation plus heating loss of means, branches, risers, etc., plus hot water domestic-heating load plus heat loss of condensation not returned.



Fitzgibbons-Compac Steel Heating Boiler for moderate-sized plants



FITZGIBBONS STEEL BOILERS—Ratings and Specifications—Table

Double-Electric-Welded Furnaces

Sizes 3800 to 19000 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler	H-76	H-86	H-98	H-108	H-120	H-132	H-144	H-160	H-170	H-200	H-220	H-250	H-270	H-310	H-330	H-360	H-380
Steam Rating.....sq. ft.	3800	4300	4900	5400	6000	6600	7200	8000	8500	10000	11000	12500	13500	15500	16500	18000	19000
A-Diam. Vert Shell...ft. in.	4-0	4-0	4-4	4-4	4-9	4-9	4-9	5-0	5-0	5-4	5-4	5-10	5-10	6-2	6-2	6-6	6-6
B-Height Bare Boiler, ft. in.	5-10	5-10	5-11	5-11	6-7	6-7	6-7	6-11	6-11	8-2	8-2	8-9	8-9	8-11	8-11	9-6	9-6
C-Length Bare Boiler, ft. in.	9-1	10-1	9-7	10-7	9-9	10-9	11-9	10-10	11-10	11-10	12-10	12-2	12-8	14-0	14-6	14-3	15-2
D-Diam. Horiz. Shell, ft. in.	3-4	3-4	3-6	3-6	4-0	4-0	4-0	4-3	4-3	4-6	4-6	5-0	5-0	5-2	5-2	5-6	5-6
E-Water Line.....ft. in.	6-0	6-0	6-0	6-0	6-7	6-7	6-7	6-11	6-11	8-3	8-3	8-9	8-9	8-11	8-11	9-6	9-6
G-Overall Height....ft. in.	7-1	7-1	7-2	7-2	7-10	7-10	7-10	8-2	8-2	9-5	9-5	10-0	10-0	10-2	10-2	11-0	11-0
H-Height of Stand...ft. in.	2-7	2-7	2-5	2-5	2-7	2-7	2-7	2-8	2-8	3-3	3-3	3-3	3-3	3-3	3-3	3-5	3-5
JxF-Smoke Uptake...in.xin.	13½x26	13½x26	14x27	14x27	14x37	14x37	14x37	14x44	14x44	15x49	15x49	16x58	16x58	17x58	17x58	18x63	18x63
L-Tube Space.....ft. in.	3-10	4-10	3-9	4-9	3-9	4-9	5-9	4-9	5-9	6-7	7-7	6-6	7-0	7-10	8-4	7-9	8-8
K-Ashpit Diameter...ft. in.	3-4	3-4	3-8	3-8	4-1	4-1	4-1	4-4	4-4	4-8	4-8	5-2	5-2	5-5	5-5	5-10	5-10
M-Base Centers.....ft. in.	5-9	6-9	6-0	7-0	6-0	7-0	8-0	7-0	8-0	8-0	8-10	8-0	8-4	9-5	10-0	9-6	10-5
N-Foundation.....ft. in.	4-6	4-6	4-10	4-10	5-3	5-3	5-3	5-6	5-6	5-10	5-10	6-4	6-4	6-8	6-8	7-0	7-0
Approx. Covering....sq. ft.	128	138	143	154	167	180	193	195	208	250	265	285	294	330	338	358	375
Approx. Weight.....lbs.	5250	6500	6650	7400	9500	9700	10000	10500	11000	13000	14500	16000	16500	18600	19000	19500	20500
Steam.....in.	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8
Return.....in.	4	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6	6
Stack Diameter.....in.	20	22	22	22	24	24	24	26	26	28	30	30	30	32	32	34	34
Stack Height.....ft.	60	65	65	70	70	70	70	80	80	80	80	85	85	100	100	125	125

Fitzgibbons Steel Boilers for Heating and Power

The FITZGIBBONS Boiler owes its high standing among architects, engineers and builders to (1) its capacity to carry its rating with ease (2) its coal-saving as compared with other types, and (3) its absence of maintenance cost.

Construction: The design embodies the strongest possible construction with a minimum of internal bracing. The combustion chamber is concentric with the vertical shell possessing similar strength. The interior of the boiler is readily visible and accessible in all parts for inspection and cleaning. Numerous handhole openings together with the manhole in the top head facilitate getting at all parts. Built completely of steel, eliminating all brick work.

Steam Pressures: The FITZGIBBONS Boiler for heating is built for 15 lb. steam pressure to conform with the rigid requirements of the *A.S.M.E.* Boiler Code and for 100, 125 and 150 lb. for power.

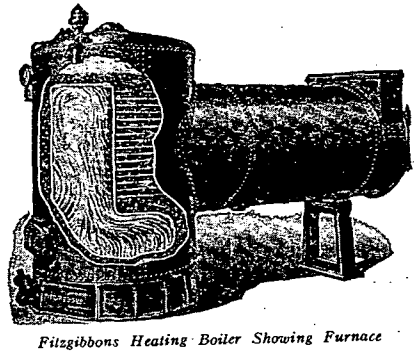
Combustion: Complete combustion of the fuel and its consumable gases in the combustion chamber with a minimum of excess air is a requisite of economical operation. The Fitzgibbons Boiler has a circular grate with no dead corners. The combustion chamber is over six feet in height, giving the ample furnace volume now recognized as essential for complete combustion. The lower crown-sheet of the furnace diverts the gases into a thorough mixture with the air admitted through the special opening over the fire-door. This mass of consumable gas is completely burned in the high combustion chamber before entering the tubes. Smokeless operation with semi-bituminous coal indicates the thoroughness of this combustion. Furnace temperatures have run close to 3000 deg. fahr.

Circulation: The second requisite of economical operation is the rapid absorption of the heat by the water. This can be effected only by properly arranged heating surfaces over which a fast circulation is maintained. The horizontal shell with the tubes in the Fitzgibbons Boiler is completely submerged. The water-line is in the vertical cylinder immediately over the combustion chamber. As a result of this unique arrangement, the circulation is always towards the front of the boiler along a fixed path increasing its speed as it approaches the combustion chamber where the source of greatest heat exists. The perfection of this circulation is evidenced by (1) the quick-steaming ability of the boiler (2) less than one per cent moisture in the steam regardless of overload carried and (3) unusually low flue-gas temperatures.

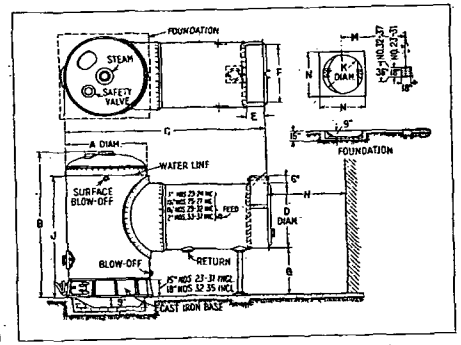
Economy: Forty years of operation under all sorts of conditions of fuel, supervision and load requirements have placed the fuel-saving characteristic of the boiler at over 20 per cent of the fuel ordinarily required by boilers of the rectangular-grate design. This economy results directly from the boiler's cylindrical construction, its complete combustion and its rapid water circulation.

Adaptability: The boiler requires little boiler-room space. To overcome unusual-space limitations caused by irregular column or girder construction, the boiler can be specially built with the fire-door placed on any radius. Any fuel can be burned; semi-bituminous; anthracite; buckwheat; oil; gas; wood or sawdust.

An ever-increasing yearly production of this single boiler attests to its correctness of design, its economy in operation and its all-around efficient service.



Fitzgibbons Heating Boiler Showing Furnace



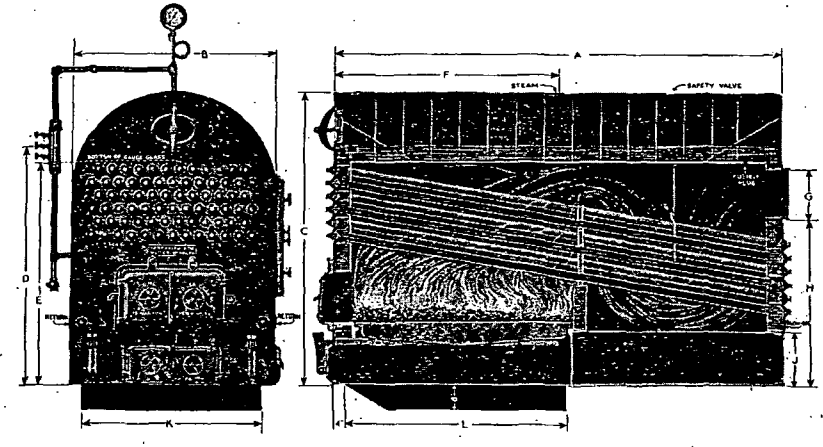
FITZGIBBONS BOILERS—Ratings and Specifications—Table 3
All-Riveted Construction—A.S.M.E. Code
Sizes 4200 to 36000 sq. ft. Steam Rating—Heating Boilers Built for 15 lb. w.s.p.
Power Boilers, for Kitchen, Laundry, Drying, Process and Similar High-Pressure Loads, Built for 100 and 125 lb.

No. of Boiler	23	24	25	26	27	29	30	31	32	33	34	35	36	37
Horsepower	40	50	60	70	80	100	125	150	175	200	225	250	300	350
Steam Rating.....sq. ft.	4200	5400	6400	7500	8500	11000	13500	16500	19000	22000	25000	28000	32000	36000
A–Diameter Vertical Shell.....ft. in.	4-1	4-5	4-8	4-10	5-1	5-5	5-11	6-3	6-7	6-9	6-11	7-3	7-8	8-4
B–Height Overall.....ft. in.	8-6	8-9	9-2	9-5	9-9	10-1	10-8	11-0	11-11	12-1	12-2	12-6	13-0	13-6
C–Length Bare Boiler.....ft. in.	9-4	10-6	10-9	12-2	12-3	13-7	13-11	15-1	15-4	16-2	17-5	18-2	19-2	19-6
D–Diam. Horizontal Shell.....ft. in.	3-5	3-8	3-11	4-1	4-4	4-7	5-1	5-3	5-7	5-9	5-9	6-1	6-6	7-1
ExF–Smoke Uptake.....in.xin.	12x24	12x31	13x36	13x42	13x48	14½x49	15½x58	17x58	18x62½	19x65	19x65	20x68	24x73	24x80
G–Height of Stand.....ft. in.	3-2	3-2	3-3	3-4	3-4	3-4	3-4	3-4	3-9	3-10	3-10	3-10	4-4	4-4
H–Space to Draw Tubes.....ft. in.	4-8	5-7	5-6	6-10	6-10	7-9	7-8	8-6	8-4	8-10	10-0	10-5	11-0	11-0
J–Water Line.....ft. in.	7-1	7-4	7-8	7-11	8-2	8-5	8-11	9-1	9-10	10-1	10-1	10-5	11-4	11-10
K–Ashpit Diameter.....ft. in.	3-4	3-8	4-0	4-1	4-4	4-8	5-2	5-5	5-10	6-0	6-2	6-6	7-0	7-6
M–Base Centers.....ft. in.	5-8	6-9	6-9	8-1	8-1	9-0	9-0	10-0	10-0	10-6	11-8	12-2	12-7	12-7
N–Foundation.....ft. in.	4-6	4-10	5-2	5-3	5-6	5-10	6-4	6-7	7-0	7-2	7-4	7-8	8-6	9-0
Steam.....in.	6	6	8	8	8	8	8	8	8	10	10	10	12	12
Return.....in.	4	4	6	6	6	6	6	6	6	6	6	6	6	6

Harrisburg Star Boiler Corporation

15 Park Row, New York

LOW PRESSURE WATER TUBE HEATING BOILERS



Standard Equipment furnished with boilers consists of shaking and dumping grates, steam gage with syphon, cast iron water column with gage glass and three brass try-cocks, pop safety valves as required, wire brushes *for cleaning outside of tubes*, tube scraper, *for cleaning inside of tubes*, hooked poker, straight poker and slice bar. Steel bases for boilers up to No. 718 inclusive.

Brick Bases required for boilers Nos. 719 to 725 inclusive. Front base plate with ash pit doors, base cleanout door and frame furnished for brick bases.

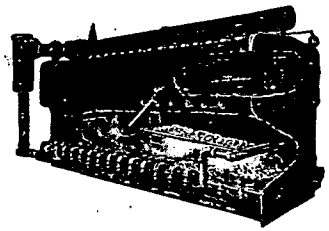
Boiler Number	Steam Capacity, Sq. Ft.	Water Evaporation, Lbs.	Grate Surface, Sq. Ft.	"A" Total Length, Ft.	"B" Total Width, In.	"C" Total Height, Ft.	"D" Water Line, In.	"G" Size Smoke Flue	"J" Height of Base	"K" Width Ash Pit	"L" Length Ash Pit	Diameter Stack One Boiler, In.	Height Stack One Boiler, Ft.	Diameter Stack Two Boilers, In.	Height Stack Two Boilers, Ft.	Brick Required for Base	Asbestos Cover, Sq. Ft.	Approx. Weight Boiler Complete
704	2750	690	9.4	7-9	39	5-5	56	10x26	15	2-8	3-8	18	50	23	50	None	76	5500
705	3450	862	10.6	7-0	43	6-0	61	13x22	15	3-0	3-8	18	50	24	50	"	77	6800
706	4150	1035	12.1	8-3	43	6-0	61	13x28	15	3-0	4-2	18	60	25	60	"	91	7300
707	5000	1242	14.8	8-3	52	6-4	63	13x31	15	3-8	4-2	20	60	27	60	"	99	8000
708	5800	1449	14.8	8-3	52	6-7	66	13x31	15	3-8	4-2	21	60	29	65	"	103	9000
709	6900	1725	18.3	9-1	56	6-8	68	13x38	15	4-0	4-8	23	60	31	65	"	118	10700
710	8300	2070	20.3	10-10	56	6-8	68	13x42	15	4-0	5-2	25	60	33	70	"	141	11300
711	9000	2242	21.8	10-10	60	6-11	69	16x36	15	4-4	5-2	25	65	34	70	"	148	11700
712	9700	2415	24.0	11-7	60	6-11	69	16x39	15	4-4	5-8	26	65	35	70	"	160	12000
713	10400	2587	26.2	12-5	60	6-11	69	16x43	15	4-4	6-2	26	65	36	70	"	171	12500
713A	11000	2760	26.2	11-7	60	7-3	73	19x36	15	4-4	6-2	27	70	36	75	"	167	12800
714	11700	2932	28.3	12-6	60	7-3	73	19x39	15	4-4	6-8	28	70	37	75	"	178	13300
715	12400	3105	30.5	13-1	60	7-3	73	19x42	15	4-4	7-2	29	70	38	75	"	188	14000
716	13800	3450	31.8	11-10	71	7-11	76	19x43	15	5-3	6-3	30	70	40	80	"	193	15500
717	15200	3795	34.4	12-11	71	7-11	76	19x47	15	5-3	6-9	31	70	42	80	"	208	16800
718	17300	4312	37.0	14-7	71	7-11	76	19x50	15	5-3	7-3	32	80	43	90	"	234	18500
719	18600	4657	41.3	12-6	90	9-1	83	21x46	18	6-10	6-3	33	85	44	90	1100	244	20000
720	20700	5175	44.7	13-10	90	9-1	83	21x51	18	6-10	6-9	34	90	46	100	1200	260	21000
721	24200	6037	51.0	16-1	90	9-1	83	21x61	18	6-10	7-9	36	100	48	110	1300	304	25200
722	27600	6900	55.4	14-1	103	10-2	90	21x66	18	7-11	7-3	38	100	51	110	1400	302	27700
723	31600	7762	55.4	14-1	103	10-6	94	21x66	18	7-11	7-3	39	110	52	110	1400	312	29300
724	35000	8625	59.4	15-9	103	10-6	94	21x71	18	7-11	7-9	40	110	54	110	1450	351	32700
725	42000	10350	63.3	17-2	103	10-10	98	21x76	18	7-11	8-3	42	110	60	110	1550	394	35600

Hart & Crouse Company

General Office: **Utica, N. Y.**

Branch Offices in Principal Cities

Manufacturers of Royal Boilers and Furnaces



Royal Smokeless Boiler

ROYAL SMOKELESS BOILERS

Actual Steam Capacities—1670 to 16,600 Sq. Ft.

The Royal Smokeless Boiler is of the water tube *down draft principle.* This principle, originated by the Hart & Crouse Co. as applied to cast iron sectional boilers, has proved to be a most effective method of burning any grade of soft coal smokelessly independent of firing skill.

The large amount of heating surface in Royal Boilers is retained intact as originally designed. Consequently they produce results with efficiency and economy.

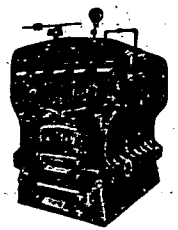
Boiler No.	Actual Capacity Steam Sq. Ft.	Actual Capacity Water Sq. Ft.	Current Rating Steam Sq. Ft.	Current Rating Water Sq. Ft.	Heating Surface Sq. Ft.	Grate Area Sq. Ft.	Length of Sections Inches	Length of Boiler Inches	Flow Tapping No. and Size	Return Tapping No. and Size	Smoke Pipe Inches
338	1,670	2,680	4,800	7,900	179	14.23	50¾	66	1-5″	2-3″	18
339	1,965	3,140	5,400	8,900	200	17.00	56¾	72	1-5″	2-3″	18
340	2,370	3,800	6,000	9,900	220	19.65	63	78	1-5″	2-3″	18
341	2,680	4,290	6,600	10,900	240	22.50	69	84	1-6″	2-4″	18
342	2,975	4,760	7,200	11,900	262	22.50	75¼	90	1-6″	2-4″	18
343	3,280	5,250	7,800	12,900	283	25.10	81¼	96	1-6″	2-4″	18
344	3,585	5,740	8,600	14,200	316	25.10	87½	102½	1-6″	2-4″	18
345	3,890	6,225	9,200	15,200	337	28.00	94	109	1-6″	2-4″	21
346	4,200	6,720	10,000	16,500	360	28.00	100	115	1-6″	2-4″	21
347	4,500	7,200	11,000	18,150	378	28.00	106¼	121	1-6″	2-4″	21
409	4,250	6,800	9,000	14,850	324	24.00	65⅜	93	1-8″	2-5″	21
410	4,750	7,600	10,000	16,500	359	27.50	72⅝	100	1-8″	2-5″	21
411	5,250	8,400	11,000	18,150	394	31.66	79⅞	108	1-8″	2-5″	21
412	5,750	9,200	12,000	19,800	427	31.66	86½	114½	1-8″	2-5″	21
413	6,250	10,000	13,000	21,450	461	31.66	93½	121½	1-8″	2-5″	21
414	6,750	10,800	14,000	23,100	496	35.50	101	129	1-8″	2-5″	24
415	7,250	11,600	15,000	24,750	531	35.50	108	136	1-8″	2-5″	24
416	7,775	12,450	16,000	26,400	565	35.50	115	143	1-8″	2-5″	24
548	7,400	11,850	14,000	23,100	511	37.50	83½	120½	1-8″	2-5″	24
549	8,470	13,550	15,800	26,070	573	45.00	93½	130½	1-8″	2-5″	24
550	9,480	15,170	17,600	29,040	642	45.00	104½	141½	1-10″	2-5″	24
551	10,200	16,330	19,400	32,010	710	45.00	114½	151½	1-10″	2-5″	24
552	11,250	18,000	21,000	34,650	773	52.50	124½	161½	1-10″	2-5″	24
553	12,200	19,550	23,200	38,280	841	52.50	135	172	1-10″	2-5″	24
554	13,000	20,800	25,000	41,250	909	52.50	145	182	1-10″	2-5″	24
555	13,900	22,250	26,800	44,220	978	52.50	155½	192½	1-10″	2-5″	24
556	14,800	23,700	28,800	47,520	1046	52.50	165½	202½	1-10″	2-5″	24
557	15,700	25,150	30,800	50,820	1114	52.50	176	213	1-10″	2-5″	24
558	16,600	26,550	32,600	53,790	1183	52.50	186½	223½	1-10″	2-5″	24
*54-8	7,400	11,850	14,000	23,100	511	37.50	83½	98½	3-6″	4-4″	24
54-9	8,470	13,550	15,800	26,070	573	45.00	93½	108½	4-6″	8-4″	24
54-10	9,480	15,170	17,600	29,040	642	45.00	104½	119½	4-6″	8-4″	24
54-11	10,200	16,330	19,400	32,010	710	45.00	114½	129½	5-6″	10-4″	24
54-12	11,250	18,000	21,000	34,650	773	52.50	124½	139½	5-6″	10-4″	24
54-13	12,200	19,550	23,200	38,280	841	52.50	135	150	5-6″	10-4″	24
54-14	13,000	20,800	25,000	41,250	909	52.50	145	160	6-6″	12-4″	24
54-15	13,900	22,250	26,800	44,220	978	52.50	155½	170½	6-6″	12-4″	24
54-16	14,800	23,700	28,800	47,520	1046	52.50	165½	180½	6-6″	12-4″	24
54-17	15,700	25,150	30,800	50,820	1114	52.50	176	191	6-6″	12-4″	24
54-18	16,600	26,550	32,600	53,790	1183	52.50	186½	201½	6-6″	12-4″	24

*Push Nipple Type.

Additional Data

Series	33″	40″	54″
Height of water line....Inches	63	68	68*
Height of flow outlet (Header type)....Inches	90	99	108
Height of flow outlet (Push Nipple type)....Inches	..	..	89
Overall width....Inches	68	78	97
Width at base....Inches	40	52	62½

*Height from top of foundation. Add 2″ for floor height.



Royal New Method Smokeless Boiler

ROYAL NEW METHOD SMOKELESS BOILERS

(UP-DRAFT TYPE)

Actual Steam Capacities— 730 to 15,732 Sq. Ft.

Actual Water Capacities—1200 to 25,966 Sq. Ft.

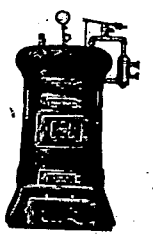
Additional Data

Series	34	41	52	68
Height of Water Line....Inches	46	54	62	68*
Height of Flow Outlet....Inches	56	65	75	89
Width of Boiler....Inches	36	44	56	80½
Width at Base....Inches	32¾	38	45	62½

*Height to top of foundation. Add 2 in. for floor height.

Boiler No.	Actual Capacity Steam Sq. Ft.	Actual Capacity Water Sq. Ft.	Current Rating Steam Sq. Ft.	Current Rating Water Sq. Ft.	Grate Area Sq. Ft.	Length of Sections Inches	Length of Boiler Inches	Steam Flows No. and Size	Steam Returns No. and Size	Water Flows No. and Size	Water Returns No. and Size
634	730	1200	1500	2450	4.43	39	49	2-4″	4-3″	2-4″	4-3″
734	870	1430	1800	2950	5.50	46	56	2-4″	4-3″	2-4″	4-3″
834	1010	1660	2100	3450	6.57	53	63	2-4″	4-3″	2-4″	4-3″
934	1150	1890	2400	3950	7.64	60	70	2-4″	4-3″	2-4″	4-3″
1034	1290	2120	2700	4450	8.71	67	77	2-4″	4-3″	2-4″	4-3″
741	1496	2468	2950	4850	7.98	52	63	2-5″	4-4″	2-5″	4-4″
841	1738	2866	3400	5600	9.54	60	71	2-5″	4-4″	2-5″	4-4″
941	1980	3264	3850	6350	11.10	68	79	2-5″	4-4″	2-5″	4-4″
1041	2200	3662	4300	7100	12.66	76	87	2-5″	4-4″	2-5″	4-4″
1141	2442	4060	4750	7850	14.22	84	95	2-5″	4-4″	2-5″	4-4″
752	2544	4195	5100	8400	11.50	59	73	2-6″	4-4″	2-6″	4-4″
852	2940	4848	5900	9725	13.75	68	82	2-6″	4-4″	2-6″	4-4″
952	3336	5501	6700	11,050	16.00	77	91	2-6″	4-4″	2-6″	4-4″
1052	3732	6154	7500	12,375	18.25	86	100	2-6″	4-4″	2-6″	4-4″
1152	4128	6807	8300	13,700	18.25	95	109	2-6″	4-4″	2-6″	4-4″
1252	4524	7460	9100	15,025	20.50	104	118	2-6″	4-4″	2-6″	4-4″
1352	4920	8113	9900	16,350	20.50	113	127	3-6″	6-4″	3-6″	6-4″
1452	5316	8766	10,700	17,675	22.75	122	136	3-6″	6-4″	3-6″	6-4″
1552	5712	9419	11,500	19,000	25.00	131	145	3-6″	6-4″	3-6″	6-4″
768	6017	9928	12,200	20,125	18.75	73	88	3-6″	6-4″	3-6″	6-4″
868	6895	11,386	14,000	23,100	22.50	83½	98½	4-6″	8-4″	4-6″	8-4″
968	7779	12,844	15,800	26,075	26.25	93½	108½	4-6″	8-4″	4-6″	8-4″
1068	8663	14,302	17,600	29,050	30.00	104½	119½	4-6″	8-4″	4-6″	8-4″
1168	9547	15,760	19,400	32,025	30.00	114½	129½	5-6″	10-4″	5-6″	10-4″
1268	10,431	17,218	21,200	35,000	33.75	124½	139½	5-6″	10-4″	5-6″	10-4″
1368	11,315	18,676	23,000	37,975	33.75	135	150	5-6″	10-4″	5-6″	10-4″
1468	12,199	20,134	24,800	40,950	37.50	145	160	6-6″	12-4″	6-6″	12-4″
1568	13,083	21,592	26,600	43,925	37.50	155½	170½	6-6″	12-4″	6-6″	12-4″
1668	13,967	23,050	28,400	46,900	41.25	165½	180½	6-6″	12-4″	6-6″	12-4″
1768	14,848	24,508	30,200	49,875	41.25	176	191	6-6″	12-4″	6-6″	12-4″
1868	15,732	25,966	32,000	52,850	45.00	186½	201½	6-6″	12-4″	6-6″	12-4″

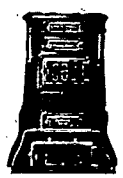
All of the above boilers are available in Hard Coal Type.



Royal Round Steam Boiler

ROYAL ROUND BOILERS

Steam No.	Actual Capacity Sq. Ft.	Current Rating Sq. Ft.	Water No.	Actual Capacity Sq. Ft.	Current Rating Sq. Ft.
1035	178	425	1134	284	700
1045	244	625	1144	390	1030
1055	325	825	1154	520	1360
1065	415	1025	1164	664	1700
1075	525	1250	1174	840	2060
1037	200	475	1136	320	780
1047	280	700	1146	450	1150
1057	375	925	1156	600	1525
1067	480	1150	1166	768	1900
1077	625	1400	1176	1000	2300
1039	218	525	1138	339	870
1049	300	775	1148	480	1275
1059	425	1025	1158	680	1700
1069	575	1275	1168	920	2100
1079	700	1600	1178	1120	2640



Royal Round Water Boiler

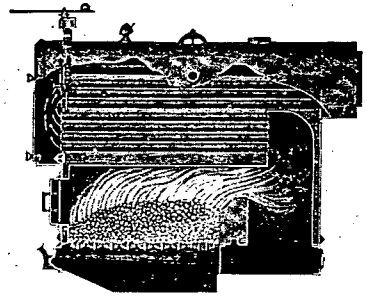
Heggie-Simplex Boiler Co.

Joliet, Illinois

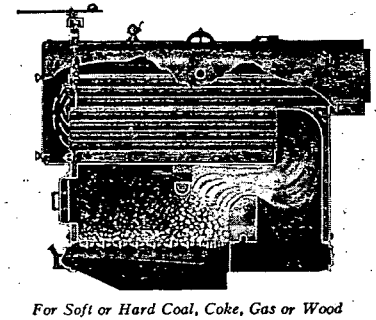
Heating Boiler Division of James G. Heggie & Sons, Manufacturers of Steel Boilers of all Kinds for over Thirty-six Years

Representatives in Principal Cities

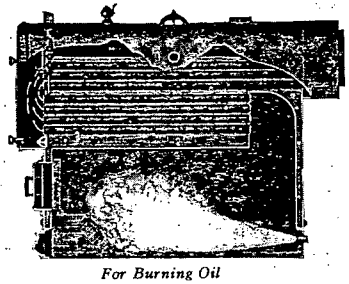
HEGGIE-SIMPLEX HEATING BOILERS



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Coke, Gas or Wood



For Burning Oil

During the thirty-six years covered by the activities of Jas. G. Heggie & Sons, boiler design has been perfected in its fundamentals. The Heggie-Simplex Boiler is the last step in this evolution. In it there is no compromise with traditional features. It is the embodiment of a scientific study of all known heating principles and requirements.

The Heggie-Simplex Boiler combines in one portable, electrically welded steel unit all the recognized advantages of both firebox and return tubular, double pass boilers. It has four distinctive features of fundamental importance:

1. An extra large firebox and a *maximum* of *direct* heating surface.
2. A secondary combustion chamber that provides ample room for complete combustion before the flues are reached.
3. A "rear-front-rear" flue passage for the gases.
4. A single, unimpeded, freely circulating body of water.

Correct heating principles find their most perfect expression in this boiler design. It secures as complete combustion of any fuel as ever has been attained in a heating boiler, with full application of its heat units.

Needless to say, Heggie-Simplex Boilers are more economical of operation than other types—in fuel consumption, number of firings, and ash handling. They are also economical of space, because of their compactness, the rear smoke outlet, and the front tube cleaning feature. No finer materials are used in any heating boilers, and none are fabricated more expertly or with greater care. While built to *A. S. M. E.* requirements, in a number of points they exceed these standards. They may be installed with unexampled ease, requiring no bricking, packing or other costly operations.

Heggie-Simplex Boilers are guaranteed to develop the capacities listed on the following pages, at the point of most economical fuel consumption. They are based upon a standard for steam of two pounds pressure at the boiler, and for water upon a mean temperature of 180 deg. fahr. as the water leaves the boiler.

Send for Catalog No. 26 to obtain more detailed information and specifications.

HEGGIE-SIMPLEX STEAM HEATING BOILERS

Number of Boiler—Direct Draft	*300	*301	*302	*303	*304	*305	*306	*307	308	309	310	311	312	313	314	315	316
Number of Boiler—Smokeless	*107	108	109	110	111	112	113	114	115	116							
Capacity—sq. ft.	600	750	900	1050	1200	1450	1700	2000	2400	2800	3300	3700	4100	4500	5000	5500	6500
Heating Surface—sq. ft.	50	64	75	86	94	116	141	158	189	220	271	294	317	365	394	423	514
Grate Area—sq. ft.	3.4	4.4	5.3	6.2	6.3	8.1	10.2	10.6	10.6	11.8	12.2	13.7	15.2	14.7	16.5	18.3	18.6
Height of Water Line—in.	48¾	55	55	55	58	58	58	62¼	62¼	62¼	69	69	69	72½	72½	72½	78½
Height of Boiler—in.	54	61¼	61¼	61¼	66	66	66	72	72	72	79	79	79	86	86	86	91
Width of Boiler—in.	24	27	27	27	30	30	30	34	34	34	40	40	40	47	47	47	52
Length of Boiler—in.	48	52	58	64	58	70	82	79	91	103	92	98	104	101	107	113	109
Diameter of Breeching—in.	10	14	14	14	18	18	18	20	20	20	22	22	22	24	24	24	26
Diameter of Stack—in.	10	12	12	12	16	16	16	18	18	20	22	20	20	24	22	22	24
Minimum Height of Stack—ft.	30	40	40	40	50	50	50	55	55	60	60	60	60	65	65	65	70
Diameter of Breeching—2 Boilers—in.	16	20	20	20	26	26	26	28	28	28	30	30	30	34	34	34	38
Diameter of Stack—2 Boilers—in.	16	18	18	18	24	24	24	26	26	26	28	28	28	32	32	32	34
Minimum Height of Stack—2 Boilers—ft.	40	50	50	50	60	60	60	65	65	65	70	70	70	75	75	75	80
Size of Steam Outlet—in.	3	4	4	4	4	4	4	6	6	6	6	6	6	8	8	8	8
Size of Return—in.	3	4	4	4	4	4	4	6	6	6	6	6	6	8	8	8	8
Number of Safety Valves	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4
Size of Safety Valves—in.	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1	1
Boiler Covering Required—sq. ft.	33	41	46	51	51	62	73	78	89	101	104	110	116	125	133	141	144
Number of Boiler—Direct Draft	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333
Number of Boiler—Smokeless	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
Capacity—sq. ft.	7000	7500	8500	10000	11000	12000	13000	14500	15500	16500	18000	20000	22000	25000	28000	31000	34000
Heating Surface—sq. ft.	550	585	722	810	922	985	1047	1166	1238	1310	1403	1565	1911	2110	2309	2502	2695
Grate Area—sq. ft.	20.7	22.7	22.9	22.9	25.5	25.5	25.5	31.0	31.0	31.0	35.8	35.8	38.0	38.0	38.0	41.8	44.8
Height of Water Line—in.	78½	78½	81	81	92¾	92¾	92¾	96	96	96	104¾	104¾	111¼	111¼	111¼	111¼	111¼
Height of Boiler—in.	91	91	97	97	108	108	108	116	116	116	126	126	132	132	132	132	132
Width of Boiler—in.	52	52	57	57	63	63	63	70	70	70	78	78	84	84	84	84	84
Length of Boiler—in.	115	121	121	133	123	129	135	129	135	141	141	153	153	165	177	189	201
Diameter of Breeching—in.	26	26	28	28	30	28	30	34	34	34	38	38	42	42	42	42	42
Diameter of Stack—in.	24	24	26	26	28	28	28	32	32	36	36	36	40	40	40	40	40
Minimum Height of Stack—ft.	70	70	75	75	75	75	75	80	80	90	90	90	100	100	100	100	110
Diameter of Breeching—2 Boilers—in.	38	38	40	40	44	44	44	50	50	54	54	54	56	56	56	56	56
Diameter of Stack—2 Boilers—in.	34	34	36	36	40	40	40	46	46	50	50	50	54	54	54	54	54
Minimum Height of Stack—2 Boilers—ft.	80	80	85	85	85	85	85	90	90	90	100	100	110	110	110	110	125
Size of Steam Outlet—in.	8	8	8	8	10	10	10	10	10	10	12	12	12	12	12	12	12
Size of Return—in.	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	6
Number of Safety Valves	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
Size of Safety Valves—in.	3	3	3½	3½	3	3	3	3	3	3	3½	3½	4	4	4	4	4
Boiler Covering Required—sq. ft.	152	160	176	193	197	206	215	230	240	250	270	293	314	337	361	390	420

HEGGIE-SIMPLEX HOT WATER HEATING BOILERS

Number of Boiler—Direct Draft	*400	*401	*402	*403	*404	*405	*406	*407	408	409	410	411	412	413	414	415	416	417	418	419	420
Number of Boiler—Smokeless	*207	208	209	210	211	212	213	214	215	216	217	218	219	220							
Capacity—sq. ft.	1000	1250	1500	1750	2000	2400	2800	3300	3900	4500	5450	6100	6750	7400	8250	9100	10700	11500	12300	13950	16400
Number of Supply Outlets	1	Heggie-Simplex Hot Water Boilers are furnished with the number of outlets specified on the contractor's order																			
Size of Supply Outlets—in.	3	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on the contractor's order																			
Number of Return Openings	1	Heggie-Simplex Hot Water Boilers are furnished with the number of openings specified on the contractor's order																			
Size of Return Openings—in.	3	3", 4", 5", 6", 7", 8", 10" or 12" are supplied, according to specifications on the contractor's order																			

*This boiler contains no bridge wall; grates completely fill the base.

NOTE.—All other measurements on Nos. 400 to 420 and on Nos. 207 to 220 are the same as on steam boilers Nos. 300 to 320.

INTERNATIONAL HEATER COMPANY

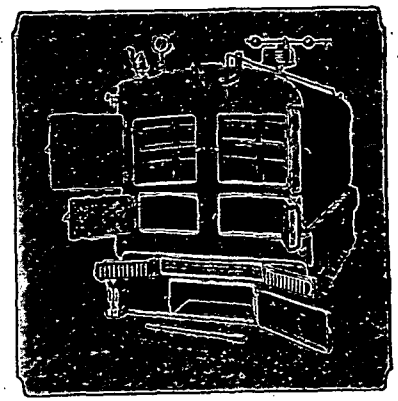
Utica, N. Y.

NEW YORK 641 West 59th St.
CHICAGO 1933-35 Wentworth Ave.
CLEVELAND 1419-1443 Davenport Ave., N.E.
DETROIT 1114 Dime Savings Bank Bldg.
PHILADELPHIA 1613 Race St.
NASHAU, N. H. 110 Chestnut St.

GUARANTEED RADIATION LOADS

International Economy Boilers for Steam or Hot Water low-pressure heating are made in three types, *viz.:* Round, Regular Sectional, and in both Mixing Arch and Wing Wall patterns of Smokeless Boilers.

The Regular and Smokeless Sectional patterns have many characteristics in common. INTERNATIONAL Guaranteed Radiation Loads make possible the immediate and accurate selection of the proper boiler size for any job. All guess work is eliminated. Proper allowance has already been made to cover piping mains and risers. These Guaranteed Radiation Loads have been determined from tests in our Research Department. The INTERNATIONAL HEATER COMPANY supports these Guaranteed Radiation Loads absolutely. The guarantee under which INTERNATIONAL Economy Steam and Water Boilers are rated, reads:



47 in. Series Economy Smokeless Boiler

"*We guarantee* INTERNATIONAL ECONOMY steam and water boilers to maintain 2 lb. steam pressure or 180 deg. temperature at the boiler, on the *guaranteed* amount of direct cast iron radiation shown for each size. Additional loads such as domestic hot water supply, direct-indirect and indirect radiators, blast coils, or rooms to be maintained below 70 deg. temperature, must be reduced to and included in equivalent square feet of direct cast iron radiation.

"This *guarantee* covers two distinct ratings, with coal of 11,500 B.t.u. and coal of 13,000 B.t.u. when the chimney provides sufficient draft to properly burn the fuel."

Both the Regular and the Smokeless types have the following distinctive features:

A long fire travel and all heating surface *below* the water line; a *low steady water* line with water gage tapped directly into the section; *dry steam guaranteed without a header and only one main outlet from boiler*; grate bar connections of sectional boilers are *outside* the ashpit; all heating surface easily *cleaned from front* of boiler through large flue doors.

***RATINGS AND DATA ON ECONOMY SMOKELESS BOILERS† (Steam Pattern)**

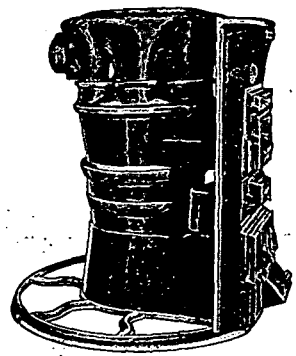
Number **	Guaranteed Radiation Loads, Sq. Ft., 13,000 B.t.u. Fuel	Guaranteed Radiation Loads, Sq. Ft., 11,500 B.t.u. Fuel	Grate Area Sq. Ft.	Coal Capacity Lbs.	Number **	Guaranteed Radiation Loads, Sq. Ft., 13,000 B.t.u. Fuel	Guaranteed Radiation Loads, Sq. Ft., 11,500 B.t.u. Fuel	Grate Area Sq. Ft.	Coal Capacity Lbs.
60-S-22	1013	837	6.1	460	140-S-34	5680	4694	17.0	1435
70-S-22	1220	1008	7.3	545	150-S-34	6116	5055	17.0	1435
80-S-22	1431	1183	8.5	630					
90-S-22	1638	1354	9.7	715	61-S-47	4073	3366	16.3	1250
100-S-22	1845	1525	11.0	800	71-S-47	4841	4000	19.5	1500
					81-S-47	5610	4636	22.8	1750
60-S-28	1305	1079	7.7	590	91-S-47	6378	5271	26.1	2000
70-S-28	1580	1306	9.3	705	100-S-47	7146	5906	19.5	1500
80-S-28	1855	1533	10.8	820	110-S-47	7915	6541	19.5	1500
90-S-28	2142	1770	12.4	935	120-S-47	8683	7176	19.5	1500
100-S-28	2417	1998	14.0	1050	130-S-47	9450	7811	22.8	1750
					140-S-47	10,225	8450	22.8	1750
70-S-34	2620	2166	11.3	985	150-S-47	11,253	9300	22.8	1750
80-S-34	3058	2527	13.2	1135	160-S-47	12,100	10,000	22.8	1750
90-S-34	3494	2888	15.1	1285	170-S-47	12,959	10,710	22.8	1750
100-S-34	3931	3249	17.0	1435	180-S-47	13,824	11,425	26.1	2000
110-S-34	4369	3611	13.2	1135	190-S-47	14,671	12,125	26.1	2000
120-S-34	4806	3972	15.1	1285	200-S-47	15,500	12,810	26.1	2000
130-S-34	5243	4333	15.1	1285	210-S-47	16,335	13,500	26.1	2000

*Judgment should be used in fitting the boiler to a job. As an example: Do not attach a short boiler to a relatively high stack, or a long boiler to a relatively low stack. Suit the boiler to the job.

**All ECONOMY Smokeless Boilers, 22 in. and 28 in. series, Nos. 70-S-34 to 100-S-34 and Nos. 61-S-47 to 91-S-47, inclusive, and corresponding water sizes, are built with grates extending full length of the boiler and using a mixing arch. All larger sizes are built with bridge and wing walls.
The Economy line of boilers does not require a header. Plug and bush tappings to size of mains.

†Send for Catalog 1992-G for sectional data or 1751-G for smokeless data.

INTERNATIONAL HEATER COMPANY



Carton Furnace

International Self Cleaning Carton Furnace

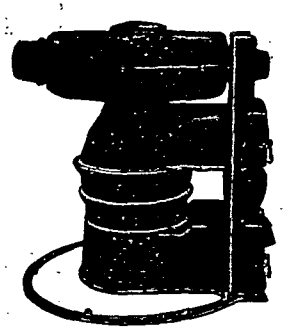
The International Self Cleaning Carton Furnace is a sturdy, powerful heater made entirely of heavy cast iron with but five principal castings used in its assembly.

It is very economical in the use of any fuel commonly used for heating purposes because of its *self cleaning* radiator.

Deep *sealed* cup joints are provided wherever castings join. The base and lower casing ring are in one piece, feed chute and combustion chamber are cast as a unit, and the ashpit is in one piece. Has patented herringbone triangular grate, large double feed door, and roomy ashpit.

Made in six sizes. Firepot diameters: 20 to 33 in.; casing diameters: 44 to 60 in.

Complete Catalog 1818-G sent on request.



Economy Furnace

International Economy Blue Front Furnace

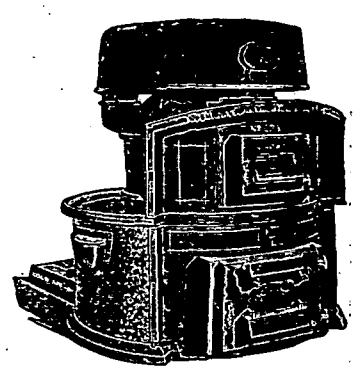
This is a moderate priced heater, but one of unusual efficiency. Proportions of heating surface, grate area, and air capacity check with scientific and accepted standards.

The front is finished in a rich blue and surface grinding assures correct fit of contact joints.

The unique Economy radiator is totally different from any other and wide air spaces cause practically 50 per cent of the air to pass toward the center over the hottest part of the fire. This heater has triangular grates, a big humidifier, large roomy ashpit, cold drop wire handles on both tight fitting feed and ashpit doors, and its ashpit, feed chute, and radiator openings extend thru the front so no smoke, gas, or dust can leak into the warm air chamber.

It is made in five sizes for hard or soft coal. Firepot diameters: 18 to 26 in.; casing diameters: 36 to 52 in.

Complete data in Catalog 1752-G.



Heavy Duty Heater

International Heavy Duty Heater

Especially designed to warm large areas; ample heating surface and large air passing capacity, heavily constructed to withstand the stresses of intermittent heating.

Large radiator is gas tight, large feed door for easy firing, anti-clinker hexagonal grates, two-piece firepots for expansion and contraction, deep gas-tight cup joints, extra deep ashpit.

Heavy Duty Heaters are especially designed for large residences and schools and will fill all requirements at a much lower installation cost than steam or hot water systems. These heaters are built to comply with the most rigid state school regulations and are effectively warming and ventilating schools, large homes, and other large buildings thruout the country.

Made in two sizes for hard or soft coal. Firepot diameters: 28 and 32 in.; casing diameters: 55 and 62 in.

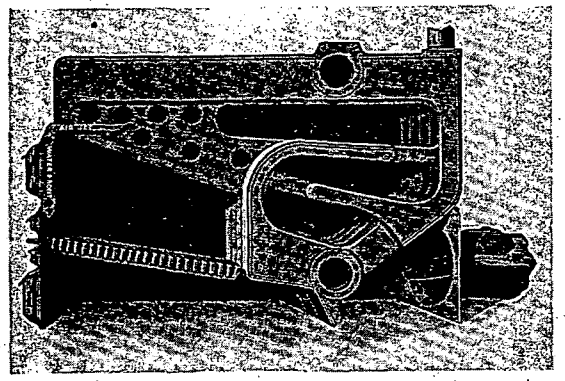
Complete data in Catalog 1978-G.

Other Types for Warming and Ventilating School Houses. Send for Bulletin 1757-G

Ironton Bernhard Boiler Co.

Ironton - Ohio

BERNHARD TRIPLE COMBUSTION BOILERS



Smokeless Boiler with the Lowest Water Line

The Consistent Boiler

The COMBUSTION from each Grate Bar being entirely taken care of in the Section directly above it, the same Ratio of GRATE Surface, FIRE Surface and FLUE Area is always maintained. Note how Gases Expand at three different points.

Boiler No.	Steam Rating	Water Rating	Grate Surface Sq. Ft.	Flue Area Through Sections Sq. In.	Lbs. Steam per Hour	B.t.u. per Hour	Height Water Line	Flow Openings
20- 5	600	1000	2.50	42	150	145,500	42"	2-3"
20- 6	800	1300	3.33	56	200	194,000	42"	2-3"
20- 7	1000	1650	4.17	70	250	242,500	42"	2-3"
20- 8	1200	2000	5.00	84	300	291,000	42"	2-3"
20- 9	1400	2350	5.84	98	350	339,500	42"	3-3"
30- 6	1600	2600	5.00	80	400	388,000	42"	2-4"
30- 7	2000	3250	6.25	100	500	485,000	42"	2-4"
30- 8	2400	3900	7.50	120	600	582,000	42"	2-4"
30- 9	2800	4550	8.75	140	700	679,000	42"	2-4"
30-10	3200	5200	10.00	160	800	776,000	42"	3-4"
30-11	3600	5850	11.25	180	900	873,000	42"	3-4"
30-12	4000	6500	12.50	200	1000	970,000	42"	3-4"
40- 8	4200	6720	10.00	160	1050	1,018,500	46"	2-5"
40- 9	4900	7840	11.66	185	1225	1,188,250	46"	2-5"
40-10	5600	8960	13.33	210	1400	1,358,000	46"	2-5"
40-11	6300	10080	15.00	235	1575	1,527,750	46"	2-5"
40-12	7000	11200	16.66	260	1750	1,697,500	46"	3-5"
40-13	7700	12320	18.33	285	1925	1,867,250	46"	3-5"
40-14	8400	13440	20.00	310	2100	2,037,000	46"	3-5"
40-15	9100	14560	21.66	335	2275	2,206,750	46"	3-5"
40-16	9800	15680	23.33	360	2450	2,376,500	46"	3-5"
40-17	10500	16800	25.00	385	2625	2,546,250	46"	4-5"
40-18	11200	17920	26.66	410	2800	2,716,000	46"	4-5"
40-19	11900	19040	28.33	435	2975	2,885,750	46"	4-5"
40-20	12600	20160	30.00	460	3150	3,055,500	46"	4-5"
40-21	13300	21280	31.66	485	3325	3,225,250	46"	4-5"
40-22	14000	22400	33.33	510	3500	3,395,000	46"	4-5"
*to	700	1120	1.67	25	175	169,750		
40-32	21000	33600	50.00	760	5250	5,092,500	46"	6-5"

*Add per Section.

Johnston Brothers, Inc.

Ferrysburg, Michigan

Established 1864

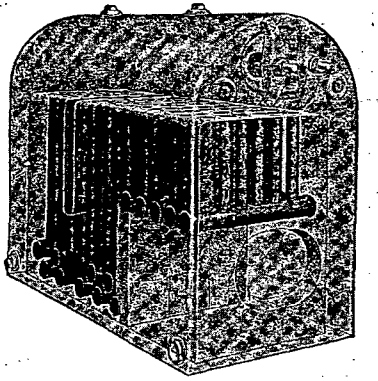
STEAM AND HOT WATER HEATING BOILERS

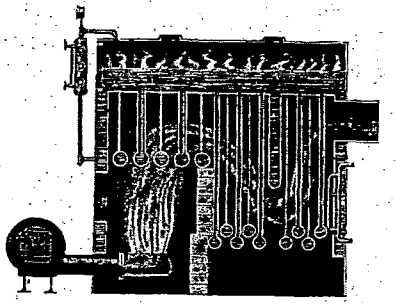
OIL BURNER TYPE

DESIGNED TO USE ANY OF THE TYPES OF DOMESTIC OIL BURNERS AND DELIVER AUTOMATIC HEAT ON EFFICIENT BASIS

ELECTRIC WELDED STEEL

In conformance to specifications given in the *A. S. M. E.* code.





Catalogue Number	OB1	OB2	OB3
Net Steam Rating	1000	1500	2000
Net Water Rating	1600	2500	3400
Heating Surface, Sq. Ft.	125	163	218
Width Overall	24 3/8	26 3/8	32 1/4
Length Overall	56 1/4	61 1/2	64 1/4
Height Overall	66	66	68
Height of Water Line, Inches	59 1/2	59 1/2	61 1/2

Lebanon Boiler Works

J. K. PETTY & CO., Inc., Proprietors

1210 Buttonwood Street - Lebanon, Pa.

Sales Offices — KOITHAN & PRYOR, Representatives

507 Harrison Building, PHILADELPHIA — 39 Cortlandt Street, NEW YORK

Representatives in Other Principal Cities

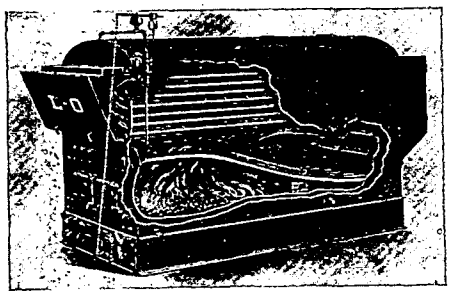
For Larger Buildings

Lebanon "L-O" Steel Boilers

Built also for high-pressure service up to 250 horsepower.

The standard unit is shipped complete with steel base, grates, bridgewall and refractory combustion arch securely attached to the boiler, ready for operation. The boiler is skidded on its own base.

For **Oil Firing** the burner is generally located in base at rear, bridgewall is omitted, and combustion arch on top of furnace water circulating tubes is extended to rear head.

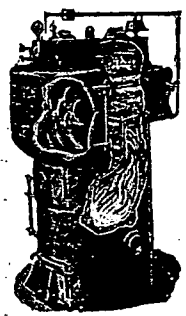


Boiler No.	Steam Radiation Sq. Ft.		Boiler Dimensions Width x Height above Floor x Length
	Coal	Oil Fuel	
LO-15	3,200	4,000	44″ x 71″ x 6′
LO-16	4,000	5,000	44″ x 71″ x 7′
LO-17	4,800	6,000	50″ x 79″ x 7′
LO-18	5,600	7,000	50″ x 79″ x 8′
LO-19	6,400	8,000	50″ x 79″ x 8′
LO-110	7,200	9,000	56″ x 86″ x 8′
LO-111	8,000	10,000	56″ x 86″ x 9′
LO-112	9,600	12,000	56″ x 86″ x 10′
LO-113	11,200	14,000	62″ x 91″ x 9′
LO-114	12,800	16,000	62″ x 91″ x 10′
LO-115	14,400	18,000	62″ x 91″ x 11′
LO-116	16,000	20,000	68″ x 97″ x 11′
LO-117	20,000	25,000	68″ x 100″ x 12′
LO-118	24,000	30,000	68″ x 106″ x 12′
LO-119	28,000	35,000	74″ x 109″ x 13′
LO-120	32,000	40,000	74″ x 113″ x 14′
LO-121	36,000	45,000	74″ x 117″ x 15′
LO-122	40,000	50,000	80″ x 118″ x 14′

For Homes and Small Buildings

Lebanon "Oil-or-Kol" Steel Boilers

Steam, Vapor or Water Heating



Boiler No.	Steam Radiation, Sq. Ft.		Boiler Dimensions
	**Hard Coal	Oil Fuel	Diam. x Hgt.
	Sq. Ft.	Sq. Ft.	Inches
*OK-118	300	375	18 x 57
*OK-121	400	500	21 x 57
*OK-124	550	700	24 x 60
*OK-127	750	925	27 x 63
*OK-130	1000	1250	30 x 63
OK-133	1300	1625	33 x 66
OK-136	1650	2050	36 x 66
OK-139	2050	2550	39 x 72
OK-142	2500	3125	42 x 72

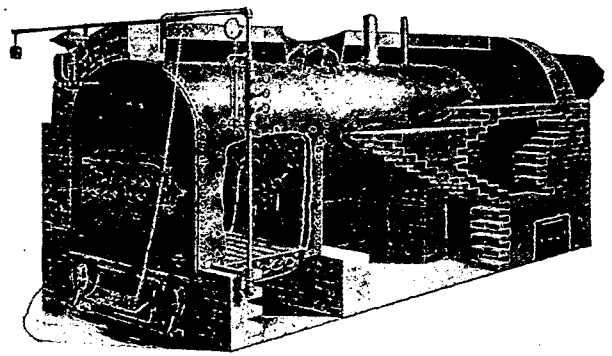
*Small-doorway sizes.
**For Soft Coal the next larger size boiler is recommended.

KEWANEE BOILER COMPANY

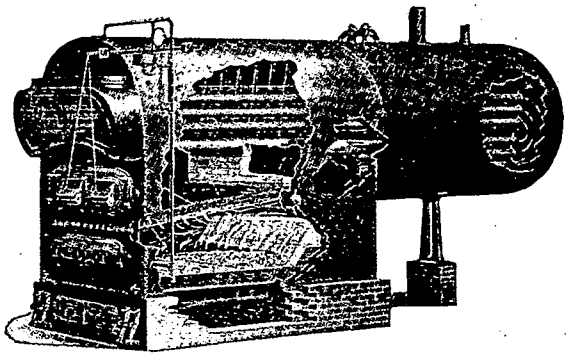
Kewanee, Illinois

BRANCHES IN ALL PRINCIPAL CITIES

Steel Heating and Power Boilers, Water Heating Garbage Burners, Tabasco Heaters, Tanks and Radiators



KEWANEE FIREBOX BOILER—*Brick-set—for Heating* Kewanee Firebox Boilers represent 35 years of intensive study and effort to make the highest grade equipment for heating buildings. They are adapted to the burning of any grade of fuel and will maintain high efficiency when operating to supply the variable demands of a heating load.



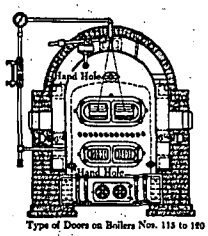
KEWANEE SMOKELESS BOILER—*Portable—for Heating* The rated capacity is the amount of direct radiation that the boiler will carry with a firing interval of three to four hours depending upon the grade of fuel used. No discount in rating is advised as reserve capacity has been allowed to care for the most severe weather conditions.

Kewanee Boilers are built of steel (riveted) using as a minimum basis the rules of construction adopted by the *American Society of Mechanical Engineers*, known as the *A. S. M. E.* Boiler Code.

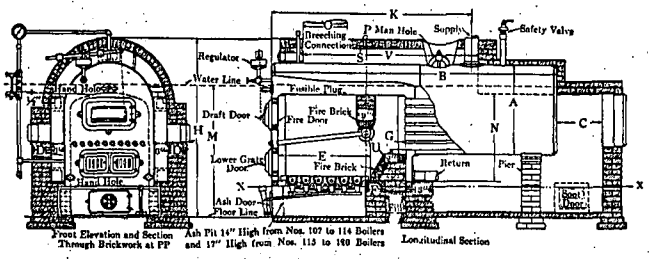
Ratings

The rated capacity of Kewanee Boilers, as shown, is the number of square feet of direct radiation or equivalent which the boiler will carry, if sufficient radiation is installed to heat the building to 70 degrees Fahrenheit.

The ratings are based on a standard for steam of 2 lb. pressure at the boiler, and for water on a mean temperature of 180 deg. Fahr. as the water leaves the boiler.



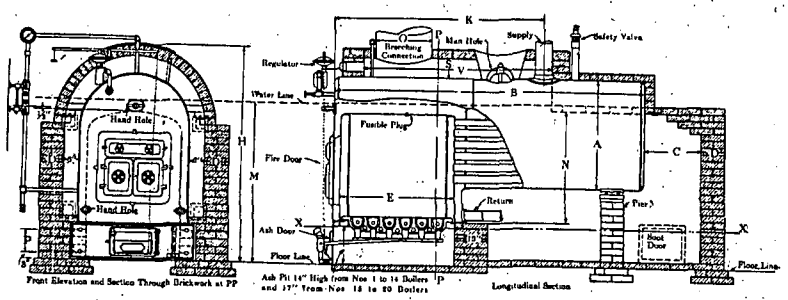
Type of Doors on Boilers Nos. 113 to 120

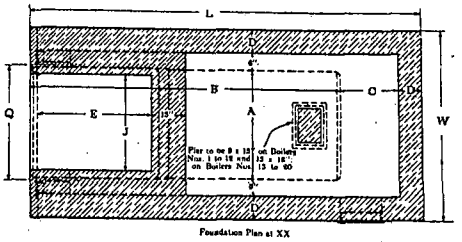


KEWANEE SMOKELESS BOILERS—BRICK-SET TYPE

Number of Boiler	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Capacity, Steam....sq. ft.	1600	2000	2300	2600	3100	3600	4000	4700	5500	6500	7500	8500	10000	11500	13000	14000	16000
Heating Surface....sq. ft.	206	243	288	297	345	393	425	480	535	628	741	839	973	1064	1194	1291	1456
Area of Upper Grate....sq. ft.	5.9	7.2	8.4	8.6	10.1	11.4	11.8	13.2	15.0	17.1	19.1	21.1	23.3	23.5	25.9	28.5	31.3
Diameter of Boiler....in.	36	36	36	42	42	42	48	48	48	54	54	60	60	66	66	72	72
Length Boiler Over-all....ft. in.	8-7	10-2	11-7	9-10	11-4	12-10	12-4	13-10	15-4	15-9	18-3	17-10	20-4	18-4	20-4	18-4	20-4
Diameter of Stack....in.	18	18	20	20	20	22	22	24	24	28	28	32	32	34	34	36	36
Height of Stack....ft.	45	45	45	50	50	50	50	55	55	60	60	60	60	70	70	70	70
Diameter of Stack, Two Boilers....in.	24	24	26	26	28	30	30	32	32	34	36	38	38	40	42	44	46
Height of Stack, Two Boilers....ft.	55	55	55	60	60	60	60	60	60	70	70	70	75	75	80	80	80
Size of Steam Opening....in.	5	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	2-2½
C—Rear Space....in.	17	17	17	22	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall....in.	9	9	9	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate....in.	31	37	43	37	43	49	43	49	55	55	61	61	67	61	67	67	73
J—Width Ash-pit....in.	31	31	31	37	37	37	43	43	43	49	49	54	54	60	60	66	66
F—Thickness Bridge Wall....in.	9	9	9	9	9	9	13	13	13	18	18	18	18	18	18	18	18
G—Grate to Tube Sheet....in.	14	14	14	17	17	17	23	23	23	23	23	29	29	29	29	29	29
U—Header to Bridge Wall....in.	7	8	9	9	10	12	10	11	12½	13	14	14	15½	14	15½	16	17
H—Height Brickwork....in.	77	77	77	83	83	83	90	90	90	96	96	108	108	114	114	120	120
K—Location Steam Supply....ft. in.	6-0	7-0	8-0	7-6	8-0	8-9	8-10	9-8	10-4	11-0	11-6	11-10	13-0	12-0	13-0	12-1	13-1
L—Length Over-all....ft. in.	10-9	12-3	13-9	12-5	13-11	15-5	14-11	16-5	17-11	18-10	21-4	20-11	23-5	21-5	23-5	21-9	23-9
M—Height Water-line....in.	55	55	55	58½	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
N—Height Side Flue....in.	36	36	36	39	39	39	42	42	42	48	48	51	51	58	58	63	63
O—Diameter Breeching Connection....in.	20	20	22	22	22	24	24	27	27	30	30	34	34	36	36	38	38
S—Top Flue Space....in.	7	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch....ft. in.	5-3	6-3	7-3	7-0	7-6	8-0	8-1	8-11	9-9	10-0	10-6	10-10	12-0	11-0	12-0	11-1	12-1
W—Width Over-all....ft. in.	5-6	5-6	5-6	6-0	6-0	6-0	6-6	6-6	6-6	7-8	7-8	8-2	8-2	8-8	8-8	9-2	9-2
Req'd at Rear to Draw Tubes....ft. in.	2-5	3-5	4-5	2-8	3-8	4-8	4-0	5-0	6-0	5-11	7-11	6-11	8-11	7-5	8-11	6-7	8-1
*Number Common Brick	2200	2350	2450	2600	2850	3100	3700	4000	4300	6000	6600	7350	7900	7800	8300	8700	9300
Number Fire Brick	85	85	85	100	100	100	130	130	130	155	155	215	215	250	250	310	310
*Common Brick for Two Boilers	3900	4100	4300	4500	4950	5350	6500	7000	7550	10500	11500	12750	13700	13200	14200	15000	16000

*Foundations not included.

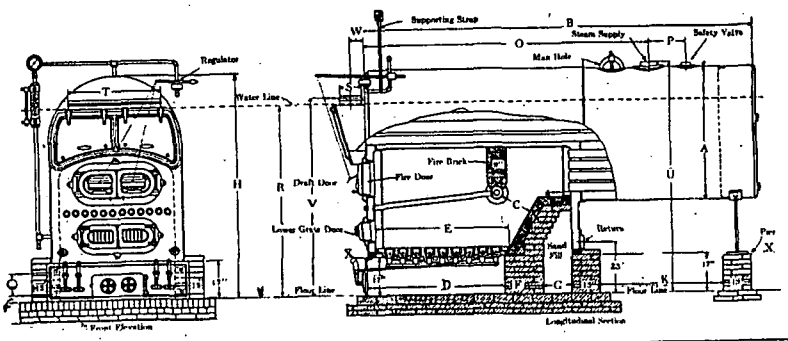


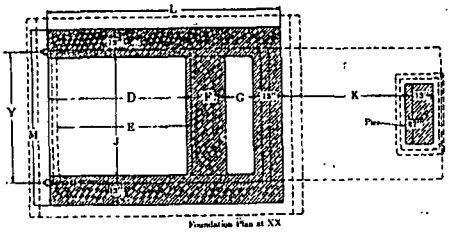


KEWANEE FIREBOX BOILERS—BRICK-SET TYPE

Number of Boiler	0	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	20
Capacity, Steam....sq. ft.	700	900	1050	1200	1400	1700	2000	2600	3000	3500	4000	4500	5500	6500	7500	8700	10000	11000	12000	14000
Diameter of Boiler....in.	24	30	30	36	36	36	42	42	48	48	48	48	54	54	60	60	66	66	72	72
Length of Boiler Over-all....ft.	7	6½	7½	8½	7½	9	10½	10	11¼	10½	12	13½	14	16½	15½	18	16	18	16	18
Heating Surface....sq. ft.	84	113	131	147	180	215	250	305	350	368	420	472	560	673	745	873	954	1080	1167	1329
Area of Grate....sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
Diameter of Breeching....in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
Diameter of Stack....in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	34	34	34
Minimum Height of Stack....ft.	35	40	40	40	40	40	45	45	45	45	50	50	50	50	55	55	60	60	60	60
Diameter of Breeching, Two Boilers....in.	16	18	20	22	22	24	24	28	32	32	32	34	36	36	40	40	40	42	44	46
Diameter of Stack, Two Boilers....in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Minimum Height of Stack, Two Boilers....ft.	40	45	45	45	45	45	45	50	50	50	50	50	55	60	60	70	70	70	70	70
Size of Steam Opening....in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	6
Size of Safety Valve....in.	1	1¼	1¼	1¼	1¼	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Rear Space....in.	14	17	17	17	17	17	17	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall....in.	9	9	9	9	9	9	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate....in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
J—Width Ash-pit....in.	19	25	25	25	31	31	31	37	37	43	43	43	49	49	54	54	60	60	66	66
H—Total Height....in.	64	70	70	70	77	77	77	83	83	90	90	90	96	96	108	108	114	114	120	120
K—Location of Supply....ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
M—Height of Water-line....in.	47	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
N—Height of Side Flue....ft. in.	2-5	2-8	2-8	2-8	3-0	3-0	3-0	3-3	3-3	3-6	3-6	3-6	4-0	4-0	4-3	4-3	4-10	4-10	5-3	5-3
O—Diameter Breeching Connection....in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
S—Top Flue Space....in.	6	6	6	6	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch....ft. in.	3-2	3-2	3-10	4-9	4-1	5-1	6-1	6-3	6-9	6-3	7-3	7-9	8-1	8-7	8-5	9-7	8-7	9-8	8-9	9-9
P—Anchor Bolt Centers for Ash-pit Front	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	11	11	11	11
Q—Anchor Bolt Centers for Ash-pit Front	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
L—Total Length....ft. in.	8-8	8-7	9-8	10-8	9-8	11-2	12-8	12-7	14-1	13-1	14-7	16-1	17-0	19-6	18-7	21-1	19-1	21-1	19-5	21-5
W—Total Width....ft. in.	4-6	5-0	5-0	5-0	5-6	5-6	5-6	6-0	6-0	6-6	6-6	6-6	7-8	7-8	8-2	8-2	8-8	8-8	9-2	9-2
*Number of Common Brick	1325	1450	1600	1750	1900	2150	2400	2650	2900	3000	3300	3600	5300	5900	6500	7200	7200	7700	7700	8200
*Common Brick for Two Boilers	2250	2450	2700	2950	3300	3750	4100	4750	5350	5400	5900	6450	8350	10350	11350	12550	12400	13450	13250	13850

*Foundations not included. NOTE—A Firing Space of about 8'-0" should be maintained at front of Boilers. This provides sufficient space to draw tubes through firedoor.

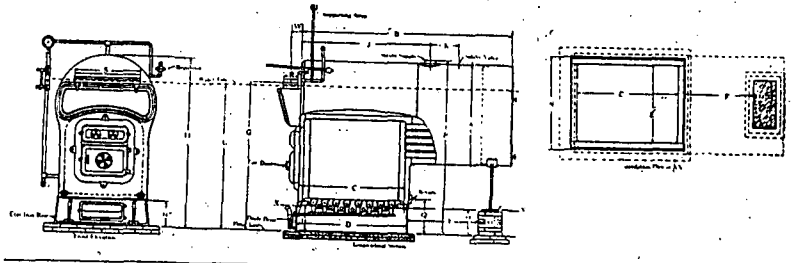




KEWANEE SMOKELESS BOILERS—PORTABLE TYPE

Number of Boiler	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
Capacity, Steam....sq. ft.	3000	3500	4000	4500	5000	5500	6000	6500	7500	8500	10000	12000	14000	16000	18000	20000	25000	30000
Heating Surface....sq. ft.	297	352	391	446	496	546	592	643	721	773	912	1053	1204	1316	1458	1549	2074	2629
Area of Upper Grate....sq. ft.	8.8	10.1	11.4	12.9	14.7	16.5	17.1	18.5	20.8	21.4	23.5	25.9	28.5	29.9	32.6	34.6	41.7	44.8
Diameter of Boiler....in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
Length of Boiler Over-all....ft. in.	9-1	10-5	11-5	10-11	11-11	12-11	12-11	13-11	15-3	16-3	15-9	17-9	16-7	17-11	17-10	18-10	20-1	24-1
Diameter of Stack....in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Height of Stack....ft.	50	55	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers....in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Height of Stack, Two Boilers....ft.	60	65	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening....in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return....in.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
Size of Safety Valve....in.	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	2-2½	2-3	2-3	2-3½
Distance Required to Open Rear Flue Doors....in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
E—Length Grate....in.	37	43	49	49	55	61	55	61	61	67	61	67	67	73	73	73	79	85
C—Header to Bridge Wall....in.	9	10	11½	11	12½	14	12½	14	14	15	15	16	16	17	17	18	18	19
D—Length Ash-pit....in.	38	44	50	50	56	62	56	62	63	69	63	69	69	75	75	75	81	87
K—Rear Wall to Pier....in.	29	39	45	27	33	39	45	51	57	63	62	80	63	74	72	79	84	126
J—Width Ash-pit....in.	37	37	37	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
M—Width Foundation....in.	46	46	46	60	60	60	66	66	79	79	85	85	91	91	97	97	103	103
L—Length Foundation....in.	61	67	73	84	90	96	90	96	107	113	107	113	113	119	119	125	131	137
H—Height Boiler....in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
U—Height Supply....in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
R—Height Water-line....in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
V—Height of Breeching Connection....in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
O—Location Supply....ft. in.	5-11	6-8	7-3	7-6	8-2	8-9	8-9	9-3	10-11	11-6	11-0	11-9	11-7	12-2	12-2	12-9	13-8	15-0
P—Location Safety Valve....in.	12	14	14	13	13	15	15	18	16	18	16	18	15	18	18	16	18	20
W—Center Breeching Connection to Front of Boiler....in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
S—Width Breeching Connection....in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
T—Length Breeching Connection....in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes....ft. in.	7-7	8-11	9-11	9-5	10-5	11-5	11-5	12-5	13-8	14-8	14-0	16-0	14-8	16-0	16-0	17-0	18-0	22-0
†Req'd at Rear to Draw Tubes....ft. in.	6-0	7-4	8-4	7-10	8-10	9-10	9-10	10-10	12-2	13-2	12-4	14-4	12-10	14-2	14-1	15-1	16-0	20-0
*Number Common Brick....	200	200	200	800	825	850	1025	1050	1300	1350	1300	1350	1375	1450	1400	1475	1575	1600
Number Fire-brick....	115	115	115	155	155	155	195	195	210	215	240	240	255	255	290	315	425	425
Outside Surface to be Covered....sq. ft.	148	157	173	184	212	221	255	265	266	280	290	330	335	360	370	400	455	545

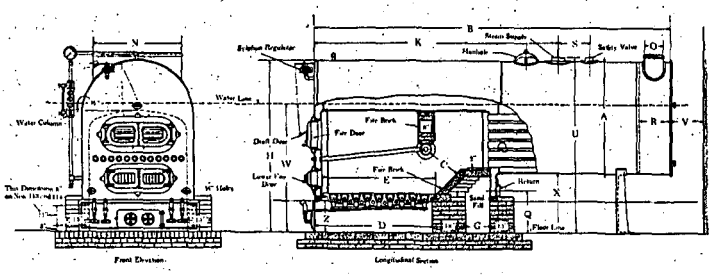
*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa.

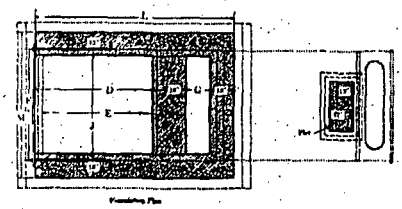


KEWANEE BOILERS—PORTABLE TYPE.

Number of Boiler	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424
Capacity, Steam....sq. ft.	2500	2900	3500	4000	4500	5000	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	28000
Heating Surface....sq. ft.	278	310	373	416	465	515	565	626	676	778	929	1040	1168	1303	1514	1711	2209	2427
Area of Grate....sq. ft.	9.6	11.1	12.6	12.9	14.7	16.5	18.8	20.8	20.7	22.9	25.5	28.0	30.8	33.5	36.6	39.6	42.9	46.1
Diameter of Boiler....in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
Length of Boiler....ft. in.	8-7	9-6	11-1	10-0	11-1	12-1	12-5	13-7	14-4	16-2	15-9	17-4	15-11	17-6	17-11	19-11	20-1	22-1
Diameter of Stack....in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Height of Stack....ft.	50	50	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers....in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Height of Stack, Two Boilers....ft.	60	60	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening....in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return....in.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
Size of Safety Valve....in.	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	2-2½	2-3	2-3	2-3
Distance Required to Open Rear Flue Doors....in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
C—Length of Fire-box....in.	38	44	50	44	50	56	56	62	56	62	62	68	68	74	74	80	80	86
D—Length of Ash-pit....in.	45	51	57	47	53	59	59	65	60	66	66	72	72	78	78	84	84	90
E—Width of Fire-box....in.	36	36	36	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
F—Ash-pit Base to Pier....ft. in.	3-3	3-8	4-9	3-9	4-4	4-10	5-2	5-10	6-7	7-11	7-5	8-5	6-11	7-11	8-4	9-10	9-10	11-4
G—Height Breeching Connection....in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
H—Height of Boiler....in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
P—Height of Steam Supply....in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
L—Height of Water-line....in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
J—Location of Steam Supply....ft. in.	4-8	5-3	6-3	5-6	6-4	8-0	8-3	8-8	8-5	9-5	9-4	10-2	9-8	11-1	11-3	12-0	12-6	12-6
K—Location of Safety Valve....in.	13	14	18	16	18	13	16	18	21	29	18	32	18	26	24	30	24	21
W—Center of Breeching Connection to Front of Boiler....in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
R—Width Breeching Connection....in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
S—Length Breeching Connection....in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes....ft. in.	7-1	8-0	9-7	8-7	9-7	10-7	11-0	12-2	12-10	14-8	14-1	15-8	14-1	15-8	16-1	18-1	18-1	20-1
†Req'd at Rear to Draw Tubes....ft. in.	5-6	6-5	8-0	6-11	7-11	8-11	9-4	10-6	11-3	13-1	12-4	13-11	12-2	13-9	14-2	16-2	16-2	18-2
*Number Common Brick....	70	70	70	450	480	510	530	560	680	710	740	760	790	820	840	885	900	935
Outside Surface to be Covered....sq. ft.	115	130	150	155	175	185	190	220	250	280	290	310	315	345	385	425	455	505

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa.

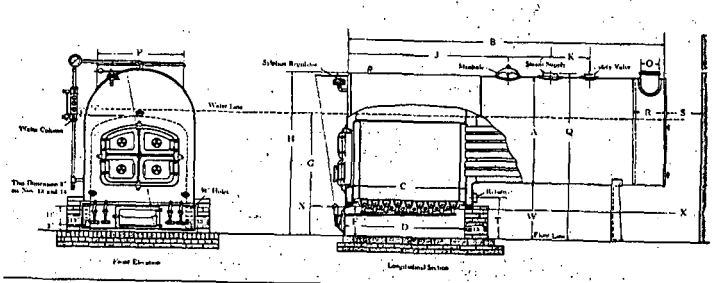


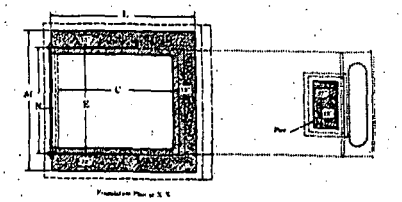


KEWANEE PORTABLE SMOKELESS BOILERS TYPE K

Number of Boiler	104K	105K	106K	107K	108K	109K	110K	111K	112K	113K	114K	115K	116K	117K	118K	119K	120K
Capacity, Steam....sq. ft.	1500	1900	2200	2500	2900	3400	3800	4400	5200	6200	7100	8100	9500	10900	12300	13300	15200
Heating Surface....sq. ft.	157	185	220	234	271	308	338	381	425	500	590	677	787	879	987	1090	1230
Area of Upper Grate....sq. ft.	5.9	7.2	8.4	8.6	10.1	11.4	11.8	13.2	15.0	17.1	19.1	21.1	23.3	23.5	25.9	28.5	31.3
Diameter of Boiler....in.	36	36	36	42	42	42	48	48	48	54	54	60	60	66	66	72	72
Length Boiler Over-all....ft. in.	9-11	11-5	12-11	11-2	12-8	14-2	13-8	15-2	16-8	17-1	19-7	19-4	21-10	19-10	21-10	19-10	21-10
Diameter of Stack....in.	18	18	20	20	20	22	22	24	24	28	28	32	32	34	34	36	36
Height of Stack....ft.	40	40	40	45	45	45	45	50	50	55	55	55	55	65	65	65	65
Diameter of Stack, Two Boilers....in.	24	24	26	26	28	30	30	32	32	34	36	38	38	40	42	44	46
Height of Stack, Two Boilers....ft.	50	50	50	55	55	55	55	55	55	65	65	65	70	70	75	75	75
Size of Steam Opening....in.	5	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	2-2½
C—Header to Bridge Wall....in.	7	8	9	9	10	12	10	11	12½	13	14	14	15½	14	15½	16	17
D—Length of Ash-pit....in.	32	38	44	38	44	50	44	50	56	57	63	63	69	63	69	69	75
E—Length of Grate....in.	31	37	43	37	43	49	43	49	55	55	61	61	67	61	67	67	73
F—Center to Center Bolts in Ash-pit Front....in.										54	54	60	60	66	66	72	72
G—Bridge Wall to Rear Wall....in.										6	6	12	12	12	12	12	12
H—Height of Boiler....in.	65	65	65	71	71	71	77	77	77	83	83	93	93	99	99	105	105
J—Width of Ash-pit....in.	31	31	31	37	37	37	43	43	43	49	49	54	54	60	60	66	66
K—Location of Steam Supply....ft. in.	6-0	7-0	8-0	7-6	8-0	8-9	8-10	9-8	10-4	11-0	11-6	11-10	13-0	12-0	13-0	12-1	13-1
L—Length of Foundation....in.	51	57	63	60	66	72	72	78	84	94	100	106	112	106	112	112	118
M—Width of Foundation....in.	40	40	40	46	46	46	54	54	54	75	75	80	80	86	86	92	92
N—Length of Breeching Connection....in.	24	24	24	30	30	30	36	36	36	46	46	50	50	54	54	68	68
O—Width of Breeching Connection....in.	10	10	10	10	10	10	10	10	10	10	10	12	12	12	12	13	13
Q—Height of Return....in.	19	19	19	19	19	19	19	19	20	20	20	23	23	23	23	23	23
R—Depth of Smoke Box....in.	16	16	16	16	16	16	16	16	16	16	16	18	18	18	18	18	18
S—Location of Safety Valve....in.	15	18	18	13	12	13	16	18	18	21	30	26	30	30	30	20	34
U—Height of Steam Supply....in.	67	67	67	73	73	73	79	79	79	85	85	95	95	101	101	107	107
V—Minimum Space Required at Rear....in.	21	21	21	24	24	24	27	27	27	30	30	33	33	36	36	39	39
W—Height of Water-line....in.	55	55	55	58½	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
X—Floor Line to Bottom of Cylinder....in.	29	29	29	29	29	29	29	29	29	29	29	33	33	33	33	33	33
Z—Height of Ash-pit....in.	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17
†Req'd at Front to Draw Tubes....in.	7	13	19	4	10	16	10	16	22	27	45	26	44	32	44	20	32
†Req'd at Rear to Draw Tubes....in.	39	51	63	45	57	69	63	75	87	92	116	102	126	108	126	102	120
*Number of Common Brick										955	980	1300	1350	1300	1350	1375	1450
Number of Fire Brick	85	85	85	115	115	115	155	155	155	195	195	210	215	240	240	255	255
Outside Surface to be Covered....sq. ft.	93	102	115	131	148	164	180	199	218	243	278	311	350	350	384	380	407

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa. Boilers No. 104K to 112K are furnished with cast iron bases





KEWANEE BOILERS PORTABLE TYPE K—UP-DRAFT

Number of Boiler	0K	1K	2K	3K	4K	5K	6K	8K	9K	10K	11K	12K	13K	14K	15K	16K	17K	18K	19K	20K
Capacity, Steam....sq. ft.	600	850	1000	1150	1300	1600	1900	2450	2850	3300	3800	4300	5200	6200	7100	8200	9500	10400	11400	13300
Heating Surface....sq. ft.	61	83	93	104	139	164	190	241	275	298	338	378	447	537	603	708	791	896	992	1129
Area of Grate....sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
Diameter of Boiler....in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
Length of Boiler Over-all....ft. in.	7-9	7-10	8-10	9-10	8-10	10-4	11-10	11-4	12-10	11-10	13-4	14-10	15-4	17-10	17-0	19-6	17-6	19-6	17-6	19-6
Diameter of Stack....in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Height of Stack....ft.	35	35	35	35	35	35	40	40	40	40	45	45	45	45	50	50	55	55	55	55
Diameter of Stack, Two Boilers....in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Height of Stack, Two Boilers....ft.	40	40	40	40	40	40	40	45	45	45	45	45	50	55	55	65	65	65	65	65
Size of Steam Opening....in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return....in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve....in.	1	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Length of Grate....in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
D—Length of Ash-pit....in.	31	33	39	45	39	45	51	51	57	51	57	63	59	65	65	71	65	71	71	77
E—Width of Ash-pit....in.	19	24	24	24	30	30	30	36	36	42	42	42	49	49	54	54	60	60	66	66
F—Height of Ash-pit....in.	12	14	14	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17
G—Height of Water-line....in.	45	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
H—Height of Boiler....in.	51	59	59	59	65	65	65	71	71	77	77	77	83	83	93	93	99	99	105	105
J—Location of Steam Supply....ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
K—Location of Safety Valve....in.	12	12	15	16	15	18	18	13	13	16	18	18	21	30	26	30	26¾	30	20	34
L—Length of Foundation....in.	32	34	40	46	40	46	52	52	58	52	58	64	72	78	78	84	78	84	84	90
M—Width of Foundation....in.	27	34	34	34	40	40	40	46	46	52	52	52	75	75	80	80	86	86	92	92
N—Center to Center Bolts in Ash-pit Front....in.													54	54	60	60	66	66	72	72
O—Width of Breeching Connection....in.	10	8	8	8	10	10	10	10	10	10	10	10	10	10	12	12	12	12	13	13
P—Length of Breeching Connection....in.	10	16	16	16	24	24	24	30	30	36	36	36	46	46	50	50	54	54	68	68
Q—Height of Steam Supply....in.	53	61	61	61	67	67	67	73	73	79	79	79	85	85	95	95	101	101	107	107
R—Depth of Smoke Box....in.	12	16	16	16	16	16	16	16	16	16	16	16	16	16	18	18	18	18	18	18
S—Minimum Space Required at Rear....in.	24	18	18	18	21	21	21	24	24	27	27	27	30	30	33	33	36	36	39	39
T—Height of Return....in.	15½	18	18	19	19	19	19	19	19	19	19	20	20	20	23	23	23	23	23	23
W—Floor Line to Bottom of Cylinder....in.	27	29	29	29	29	29	29	29	29	29	29	29	29	29	33	33	33	33	33	33
†Req'd at Front to Draw Tubes....in.		19	20	20	20	26	31	26	32	32	38	44	49	67	55	73	61	73	49	62
†Req'd at Rear to Draw Tubes....in.		32	39	45	39	51	63	57	69	63	75	87	92	116	102	126	108	126	102	122
*Number of Common Brick													460	490	710	740	740	760	790	820
Outside Surface to be Covered....sq. ft.	55	68	77	85	91	106	120	133	149	157	177	197	200	235	275	314	311	345	338	366

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa. Boilers No. 0K to No. 12K are furnished with cast iron base.
Full height back stand furnished with all boilers, no pier, see Letter W.

Molby Boiler Company, Incorporated

Subsidiary of The Universal Pipe and Radiator Company

GRAYBAR BUILDING, LEXINGTON AVENUE AT 43rd STREET, NEW YORK

Plant: LANSDALE, PA.

Molby Magazine-Feed Downdraft-Crossdraft Boilers and Heavy Duty Tank Heaters *with adjustable side grate for burning No. 1 Buckwheat Anthracite*

Highest Medal Award of Merit and Diploma: Sesqui-Centennial, Philadelphia, 1926.

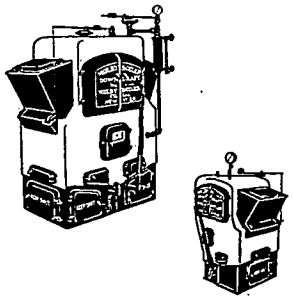
Built throughout in accordance with codes of the *A.S.M.E.* and the *A.S.H.&V.E.*

THE MOLBY is easy to operate, is self feeding, and gives a steady, even heat over long periods with low-priced No. 1 Buckwheat Anthracite. Also burns sized free-burning bituminous with proper chimney draft. Also coke. Magazines need re-filling only once every 12 to 24 hours. Cast iron sectional construction throughout.

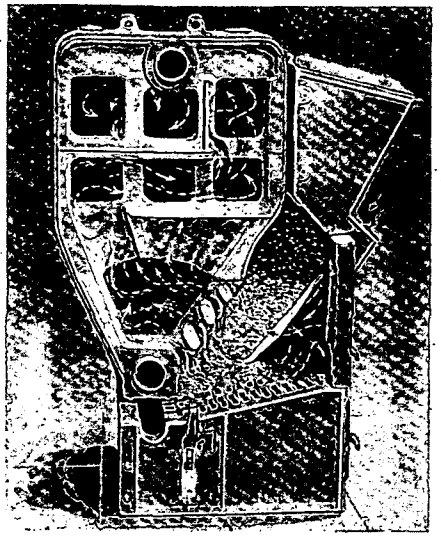
Ratings are based on the assumption that a good grade of No. 1 Buckwheat Anthracite is to be used and that the chimney is of such area, height and tightness as to produce the required draft; also that the boiler, mains and connections shall be covered with an insulating material. These ratings, under the same conditions, may be used for sized soft coal of the free-burning and non-caking variety.

Should larger sizes of good grades of Anthracite be used, a given boiler—other conditions being the same—would burn with equal efficiency, 20 per cent more coal. Thus, when such larger sizes are regularly used, the ratings shown are increased 20 per cent.

The MOLBY will heat home—large apartment house—or commercial building—having a good chimney, just as successfully and just as easily with low-priced small coal as ordinary boilers burning the expensive sizes.



THE cross-sectional views on this and the next page show the construction of the sections and the relative position of the reserve coal in the magazine. Note the downdraft and crossdraft travel of the gases through the fire and into the combustion chamber.



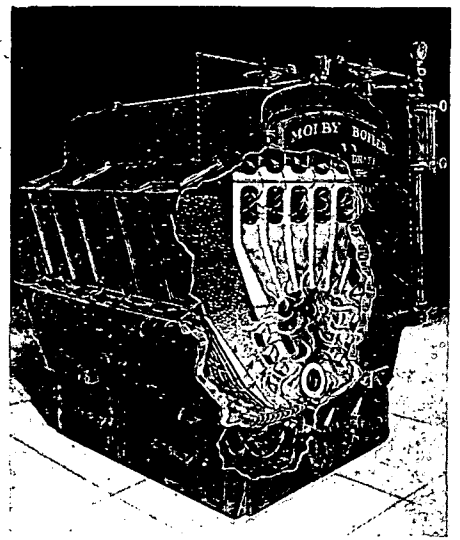
SIZES, CAPACITIES, DIMENSIONS AND PRICES

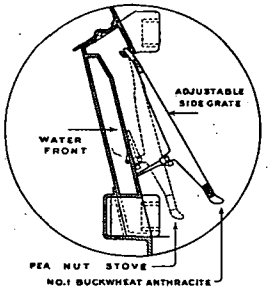
STEAM						STEAM AND WATER							WATER				
						Size—Inches											
Number	Steam Vapor	Water Line	Returns	Steam Rating	List Price	Height	Width	Length	Smoke Pipe	Outlets	Chimney Flue	Approximate Shipping Weight	Number	Water Cipher	Return	Water Rating	List Price
26" Series																	
S-4026	Adageo	48	2-3	500	$ 407.00	54	41	35½	10	2-3	8x12	1890	W-4026	Domo	2-3	850	$379.74
S-5026	Addieo	48	2-3	675	492.14	54	41	42	10	2-3	8x12	2230	W-5026	Doseo	2-3	1125	461.99
S-6026	Admito	48	2-3	850	577.28	54	41	48½	10	2-3	8x12	2580	W-6026	Doffo	2-3	1400	544.22
S-7026	Adzo	48	2-3	1025	662.42	54	41	55	10	2-3	12x12	2950	W-7026	Doveo	2-3	1700	626.46
S-8026	Adelo	48	2-3	1200	747.56	54	41	61½	10	2-3	12x12	3300	W-8026	Docko	2-3	2000	708.69
31" Series																	
S-4031	Bugo	54	2-4	1000	681.45	62½	61	37⅜	14	2-3	8x12	3320	W-4031	Edamo	2-4	1650	658.71
S-5031	Buffo	54	2-4	1350	837.54	62½	61	44	14	2-3	12x12	3820	W-5031	Edgeo	2-4	2250	809.48
S-6031	Bullo	54	2-4	1700	960.99	62½	61	50⅜	14	2-3	12x12	4290	W-6031	Edito	2-4	2850	928.73
S-7031	Buno	54	2-4	2050	1169.58	62½	61	56¾	14	3-3	12x16	4690	W-7031	Edicto	2-4	3425	1130.21
S-8031	Bulbo	54	2-4	2400	1297.29	62½	61	63⅛	14	3-3	12x16	5100	W-8031	Edeno	2-4	4000	1253.57
S-9031	Buoyo	54	2-4	2750	1410.81	62½	61	69½	14	3-3	16x16	5510	W-9031	Educeo	2-4	4575	1363.22
S-10031	Bungo	54	2-4	3100	1524.33	62½	61	75⅞	14	3-3	16x16	5930	W-10031	Eduxo	2-4	5150	1472.87
47" Series																	
S- 5047	Calxo	67½	2-5	2550	1384.82	80	75½	50½	14	2-4	12x16	5990	W-5047	Fluxo	2-5	4250	1338.38
S- 6047	Calfo	67½	2-5	3200	1611.86	80	75½	59	14	2-4	16x16	7150	W-6047	Fledo	2-5	5325	1557.68
S- 7047	Caro	67½	3-5	3850	1838.90	80	75½	67½	16	3-4	16x16	8310	W-7047	Flipo	3-5	6400	1776.98
S- 8047	Carpo	67½	3-5	4500	2065.94	80	75½	76	16	3-4	16x20	9500	W-8047	Flowo	3-5	7500	1996.28
S- 9047	Caseo	67½	3-5	5150	2292.98	80	75½	84½	18	3-4	16x20	10650	W-9047	Flungo	3-5	8575	2215.58
S-10047	Cadio	67½	3-5	5800	2520.02	80	75½	93	18	4-4	20x20	11840	W-10047	Flusho	3-5	9650	2434.88
S-11047	Cabo	67½	3-5	6450	2775.44	80	75½	101½	18	4-4	20x20	13000	W-11047	Flinto	3-5	10725	2681.60
S-12047	Cando	67½	3-5	7100	3002.48	80	75½	110	18	4-4	20x24	14150	W-12047	Flato	3-5	11800	2900.90
S-13047	Camo	67½	3-5	7750	3229.52	80	75½	118½	18	4-4	20x24	15320	W-13047	Fleigo	3-5	12925	3120.20

Note.—In ordering 26 in. boilers state whether you wish same fitted up with right hand or left hand end to the chimney. Length includes Smoke Box.

Equipment.—Each steam boiler is equipped with a full set steam trimmings (26 in. series, 1 pressure regulator; 31 in. and 47 in. series, 2 pressure regulators.)

Water boilers are furnished with two water temperature regulators, except 26 in. series which are equipped with one. A complete set of firing and cleaning tools, together with instruction books for setting up and operation, accompany each boiler.





Side grate easily adjusted for small coal or large coal

LOSS of valuable heat units is impossible because the fuel is added to the *draft side* of the fire.

The air supporting the combustion enters the fire chamber through the *adjustable side grate*, passes through the incandescent fire and is drawn through the water grate with the gases at a flaming temperature. Air and gases mix upon entering the combustion chamber.

NATIONAL RADIATOR COMPANY

General Offices: JOHNSTOWN, PA.

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PHILADELPHIA, 121 N. Broad Street
BALTIMORE, 2622 Frisby Street
WASHINGTON, 2205 Fifth St., N.E.

Branches

RICHMOND, 3032 Norfolk Street
PITTSBURGH, 1402 Arrott Building
CLEVELAND, 6308 Kinsman Road
CINCINNATI, Cor. Spring Grove and Elmira Aves.
CHICAGO, 2445 N. Keeler Ave.

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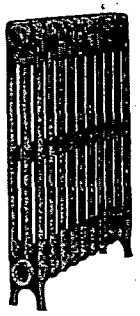
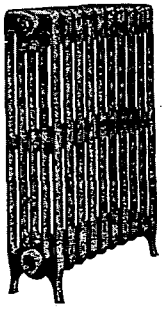
Manufacturers of

National Smokeless, Novus Upright and Sectional, Acme Round, Radium Gas and Hot Water Supply Boilers, and Aero Radiators.

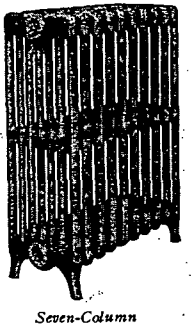


Three-Column

Four-Column

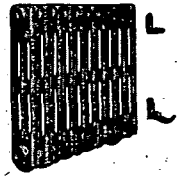


Five-Column



Seven-Column

Patents Applied For



Legless Radiator

AERO RADIATORS

Awarded Gold Medal at Sesqui-Centennial, Philadelphia, Pa., 1926

The Aero Radiator was designed by Engineers with more than 30 years experience in radiator manufacture. In the Aero line is represented a real effort to simplify the multiplicity of radiator patterns and heights.

Large buildings are now warmed with the more modern, efficient, economical and easily controlled vapor and vacuum systems. These necessitate the use of a radiator pattern with top and bottom nipple connection—the type known as a water section. The demand for the straight steam section, with bottom nipple connection only, is consequently negligible.

The Aero Radiator is made in one type only—the top and bottom nipple connected section.

It is tapped top and bottom both ends. The top tappings are plugged and the bottom tappings bushed to size required.

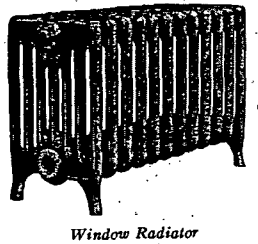
All radiators are vented for both steam and hot water. One vent is plugged. Any Aero Radiator can be used for either steam, hot water or vapor.

Aero Radiators are made in four patterns—Three, Four, Five and Seven Column. A total of 18 heights comprises the entire line.

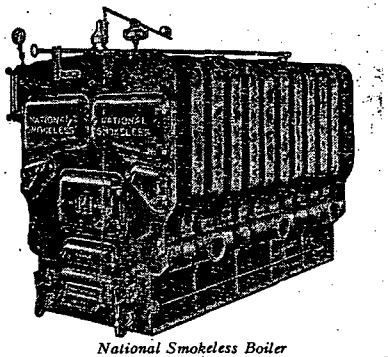
Roughing-in measurements are standard. All sections measure 2½ in. from center to center.

The Three-Column pattern is 5⅛ in. wide, the Four Column is 6⅝ in. wide, the Five-Column pattern 8⅜ in. wide and the Seven-Column pattern 12 in. With these widths and standard roughing-in measurements they can be used on any standard specification.

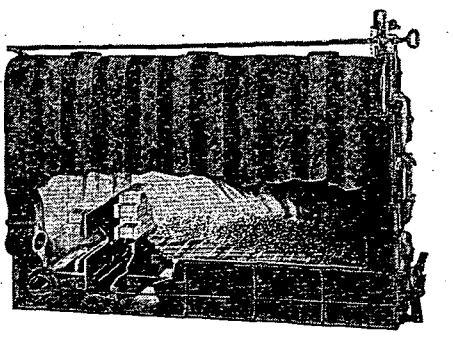
Aero Radiators are authoritatively rated by Cornell University, Ithica, N. Y.



Window Radiator



National Smokeless Boiler



Sectional View

Patented

SIZES, RATINGS AND MEASUREMENTS

Size	Steam Rating	Water Rating	Number Sections	Number Grates	Fire Chamber Area Sq. Ft.	Height Water Line Inches*	Height Top Outlet Inches	Height Including Trimmings*	Width Boiler Inches	Width Including Trimmings Inches*	Length Including Smokehood Inches	Size Base Inches	Outlets No. and Size	Size Smoke Pipe
25- 8	2450	4000	8	5	8.43	49	57¼	65⅝	36½	40¾	67⅝	27⅞x 53⅜	3-4"	12
25- 9	2775	4550	9	6	9.59	49	57¼	65⅝	36½	40¾	74⅝	27⅞x 60⅜	3-4"	12
25-10	3100	5100	10	7	10.75	49	57¼	65⅝	36½	40¾	81⅝	27⅞x 67⅜	3-4"	12
25-11	3425	5650	11	8	11.91	49	57¼	65⅝	36½	40¾	88⅝	27⅞x 74⅜	3-4"	12
25-12	3750	6200	12	9	13.07	49	57¼	65⅝	36½	40¾	95⅝	27⅞x 81⅜	3-4"	12
31- 8	3600	5925	8	5	11.93	52	61	71¼	50	54	73	33¼x 59	3-5"	15
31- 9	4050	6675	9	6	13.62	52	61	71¼	50	54	80½	33¼x 66½	3-5"	15
31-10	4500	7425	10	7	15.31	52	61	71¼	50	54	88	33¼x 74	3-5"	15
31-11	4950	8175	11	8	17.00	52	61	71¼	50	54	95½	33¼x 81½	3-5"	15
31-12	5400	8925	12	9	18.69	52	61	71¼	50	54	103	33¼x 89	3-5"	15
31-13	5850	9675	13	10	20.38	52	61	71¼	50	54	110½	33¼x 96½	3-5"	15
36- 8	5200	8600	8	5	16.00	60¼	70	78¾	56	60	79⅛	41⅜x 65⅛	3-5"	16
36- 9	5900	9750	9	6	18.25	60¼	70	78¾	56	60	87½	41⅜x 73½	3-5"	17¼
36-10	6600	10,900	10	7	20.50	60¼	70	78¾	56	60	95⅞	41⅜x 81⅞	3-5"	17¼
36-11	7300	12,050	11	8	22.75	60¼	70	78¾	56	60	104¼	41⅜x 90¼	3-5"	17¼
36-12	8000	13,200	12	9	25.00	60¼	70	78¾	56	60	112⅝	41⅜x 98⅝	3-5"	17¼
36-13	8700	14,350	13	10	27.25	60¼	70	78¾	56	60	121	41⅜x107	4-5"	17¼
36-14	9400	15,500	14	10	29.50	60¼	70	78¾	56	60	129⅜	41⅜x115⅜	4-5"	17¼
36-15	10,100	16,650	15	11	31.75	60¼	70	78¾	56	60	137¾	41⅜x123¼	4-5"	17¼
36-16	10,800	17,800	16	11	34.00	60¼	70	78¾	56	60	146⅛	41⅜x132⅛	4-5"	17¼
48- 9	9600	15,825	9	6	28.88	68	80	89	67	71	109¼	53⅞x 89¼	3-6"	20
48-10	10,775	17,775	10	7	32.43	68	80	89	67	71	119⅞	53⅞x 99⅞	3-6"	20
48-11	11,950	19,725	11	8	35.98	68	80	89	67	71	130½	53⅞x110½	4-6"	20
48-12	13,125	21,675	12	9	39.53	68	80	89	67	71	141⅛	53⅞x121⅛	4-6"	20
48-13	14,300	23,625	13	10	43.08	68	80	89	67	71	151¾	53⅞x131¾	5-6"	20
48-14	15,475	25,575	14	10	46.63	68	80	89	67	71	162⅜	53⅞x142⅜	5-6"	20
48-15	16,650	27,525	15	11	50.18	68	80	89	67	71	173	53⅞x153	5-6"	20
48-16	17,825	29,475	16	11	53.73	68	80	89	67	71	183⅝	53⅞x163⅝	5-6"	20

*Applies to steam boilers only.

Sylph-Oil Air Regulator Patents Applied For

The National Up-Draft Smokeless Boiler will conform to any smoke ordinance.

Burning smoke depends upon the temperature to which the air discharged over the fire is preheated. The National Preheating Air device heats air to in excess of 1000 deg. It is discharged into the smoke and gases as they pass over the Refractory Bridge wall into the Combustion Chamber.

The National Smokeless Boiler will clear to the No. 1 Smoke Screen in from 10 to 15 seconds and to a clear stack in less than one minute after firing a charge of green coal.

National Smokeless boilers show an average increase of 28 per cent in evaporation on the same fuel charge and consequently are very economical in operation.

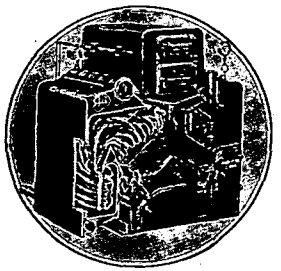
The volume of preheated air necessary to burn smoke varies with the state of combustion. The air should be gradually decreased and cut off almost completely during a period of about 20 minutes from the time fuel is charged. Unless this is done the preheated air has a tendency to chill rather than increase the gas temperatures and the boiler efficiency and evaporation is decreased.

The Sylph-Oil Regulator operates the Preheating Air Device automatically and positively can be regulated to close the air intake in any time from one half-a minute to one hour after fuel is charged.

Newport Boiler Company

General Offices: 529 S. Franklin St., Chicago

MAGAZINE FEED



OIL BURNING

DISTRIBUTORS—All Principal Cities United States and Canada

This boiler cuts fuel bills from 30 to 50 per cent burning No. 1 Buckwheat coal

"Newport"—alone, provides these Heater essentials:

Convenience Coaling only necessary from once a day to once a week, depending upon the weather. It is therefore the Home Owner's choice.

Economy "Newport" combustion is complete, conforming to all the laws of science. Saves from $5 to $7 per ton, burning No. 1 Buckwheat coal.

Uniform Heat is provided by the never varying thickness of the fuel bed, that supplies heat for every nook and corner, automatically controlled.

Adaptability the patented, adjustable throat, which is water cooled, insures maximum efficiencies, burning all sizes and kinds of coal, coke or oil.

NEWPORT COAL BURNING BOILERS

Boiler Number Steam	Rating Square Feet	*Maximum Direct Radiation Load	Boiler Number Water	Rating Square Feet	*Maximum Direct Radiation Load	Length Overall	Width Overall	Chimney Flue	
								Size Inches	Height Feet
STEAM			WATER						
S-4	594	340	W-4	1000	572	30¼"	32"	8 x 12	35
S-5	750	430	W-5	1250	714	36½"	32"	8 x 12	35
S-6	907	518	W-6	1500	857	42¾"	32"	8 x 12	40
S-7	1063	607	W-7	1750	1000	49"	32"	12 x 12	40
S-8	1219	696	W-8	2000	1143	55¼"	32"	12 x 12	45
S-55	1375	786	W-55	2282	1304	44"	56"	12 x 12	40
S-66	1688	965	W-66	2782	1590	50¼"	56"	12 x 16	45
S-77	2000	1143	W-77	3313	1893	56½"	56"	12 x 16	45
S-88	2313	1322	W-88	3813	2179	62¾"	56"	16 x 16	50
S-99	2625	1500	W-99	4313	2464	69"	56"	16 x 16	50
S-1010	2938	1679	W-1010	4813	2749	75¼"	56"	18 x 18	50
S-1111	3250	1858	W-1111	5313	3035	81½"	56"	18 x 18	55

NEWPORT OIL BURNING BOILERS

O-S-4	594	340	O-W-4	1000	572	30¼"	32"	8 x 12	35
O-S-5	750	430	O-W-5	1250	714	36½"	32"	8 x 12	35
O-S-6	907	518	O-W-6	1500	857	42¾"	32"	8 x 12	40
O-S-7	1063	607	O-W-7	1750	1000	49"	32"	12 x 12	40
O-S-8	1219	696	O-W-8	2000	1143	55¼"	32"	12 x 12	45
O-S-55	1375	786	O-W-55	2282	1304	44"	56"	12 x 12	40
O-S-66	1688	965	O-W-66	2782	1590	50¼"	56"	12 x 16	45
O-S-77	2000	1143	O-W-77	3313	1893	56½"	56"	12 x 16	45
O-S-88	2313	1322	O-W-88	3813	2179	62¾"	56"	16 x 16	50
O-S-99	2625	1500	O-W-99	4313	2464	69"	56"	16 x 16	50
O-S-1010	2938	1679	O-W-1010	4813	2749	75¼"	56"	18 x 18	50
O-S-1111	3250	1858	O-W-1111	5313	3035	81½"	56"	18 x 18	55

*The "Maximum Direct Radiation Load" is the maximum actual amount of square feet of cast iron column radiation or its equivalent that we recommend be attached to boiler. *This amount provides a safety factor of 75 per cent, being ample* for average conditions, to take care of the load imposed by mains, risers, etc., but does not provide an allowance for the heating of water for domestic use, or any extra load where attached radiation will condense more than 0.25 (¼) lb. of steam, per square foot per hour.

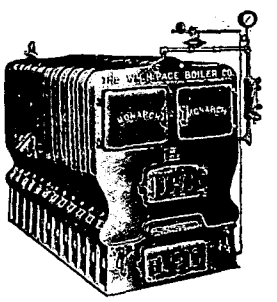
The water line on all Steam Boilers is 40½ in. Height overall Coal Boilers 62 in. Oil Boilers 48¾ in.

The Wm. H. Page Boiler Co.

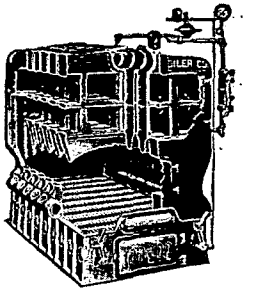
200 Madison Avenue, New York

BOSTON, 123 Beverly Street
BROOKLYN, Bush Terminal
CLEVELAND, Rose Building
MEADVILLE, PA., Factory

Makers of Boilers for more than 70 Years



Monarch Smokeless



Monarch Water Tube

Monarch Sectional Steam and Water Boilers

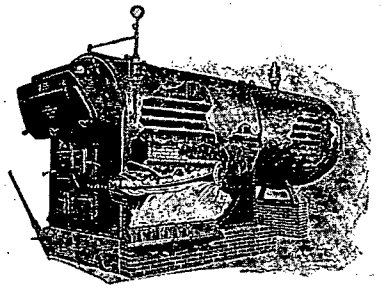
No.	Rating Sq. Ft. Steam	Rating Sq. Ft. Water	*Size of Grate Inches	*Full Area of Grate Sq. Ft.	Height Overall Inches Steam	Width Overall Inches Steam	Height Overall Inches Water	Width Overall Inches Water	Total Length Inches	Water Line Inches Steam	Outlets and Inlets Inches	Size of Smoke Pipe Inches
4-22	850	1400	22 x 20	3.06	60½	39¼	52	35	35¼	41	2-3	13
5-22	1075	1775	22 x 26⅜	4.03	60½	39¼	52	35	41⅝	41	2-3	13
6-22	1300	2150	22 x 32¼	5.00	60½	39¼	52	35	48	41	2-3	13
7-22	1525	2525	22 x 39⅛	5.98	60½	39¼	52	35	54⅞	41	2-3	13
4-28	1600	2650	28 x 24¼	4.82	73	45¼	64½	41	44⅞	51	2-5	15
5-28	2100	3475	28 x 33⅛	6.45	73	45¼	64½	41	53¼	51	2-5	15
6-28	2600	4300	28 x 41½	8.07	73	45¼	64½	41	61⅝	51	2-5	15
7-28	3100	5125	28 x 49⅞	9.70	73	45¼	64½	41	70	51	2-5	15
8-28	3600	5950	28 x 58¼	11.32	73	45¼	64½	41	78⅜	51	2-5	15
9-28	4100	6775	28 x 66⅝	12.96	73	45¼	64½	41	86¾	51	2-5	15
5-40	3400	5600	40 x 33⅛	9.20	81	59¼	72½	55	52	58	2-5	21
6-40	4200	6925	40 x 41½	11.52	81	59¼	72½	55	60⅜	58	2-5	21
7-40	5000	8250	40 x 49⅞	13.85	81	59¼	72½	55	68¼	58	2-5	21
8-40	5800	9575	40 x 58¼	16.18	81	59¼	72½	55	77⅛	58	2-5	21
9-40	6600	10,900	40 x 66⅝	18.50	81	59¼	72½	55	85½	58	2-5	21
10-40	7400	12,200	40 x 75	20.82	81	59¼	72½	55	93⅞	58	2-5	21
11-40	8200	13,525	40 x 83⅜	23.13	81	59¼	72½	55	102¼	58	3-5	21
12-40	9000	14,850	40 x 91¾	25.50	81	59¼	72½	55	110⅝	58	3-5	21
6-60	6600	10,900	60 x 41½	17.29	82¾	85⅜	74¼	81⅛	64⅜	60	2-6	26
7-60	8200	13,525	60 x 49⅞	20.78	82¾	85⅜	74¼	81⅛	72¾	60	2-6	26
8-60	9800	16,175	60 x 58¼	24.27	82¾	85⅜	74¼	81⅛	81⅛	60	2-6	26
9-60	11,400	18,800	60 x 66⅝	27.76	82¾	85⅜	74¼	81⅛	89½	60	3-6	26
10-60	13,000	21,450	60 x 66⅜	31.25	82¾	85⅜	74¼	81⅛	97⅞	60	3-6	26
11-60	14,600	24,100	60 x 66⅜	34.74	82¾	85⅜	74¼	81⅛	106¼	60	3-6	26
12-60	16,200	26,725	60 x 75	38.22	82¾	85⅜	74¼	81⅛	114⅝	60	3-6	26
13-60	17,800	29,375	60 x 75	41.72	82¾	85⅜	74¼	81⅛	123	60	3-6	26
14-60	19,400	32,000	60 x 75	45.20	82¾	85⅜	74¼	81⅛	131⅜	60	3-6	26
15-60	21,000	34,650	60 x 83⅜	48.69	82¾	85⅜	74¼	81⅛	139¾	60	3-6	26
16-60	22,600	37,300	60 x 83⅜	52.18	82¾	85⅜	74¼	81⅛	148⅛	60	3-6	26
17-60	24,200	39,950	60 x 83⅜	55.67	82¾	85⅜	74¼	81⅛	156½	60	3-6	26
18-60	25,800	42,600	60 x 91¾	59.16	82¾	85⅜	74¼	81⅛	164⅞	60	3-6	26
19-60	27,400	45,200	60 x 91¾	62.65	82¾	85⅜	74¼	81⅛	173¼	60	3-6	26
20-60	29,000	47,850	60 x 91¾	66.14	82¾	85⅜	74¼	81⅛	181⅝	60	3-6	26

Ratings, as given, are derived from tests made in accordance with the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Low-Pressure Boiler Testing Code.

*Bridgewall sections are furnished for shortening grates. Grate areas as given above are for entire length of firebox, but unless otherwise ordered, bridgewall section will be shipped with boilers larger than No. 9-28, 12-40 and 9-60, to reduce grate to length in table of dimensions.

OIL CITY BOILER WORKS — Oil City ~ Pa.

NEW YORK, N. Y., 501 Fifth Ave.
PITTSBURGH, PA., 1116 House Bldg.
ATLANTA, GA., 315 Glenn Bldg.
BALTIMORE, MD., Dukehart Bldg.
INDIANAPOLIS, IND., 117 East Michigan St.
RICHMOND, VA., American National Bank Bldg.
DETROIT, MICH., 715 Donovan Bldg.
CHICAGO, ILL., 19 W. Jackson Blvd.
LOS ANGELES, CALIF., 1003 Union Trust Bldg.
CHARLOTTE, N. C., 225 Latta Arcade
CINCINNATI, O., S. W. Cor. 3rd and Walnut Sts.
OKLAHOMA CITY, OKLA., P. O. Box No. 87.
SHREVEPORT, LA., P. O. Box No. 298



"Oil City" Smokeless Boiler

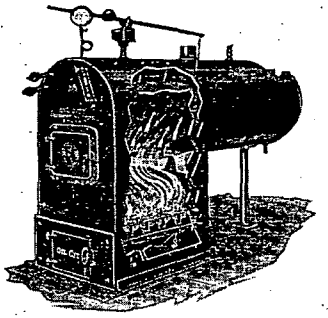
"OIL CITY" low pressure boilers are offered to the trade as the last word in "Heating Economy" comprising in one unit all the elements of a modern plant for steam or hot water heating, especially adapted for Schools, Office Buildings, Hotels, Churches, Club Houses, Hospitals or for any purpose where the service of a universally recognized fire box boiler of high merit is desired.

"OIL CITY" boilers are designed and constructed to meet all requirements of modern engineering as formulated by the *American Society of Mechanical Engineers*, the boiler laws of the various states and cities, and are backed by 35 years of successful practical experience.

Description—"OIL CITY" boilers are built in smokeless and straight draft types for portable and brick settings, self contained with all steel construction thoroughly braced, stayed, inspected, and tested for 15 lb. working pressure.

These boilers have large fire boxes thereby insuring ample combustion space in which heat-giving gases and air freely mix before entering tubes.

The arrangement of tubes in relation to shell allows free circulation of water at all times, together with large steam space, insuring dry steam and steady water level.



"D" Type Boiler

The above view shows the new "D" type residential boiler built in capacities 400 to 2000 sq. ft. direct steam radiation. Send for Circular H-23.

Ratings—Ratings are very conservative, only such parts of the boiler coming in actual contact with passage of the hot gases, and lying below the zone of normal water level being considered as heating surface.

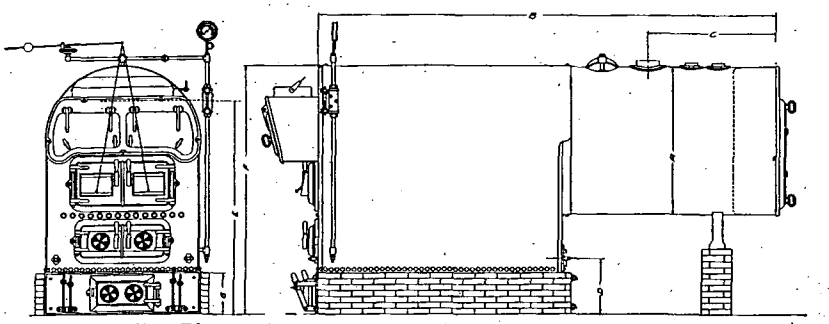
Equipment—Equipment with all boilers includes, in addition to complete set of shaking grates, all the necessary castings, safety valves, steam gauge, water column, etc., required for a complete installation.

Oil Fired—Where oil is used exclusively we recommend our new Series 1900 Portable Return Tubular Fire Box Oil Burning Boiler. Complete specifications and measurements shown in Circular H-22.

Every "OIL CITY" boiler bears the official stamp of the *A. S. M. E.* Boiler Code, indicating the pressure at which the boiler may be worked.

At a small increase in cost "OIL CITY" boilers are furnished, braced and stayed, for a safe working pressure of 100 lb. Complete specifications, measurements and weights shown in Catalog H-9.

SPECIFICATIONS AND GENERAL DIMENSIONS ON NEXT PAGE.



Settling Plan and Measurements "Oil City" Heating Boilers

"Oil City" Smokeless

NUMBER OF BOILER			807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824
CAPACITY - STEAM		Sq. Ft.	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500
CAPACITY - WATER		Sq. Ft.	3000	5000	6600	7400	8300	9100	9900	10700	12400	14000	15500	17000	18500	20000	21500	23000	24500	26000
BOILER DIAMETER	A	In.	48	48	48	54	54	54	60	60	60	60	66	66	66	72	72	72	78	78
BOILER LENGTH	B	Ft. & In.	9-1	10-5	11-5	10-11	11-11	12-11	12-11	13-11	15-5	16-5	15-9	17-9	16-7	17-11	17-10	18-10	20-1	21-1
REAR TO OUTLET	C	Ft. & In.	3-2	3-9	4-2	3-5	3-9	4-2	4-6	4-8	4-4	4-9	4-4	4-9	5-0	5-9	5-8	6-1	6-5	6-9
FLOOR TO RETURN	D	In.	19	19	19	19	19	19	22½	22½	22½	22½	23	23	23	23	23	23	23	23
FLOOR TO WATER LINE	E	In.	71	71	71	76	76	76	87	87	87	87	90	90	96	96	97	97	105	105
HEIGHT OVER BOILER	F	Ft. & In.	7-0	7-0	7-0	7-5	7-5	7-5	8-5	8-5	8-5	8-5	8-11	8-11	9-5	9-5	9-7	9-7	10-1	10-1
HEIGHT ASH PIT	G	Ft. & In.	14	14	14	14	14	14	17	17	17	17	17	17	17	17	17	17	17	17
SIZE OUTLET		In.	6	6	6	6	6	6	7	7	7	7	8	8	8	8	8	8	10	10
SIZE RETURN		In.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
SIZE SMOKE OUTLET		In.	10-36	10-36	10-36	10-42	10-42	10-42	12-48	12-48	12-48	12-48	15-30	15-30	17-34	17-34	17-60	17-60	20-64	20-64
DIA. BREECHING - ONE BOILER		In.	22	22	22	24	24	24	26	26	28	28	30	32	34	34	36	36	40	42
DIA. BREECHING - TWO BOILERS		In.	30	30	30	34	34	34	38	38	40	40	44	46	50	50	52	52	58	58
DIA. STACK - ONE BOILER		In.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
DIA. STACK - TWO BOILERS		In.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
HEIGHT STACK - ONE BOILER		Ft.	30	35	35	35	35	60	60	60	65	65	65	70	70	70	80	90	90	100
HEIGHT STACK - TWO BOILERS		Ft.	60	65	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
REQD TO OPEN REAR DOORS		In.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43

"Oil City" Direct Draft Type

NUMBER OF BOILER			907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924
CAPACITY - STEAM		Sq. Ft.	1500	2500	3500	4000	4500	5000	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	30000
CAPACITY - WATER		Sq. Ft.	4400	9000	5800	6600	7400	8300	9100	9900	11600	13200	15700	18200	21500	24800	28500	33000	40000	48000
BOILER DIAMETER	A	In.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
BOILER LENGTH	B	Ft. & In.	3-7	3-6	11-1	10-0	11-1	12-1	12-5	13-7	14-4	16-2	15-3	17-4	15-11	17-6	17-11	19-11	20-1	22-1
REAR TO OUTLET	C	Ft. & In.	3-11	4-3	4-10	4-7	4-9	4-11	4-12	4-11	5-11	6-3	6-5	7-2	6-3	6-5	6-8	7-11	7-7	9-7
FLOOR TO RETURN	D	In.	19	19	19	19	19	19	22½	22½	22½	22½	23	23	23	23	23	23	23	23
FLOOR TO WATER LINE	E	In.	71	71	71	76	76	76	87	87	87	87	90	90	96	96	97	97	105	105
HEIGHT OVER BOILER	F	Ft. & In.	7-0	7-0	7-0	7-5	7-5	7-5	8-5	8-5	8-5	8-5	8-11	8-11	9-5	9-5	9-7	9-7	10-1	10-1
HEIGHT ASH PIT	G	Ft. & In.	14	14	14	14	14	14	17	17	17	17	17	17	17	17	17	17	17	17
SIZE OUTLET		In.	6	6	6	6	6	6	7	7	7	7	8	8	8	8	8	8	10	10
SIZE RETURN		In.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
SIZE SMOKE OUTLET		In.	10-36	10-36	10-36	10-42	10-42	10-42	12-48	12-48	12-48	12-48	15-30	15-30	17-34	17-34	17-60	17-60	20-64	20-64
DIA. BREECHING - ONE BLR.		In.	22	22	22	24	24	24	26	26	28	28	30	32	34	34	36	36	40	42
DIA. BREECHING - TWO BLRS.		In.	30	30	30	34	34	34	38	38	40	40	44	46	50	50	52	52	56	56
DIA. STACK - ONE BLR.		In.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
DIA. STACK - TWO BLRS.		In.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
HEIGHT STACK - ONE BLR.		Ft.	30	30	35	35	35	60	60	60	65	65	65	70	70	70	80	90	90	100
HEIGHT STACK - TWO BLRS.		Ft.	60	60	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
REQD TO OPEN REAR DOORS		In.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43

Orr & Sembower, Inc.

ESTABLISHED 1885

Reading, Pa.

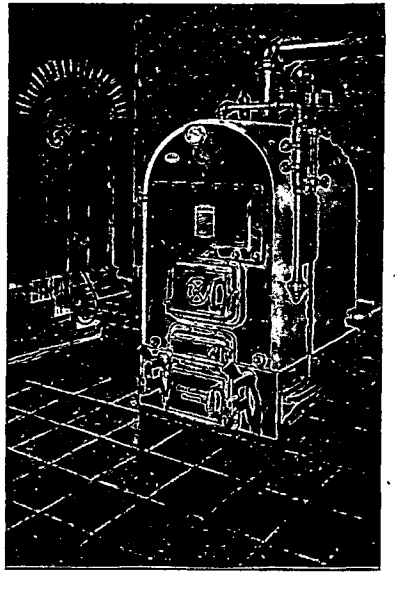
"Knowlton 'Watertoob' Steel Heating Boilers"

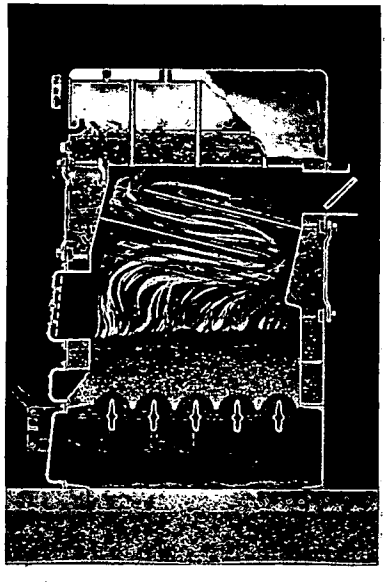
Knowlton "Watertoob" Steel Boilers are designed for use in homes, Apartments, small factories, etc., meet all the requirements of the *American Society of Mechanical Engineers*, and the boiler laws of the various states and cities, and being highly efficient, installation guarantees "Complete Heating Satisfaction."

The "Watertoob" construction of the Knowlton Boiler is very efficient and unique. The use of many copper tubes of small diameter, and the inclination of these tubes permits very rapid circulation, and heat transmission to the water. Arsenical copper tubes are used in the "Watertoob" construction because of their rapid heat absorption, and because they effectively resist corrosion from water and gases.

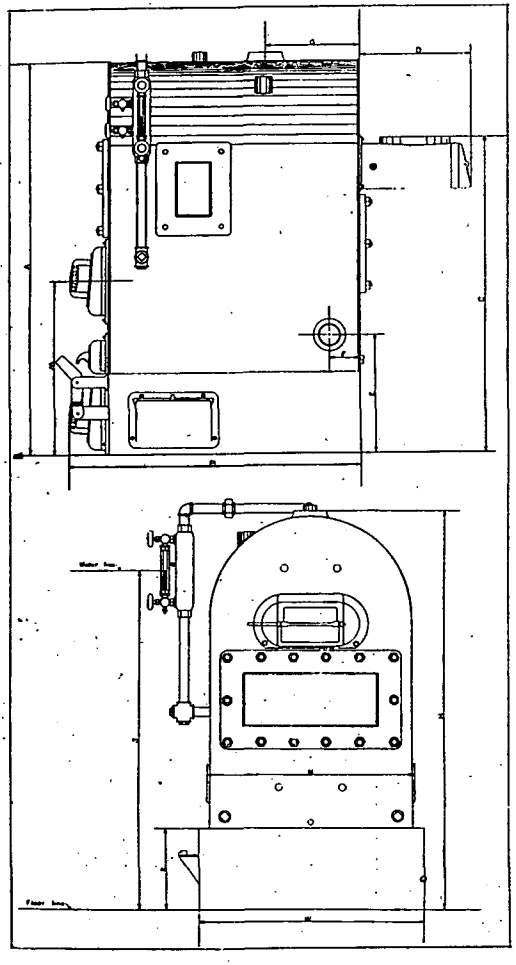
The following are the combined features and advantages found in no other one Boiler:

1. **Built of Steel.**
   Made of ¼ in. copper bearing steel. All electrically welded in one unit. No seams can break or crack. The copper increases the resistance of the steel to corrosion.
2. **Water-Tube Type.**
   The type found in all modern power plants. Effective water circulation. Raises steam rapidly. Tubes easy to replace. Conserves floor space.
3. **"Watertoob" Construction.**
   The tubes are made of arsenical copper. Longer life than steel tubes, greater heat absorbing qualities, tubes placed close together on an angle, increasing water circulation and heating efficiency. Easy to clean.
4. **Long Gas Travel.**
   Construction is such that the gas cannot take short cut to the chimney. Gas travel is equivalent to about three times the length of the fire box, heating the water to a degree that would be otherwise impossible, and making low stack temperatures.
5. **Water Circulation.**
   Construction of tubes heats water quickly and gives rapid continuous circulation. This is due to the angular position of the tubes by means of which the movement of the hot water to the top is accelerated. It is further due to the fact that the copper tubes transmit the heat to a maximum degree.





6. **Fuel Saving.**
   Requires about one-third less fuel than ordinary boilers.
7. **Grates.**
   Built like a stone crusher. Semi-circular construction crushes clinkers and does not allow coal to drop through. Ashes can be accumulated in rear half in mild weather to hold temperature down.
8. **Easy to Install.**
   Comes completely assembled in one unit, making the cost of installation low.
9. **Easy to Operate.**
   Fires up quickly in the coldest weather. Grate Construction and damper control is such that temperature can be held down on milder days. Firing periods about 8 hours apart in zero weather.
10. **Easy to Keep Clean.**
    Easy access to all parts of the boiler for cleaning purposes.



11. **Large Water Capacity and Steam Space.**
    No danger of excessive moisture in steam, or rapid loss of water line due to ordinary leaks.
12. **Rated Radiation.**
    Rated according to the net amount of radiation they will supply. Only one rating and this one absolutely guaranteed. Makes selection of proper size boiler possible without guesswork.
13. **Maximum Efficiency with Coal, Oil or Gas.**
    The higher heat absorbing qualities of steel construction and copper tubes make it the only logical type for use with coal, oil or gas.
14. **Cost.**
    The cost of the Knowlton "Watertoob" Steel Boiler installed is very little more than that of a cast iron boiler of the *proper* size.

"KNOWLTON BOILERS" are built by Manufacturers having 43 years of successful practical experience.

"Knowlton" Heating Boiler Dimension Chart

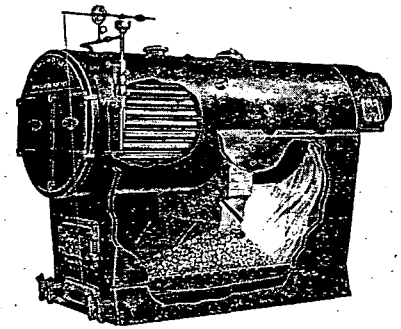
Boiler No.	2	3	4	5	6	7
Steam rating, sq. ft.	520	770	1060	1300	1620	1820
Hot Water rating, sq. ft.	860	1270	1750	2150	2680	3010
Dimensions A	In. 53¼	In. 54⅛	In. 58⅛	In. 59⅜	In. 62⅜	In. 62⅞
B	31	37	43	49	54	54
C	41	41¾	46⅜	47⅜	50⅛	50⅜
D	13¾	15	16	17½	18¾	18¾
E	15¼	15½	17½	17½	18	18
F	4⅜	4⅞	4⅜	4⅜	4⅜	4⅜
G	4⅜	4⅞	13⅜	13⅛	12⅞	12⅞
H	54¼	55¼	59¼	60¾	63⅜	64
J	45	46	50	51⅜	54	54½
K	10	10	12	12	12	12
M	23¾	23¾	25¾	25¾	25¾	25¾
N	27¾	30¾	30¾	33¾	33¾	36¾
W	30	33	33	36	36	39
Outlets No. and Size	1-3	1-4	1-4	1-4	1-6	1-6
Inlets No. and Size	2-2½	2-3	2-3	2-3	2-4	2-4
Stack Diam.	8	9	10	11	12	12
Grate Area sq. ft.	2.5	3.83	4.8	6.5	7.58	8.46
Fire Box Dimensions Inches	18 x 20	23 x 24	23 x 30	26 x 36	26 x 42	29 x 42

Pacific Steel Boiler Corporation

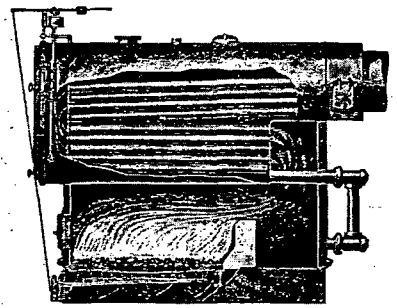
Manufacturers of

Pacific Steel Heating Boilers, Pacific Circulating Tanks

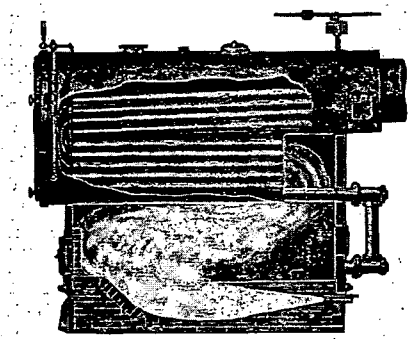
Waukegan, Illinois and Bristol, Pennsylvania



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Gas or Wood



For Burning Oil

P A C I F I C

STEEL HEATING BOILERS

Pacific Steel Heating Boilers are built for steam or hot water heating using soft coal, hard coal, oil, gas, or wood as fuel.

They are constructed of steel according to the *A. S. M. E.* Code for building low pressure steel heating boilers. Every joint and seam in the Pacific is electrically welded and each boiler is built and tested to a pressure many times its normal working pressure under the supervision of an inspector stationed in our plant by one of the largest insurance companies.

Because of the compact design, Pacific Boilers save from 25 to 40 per cent. of the boiler room floor space required by other steel firebox boilers, (see dimensions given on opposite page).

The catalog ratings on Pacific Boilers are based on heating surface with steam at two pounds gauge pressure, hot water at 180 deg. at boiler. Any Pacific Boiler will carry its full rated load in direct cast iron radiation. Extra capacity must be allowed for exposed piping, storage tank, pipe coils or indirect radiators and for buildings where normal temperatures below 70 deg. F. are to be maintained.

PACIFIC SMOKELESS BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
609	1900	64½	14	13	50	6.77	152.0	4	2½	67	42½	75	52	33½	12	33	27½	NOT LESS THAN SIX INCHES
610	2400	64½	14	13	50	8.16	189.0	4	2½	79	42½	75	64	33½	12	41	27½	
611	2900	68¼	16	15	55	9.47	234.0	5	3	81	46½	78	64	37½	12	41	31½	
612	3400	68¼	16	15	55	11.06	279.0	5	3	93	46½	78	76	37½	12	49	31½	
613	4000	68½	18	17	60	11.85	318.0	5	3	94	49¼	79¼	76½	39½	12	49	33½	
614	4500	68½	18	17	60	12.70	372.0	5	3	106	49¼	79¼	88½	39½	12	53	33½	
615	5000	75½	18	17	60	12.07	392.0	6	3	96	58	89¼	76½	45½	12	41	39½	
616	5500	75½	18	17	65	13.10	425.0	6	3	102	58	89¼	82½	45½	12	45	39½	
617	5800	75½	18	17	65	15.15	457.6	6	3	108	58	89¼	88½	45½	12	53	39½	
618	6500	82¼	24	22	65	16.42	508.5	8	4	98	62½	96	76½	51½	12	49	45½	
619	7500	82¼	24	22	70	18.83	594.8	8	4	110	62½	96	88½	51½	12	57	45½	
620	8500	82¼	24	22	70	20.00	637.5	8	4	116	62½	96	94½	51½	12	61	45½	
621	9000	89½	26	24	70	19.11	708.7	8	4	112	70½	106	88½	58½	12	49	52½	
622	10000	89½	26	24	75	20.50	809.5	8	4	124	70½	106	100½	58½	12	53	52½	
623	12000	99½	30	28	75	25.14	864.5	8	4	113	77½	117¾	88½	63	15	61	57	
624	14000	99½	30	28	75	26.64	988.8	8	4	125	77½	117¾	100½	63	15	65	57	
625	15500	106	32	30	85	32.6	1183.8	8	5	127	86	125¾	100½	83½	15	57	77	
626	18000	106	32	30	85	34.7	1332.9	8	5	139	86	125¾	112½	83½	15	61	77	
627	20500	106	32	30	90	36.8	1482.0	10	6	151	86	125¾	124½	83½	15	65	77	
628	22000	119	36	33	100	39.1	1583.1	10	6	144	95½	140	113¾	96½	18	61	90½	
629	25000	119	36	33	100	41.4	1759.0	10	6	156½	95½	140	125¾	96½	18	65	90½	
630	28000	119	36	33	100	43.7	1934.9	10	6	168½	95½	140	137¾	96½	18	69	90½	

For Pacific Oil Fired Boilers use the above specification.

PACIFIC DIRECT DRAFT BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
209	1600	64½	14	13	45	6.77	152.0	4	2½	67	42½	75	52	33½	12	33	27½	NOT LESS THAN SIX INCHES
210	1900	64½	14	13	45	8.16	189.0	4	2½	79	42½	75	64	33½	12	41	27½	
211	2400	68¼	16	15	50	9.47	234.0	5	3	81	46½	78	64	37½	12	41	31½	
212	2900	68¼	16	15	50	11.06	279.0	5	3	93	46½	78	76	37½	12	49	31½	
213	3300	68½	18	17	55	11.85	318.0	5	3	94	49¼	79¼	76½	39½	12	49	33½	
214	3800	68½	18	17	55	12.70	372.0	5	3	106	49¼	79¼	88½	39½	12	53	33½	
215	4100	75½	18	17	55	12.07	392.0	6	3	96	58	89¼	76½	45½	12	41	39½	
216	4500	75½	18	17	60	13.10	425.0	6	3	102	58	89¼	82½	45½	12	45	39½	
217	5000	75½	18	17	60	15.15	457.6	6	3	108	58	89¼	88½	45½	12	53	39½	
218	5500	82¼	24	22	60	16.42	508.5	8	4	98	62½	96	76½	51½	12	49	45½	
219	6500	82¼	24	22	65	18.83	594.8	8	4	110	62½	96	88½	51½	12	57	45½	
220	7000	82¼	24	22	65	20.00	637.5	8	4	116	62½	96	94½	51½	12	61	45½	
221	7500	89½	26	24	65	19.11	708.7	8	4	112	70½	106	88½	58½	12	49	52½	
222	8500	89½	26	24	70	20.50	809.5	8	4	124	70½	106	100½	58½	12	53	52½	
223	10000	99½	30	28	70	25.14	864.5	8	4	113	77½	117¾	88½	63	15	61	57	
224	11500	99½	30	28	70	26.64	988.8	8	4	125	77½	117¾	100½	63	15	65	57	
225	13000	106	32	30	75	32.6	1183.8	8	5	127	86	125¾	100½	83½	15	57	77	
226	15000	106	32	30	75	34.7	1332.9	8	5	139	86	125¾	112½	83½	15	61	77	
227	17000	106	32	30	80	36.8	1482.0	10	6	151	86	125¾	124½	83½	15	65	77	
228	19000	119	36	33	90	39.1	1583.1	10	6	144	95½	140	113¾	96½	18	61	90½	
229	22000	119	36	33	90	41.4	1759.0	10	6	156½	95½	140	125¾	96½	18	65	90½	
230	25000	119	36	33	90	43.7	1934.9	10	6	168½	95½	140	137¾	96½	18	69	90½	

Pacific Boilers are constructed with smoke outlet at the rear and all of the tubes, both upper and lower banks, are cleaned or removed from the front of the boiler through the front flue doors. Space at rear of boiler is not necessary.

Complete catalog showing all types and sizes Pacific Boilers will be furnished on request.

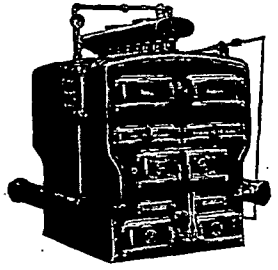
Pierce, Butler & Pierce Mfg. Corp.

General Sales Offices
41 EAST 42nd STREET NEW YORK, N. Y.

For List of Factories and Branches, see Page 656

Cast iron water boilers 100 to 23,450 sq. ft. capacity. Cast iron steam boilers 325 to 14,200 sq. ft. capacity. Firebox heating boilers, capacity steam radiation 2,500 to 25,000 sq. ft.; capacity water radiation 4,000 to 40,000 sq. ft. Radiators—all types

The Pierce-American Boiler



A 30-year record of proved successful performance

Sizes and Dimensions

No.*	Sections	Length	BOILER AND HEADERS Width	BOILER AND HEADERS Height	Height Water Line on S. B.	No. and Size, Outlets	No. and Size, Returns	Smoke Pipe Dia.	Size of Flue	Chimney Height	CAPACITY SQ. FT. Steam Boilers	CAPACITY SQ. FT. Water Boilers
214	4	47	45	56⅛	40¼	2-3	2-3	9½	10x10	30	600	1000
215	5	55	45	56⅛	40¼	2-3	2-3	9½	10x10	30	800	1325
216	6	63	45	56⅛	40¼	2-3	2-3	9½	10x10	35	1000	1650
265	5	55	51	64½	47⅞	2-3	2-3	11¾	12x12	35	1400	2325
266	6	63	51	64½	47⅞	2-4	2-4	11¾	12x16	35	1750	2900
267	7	71	51	64½	47⅞	2-4	2-4	11¾	12x16	40	2100	3475
268	8	79	51	64½	47⅞	2-4	2-4	11¾	16x16	40	2450	4050
325	5	55	59¼	67	49	2-4	2-4	14	12x16	35	1700	2825
326	6	63	59¼	67	49	2-5	2-5	14	12x16	40	2250	3700
327	7	71	59¼	67	49	2-5	2-5	14	16x16	40	2800	4625
328	8	79	59¼	67	49	2-5	2-5	14	16x16	45	3350	5525
329	9	87	59¼	67	49	2-5	2-5	14	16x20	50	3900	6450
3210	10	95	59¼	67	49	2-5	2-5	14	20x20	60	4450	7350
405	5	55	66½	69¼	51	2-4	2-4	15¼	16x16	45	2600	4300
406	6	63	66½	69¼	51	2-5	2-5	15¼	16x20	45	3250	5375
407	7	71	66½	69¼	51	2-5	2-5	15¼	16x20	50	3900	6450
408	8	79	66½	69¼	51	2-5	2-5	15¼	20x20	50	4550	7500
409	9	87	66½	69¼	51	2-5	2-5	15¼	20x20	55	5200	8600
4010	10	95	66½	69¼	51	2-5	2-5	15¼	20x20	55	5850	9650
4011	11	103	66½	69¼	51	2-5	2-5	15¼	20x20	60	6500	10725
4012	12	111	66½	69¼	51	2-5	2-5	15¼	20x24	60	7150	11800
466	6	68	79	82	55¾	2-6	2-6	19¼	24x24	65	5400	8925
467	7	76	79	82	55¾	2-6	2-6	19¼	24x24	70	6500	10725
468	8	84	79	82	55¾	2-6	2-6	19¼	24x24	75	7600	12550
469	9	92	79	82	55¾	2-6	2-6	19¼	24x28	80	8700	14350
4610	10	100	79	82	55¾	2-6	2-6	19¼	24x28	85	9800	16150
4611	11	108	79	82	55¾	2-6	2-6	19¼	28x28	95	10900	18000
4612	12	116	79	82	55¾	2-6	2-6	19¼	28x28	100	12000	19825
4613	13	124	79	82	55¾	2-6	2-6	19¼	28x28	105	13100	21625
4614	14	132	79	82	55¼	2-6	2-6	19¼	28x32	110	14200	23450

*Steam boilers are designated by the letter "S" before the number, as S-214, S-215, etc. Water boilers are designated by the letter "W," as W-214, W-215, etc.

All measurements are in inches, except where otherwise noted. Special sizes or location of tappings can be furnished at prices shown in discount sheet. Blank grates sections for brick fire wall to reduce size of grate will be supplied without extra charge with boiler if so ordered.

(*See page 656, Valve Section*)

PIERCE FIREBOX BOILERS

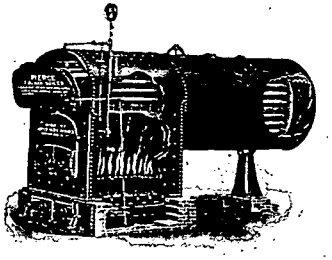
Built by

Ames Iron Works

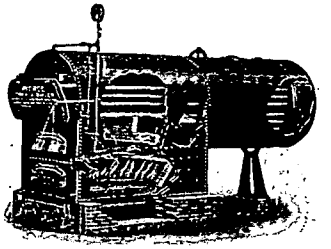
Division of

Pierce, Butler & Pierce Manufacturing Corporation

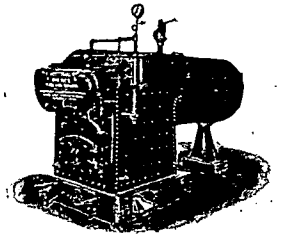
OSWEGO, N. Y.



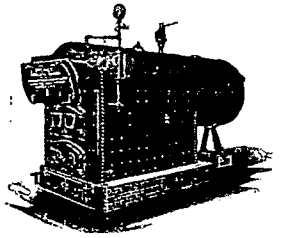
Series 600
For Description, see p. 426.



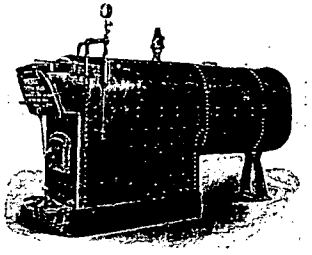
Series 700
For Description, see p. 427.



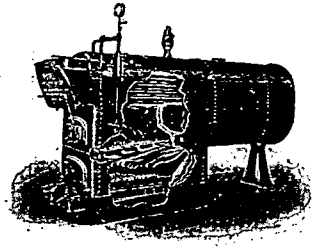
Series 800
For Description, see p. 428.



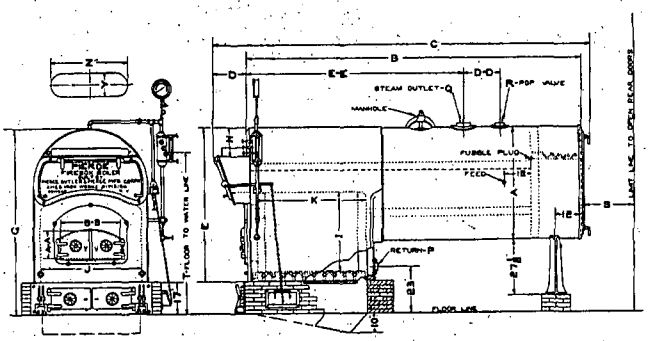
Series 900
For Description, see p. 429.

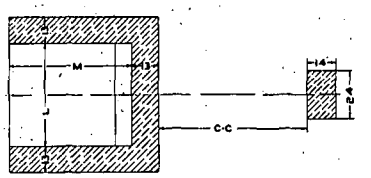


Series 1000
For Description, see p. 430.



Series 2000
For Description, see p. 431.

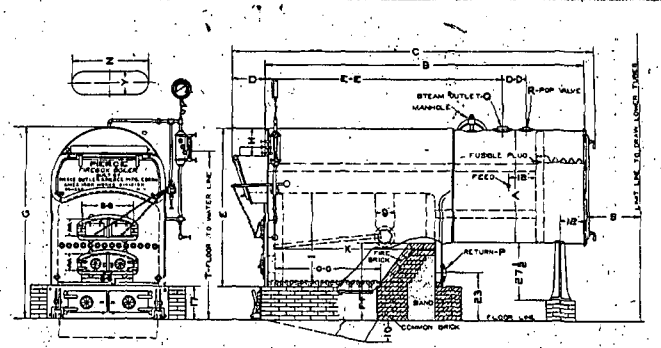


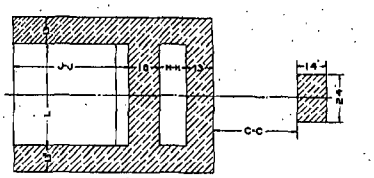


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 600

NUMBER OF SIZE		613	614	615	616	617	618	619	620	621	622	623	624
Code Word		Kail	Kate	Keel	Kelp	Khan	Kill	King	Knee	Knot	Kohl	Kroo	Kurd
Capacity Steam Radiation	Sq. Ft.	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	28000
Capacity Water Radiation	Sq. Ft.	8250	9000	10500	12000	15250	16500	19500	22500	26250	30000	37500	42000
Grate Area	Sq. Ft.	19.5	20.6	20.6	22.9	25.5	28.0	30.8	33.5	36.6	39.6	42.9	46.1
Heating Surface	Sq. Ft.	572	736	676	778	929	1040	1168	1303	1514	1711	2209	2427
*Diameter Breeching	In.	28	28	28	28	32	32	34	34	36	36	42	42
*Diameter Smoke Stack	In.	26	26	26	26	30	30	32	32	34	34	40	40
*Minimum Length Smoke Stack	Ft.	60	60	65	65	65	70	70	70	80	90	90	100
Weight Boiler without Fixtures	Lbs.	13300	14300	14500	15500	19200	20300	20200	23900	27300	29300	35800	39800
Weight Boiler Complete	Lbs.	15100	16200	16400	17600	21500	22700	23000	26800	30500	32700	39500	43700
A Diameter Shell	In.	60	60	60	60	66	66	72	72	78	78	84	84
B Length Shell		12′ 5″	13′ 7″	14′ 4″	16′ 2″	15′ 9″	17′ 4″	15′11″	17′ 6″	17′11″	19′11″	20′ 1″	22′ 1″
C Length Over All		14′ 4½″	15′ 6½″	16′ 3½″	18′ 1½″	17′11″	19′ 6″	18′ 3″	19′10″	20′ 3″	22′ 3″	22′ 8″	24′ 8″
D Depth Smoke Box Over All	In.	20	20	20	20	22½	22½	24½	24½	24½	24½	27½	27½
G Floor Line to Top Shell	In.	101	101	101	101	107	107	113	113	115	115	121	121
H Top Smoke Box to Top Shell	In.	15	15	15	15	16	16	17½	17½	17½	17½	16	16
I Height Furnace above Grates	In.	43	43	43	43	46	46	48½	48½	49	49	52	52
J Width Furnace	In.	53	53	53	53	59	59	65	65	71	71	77	77
K Length Furnace	In.	53	56	56	62	62	68	68	74	74	80	80	86
L Width Ash Pit	In.	53	53	53	53	59	59	65	65	71	71	77	77
M Length Ash Pit	In.	53	53	53	53	59	59	65	65	71	71	77	77
†P Size Return	In.	57	60	60	66	66	72	72	78	78	84	84	90
†Q Size Steam Outlet	In.	5	5	5	5	6	6	6	6	6	6	6	6
†R No. and Size Pop Valves	In.	7	7	7	7	8	8	8	8	8	8	10	10
S Required to Open Rear Doors	In.	3	3	3	3	3½	3½	4	4	4½	2-3	2-3	2-3
T Height Water Line	In.	32	32	32	32	35	35	38	38	41	41	44	44
Y Width Stack Base	In.	87	87	87	87	99	90	96	96	97	97	105	105
Z Length Stack Base	In.	12½	12½	12½	12½	15	15	17	17	17	17	20	20
CC Location Rear Pier	In.	46	46	46	46	50	50	54	54	60	60	64	64
DD Location Pop Valve	In.	5′ 1″	6′ 0″	6′ 9″	8′ 1″	7′ 8″	8′ 9″	7′ 4″	8′ 5″	8′10″	10′ 4″	10′ 6″	12′ 0″
EE Location Steam Outlet		16	18	21	27	18	30	18	24	24	30	24	21
Number Common Brick		8′ 3″	8′ 8″	8′ 5″	9′ 5″	9′ 4″	10′ 2″	9′ 8″	11′ 1″	11′ 3″	12′ 0″	12′ 6″	12′ 6″
Out Surface to be Covered	Sq. Ft.	665	680	680	710	740	760	790	820	840	885	900	935
		190	220	250	280	290	310	315	345	385	425	455	505

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

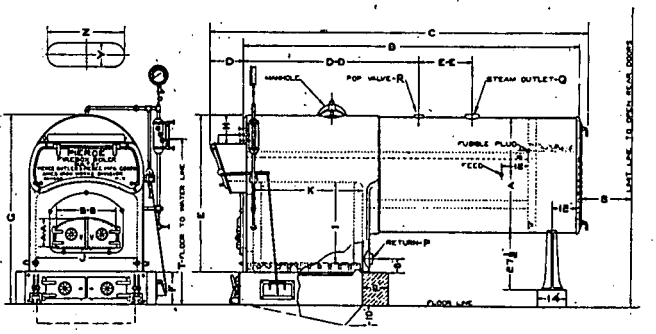


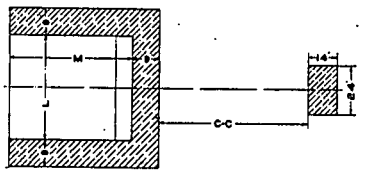


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 700

NUMBER OF SIZE		713	714	715	716	717	718	719	720	721	722	723	724
Code Word		Kairo	Karat	Kayak	Kazoo	Kedge	Ketch	Kiddy	Klang	Knack	Knell	Koran	Kraal
Capacity Steam Radiation	Sq. Ft.	6000	6500	7500	8500	10000	12000	14000	16000	18000	20000	25000	30000
Capacity Water Radiation	Sq. Ft.	9000	9750	11250	12750	15000	18000	21000	24000	27000	30000	37500	45000
Area Upper Grate	Sq. Ft.	17.7	19.3	20.0	21.4	23.5	25.9	28.5	29.9	32.6	34.6	41.7	44.8
Heating Surface	Sq. Ft.	601	652	721	773	912	1053	1204	1316	1458	1549	2074	2629
*Diameter Breeching	In.	28	28	28	28	32	32	34	34	36	36	42	42
*Diameter Smoke Stack	In.	26	26	26	26	30	30	32	32	34	34	40	40
*Minimum Length Smoke Stack	Ft.	60	60	65	65	65	70	70	70	80	90	90	100
Weight Boiler without Fixtures	Lbs.	14500	15200	16200	16900	19700	21300	23300	24800	28000	29200	38500	42100
Weight Boiler Complete	Lbs.	16300	17100	18200	19100	21900	23700	26000	27700	31100	32300	42100	45900
A Diameter Shell	In.	60	60	60	60	66	66	72	72	78	78	84	84
B Length Shell		12′11″	13′11″	15′ 3″	16′ 3″	15′ 9″	17′ 9″	16′ 7″	18′ 0″	17′10″	18′10″	20′ 1″	24′ 1″
C Length Over All		14′10½″	15′10½″	17′ 2½″	18′ 2½″	17′11″	19′11″	18′11″	20′ 4″	20′ 2″	21′ 2″	22′ 8″	26′ 8″
D Depth Smoke Box Over All	In.	20	20	20	20	22½	22½	24½	24½	24½	24½	27½	27½
G Floor Line to Top Shell	In.	101	101	101	101	107	107	113	113	115	115	121	121
H Top Smoke Box to Top Shell	In.	15	15	15	15	16	16	17½	17½	17½	17½	16	16
J Width Furnace	In.	53	53	53	53	59	59	65	65	71	71	77	77
K Length Furnace	In.	75	81	90	96	90	96	96	102	102	108	114	120
L Width Ash Pit	In.	53	53	53	53	59	59	65	65	71	71	77	77
†P Size Return	In.	5	5	5	5	6	6	6	6	6	6	6	6
†Q Size Steam Outlet	In.	7	7	7	7	8	8	8	8	8	8	10	10
†R No. and Size Pop Valves	In.	3	3½	3½	4	4	4	4½	2-3	2-3	2-3	2-3½	2-3½
S Required to Draw Lower Tubes	In.	34	40	49	55	51	69	51	62	60	66	75	117
T Height Water Line	In.	87	87	87	87	90	90	96	96	97	97	105	105
Y Width Stack Base	In.	12½	12½	12½	12½	15	15	17	17	17	17	20	20
Z Length Stack Base	In.	46	46	46	46	50	50	54	54	60	60	64	64
CC Location Rear Pier	In.	40	46	58	64	64	82	68	79	77	83	92	134
DD Location Pop Valve	In.	14	18	16	18	16	18	15	18	15	16	18	20
EE Location Steam Outlet		9′ 9″	10′ 3″	10′ 11″	11′ 6″	11′ 0″	11′ 9″	11′ 7″	12′ 2″	12′ 2″	12′ 9″	13′ 8″	15′ 0″
GG Length Lower Grates	In.	52	58	61	67	61	67	67	73	73	73	79	85
HH Width Sand Fill	In.	13	13	13	13	13	13	13	13	13	19	19	19
JJ Location Bridge Wall	In.	53	59	63	69	63	69	69	75	75	75	81	87
Number Common Brick		1160	1210	1300	1350	1300	1350	1375	1450	1400	1475	1575	1600
Number Fire Brick		195	195	210	215	240	240	255	255	290	315	425	425
Out Surface to be Covered	Sq. Ft.	255	265	266	280	290	330	335	360	370	400	455	545

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

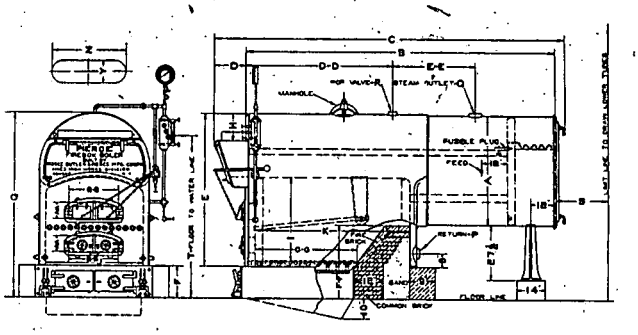


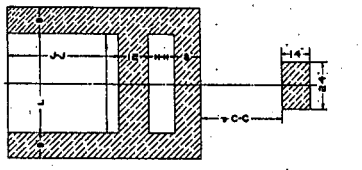


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 800

NUMBER OF SIZE	810	812	813	814	815	816	818	820	823	825	827	830	833	837	840
Code Word	Fagus	Fahan	Faint	Fairy	Faker	Falca	False	Famed	Fancy	Fangl	Fanon	Farce	Fastu	Fatal	Favos
Capacity Steam Radiation...Sq. Ft.	5150	6500	7200	7600	8250	9000	10000	11500	13000	15000	16500	18000	20000	22500	25000
Capacity Water Radiation...Sq. Ft.	7725	9750	10800	11400	12375	13500	15000	17250	19500	22500	24750	27000	30000	33750	37500
Grate Area...Sq. Ft.	16.0	18.0	20.0	22.5	22.5	24.7	24.7	27.5	30.0	30.0	33.0	35.7	36.0	42.0	42.0
Heating Surface...Sq. Ft.	511	613	661	726	763	826	900	1027	1158	1255	1349	1501	1644	1877	2017
*Diameter Breeching...In.	26	26	26	30	30	30	30	34	34	34	36	36	38	38	38
*Diameter Smoke Stack...In.	24	24	24	28	28	28	28	32	32	32	34	34	36	36	36
*Minimum Length Smoke Stack...Ft.	60	75	80	60	65	75	85	70	80	90	80	90	85	105	115
Weight Boiler without Fixtures...Lbs.	9270	10400	11160	11910	12130	12970	13670	16560	17940	19060	20840	22060	24520	26980	28890
Weight Boiler Complete...Lbs.	10980	12320	13170	14120	14340	15340	16040	19190	20750	21860	23920	25340	27840	30730	32640
A Diameter Shell...In.	54	54	54	60	60	60	60	66	66	66	72	72	78	78	78
B Length Shell	11′ 9″	13′ 9″	14′ 9″	13′ 0″	13′ 6″	14′ 6″	15′ 6″	14′ 0″	15′ 6″	16′ 6″	15′ 6″	17′ 0″	15′ 6″	17′ 6″	18′ 6″
C Length Over All	13′ 6″	15′ 6″	16′ 6″	14′ 11″	15′ 5″	16′ 5″	17′ 5″	16′ 2″	17′ 8″	18′ 8″	17′ 8″	19′ 2″	18′ 0″	20′ 0″	21′ 0″
D Depth Smoke Box Over All...In.	18	18	18	20	20	20	20	23	23	23	23	23	27	27	27
F Height Ash Pit...In.	14	14	14	14	14	14	14	14	14	14	18	18	18	18	18
G Floor Line to Top Shell...In.	89	89	89	95	95	95	95	101	101	101	111	111	119	119	119
H Top Smoke Box to Top Shell...In.	13½	13½	13½	12¾	12¾	12¾	12¾	15¾	15¾	15¾	18½	18½	16	16	16
I Height Furnace Above Grates...In.	40	40	40	43	43	43	43	46	46	46	49	49	55	55	55
J Width Furnace...In.	48	48	48	54	54	54	54	60	60	60	66	66	72	72	72
K Length Furnace...In.	48	54	60	60	60	66	66	66	72	72	72	78	72	84	84
L Width Ash Pit...In.	48	48	48	54	54	54	54	60	60	60	66	66	72	72	72
M Length Ash Pit...In.	52	58	64	64	64	70	70	70	76	76	76	82	76	88	88
†P Size Return...In.	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6
†Q Size Steam Outlet...In.	6	6	6	8	8	8	8	8	8	8	8	8	10	10	10
†R Number and Size Pop Valves	2½	2½	3	3	3	3½	3½	3½	4	4	4	4½	4½	2-3	2-3
S Required to Open Rear Doors...In.	31	31	31	34	34	34	34	37	37	37	40	40	43	43	43
T Height Water Line...In.	76	76	76	83	83	83	83	86	86	86	93	93	103	103	103
Y Width Stack Base...In.	12	12	12	14	14	14	14	17	17	17	17	17	20	20	20
Z Length Stack Base...In.	41	41	41	47	47	47	47	51	51	51	57	57	56	56	56
CC Location Rear Pier...In.	65	83	89	66	72	78	90	72	84	96	84	96	84	96	108
DD Location Pop Valve...In.	36	36	36	36	36	36	42	42	42	42	50	50	50	50	50
EE Location Steam Outlet...In.	24	30	30	30	30	36	36	30	36	40	45	48	48	48	48
Number Common Brick	345	370	395	405	405	425	425	435	455	455	605	635	625	680	680
Out Surface to be Covered...Sq. Ft.	200	225	240	240	250	265	280	280	305	325	335	365	365	410	430

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

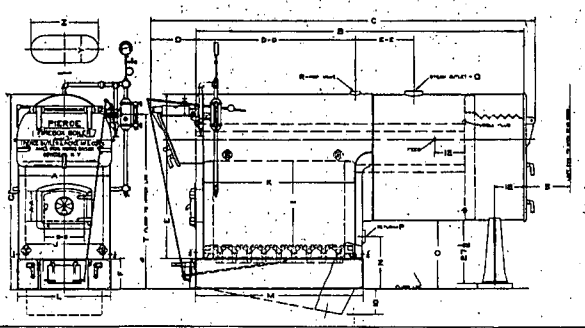


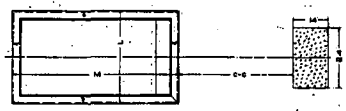


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 900

NUMBER OF SIZE	910	912	913	914	915	916	918	920	923	925	927	930	933	937
Code Word	Fehme	Felid	Felon	Feluc	Femur	Fence	Fenks	Feoff	Ferny	Fervu	Feuda	Fever	Fewel	Feyre
Capacity Steam Radiation...Sq. Ft.	5200	6100	6500	7500	8200	9000	10250	12000	13500	15250	16000	18000	20000	23500
Capacity Water Radiation...Sq. Ft.	7800	9150	9750	11250	12300	13500	15375	18000	20250	22875	24000	27000	30000	35250
Area Upper Grate...Sq. Ft.	15.8	17.8	19.7	22.2	22.2	24.5	24.5	26.7	29.6	32.1	34.6	35.3	35.3	39.9
Heating Surface...Sq. Ft.	517	597	622	718	765	831	901	1009	1154	1286	1330	1500	1662	1810
*Diameter Breeching...In.	26	26	26	30	30	30	30	30	34	34	34	36	36	36
*Diameter Smoke Stack...In.	24	24	24	28	28	28	28	28	32	32	32	34	34	34
*Minimum Length Smoke Stack...Ft.	60	75	80	60	65	75	85	95	80	90	100	90	100	110
Weight Boiler without Fixtures...Lbs.	10290	11300	11850	13260	13660	14760	15370	16670	20180	21480	22790	24000	24470	26550
Weight Boiler Complete...Lbs.	12010	13170	13870	15480	15880	17160	17770	19230	23040	24300	26000	27300	27740	30230
A Diameter Shell...In.	54	54	54	60	60	60	60	60	66	66	66	72	72	72
B Length Shell	11′ 9″	13′ 3″	13′ 9″	12′ 10″	13′ 6″	14′ 6″	15′ 6″	17′ 0″	15′ 6″	17′ 0″	17′ 6″	17′ 0″	18′ 6″	20′ 0″
C Length Over All	13′ 6″	15′ 0″	15′ 6″	14′ 9″	15′ 5″	16′ 5″	17′ 5″	18′ 11″	17′ 8″	19′ 2″	19′ 8″	19′ 9″	20′ 8″	22′ 2″
D Depth Smoke Box Over All...In.	18	18	18	20	20	20	20	20	23	23	23	23	23	23
F Height Ash Pit...In.	14	14	14	14	14	14	14	14	14	14	14	18	18	18
G Floor Line to Top Shell...In.	92	92	92	98	98	98	98	98	104	104	104	114	114	114
H Top Smoke Box to Top Shell...In.	13½	13½	13½	12¾	12¾	12¾	12¾	12¾	15¾	15¾	15¾	18½	18½	18½
J Width Furnace...In.	48	48	48	54	54	54	54	54	60	60	60	66	66	66
K Length Furnace...In.	74	78	84	84	85	90	92	96	97	104	108	102	104	114
L Width Ash Pit...In.	48	48	48	54	54	54	54	54	60	60	60	66	66	66
†P Size Return...In.	4	4	4	6	6	6	6	6	6	6	6	6	6	6
†Q Size Steam Outlet...In.	6	6	6	8	8	8	8	8	8	8	8	10	10	10
†R Number and Size Pop Valves	3	3	3½	3½	3½	4	4	4	4½	2-3	2-3	2-3	2-3	2-3½
S Required to Draw Lower Tubes...In.	24	38	38	21	28	35	45	59	40	51	53	53	69	77
T Height Water Line...In.	79	79	79	86	86	86	86	86	89	89	89	96	96	96
Y Width Stack Base...In.	12	12	12	14	14	14	14	14	17	17	17	17	17	17
Z Length Stack Base...In.	41	41	41	47	47	47	47	47	51	51	51	57	57	57
CC Location Rear Pier...In.	40	54	54	41	48	55	65	79	60	71	73	73	89	97
DD Location Pop Valve...In.	24	24	24	24	24	48	48	48	48	48	48	48	48	48
EE Location Steam Outlet...In.	30	36	36	30	36	36	36	48	36	36	36	36	48	48
GG Length Lower Grates...In.	48	54	60	60	60	66	66	72	72	78	84	78	78	88
HH Width Sand Fill...In.	14	12	12	12	13	12	14	12	13	14	12	12	14	14
JJ Location Bridge Wall...In.	51	57	63	63	63	69	69	75	75	81	87	81	81	91
Number Common Brick	690	715	740	785	790	810	815	835	880	910	930	1155	1165	1215
Number Fire Brick	80	80	80	90	90	90	90	90	110	110	110	120	120	120
Out Surface to be Covered...Sq. Ft.	215	230	250	245	255	270	285	310	315	340	350	370	400	430

Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated. *Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price. †Size and location of all steam openings shown apply for 15 pounds pressure. This information will be given for higher pressures upon request.

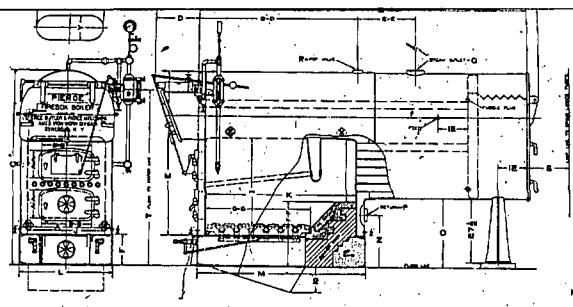


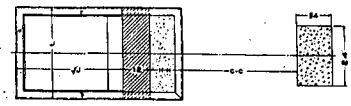


Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Plain Furnace—Series 1000

NUMBER OF SIZE		1022	1027	1033	1040	1046	1052	1058	1065	1070	1075	1085	1095	1110	1120	1130
Code Word		Aard	Abba	Aces	Adam	Aeon	Afar	Aged	Airy	Alas	Amic	Anet	Apod	Arab	Asse	Atom
Capacity Steam Radiation	Sq. Ft.	2250	2750	3300	4000	4600	5200	5800	6500	7000	7500	8500	9500	11000	12000	13000
Capacity Water Radiation	Sq. Ft.	3375	4125	4950	6000	6900	7800	8700	9750	10500	11250	12750	14250	16500	18000	19500
Grate Area	Sq. Ft.	7.3	9.4	10.4	12.9	14.2	15.5	16.5	18.0	19.5	21.0	21.0	22.8	24.5	28.0	28.0
Heating Surface	Sq. Ft.	230	280	335	386	446	499	556	604	657	699	782	888	994	1093	1181
*Diameter Smoke Stack	In.	18	18	18	22	22	22	24	24	24	24	26	26	26	30	30
*Minimum Length Smoke Stack	Ft.	50	70	85	55	70	85	60	70	80	90	85	95	105	85	105
Weight Boiler without Fixtures	Lbs.	5800	5900	6000	7500	7700	8000	9300	9500	9700	9900	12300	12700	13200	15100	15700
Weight Boiler Complete	Lbs.	7100	7300	7500	9300	9600	9900	11300	11600	12000	12300	15000	15600	16300	18400	19000
A	Width Shell	30	30	30	36	36	36	42	42	42	42	48	48	48	54	54
B	Length Shell	8′ 6″	10′ 0″	11′ 6″	11′ 0″	12′ 4″	13′ 6″	11′ 6″	12′ 4″	13′ 3″	14′ 0″	12′ 0″	13′ 3″	14′ 6″	14′ 0″	14′ 9″
C	Length Over All	10′ 4″	11′10″	13′ 4″	13′ 1″	14′ 5″	15′ 7″	13′ 7″	14′ 5″	15′ 4″	16′ 1″	14′ 1″	15′ 4″	16′ 7″	16′ 4″	17′ 1″
D	Depth Smoke Box Over All	18	18	18	21	21	21	21	21	21	21	21	21	21	24	24
E	Height Boiler Only	61⅜	61⅜	61⅜	65⅜	65⅜	65⅜	75¼	75¼	75¼	75¼	82¾	82¾	82¾	86⅜	86⅜
F	Height Channel Base	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15
G	Floor Line to Top Shell	73⅜	73⅜	73⅜	77⅜	77⅜	77⅜	87¼	87¼	87¼	87¼	97¾	97¾	97¾	101⅜	101⅜
H	Top Smoke Box to Top Shell	9¼	9¼	9¼	8¼	8¼	8¼	11	11	11	11	12½	12½	12½	14¼	14¼
I	Height Furnace above Grates	30	30	30	33	33	33	36	36	36	36	38	38	38	40	40
J	Width Furnace	25	25	25	31	31	31	36	36	36	36	42	42	42	48	48
K	Length Furnace	42	54	60	60	66	72	66	72	78	84	72	78	84	84	84
L	Width Channel Base	31⅛	31⅛	31⅛	37⅛	37⅛	37⅛	43⅛	43⅛	43⅛	43⅛	49⅛	49⅛	49⅛	55⅛	55⅛
M	Length Channel Base	48¾	60¾	66¼	66¾	72¾	78¾	74¼	80¼	86¼	92¼	80¼	86¼	92¼	92¼	92¼
N	Location Return	20½	20½	20½	20¾	20¾	20¾	21	21	21	21	21⅞	21⅞	21⅞	22⅜	22⅜
O	Floor Line to Bottom Shell	27½	27½	27½	27⅜	27⅜	27⅜	30⅛	30⅛	30⅛	30⅛	29¼	29¼	29¼	31¾	31¾
P	Size Return	3	3	3	4	4	4	4	4	4	4	5	5	5	6	6
Q	Size Steam Outlet	5	5	5	6	6	6	6	6	6	6	7	7	7	8	8
R	Size Pop Valve	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½
S	Required to Open Rear Doors	40	40	40	42	42	42	25	25	25	25	28	28	28	31	31
T	Height Water Line	64⅝	64⅝	64⅝	69⅝	69⅝	69⅝	76½	76½	76½	76½	85½	85½	85½	87⅞	87⅞
Y	Width Stack Base	13	13	13	16	16	16	16	16	16	16	15	15	15	19	19
Z	Length Stack Base	22	22	22	27	27	27	32	32	32	32	37	37	37	42	42
AA	Height Fire Door Opening	12	12	12	12	12	12	14	14	14	14	13	13	13	14	14
BB	Width Fire Door Opening	16	16	16	20	20	20	24	24	24	24	28	28	28	34	34
CC	Location Rear Pier	33¾	39¾	51¾	45¾	55¾	63¾	44¼	48¼	53¼	56¼	44¼	53¼	62¼	56¼	65¼
DD	Location Pop Valve	43	55	61	61	67	73	68	74	80	86	74	80	86	86	86
EE	Location Steam Outlet	22	24	32	26	34	36	26	30	32	34	26	32	36	48	48
	Out Surface to be Covered	Sq. Ft. 96	116	132	140	156	169	169	181	193	211	199	219	239	246	264

BOILERS BUILT FOR 15 POUNDS PRESSURE ONLY. Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated.
*Smoke stacks and smoke connections or breechings are not furnished unless specially ordered and at extra price.





Data and Setting Dimensions—
PIERCE FIREBOX BOILER
with Downdraft Furnace—Series 2000

NUMBER OF SIZE		2022	2027	2033	2040	2046	2052	2058	2065	2070	2075	2085	2095	2110	2120	2130
Code Word		Abhor	Acorn	Adder	Afoot	Aglee	Alban	Amber	Ankle	Apoda	Ardor	Aster	Atone	Auger	Avale	Awing
Capacity Steam Radiation	Sq. Ft.	2250	2750	3300	4000	4600	5200	5800	6500	7000	7500	8500	9500	11000	12000	13000
Capacity Water Radiation	Sq. Ft.	3375	4125	4950	6000	6900	7800	8700	9750	10500	11250	12750	14250	16500	18000	19500
Area Upper Grate	Sq. Ft.	4.6	6.6	7.6	8.9	10.1	11.4	11.8	13.3	14.7	16.2	15.5	17.2	19.0	21.7	21.7
Heating Surface	Sq. Ft.	230	280	335	386	446	499	556	604	657	699	782	888	994	1093	1181
*Diameter Smoke Stack	In.	18	18	18	22	22	22	24	24	24	24	26	26	26	30	24
*Minimum Length Smoke Stack	Ft.	50	70	85	55	70	85	60	70	80	90	85	95	105	85	105
Weight Boiler without Fixtures	Lbs.	5800	5900	6000	7500	7700	8000	9300	9500	9700	9900	12300	12700	13200	15100	15700
Weight Boiler Complete	Lbs.	7100	7300	7500	9300	9600	9900	11300	11600	12000	12300	15000	15600	16300	18400	19000
A	Width Shell	30	30	30	36	36	36	42	42	42	42	48	48	48	54	54
B	Length Shell	8′ 6″	10′ 0″	11′ 6″	11′ 0″	12′ 4″	13′ 6″	11′ 6″	12′ 4″	13′ 3″	14′ 0″	12′ 0″	13′ 3″	14′ 6″	14′ 0″	14′ 9″
C	Length Over All	10′ 4″	11′10″	13′ 4″	13′ 1″	14′ 5″	15′ 7″	13′ 7″	14′ 5″	15′ 4″	16′ 1″	14′ 1″	15′ 4″	16′ 7″	16′ 4″	17′ 1″
D	Depth Smoke Box Over All	18	18	18	21	21	21	21	21	21	21	21	21	21	24	24
E	Height Boiler Only	61⅜	61⅜	61⅜	65⅜	65⅜	65⅜	75¼	75¼	75¼	75¼	82¾	82¾	82¾	86⅜	86⅜
F	Height Channel Base	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15
G	Floor Line to Top Shell	73⅜	73⅜	73⅜	77⅜	77⅜	77⅜	87¼	87¼	87¼	87¼	97¾	97¾	97¾	101⅜	101⅜
H	Top Smoke Box to Top Shell	9¼	9¼	9¼	8¼	8¼	8¼	11	11	11	11	12½	12½	12½	14¼	14¼
I	Hght. Furn. above Lower Grates	30	30	30	33	33	33	36	36	36	36	38	38	38	40	40
J	Width Furnace	25	25	25	31	31	31	36	36	36	36	42	42	42	48	48
K	Length Furnace	42	54	60	60	66	72	66	72	78	84	72	78	84	84	84
L	Width Channel Base	31⅛	31⅛	31⅛	37⅛	37⅛	37⅛	43⅛	43⅛	43⅛	43⅛	49⅛	49⅛	49⅛	55⅛	55⅛
M	Length Channel Base	48¼	60¼	66¼	66¾	72¾	78¾	74¼	80¼	86¼	92¼	80¼	86¼	92¼	92¼	92¼
N	Location Return	20½	20½	20½	20¾	20¾	20¾	21	21	21	21	21⅞	21⅞	21⅞	22⅜	22⅜
O	Floor Line to Bottom Shell	27½	27½	27½	27⅜	27⅜	27⅜	30⅛	30⅛	30⅛	30⅛	29¼	29¼	29¼	31¾	31¾
P	Size Return	3	3	3	4	4	4	4	4	4	4	5	5	5	6	6
Q	Size Steam Outlet	5	5	5	6	6	6	6	6	6	6	7	7	7	8	8
R	Size Pop Valve	1¼	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½
S	Required to Draw Lower Tubes	40	40	40	42	42	42	25	25	29	32	28	29	38	32	41
T	Height Water Line	64⅝	64⅝	64⅝	69⅝	69⅝	69⅝	76½	76½	76½	76½	85½	85½	85½	87⅞	87⅞
Y	Width Stack Base	13	13	13	16	16	16	16	16	16	16	15	15	15	19	19
Z	Length Stack Base	22	22	22	27	27	27	32	32	32	32	37	37	37	42	42
AA	Height Fire Door Openings	11	11	11	11	11	11	11	11	11	11	11¼	11¼	11¼	11¼	11¼
BB	Width Fire Door Openings	20	20	20	20	20	20	20	20	20	20	29¼	29¼	29¼	29¼	29¼
CC	Location Rear Pier	33¾	39¼	51¾	45¾	55¾	63¾	44¼	48¼	53¼	56¼	44¼	53¼	62¼	56¼	65¼
DD	Location Pop Valve	43	55	61	61	67	73	68	74	80	86	74	80	86	86	86
EE	Location Steam Outlet	22	24	32	26	34	36	26	30	32	34	26	32	36	48	48
FF	Height Bridge Wall	28	28	28	28	28	28	30	30	30	30	29	29	29	35	35
GG	Length Lower Grates	30	42	48	42	48	54	48	54	60	66	54	60	66	66	66
HH	Width Sand Fill	5	5	5	11	11	11	12	12	12	12	12	12	12	12	12
JJ	Location Bridge Wall	31½	43½	49½	43½	49½	55½	50	56	62	68	56	62	68	68	68
	Out Surface to be Covered	Sq. Ft. 96	116	132	140	156	169	169	181	193	211	199	219	239	246	264

BOILERS BUILT FOR 15 POUNDS PRESSURE ONLY. Safety valves will be furnished to conform to the requirements of the state or municipality in which boiler is to be operated.
*Smoke stacks and smoke connections or breeching are not furnished unless specially ordered and at extra price.

RICHMOND RADIATOR COMPANY

INCORPORATED

Executive Office

1480 Broadway, New York

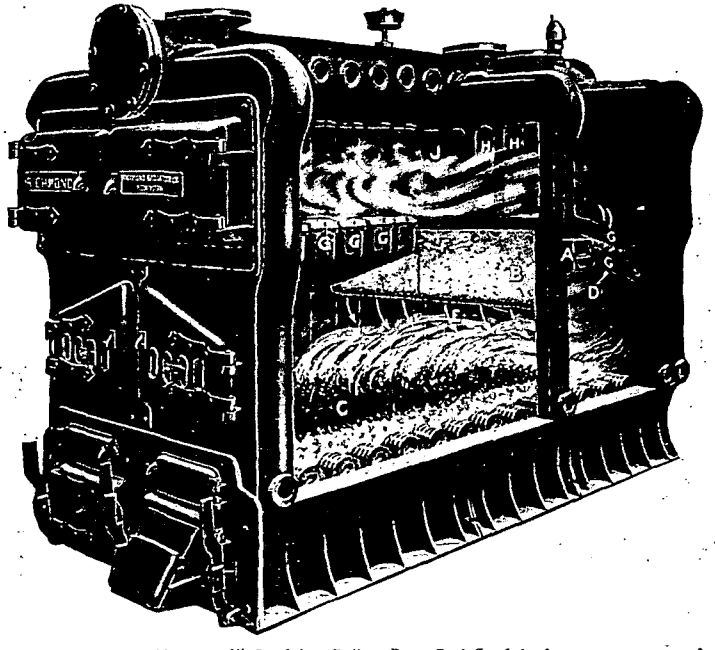
Branch Offices

CHICAGO, 1010 Wrigley Building
BOSTON, 460 Park Square Building
PHILADELPHIA, 2241 North American St.
CLEVELAND, Cedar Avenue and Ashland Road
HARRISBURG, PA., 116 S. Second St.

Gas Boiler Division: 2220 Chestnut Street, Philadelphia, Pa.

Radiator, Enameldware and Heatomat Plant, Uniontown, Pa.

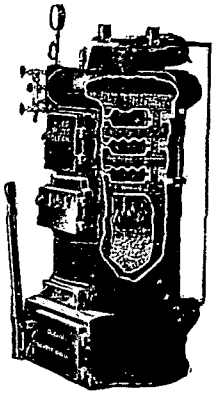
Boiler Plant, Norwich, Conn.



"Richmond" Smokeless Boilers Burn Coal Smokelessly

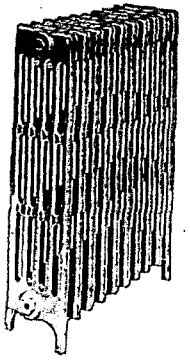
"Richmond" Heavy Duty Smokeless Boilers

Designed for Fuel Economy. Burns all grades of Hard or Soft Coal, Coke, Lignite, Natural Gas and Fuel Oils. Meets the requirements of the most rigid Smoke Ordinances. A 51 in. Boiler, 7 to 16 Sections, Steam and Hot Water.



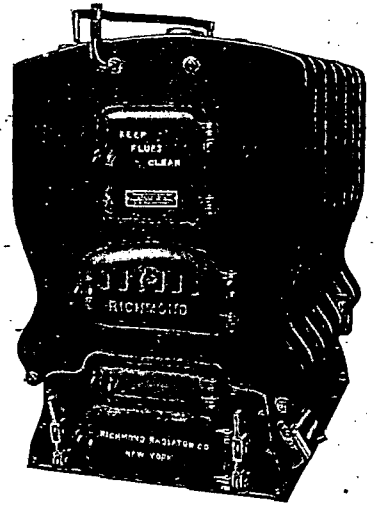
Richmond "DeLuxe"

Official tests credit this boiler with a greater heating surface and efficiency than others of equal diameter and number of sections. Made for Steam and Hot Water in fifteen sizes.



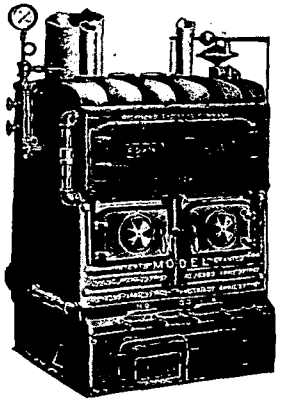
The "RICHMOND"

A masterpiece of design. Greater heating surface and space between sections. No protruding surfaces. Tested at Frost Laboratories in accordance with code of *A. S. H. & V. E.* Three, five and seven tubes, in several heights.



"Richmond" 25 and 36 in. *Sectional Boilers*

Burn Hard and Soft Coal, Coke, Gas and Fuel Oils. Incorporates a maximum of direct fire surface, quick internal circulation and rapid flow of water. For Steam, Vapor, Vacuum and Hot Water Heating.



"Richmond" Model Sectional Boilers

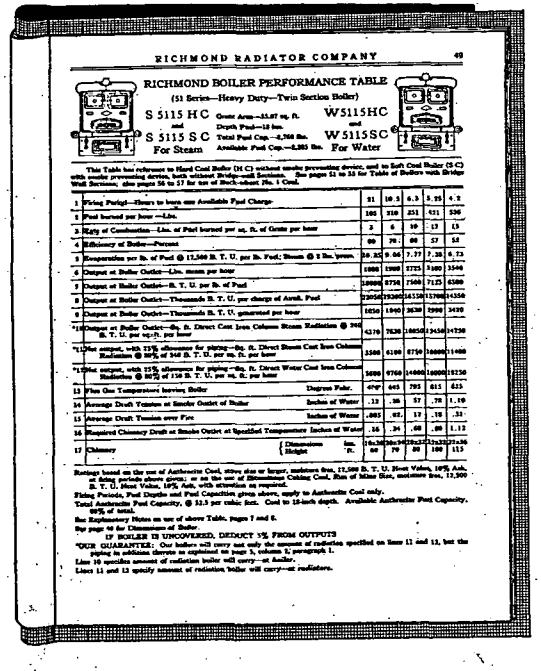
For Steam and Hot Water. Three to twelve sections, 18, 22, 30 and 40 in. grates. Compact, accessible, efficient heating surface and circulation system.

"THE RICHMOND ENGINEERING DATA BOOK"

is filled with helpful information

Engineers!! Architects!! Heating Contractors!! will find "The RICHMOND Data Book" a useful and dependable member of their engineering and estimating Staff.

It is Original—Authoritative—Helpful—and gives the answer to boiler selection problems.



RICHMOND RADIATOR COMPANY 49

RICHMOND BOILER PERFORMANCE TABLE

(51 Series—Heavy Duty—Twin Section Boiler)

S 5115 HC and S 5115 SC For Steam — W5115HC and W5115SC For Water

1	Firing Period—Hours to burn one Available Fuel Charge		31	10.3	6.3	5.25	4.5
2	Fuel burned per hour—Lbs.		105	310	251	421	500
3	Rate of Combustion—Lbs. of Fuel burned per sq. ft. of Grate per hour		3	6	10	12	15
4	Efficiency of Boiler—Percent		80	70	66	57	54
5	Evaporation per lb. of Fuel @ 17,500 B. T. U. per lb. Fuel; Steam @ 2 lbs. pressure		16.35	9.66	7.77	7.36	6.73
6	Output at Boiler Outlet—Lbs. steam per hour		1680	1900	1725	3100	3360
7	Output at Boiler Outlet—B. T. U. per lb. of Fuel		14000	8750	7560	7125	6300
8	Output at Boiler Outlet—Thousands B. T. U. per charge of Aver. Fuel		2205	2700	2455	2250	1950
9	Output at Boiler Outlet—Thousands B. T. U. generated per hour		1650	1900	1650	2700	3150
10	Output at Boiler Outlet—Sq. ft. Direct Cast Iron Column Steam Radiation @ 240 B. T. U. per sq. ft. per hour		4270	7520	6865	11250	13125
11	Net output, with 15% allowance for piping—Sq. ft. Direct Steam Cast Iron Column Radiation @ 200 B. T. U. per sq. ft. per hour		3560	6100	5750	9600	11000
12	Net output, with 15% allowance for piping—Sq. ft. Direct Water Cast Iron Column Radiation @ 150 B. T. U. per sq. ft. per hour		5690	9760	9200	15000	17250
13	Flue Gas Temperature leaving Boiler	Degrees Fahr.	470	605	795	815	855
14	Average Draft Tension at Smoke Outlet of Boiler	Inches of Water	.12	.36	.57	.76	1.10
15	Average Draft Tension over Fire	Inches of Water	.085	.22	.37	.55	.81
16	Required Chimney Draft at Smoke Outlet at Specified Temperature	Inches of Water	.16	.54	.90	1.35	1.13
17	Chimney	Diameter In.	16	20	24	28	32
		Height Ft.	60	70	80	100	115

Ratings based on the use of Anthracite Coal, stove size or larger, moisture free, 12,500 B. T. U. Heat Value, 10% Ash, at firing intervals given, or on the use of Bituminous Coking Coal, Run of Mine Size, moisture free, 12,500 B. T. U. Heat Value, 10% Ash, with attention as required.

Firing Periods, Fuel Depths and Fuel Capacities given above, apply to Anthracite Coal only.

Total Anthracite Fuel Capacity, @ 52.5 per cubic foot. Coal to 12-inch depth. Available Anthracite Fuel Capacity, 80% of total.

See Explanatory Notes on use of above Table, pages 7 and 8.

See page 60 for Dimensions of Boiler.

IF BOILER IS UNCOVERED, DEDUCT 15% FROM OUTPUTS

*OUR GUARANTEE: Our boilers will carry not only the amount of radiation specified on lines 11 and 12, but the piping to additional thereto as explained on page 7, column 1, paragraph 1.

Line 10 specifies amount of radiation boiler will carry—at Boiler.

Lines 11 and 12 specify amount of radiation boiler will carry—at radiators.

Men who specify and buy boilers have need of such a book as this and RICHMOND has compiled it.

In addition to the volume of engineering information it includes, there is a performance data page similar to the one shown, for every RICHMOND Boiler, round and square. The page reproduced is the detailed performance table of the RICHMOND Heavy Duty Boiler illustrated on the second preceding page. Such data based upon Official Codes are a dependable guide for Engineers, Architects and Contractors in the selection of a boiler that will *perform* most efficiently and economically.

Contents

Below is a skeleton list of the contents of "The RICHMOND Engineering Data Book:"

Foreword.
Standard Requirements.
Explanatory Notes Regarding Performance Tables.
Dimensions, etc., of Round Boiler.
Guarantee of Ratings.
A. S. M. E. Boiler Construction Code.
A. S. H. & V. E. Boiler Testing Code.
Heating and Piping Contractors' Formula for Output Tests.
A. S. H. & V. E. Formula for computing Radiation.
Heating and Piping Contractors' National Association's Formula for computing Radiation.
Buckwheat Coal Grates for Boilers.
Boiler and Pipe Covering.
Chimney Data.

Richmond Boilers are Code Boilers

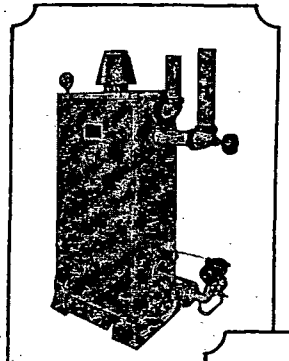
All RICHMOND Boilers are Built, Tested, Rated and Ratings Certified according to the official interpretation of Standard Codes. *Ratings are based upon exact boiler outputs*—that is, the exact amount of direct cast iron column radiation boilers will carry in addition to piping uncovered, boiler only covered.

Sent upon Request

Address our Executive Office or nearest Branch Office for copy of "The RICHMOND Engineering Data Book."

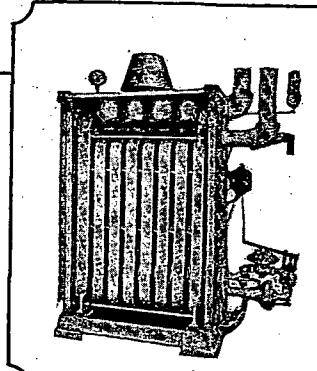
THE RICHMOND HEATOMAT GAS BOILER

For efficiency, simplicity, and construction in accordance with soundest principles of engineering



Engineering skill and an exacting construction policy have produced in the RICHMOND Heatomat, a Gas Boiler that translates 85 per cent of the fuel value into heat. Made for Steam, Hot Water, or Vapor Systems—to be used in small or large houses, office buildings, hotels and apartment houses.

RICHMOND HEATOMAT GAS BOILER



The Heatomat is modeled along the lines of the larger power plant boilers combining efficiency with utmost simplicity.

Outstanding features of the Heatomat

Vertical Tubular Construction.

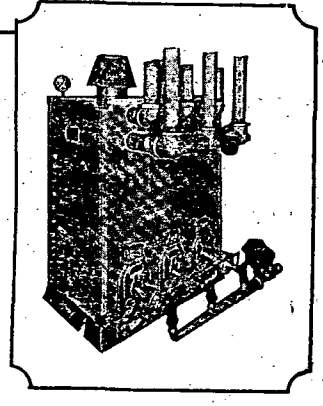
Preheating return water flow with flue gas heat.

Water cooled walls absorb burner heat.

Secondary air intake regulated with gas flow.

Heat transmission scientifically baffled.

Only one burner, one primary air setting for battery.



The RICHMOND Heatomat catalog includes data on cost of gas boiler operation versus coal. Also complete description of exclusive mechanical features sizes, ratings, cost, etc. Address:—

RICHMOND RADIATOR COMPANY

Gas Products Division

2220 Chestnut Street, **Philadelphia, Pa.,** or Branch Offices.

The H. B. Smith Company

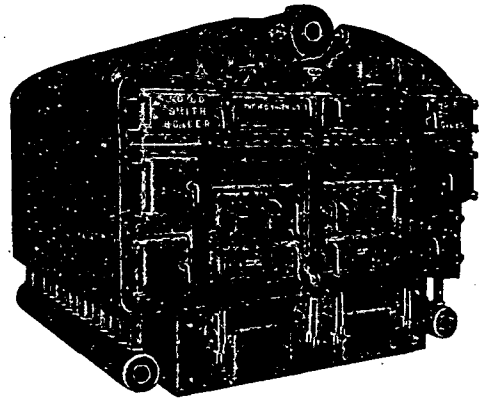
Works: Westfield, Mass.

WESTFIELD, MASS. 57 Main Street

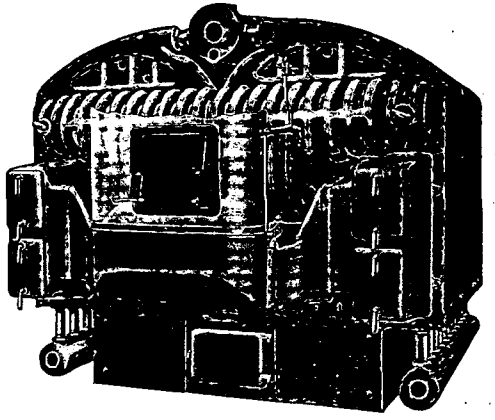
NEW YORK, 10 East 39th Street BOSTON, 640 Main Street, Cambridge

CLEVELAND, 1108 Webster Avenue, S.E. PHILADELPHIA, 49th St. and Grays Ave.

Manufacturers of Boilers and Radiators for Steam and Water Heating



No. 60 Smith Boiler—Front



No. 60 Smith Boiler—Back

SMITH SMOKELESS BOILERS

Nos. 27, 36, 42, 60

For Anthracite Coal, Oil, Gas, Coke and all Bituminous Coals.
When Bituminous Coal contains over 22½% volatile Oxygen Torch should be installed.

With Oxygen Torch

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches: Width	Nominal Size of Fire Pot, Inches: Length	Total Length of Boiler Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
			No. 27			
10	27	36	77	62	2,700	4,450
11	27	42	83	68	3,000	4,950
12	27	48	89	74	3,300	5,450
13	27	54	95	80	3,600	5,950
14	27	60	101	86	3,900	6,425
15	27	66	107	92	4,200	6,925
			No. 36			
11	36	42	87	68	4,300	7,100
12	36	48	93	74	4,800	7,925
13	36	54	99	80	5,300	8,750
14	36	60	105	86	5,800	9,575
15	36	66	111	92	6,300	10,400
			No. 60			
12	60	42	110	73	10,800	17,800
13	60	48	116	79	12,000	19,800
14	60	54	122	85	13,200	21,800
15	60	60	128	91	14,400	23,750
16	60	66	134	97	15,600	25,750
17	60	66	140	103	16,800	27,700
18	60	72	146	109	18,000	29,700
19	60	78	152	115	19,200	31,700
20	60	78	158	121	20,400	33,650

Additional Data Applying to Smokeless Boilers

Boiler No.	27	36	42	60
Width at foundation	35″	48¼″	50″	72″
Width of boiler, steam	56″	72″	68⅞″	98″
Width of boiler, water	59″	76″	68⅞″	98″
Height of boiler	80″	83″	76¾″	87″
Height of water line	57″	59″	60″	69″
Oval smoke pipe equivalent to	13½″ round	15½″ round	...	29½″ round

Supply Drum Tappings*

Outside diameter.....12 in.
Tapped for 2-in. lock-nut nipples. Front end tapped 2 in. Rear end tapped one 4 in. and one 2 in.

Tappings on Top
No. 60

Number of Sections	Size of Tappings 4″	5″	6″	8″
	Number of Tappings			
8	2		2	
9	2		2	
10		2		2
11		2		2
12		2		2
13		2		2
14		2		3
15		2		3
16		2		3
17		2		3
18		2		3
19		2		3
20		2		3

No. of Sections in Boiler	Nominal Size of Fire Pot, Inches: Width	Nominal Size of Fire Pot, Inches: Length	Total Length of Boiler Inches	Length at Foundation, Inches	Steam Rating, Feet	Water Rating, Feet
			No. 27			
5	27	24	47	32	1,200	1,975
6	27	30	53	38	1,500	2,475
7	27	36	59	44	1,800	2,975
8	27	42	65	50	2,100	3,475
9	27	48	71	56	2,400	3,950
10	27	54	77	62	2,700	4,450
11	27	60	83	68	3,000	4,950
12	27	60	89	74	3,300	5,450
12	27	66	89	74	3,300	5,450
13	27	66	95	80	3,600	5,950
13	27	72	95	80	3,600	5,950
14	27	66	101	86	3,900	6,425
14	27	78	101	86	3,900	6,425
			No. 36			
7	36	36	63	44	2,300	3,800
8	36	42	69	50	2,800	4,625
9	36	48	75	56	3,300	5,450
10	36	54	81	62	3,800	6,275
11	36	60	87	68	4,300	7,100
12	36	60	93	74	4,800	7,925
12	36	66	93	74	4,800	7,925
13	36	66	99	80	5,300	8,750
13	36	72	99	80	5,300	8,750
14	36	66	105	86	5,800	9,575
14	36	78	105	86	5,800	9,575
15	36	72	111	92	6,300	10,400
15	36	84	111	92	6,300	10,400
			No. 60			
8	60	36	86	49	6,000	9,900
9	60	42	92	55	7,200	11,900
10	60	48	98	61	8,400	13,850
11	60	54	104	67	9,600	15,850
12	60	60	110	73	10,800	17,800
13	60	66	116	79	12,000	19,800
14	60	72	122	85	13,200	21,800
15	60	78	128	91	14,400	23,750
16	60	84	134	97	15,600	25,750
17	60	78†	140	103	16,800	27,700
18	60	84†	146	109	18,000	29,700
19	60	84†	152	115	19,200	31,700
20	60	84†	158	121	20,400	33,650

NOTE—Additional data pertaining to No. 42 boiler, furnished on application.

Return Drums*

Steam Boilers

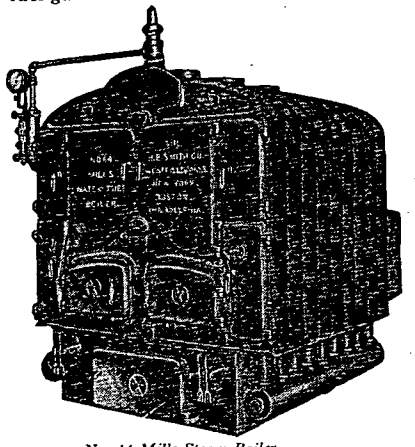
Outside diameter.....8 in.
Tapped for 2-in. lock-nut nipples.
Front ends tapped.....2½ in.
Rear ends tapped.....5 in.
Undersides tapped.....1¼ in.

Fire Tools and Steam Trimmings Furnished

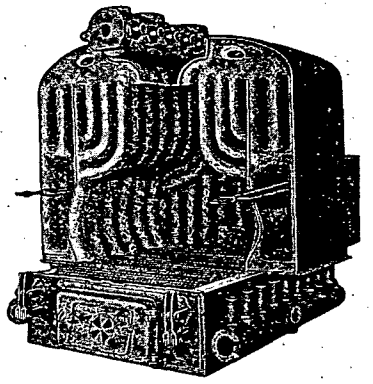
*When boiler is to be used for water warming, specify on order the size of supply and return pipe tappings. Tappings other than those listed are special. Order must specify size.

Mills Water Tube Steam and Water Boilers

Sectional cast iron boilers which are moderate in first cost, low maintenance and extremely economical in fuel. Sectional view shows large combustion chamber and vertical waterways of small area. The latter absorb the heat quickly, circulate the water rapidly and make dry steam. May be fired with anthracite coal, wood, coke or fuel gas.



No. 44 Mills Steam Boiler

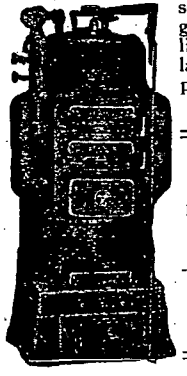


No. 44 Mills Boiler—Interior

Size of Boiler	Nominal Width Fire Pot Inches	Commercial Rating—Capacity in Sq. Ft.		Max. Allowable Working Pressure		
		Steam	Water	Steam	Water (Open Tank)	Water (Closed Tank)
No. 24	24	700 to 2025	1175 to 3350	15 lb.	30 lb.	15 lb.
No. 34	34	2000 to 5200	3300 to 8575	15 lb.	30 lb.	15 lb.
No. 44	44	3600 to 9000	5950 to 14,850	15 lb.	30 lb.	15 lb.
No. 48	48	4800 to 12,000	7925 to 19,800	15 lb.	60 lb.	30 lb.

H-B Steam and Water Boilers

H-B Boilers have three waterways between sections. They are the only boilers in which ascending and descending currents of water are circulated through separate connections, giving a steady water line and rapid circulation without back pressure.



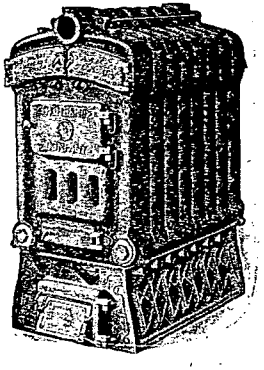
Commercial Ratings

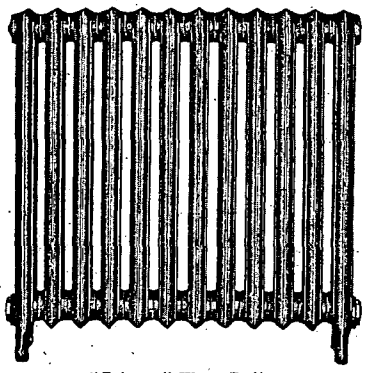
Diam. of Fire Pot Inches	Steam Rating Feet	Water Rating Feet
15 to 27	250 to 1000	425 to 1650

17 Hy-Test Boiler

For Hot Water Supply
A. S. M. E. Standard

Maximum allowable working pressure, 120 lb. Open Tank; 80 lb. Closed Tank.





"Princess" Water Radiator

Princess Direct Radiators

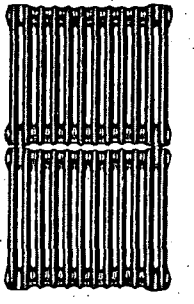
For sanitary reasons, radiators with wide spacing should be demanded.

If ordinary radiators are not sanitary enough for hospitals, they are not sanitary for the home. To meet hospital specifications some manufacturers make special radiators with wide spacing and charge an increased price.

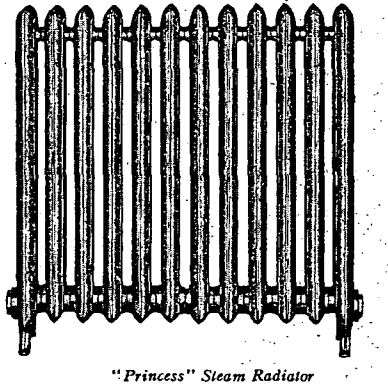
Princess Radiators are the standard radiators of The H. B. Smith Co. and are sold at regular list prices.

Princess Wall Radiators

Suited for all places where direct radiators or pipe coils cannot be used. Especially desirable in locations where floor space is valuable and where wall, column or ceiling space is more available. They possess extreme flexibility of size and arrangement. Made in two heights, 15 and 22 in. Can be furnished with heating surfaces from 5 sq. ft. up, in multiples of 2½ sq. ft. Corresponding lengths in 22 in. radiator are from 9 in. up, in multiples of 4 in. (1 in. allowed in over all length for plugs and bushings). In the 15 in. radiator, corresponding lengths are from 13 in. up, in multiples of 6 in. By combinations of the two heights, these radiators can be arranged in tiers, either for horizontal runs or for column work. Hung horizontally, they make excellent ceiling radiators.



"Princess" Wall Radiator



"Princess" Steam Radiator

Spencer Heater Company

Williamsport, Pa.

NEW YORK BOSTON SYRACUSE PHILADELPHIA ALBANY BALTIMORE HARRISBURG BUFFALO SCRANTON ROCHESTER

Builders of Spencer Heaters

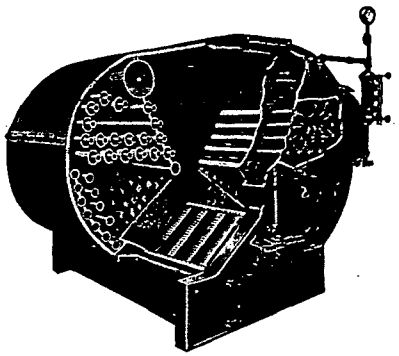
SPENCER HEATERS

Give uniform heat over long periods and use small size hard coal with least attention to the fire.

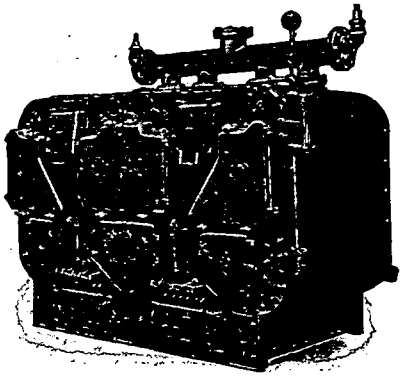
The magazine-feed feature is built into the heater and requires no adjustment. The magazine holds a supply of coal sufficient for 8 to 12 hours in severe weather or for a proportionately longer period in milder weather.

Spencer Heaters are economical and efficient.

Due to the magazine-feed feature of the Spencer Heater it is impracticable to obtain a firing period of less than 8 hours. Therefore ratings of Spencer Heaters are based upon an evaporation of 8 lbs. of water per lb. of coal burned, the rated evaporation having been obtained in actual test using fresh mined No. 1 Buckwheat coal as fuel.



50 Series. Spencer Tubular Heater



100 Series. Spencer Tubular Heater

SPENCER TUBULAR STEAM HEATERS

	Heater Number	Rating Sq. Ft. Radiation	Fire Surface Sq. Ft.	Heating Surface Sq. Ft.	Tapping Flow	Tapping Return	Overall Length Ins.	Overall Width Ins.	Water Line Ins.	Draft to Develop Rating Ins. H_2O	Size Chimney Flue
50 Series	15	2,000	12.00	282	2-4"	2-2½"	72½	62½	56	.23	18"x18"x50'
	17	2,500	13.50	309	2-4"	2-2½"	78½	62½	56	.24	18"x18"x55'
	19	3,000	15.00	337	2-4"	2-2½"	84½	62½	56	.25	18"x18"x60'
	20	3,500	16.50	365	2-4"	2-2½"	90½	62½	56	.26	18"x18"x65'
	21	4,000	18.00	393	2-4"	2-2½"	96½	62½	56	.27	18"x18"x65'
	3-45	4,500	18.05	389	2-5"	2-2½"	99½	81¼	59	.24	18"x18"x50'
	3-50	5,000	20.24	429	2-5"	2-2½"	105¼	81¼	59	.25	18"x18"x55'
	3-55	5,500	22.56	468	2-5"	2-2½"	112	81¼	59	.26	18"x18"x60'
	3-60	6,000	24.83	506	2-5"	2-2½"	118¼	81¼	59	.27	20" Diam. x 65'
	3-70	7,000	27.00	547	2-5"	2-2½"	124½	81¼	59	.28	20" Diam. x 70'
100 Series	3-80	8,000	30.35	560	1-8"	2-2½"	98	116⅛	66	.27	24" Diam. x 65'
	3-90	9,000	34.70	621	1-8"	2-2½"	104¼	116⅛	66	.28	24" Diam. x 65'
	3-105	10,500	39.05	683	1-8"	2-2½"	110½	116⅛	66	.29	30" Diam. x 65'
	3-120	12,000	43.40	745	1-8"	2-2½"	116¾	116⅛	66	.30	30" Diam. x 70'
	3-140	14,000	47.75	807	1-8"	2-2½"	123	116⅛	66	.32	36" Diam. x 70'
	3-160	16,000	52.10	869	1-8"	2-2½"	129¼	116⅛	66	.34	36" Diam. x 70'

Heaters No. 3-45 to 3-160 are furnished with steel jackets and 1½ in. Rockwool asbestos covering, also pipe header.

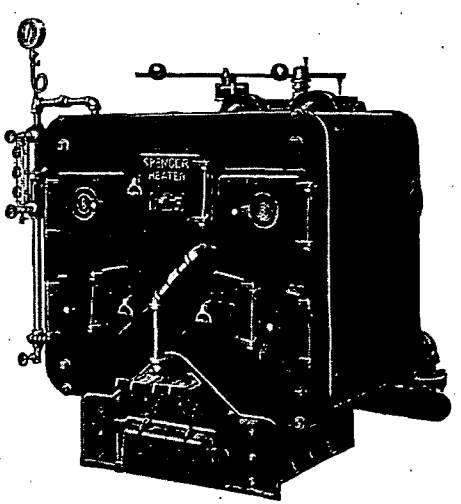
Heaters No. 15-21 are furnished with steel jackets only.

Chimney Flue sizes are based on a maximum Flue Temperature at Boiler Smoke outlet of 500 deg. fahr.

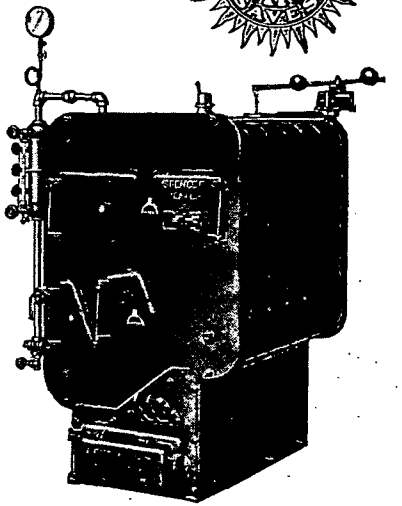
SPENCER HEATERS are adaptable for residences, apartment houses, churches, schools, public and commercial buildings, theatres, green houses, garages and all other types of buildings heated by low pressure steam, vapor, or hot water.

For over 25 years SPENCER HEATERS have been tried and tested under the most severe climatic conditions. There are thousands of successful installations throughout the entire country.

Write for illustrated catalog containing complete information.



No. 2 Series. Spencer Sectional Heater



No. 1 Series. Spencer Sectional Heater

SPENCER SECTIONAL STEAM HEATERS

Heater Number	Rating Sq. Ft. Radiation	Fire Surface Sq. Ft.	Tapping Flow	Tapping Return	Overall Length Ins.	Overall Width Ins.	Water Line Ins.	Draft to Develop Rating Ins. H_2O	Size Chimney Flue
1-5-S	600	2.26	1-4"	2-4"	48⅛	37⅛	50"	0.12	8½"x13"x35'
1-6-S	750	2.82	1-4"	2-4"	54⅜	37⅛	50"	0.13	8½"x13"x35'
1-7-S	900	3.38	1-4"	2-4"	60⅝	37⅛	50"	0.14	8½"x13"x40'
1-8-S	1,050	3.95	1-4"	2-4"	66⅞	37⅛	50"	0.15	13" x13"x40'
1-9-S	1,200	4.51	1-4"	2-4"	73⅛	37⅛	50"	0.16	13" x13"x40'
2-6-S	1,300	5.64	2-4"	2-4"	68⅜	57⅜	50"	0.17	13" x13"x40'
2-7-S	1,600	6.77	2-4"	2-4"	74⅞	57⅜	50"	0.18	13" x13"x40'
2-8-S	2,000	7.90	2-4"	2-4"	81⅛	57⅜	50"	0.19	13" x13"x40'
2-9-S	2,400	9.03	2-4"	2-4"	87⅜	57⅜	50"	0.20	13" x13"x40'
2-10-S	2,800	10.16	2-4"	2-4"	93⅝	57⅜	50"	0.21	13" x18"x45'
2-11-S	3,200	11.28	2-4"	2-4"	99⅞	57⅜	50"	0.21	13" x18"x45'

SPENCER SECTIONAL WATER HEATERS

1-5-W	1,000	2.26	2-4"	2-4"	48⅛	37⅛	.....	0.12	8½"x13"x35'
1-6-W	1,250	2.82	2-4"	2-4"	54⅜	37⅛	.....	0.13	8½"x13"x35'
1-7-W	1,500	3.38	2-4"	2-4"	60⅝	37⅛	.....	0.14	8½"x13"x40'
1-8-W	1,750	3.95	2-4"	2-4"	66⅞	37⅛	.....	0.15	13" x13"x40'
1-9-W	2,000	4.51	2-4"	2-4"	73⅛	37⅛	.....	0.16	13" x13"x40'
2-6-W	2,100	5.64	2-4"	2-4"	68⅜	57⅜	.....	0.17	13"x13"x40'
2-7-W	2,600	6.77	2-4"	2-4"	74⅞	57⅜	.....	0.18	13"x13"x40'
2-8-W	3,200	7.90	2-4"	2-4"	81⅛	57⅜	.....	0.19	13"x13"x40'
2-9-W	3,800	9.03	2-4"	2-4"	87⅜	57⅜	.....	0.20	13"x13"x40'
2-10-W	4,500	10.16	2-4"	2-4"	93⅝	57⅜	.....	0.21	13"x18"x45'
2-11-W	5,100	11.28	2-4"	2-4"	99⅞	57⅜	.....	0.21	13"x18"x45'

Richardson & Boynton Co.

Manufacturers of
"RICHARDSON" "PERFECT"
Heating and Cooking Apparatus Since 1837

BOSTON	CHICAGO	NEW YORK
94 Federal Street	3639 South Ashland Avenue	260 Fifth Avenue
BUFFALO	**MINNEAPOLIS**	**PHILADELPHIA**
Jackson Bldg., 220 Delaware Avenue	100 North Seventh Street	1308 Arch Street

Gas-Era Gas Fired Boilers

Gas-Era gas fired steam and hot water boilers are tamper-proof and free from all adjustments that are likely to get out of order.

They operate properly and dependably at extremely low gas pressure.

They develop a sufficient stack temperature to prevent condensation of the moisture content of the products of combustion.

They may be very easily cleaned through cleanout openings on top of boiler without disturbing the jacket.

Vertical burner adjustment permits the efficient burning of any kind of gas.

They have a steady water line and will not prime under high rates of combustion.

Burners and mixers are of rugged construction to stand the abuse of hard service.

Constructed throughout of cast iron for durability.

Capacity of Gas-Era Boilers may be increased when desired. Built on the Multiple Unit System.

High efficiency, attained without complicated construction, keeps fuel consumption costs to a minimum.

Thermostatic pilot control opens control circuit any time pilot flame is extinguished, through closing main gas valve. Gas cannot be turned on until pilots are lighted, when heat thus generated automatically closes circuit and boiler resumes operation.

Heating surface so distributed that radiant heat traveling either vertically or horizontally strikes water backed heating surface.

Gas-Era Boilers

STEAM			WATER			STEAM			WATER		
Boiler No.	Rating	Approx. Shipping Weight	Boiler No.	Rating	Approx. Shipping Weight	Boiler No.	Rating	Approx. Shipping Weight	Boiler No.	Rating	Approx. Shipping Weight
13-S	400	1180	13-W	650	1100	1327-S	5200	7200	1327-W	8450	7150
25-S	800	1700	25-W	1300	1650	1429-S	5600	7700	1429-W	9100	7650
37-S	1200	2200	37-W	1950	2150	1531-S	6000	8200	1531-W	9750	8150
49-S	1600	2700	49-W	2600	2650	1634-S	6400	9100	1634-W	10,400	9050
511-S	2000	3200	511-W	3250	3150	1838-S	7200	9600	1838-W	11,700	9550
613-S	2400	3700	613-W	3900	3650	2042-S	8000	10,600	2042-W	13,000	10,550
715-S	2800	4200	715-W	4550	4150	2246-S	8800	11,600	2246-W	14,300	11,550
817-S	3200	4700	817-W	5200	4650	2450-S	9600	12,600	2450-W	15,600	12,550
919-S	3600	5200	919-W	5850	5150	2654-S	10,400	13,600	2654-W	16,900	13,550
1021-S	4000	5700	1021-W	6500	5650	2858-S	11,200	14,600	2858-W	18,200	14,550
1123-S	4400	6200	1123-W	7150	6150	3062-S	12,000	15,600	3062-W	19,800	15,550
1225-S	4800	6700	1225-W	7800	6650						

Standard Equipment with all Gas Boilers

Insulated metallic jacket, draft hood, gas pressure regulator, electric gas valve, thermostatic safety pilot, main gas cock, pilot gas cock, draw-off cock, flue cleaning brush.

Standard Equipment

Steam Boilers

Automatic steam and vapor pressure regulator and low water cut-off; water gage and try cocks, retard steam gage, pop safety valve.

Standard Equipment

Water Boilers

Automatic water temperature regulator, altitude gage, thermometer.

Complete information will be sent upon request:

"Richardson" Boilers for Steam, Hot Water and Vapor.

"Perfect" Warm Air Heaters.

"Richardson" Hot Water Heaters and Specialties.

The Thatcher Company

New York
Chicago

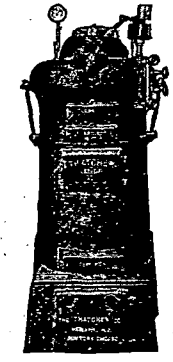
39-41 St. Francis St.
Newark, N. J.

Agencies in All Principal Cities

Boilers—Furnaces—Ranges

Thatcher Round Boiler

Steam or Water



Thatcher Round Boiler

No.	Gross Rating Sq. Ft.	Limit Load of Radiation or Equivalent	Grate Area Sq. Ft.	Coal Carrying Capacity Lbs.	Height to Top Outlet Inches	Height to Water Line Inches	Flow Openings Inches	Return Openings Inches
1700-S	200	140	1.39	120	44	38	1-2½	2-2½
1701-S	250	175	1.39	133	48¼	42¼	1-2½	2-2½
1702-S	300	200	1.39	133	53¼	47¼	1-2½	2-2½
1703-S	350	225	1.39	133	57¼	51¼	1-2½	2-2½
1901-S	400	250	1.77	148	49½	43½	1-3	2-2½
1902-S	450	300	1.77	148	54½	48½	1-3	2-2½
1903-S	500	325	1.77	148	58½	52½	1-3	2-2½
2001-S	550	350	2.18	190	51¼	45¼	1-3	2-3
2002-S	600	400	2.18	190	56¼	50¼	1-3	2-3
2003-S	650	425	2.18	190	60¼	54¼	1-3	2-3
2301-S	725	475	2.90	265	53½	47½	2-4	2-3
2302-S	800	525	2.90	265	58½	52½	2-4	2-3
2303-S	875	550	2.90	265	62½	56½	2-4	2-3
2601-S	925	600	3.69	355	54	48	2-4	2-4
2602-S	1000	650	3.69	355	59	53	2-4	2-4
2603-S	1075	700	3.69	355	63	57	2-4	2-4
2901-S	1150	750	4.55	445	55½	49½	2-4	2-4
2902-S	1250	800	4.55	445	60½	54½	2-4	2-4
2903-S	1350	850	4.55	445	64½	58½	2-4	2-4

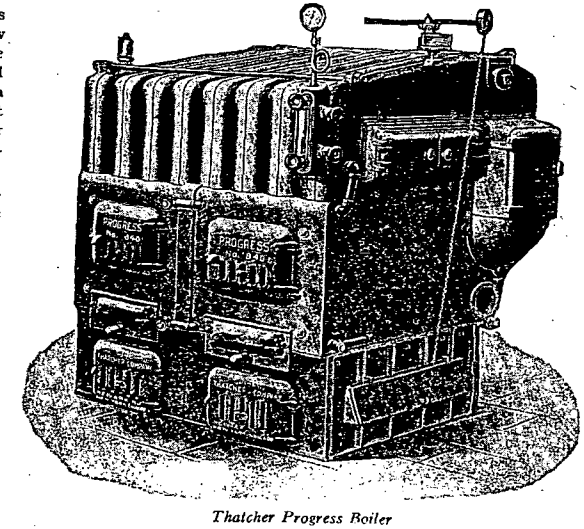
This New Thatcher Round Boiler is designed to secure the greatest amount of heating surface by thin waterways staggered fire travel in the wheel sections, cast in crown sheet, and four special flues through the dome.

Thatcher Progress with Low Water Line

The Thatcher Progress has such an unusually low water line that it can be used in the shallowest kind of cellars without need of a boiler pit. The fact that either half of a twin boiler may be used alone is another big advantage.

The scientific construction embodies the triple fire travel principle which forces the smoke and hot gases to go three times the length of the boiler before going up the flue, thus obtaining all their heat units.

Furnished single and twin boilers to care for from 1150 to 18,000 sq. ft. of steam and from 1925 to 31,750 sq. ft. of hot water radiation. It is especially adapted to oil burning and has proven of value to all heating men.



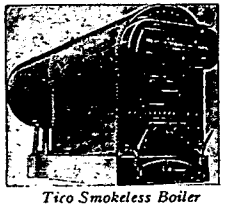
Thatcher Progress Boiler

The Titusville Iron Works Company

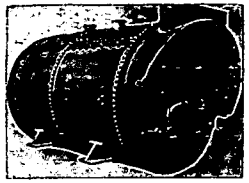
Titusville, Pennsylvania

Manufacturers of Fire Tube Steel Boilers for Power and Heating; Fronts, Grates, Castings, Smoke Stacks, Tanks and Oil Well Boilers; Steam, Gas, Oil and Gasoline Engines; Pumping Powers and Oil Well Machinery

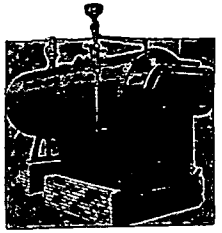
New York Office.....152 West 42nd St. Detroit Office.....204 Owen Bldg. Los Angeles Office.....940 Maple Ave.
Chicago Office, 1124 Harris Trust Bldg. Pittsburgh Office—Farmers Bank Bldg. St. Louis Office, 401-2 Bk of Commerce Bldg.
Buffalo Office.....Marine Trust Bldg. Washington Office—Woodward Bldg. Philadelphia Office, 807 Liberty Trust Bldg.



Tico Smokeless Boiler

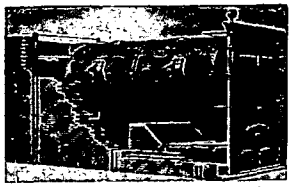


Titusville Standard Internal Fired Scotch Type Boiler



Tico Return Tubular Fire Box Boiler

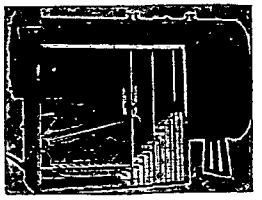
Titusville Vertical Tubular Boiler



Titusville Standard Tubular Boiler and Setting

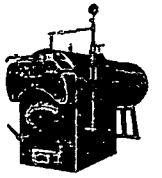
The Organization and Facilities

We manufacture a complete line of fire tube steam boilers to meet all general heating and power requirements. We also make a specialty of boilers built to architects' and engineers' specifications.



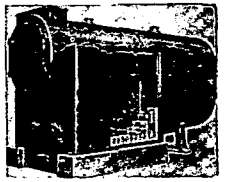
Perfection Down Draft Smokeless Boiler

Our shop is one of the largest and best equipped boiler manufacturing plants in the country. It is provided with the latest improved machinery including hydraulic and pneumatic riveting machines, as well as hydraulic flanging equipment. Engineering skill, careful workmanship and the best of materials are combined to make TITUSVILLE BOILERS better made boilers for every purpose.



Welded Type Boiler

All boilers are made in strict accordance with the latest boiler code of the *American Society of Mechanical Engineers* and can be made, if desired, to conform to local requirements.



Titusville Perfection Boiler—Built in Sizes 25 H. P. to 200 H. P. from 15 lbs. to 150 lbs Working Pressure

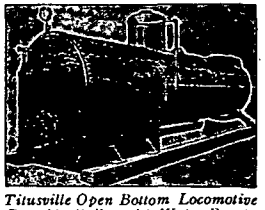
A large supply of material for all types of boilers is constantly carried and an adequate stock of completed TICOS and ACME FIREBOX Boilers is always ready for immediate shipment.

Titusville Jacketed Tubeless Water Heater —for Heating Domestic Hot Water by Direct Circulation

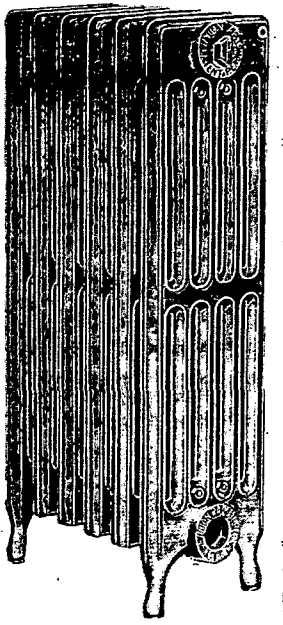
Thorough inspections and tests are constantly made during the construction and all workmanship and material is guaranteed first class in every respect.

In addition to the line of TITUSVILLE Boilers illustrated herewith we manufacture pneumatic and storage tanks of every description.

Descriptive Bulletins will be sent on request.



Titusville Open Bottom Locomotive Portable Boiler with Water Front



Union Radiator Company

Johnstown, Pa.

UNION ART RADIATORS

UNION ART RADIATORS

Section	Three-Column: * Length 2½ In. per Section	34 In. High 3⅜ Ft. per Section	31 In. High 3¼ Ft. per Section	26 In. High 2¼ Ft. per Section	22 In. High 2 Ft. per Section	Five-Column: Section	* Length 2½ In. per Section	34 In. High 5 Ft. per Section	31 In. High 4½ Ft. per Section	26 In. High 3¾ Ft. per Section	22 In. High 3 Ft. per Section	17 In. High 2¼ Ft. per Section
2	5	7⅛	6½	5½	4	2	5	10	9	7½	6	4½
3	7½	11	9¾	8¼	6	3	7½	15	13½	11¼	9	6¾
4	10	14⅜	13	11	8	4	10	20	18	15	12	9
5	12½	18⅛	16¼	13¾	10	5	12½	25	22½	18¾	15	11¼
6	15	22	19½	16½	12	6	15	30	27	22½	18	13½
7	17½	25⅜	22¾	19¼	14	7	17½	35	31½	26¼	21	15¾
8	20	29⅛	26	22	16	8	20	40	36	30	24	18
9	22½	33	29¼	24¾	18	9	22½	45	40½	33¾	27	20¼
10	25	36⅜	32½	27½	20	10	25	50	45	37½	30	22½
11	27½	40⅛	35¾	30¼	22	11	27½	55	49½	41¼	33	24¾
12	30	44	39	33	24	12	30	60	54	45	36	27
13	32½	47⅜	42¼	35¾	26	13	32½	65	58½	48¾	39	29¼
14	35	51⅛	45½	38½	28	14	35	70	63	52½	42	31½
15	37½	55	48¾	41¼	30	15	37½	75	67½	56¼	45	33¾
16	40	58⅜	52	44	32	16	40	80	72	60	48	36
17	42½	62⅛	55¼	46¾	34	17	42½	85	76½	63¾	51	38¼
18	45	66	58½	49½	36	18	45	90	81	67½	54	40½
19	47½	69⅜	61¾	52¼	38	19	47½	95	85½	71¼	57	42¾
20	50	73⅛	65	55	40	20	50	100	90	75	60	45
21	52½	77	68¼	57¾	42	21	52½	105	94½	78¾	63	47¼

*Add ½ in. to length of radiator for each bushing.
Tappings—1½ in. and bushed. 4½ in. from floor to center of tapping on water and steam, both feed and return.
Width of radiator, 5⅛ in.

*Add ½ inch to length of radiator for each bushing.
Tappings—1½ in. and bushed. 4½ in. from floor to center of tapping on water or steam, both feed or return.
Width of radiator, 8⅞ in.

UNION ART RADIATORS—Seven-Column

Section	* Length 3 In. per Sec.	38 In. High 8 Ft. per Sec.	32 In. High 7 Ft. per Sec.	26 In. High 6 Ft. per Sec.	21 In. High 5 Ft. per Sec.	Section	* Length 3 In. per Sec.	38 In. High 8 Ft. per Sec.	32 In. High 7 Ft. per Sec.	26 In. High 6 Ft. per Sec.	21 In. High 5 Ft. per Sec.	Section	* Length 3 In. per Sec.	38 In. High 8 Ft. per Sec.	32 In. High 7 Ft. per Sec.	26 In. High 6 Ft. per Sec.	21 In. High 5 Ft. per Sec.
2	6	16	14	12	10	13	39	104	91	78	65	23	69	184	161	138	115
3	9	24	21	18	15	14	42	112	98	84	70	24	72	192	168	144	120
4	12	32	23	24	20	15	45	120	105	90	75	25	75	200	175	150	125
5	15	40	35	30	25	16	48	128	112	96	80	26	78	208	182	156	130
6	18	48	42	36	30	17	51	136	119	102	85	27	81	216	189	162	135
7	21	56	49	42	35	18	54	144	126	108	90	28	84	224	196	168	140
8	24	64	56	48	40	19	57	152	133	114	95	29	87	232	203	174	145
9	27	72	63	54	45	20	60	160	140	120	100	30	90	240	210	180	150
10	30	80	70	60	50	21	63	168	147	126	105	31	93	248	217	186	155
11	33	88	77	66	55	22	66	176	154	132	110	32	96	256	224	192	160

*Add ½ in. to length of radiator for each bushing. Width of radiator, 12⅛ in.
Tappings—1½ in. and bushed. 4½ in. from floor to center of tapping on water radiators or supply end of two-pipe steam radiators. From floor to bottom of tapping of one-pipe steam or return of two-pipe steam, 3½ in.

UNION ART RADIATORS—Seven-Column Window

Section	* Length 3 In. per Sec.	19½ In. High 5 Ft. per Sec.	16½ In. High 4 Ft. per Sec.	15 In. High 4 Ft. per Sec.	Section	* Length 3 In. per Sec.	19½ In. High 5 Ft. per Sec.	16½ In. High 4 Ft. per Sec.	15 In. High 4 Ft. per Sec.	Section	* Length 3 In. per Sec.	19½ In. High 5 Ft. per Sec.	16½ In. High 4 Ft. per Sec.	15 In. High 4 Ft. per Sec.
2	6	10	8	8	11	33	55	44	44	19	57	95	76	76
3	9	15	12	12	12	36	60	48	48	20	60	100	80	80
4	12	20	16	16	13	39	65	52	52	21	63	105	84	84
5	15	25	20	20	14	42	70	56	56	22	66	110	88	88
6	18	30	24	24	15	45	75	60	60	23	69	115	92	92
7	21	35	28	28*	16	48	80	64	64	24	72	120	96	96
8	24	40	32	32	17	51	85	68	68	25	75	125	100	100
9	27	45	36	36	18	54	90	72	72	26	78	130	104	104
10	30	50	40	40										

*Add ½ in. to length of radiator for each bushing. Tappings—1½ in. and bushed. Width of radiator, 12⅛ in.
The 19½ in. and the 15 in. radiator measure 3 in. from floor to center of tapping on water radiators or supply end of two-pipe steam radiators. From floor to bottom of one-pipe steam or return end of two-pipe steam, 2 in. The 16½ in. radiator measures 4½ in. from floor to center of tapping on water radiators or supply end of two-pipe steam radiators. From floor to bottom of tapping on one-pipe steam or return end of two-pipe steam, 3½ in.

UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES: DETROIT, MICHIGAN

Manufacturers of Capitol Boilers and United States Radiators

Branch and Sales Offices

*BOSTON, MASS.	*BROOKLYN, N. Y.	*CINCINNATI, OHIO	*KANSAS CITY, MO.
*CAMBRIDGE, MASS.	*HARRISON, N. J.	DETROIT, MICH.	*ST. LOUIS, MO.
*PORTLAND, ME.	*PHILADELPHIA, PA.	*CHICAGO, ILL.	*DES MOINES, IOWA
*SPRINGFIELD, MASS.	*BALTIMORE, MD.	*MILWAUKEE, WIS.	*OMAHA, NEB.
*PROVIDENCE, R. I.	BUFFALO, N. Y.	*INDIANAPOLIS, IND.	*DENVER, COLO.
*NEW HAVEN, CONN.	*ROCHESTER, N. Y.	*LOUISVILLE, KY.	*PORTLAND, ORE.
*TROY, N. Y.	PITTSBURGH, PA.	*BIRMINGHAM, ALA.	*SEATTLE, WASH.
NEW YORK, N. Y.	*CLEVELAND, OHIO	*ST. PAUL, MINN.	*SAN FRANCISCO, CALIF.
*NEW ROCHELLE, N. Y.	*COLUMBUS, OHIO		*LOS ANGELES, CALIF.

*Assembling Plants located at points indicated by asterisk

Manufacturing Plants Located in Following Cities

CORRY, PA.; DETROIT, MICH.; DUNKIRK, N. Y.; EDWARDSVILLE, ILL.; GENEVA, N. Y.; WEST NEWTON, PA.

GUARANTEE

The UNITED STATES RADIATOR CORPORATION will give with each Capitol Boiler sold, an absolute guarantee in writing that it will properly heat its full published amount of direct cast iron radiation provided only that the boiler is connected to a correctly installed system and that the recognized standard requirements are followed. Should any Capitol Boiler not meet these conditions, the additional capacity necessary will be supplied without charge by the UNITED STATES RADIATOR CORPORATION.

Capitol Dependable Smokeless Boilers

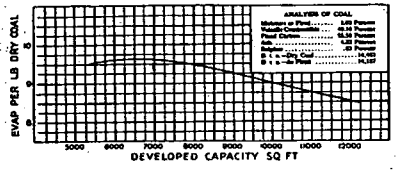
"Smokeless" simply means complete combustion. And all of the carbon which forms smoke cannot be burned without the correct amount of air, oxygen.

The auxiliary inlets that supply air for complete combustion in Capitol Smokeless Boilers are not dependent upon the skill, guesswork or memory of the fireman.

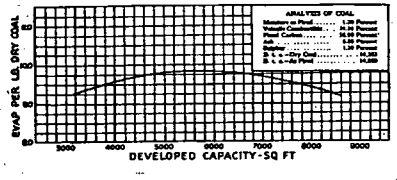
Their size for each boiler rating is definitely determined in the Capitol Testing Laboratory and permanently fixed at the factory. They need no adjusting. The intensity of the fire itself governs the amount of air drawn in. To further assure accuracy, every Capitol auxiliary inlet is always an integral part of a single boiler section and is never placed between two sections where faulty assembly will cause a variance.

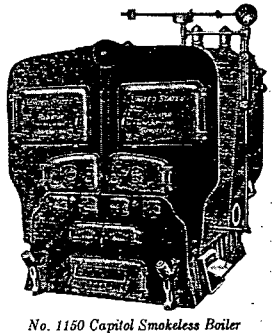
The efficiency of Capitol Smokeless Boilers is shown strikingly by the typical performance curves on these pages. These charts are based on many individual tests and the ratings are fixed conservatively. Notice the high volatile coal used for these tests.

PERFORMANCE CURVE No. 1150 CAPITOL BOILER

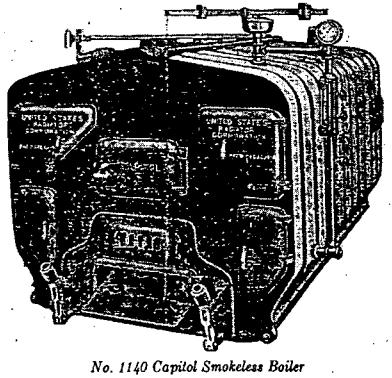


PERFORMANCE CURVE No. 1140 CAPITOL BOILER



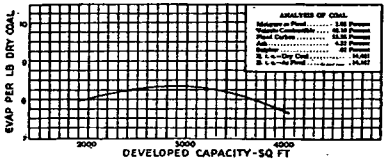


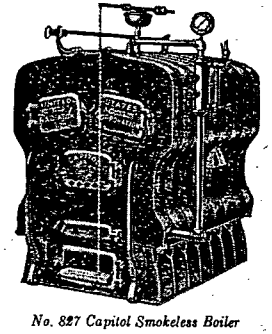
No. 1150 Capitol Smokeless Boiler



No. 1140 Capitol Smokeless Boiler

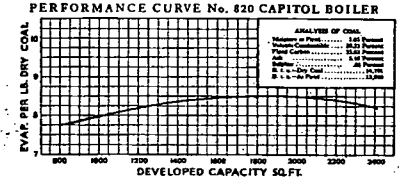
PERFORMANCE CURVE No. 1127 CAPITOL BOILER

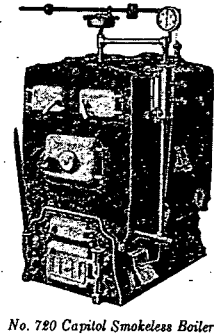




No. 827 Capitol Smokeless Boiler

PERFORMANCE CURVE No. 820 CAPITOL BOILER





No. 720 Capitol Smokeless Boiler

Capitol Smokeless Boilers

RADIATOR LOADS AND DIMENSIONS

Boiler No.	*Direct Cast Iron Radiator Loads, Sq. Ft.		Height of Water Line, Inches	Grate Area Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets and Inlets	Min. Chimney Sizes	
	Steam	Water					Height Feet	Dimensions Inches
750	4700	7755	66	18.29	29.67	3–5″	55	24 x 24
850	5350	8825	66	21.33	34.68	4–5″	60	24 x 24
950	5850	9655	66	21.33	34.68	4–5″	65	24 x 28
1050	6500	10725	66	24.37	39.69	5–5″	70	24 x 28
1150	7000	11550	66	24.37	39.69	6–5″	80	28 x 28
1250	7650	12620	66	27.41	44.71	6–5″	90	28 x 32
1350	8150	13450	66	27.41	44.71	6–5″	95	32 x 32

*See Guaranteed Heating.

Height including trimmings 92 in.; width 82 in.

Specify if back or top outlet smokehood is required.

740	2500	4125	49	8.15	10.40	2–5″	50	18 x 18
840	3000	4950	49	10.31	13.30	2–5″	55	18 x 20
940	3500	5775	49	10.31	13.30	2–5″	60	20 x 20
1040	4050	6680	49	12.47	16.30	3–5″	65	20 x 24
1140	4500	7425	49	14.63	19.25	3–5″	70	24 x 24
1240	4900	8085	49	14.63	19.25	3–5″	70	24 x 28
1340	5400	8910	49	16.79	22.20	3–5″	75	24 x 28

Height including trimmings 71 in.; width 75 in.

Equipped with combination top and back outlet smokehood.

627	1000	1650	45½	5.32	7.93	2–4″	40	12 x 12
727	1225	2020	45½	6.55	9.75	2–4″	40	12 x 12
827	1450	2390	45½	7.78	11.37	3–4″	45	12 x 12
927	1675	2760	45½	9.01	13.09	3–4″	45	12 x 16
1027	1900	3135	45½	10.24	14.81	3–4″	45	12 x 16
1127	2125	3505	45½	11.47	16.53	3–4″	50	12 x 16
1227	2350	3875	45½	12.70	18.25	4–4″	50	12 x 16

Height including trimmings 68½ in.; width 50¾ in.

Specify if back or top outlet smokehood is required.

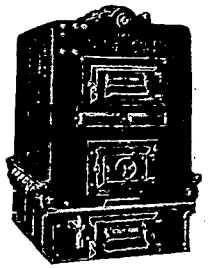
520	600	990	46½	3.48	4.32	2–3″	40	12 x 12
620	800	1320	46½	4.37	5.42	2–3″	40	12 x 12
720	1000	1650	46½	5.26	6.52	3–3″	40	12 x 16
820	1200	1980	46½	6.15	7.62	3–3″	45	12 x 16

Height including trimmings 66½ in.; width 45 in.

Specify if back or top outlet smookhood is required.

Universal Smokeless Boiler Company

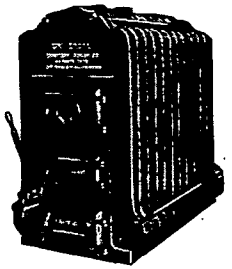
Ravenna, Ohio



100% Water Tube Cast Iron Sectional Heating Boilers

for

Coal, Coke, Wood, Gas and Oil



The CERTIFIED NET ALLOWABLE LOAD shown below is the guaranteed net capacity of the boiler as APPROVED and ADOPTED by the *Heating and Piping Contractors' Association* (Cleveland branch) and used by them in connection with their "CERTIFIED HEATING."

THE PIPING is already figured in as a part of the load so that no allowance need be made for same except in special cases such as garages, factories, etc., that use the piping for radiation purposes.

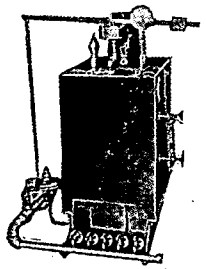
Double Grate Down-Draft "Smokeless" — **Single Grate Up-Draft "Smoke Preventing"**

Water Line, 61 in. Height, 73 in. Width, 49 in.				Water Line, 48 in. Height, 60 in. Width, 49 in.							
Boiler No. Steam	"Certified" Net Allowable Load	Catalog Rating	Sections	Boiler No. Steam	"Certified" Net Allowable Load	Catalog Rating	Sections	Boiler No. Steam	"Certified" Net Allowable Load	Catalog Rating	Sections
S-32	1190	3800	7	S-118	5280	12650	21	S-332	1575	4675	7
S-42	1670	4500	8	S-119	5480	13000	22	S-342	1885	5350	8
S-43	1905	5200	9	S-1110	6450	15000	23	S-343	2215	6000	9
S-53	2140	5700	10					S-352	2325	6650	9
S-54	2400	6400	11	Water Line, 57" Height, 67" Width, 36"				S-353	2400	7100	10
S-64	2670	7100	12								
S-65	2890	7800	13					S-354	2475	7500	11
S-74	3100	8150	13					S-362	2550	8000	10
S-75	3250	8500	14	S-432	675	1650	7	S-363	2770	8450	11
S-84	3440	8850	14	S-433	735	1800	8	S-364	3025	8900	12
S-85	3640	9200	15	S-443	920	2200	9	S-373	3250	9350	12
S-95	3970	9750	16	S-444	1000	2400	10				
S-96	4130	10150	17	S-454	1135	2700	11	S-374	3490	9800	13
S-97	4280	10500	18	S-455	1270	3000	12	S-375	3730	10200	14
S-106	4510	11000	18	S-465	1435	3250	13	S-383	3980	10650	13
S-107	4640	11250	19	S-466	1525	3450	14	S-384	4260	11100	14
S-108	4870	12100	20	S-476	1660	3800	15	S-385	4480	11550	15
S-117	5110	12250	20	S-477	1745	4000	16	S-394	4740	12000	15

Water Line, 47" Height, 57" Width, 36"			
S-395	5020	12450	16
S-396	5280	12900	17
S-397	5550	13350	18
S-532	525	2880	7
S-542	630	3600	8
S-552	715	3900	9
S-553	870	4200	10
S-562	980	4320	10
S-572	1090	5040	11
S-573	1210	5400	12
S-582	1315	5760	12
S-592	1430	6480	13
S-593	1540	6830	14

UNIVERSAL GAS BOILERS FOR STEAM AND WATER

With Metallic Jacket Lined with Super Fire Felt. Plain Section for Steam or Water. Height of Water Line 30 inches.



Gas Boiler

Steam P. S. Water P. W.	Steam Rating	Water Rating	Steam P. S. Water P. W.	Steam Rating	Water Rating	Steam P. S. Water P. W.	Steam Rating	Water Rating
No. 31	300	480	No. 33	1600	2585	No. 35	3100	4985
41	400	665	43	1750	2825	45	3250	5225
51	550	905	53	1900	3065	55	3400	5465
61	700	1145	63	2050	3305	65	3550	5705
32	850	1385	73	2200	3545	75	3700	5945
42	1000	1625	34	2350	3785	36	3950	6185
52	1150	1865	44	2500	4025	46	4100	6425
62	1300	2105	54	2650	4265	56	4250	6665
72	1450	2345	64	2800	4505	66	4400	6905
			74	2950	4745	76	4550	7145

Special Circulating Section—For Steam

Height of Water Line 33 inches

No. T. S.	Steam Rating	No. T. S.	Steam Rating	No. T. S.	Steam Rating	No. T. S.	Steam Rating	No. T. S.	Steam Rating	No. T. S.	Steam Rating
31	380	32	1020	33	1920	34	2820	35	3720	36	4620
41	480	42	1200	43	2100	44	3000	45	3900	46	4800
51	660	52	1380	53	2280	54	3180	55	4080	56	4980
61	840	62	1560	63	2460	64	3360	65	4260	66	5160
..	....	72	1740	73	2640	74	3540	75	4440	76	5340

STEAM OR VAPOR BOILERS—Outlet, 2-3 in. Fifteen-section one extra 1½ in. outlet for every 10 sections. Returns, 2-3 in. Trimmings—Safety valve, steam gage, water glass complete with try cock, automatic gas control valve, automatic steam pressure regulator, metal bellows type; pilot, complete with lava tip and cut-off valve; gas pressure regulator, hand control valve.

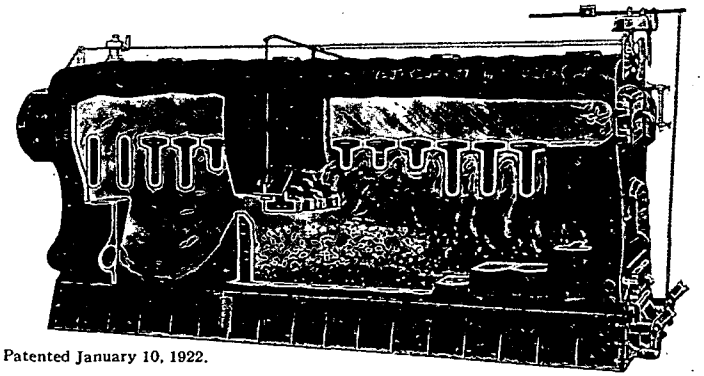
WATER BOILERS—Outlets, 2-3 in. Returns, 2-3 in. Trimmings—Thermometer, altitude gage, automatic gas control valve, pilot, gas pressure regulator, hand control valve.

Utica Heater Company

Utica, New York

365 E. Illinois St. CHICAGO, ILL. — 628 Union Building CLEVELAND, O. — 1843 Grand Central Term'l NEW YORK, N. Y.

Representatives In Principal Jobbing Centers



Patented January 10, 1922.

Cut-away View, showing Primary and Secondary Combustion Chambers and Air Inlets

Utica-Imperial SUPER-SMOKELESS Boilers

Burn Soft Coal Smokelessly—Use Any Available Fuel

Performance—

In Utica-Imperial SUPER-SMOKELESS Boilers, smoke, soot, heavy volatile gases, and all combustible products of distillation are consumed *as fuel*, on the principal of *active* 2-stage combustion. This is accomplished by the admission, *at the proper place*, of a secondary supply of air, *highly heated*, and delivered in jets.

At a point where combustible matter, released in the original fire, passes closely over the bed of incandescent coke, the heated oxygen mixes with it in blasts of high velocity. Combustible matter is at once ignited and passes into the secondary chamber as a bluish-white volume of burning gases. *Results:* exceptionally high temperature—heat transfer—fuel efficiency; clean, soot-free flues and chimney; strict compliance with the most rigid smoke ordinances.

Spiral Gas Travel—

Incandescent as they enter the flues, the gases are given a distinct rotary motion in their travel forward and back through the boiler. This whirling motion greatly increases the amount of heating surface over which the gases must pass, and lengthens the time that the gases remain within the boiler.

The centrifugal motion causes *all* of the gases to be brought into intimate "scrubbing" contact with *all* of the heating surface. None of the heating surface is at *any* time ineffective. *Results:* unusually efficient *utilization* of the neat generated.

Dry Steam—

Tests made under ordinary operating conditions reveal steam entering mains 99.97 per cent dry.

Construction—

Sectional. High grade cast iron, constantly checked by chemical analysis to insure strength and durability of every casting.

Operation—

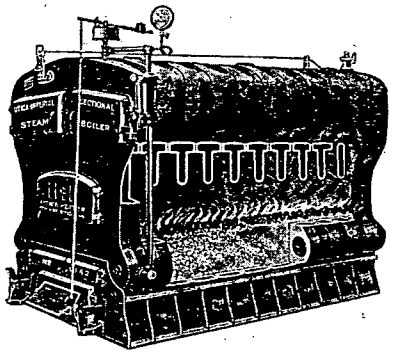
Extremely simple. Long firing periods. No special skill or training required.

Utilizes any heating fuel and has proved especially efficient with oil-burner.

Ratings—

Conservative. Determined from tests made in accordance with requirements of the *A. S. H. & V. E.* and the *A. S. M. E.* Our high efficiency ratings indicate output for average conditions with a minimum of fuel consumption. High output ratings indicate reserve capacity of boilers and are useful for comparison with other commercial ratings. Fully guaranteed for delivery of steam at boiler outlets under stated conditions of tests.

Capacities and Dimensions of Utica-Imperial SECTIONAL Boilers



Designed primarily for use in localities where anthracite is the commonly used fuel. Also, owing to the high efficiency of the heat-absorbing surfaces, these boilers are ideally suited to use of oil-burners. Water-filled tongues, which extend from the crown sheets deep down into the combustion chamber, provide an unusually large area of heat-absorbing surface at a point where high temperatures make such extra surface extremely valuable. Gases travel through the flues with a rotating motion similar to that described under our SUPER-SMOKELESS Boilers.

Capacities and Dimensions of Utica-Imperial SECTIONAL Boilers

Boiler No. Steam	Steam Ratings, Sq. Ft.		Boiler No. Water	Water Ratings, Sq. Ft.		Grate Area Sq. Ft.	No. and Size of Outlets Inches	Diameter of Smoke Collar Inches	Length of Sections Only Inches	Length of Sections and Smoke Box Inches
	High Efficiency	High Output		High Efficiency	High Output					
S-423	750	1000	W-423	1200	1600	3.75	1-4	12	29	40¼
S-523	1000	1400	W-523	1600	2240	5.00	1-4	12	37¼	48½
S-623	1250	1800	W-623	2000	2880	6.25	2-4	12	45½	56¾
S-723	1500	2200	W-723	2400	3520	7.50	2-4	14	53¾	63¼
S-823	1750	2600	W-823	2800	4160	8.75	2-4	14	62	71½
S-923	2000	3000	W-923	3200	4800	10.00	3-4	14	70¼	79¾
S-532	1700	2750	W-532	2720	4400	7.32	1-5	12	37¼	49¾
S-632	2150	3400	W-632	3440	5440	9.10	2-5	12	45½	58
S-732	2600	4050	W-732	4160	6480	10.87	2-5	12	53¾	66¼
S-832	3050	4700	W-832	4880	7520	12.65	2-5	14	62	74¼
S-932	3500	5350	W-932	5600	8560	14.42	3-5	14	70¼	82½
S-642	3100	5100	W-642	4960	8160	12.03	2-5	14	45½	57½
S-742	3750	6000	W-742	6000	9600	14.38	2-5	14	53¾	65¾
S-842	4400	6900	W-842	7040	11,040	16.73	3-5	14	62	74
S-942	5050	7800	W-942	8080	12,480	19.08	3-5	16	70¼	82½
S-1042	5700	8700	W-1042	9120	13,920	21.43	3-5	16	78½	90¾
S-1142	6350	9600	W-1142	10,160	15,360	23.77	3-5	16	86¾	99
S-1242	7000	10,500	W-1242	11,200	16,800	23.77	4-5	16	95	107¼

Capacities and Dimensions of Utica-Duplex SECTIONAL Boilers

Boiler No. Steam	Steam Ratings, Sq. Ft.		Boiler No. Water	Water Ratings, Sq. Ft.		Grate Area Sq. Ft.	No. and Size of Outlets Inches	Diameter of Smoke Collar Inches	Length of Sections Only Inches	Length of Sections and Smoke Box Inches
	High Efficiency	High Output		High Efficiency	High Output					
S-684	7200	11,000	W-684	11,520	17,600	24.06	8	28	45½	62½
S-784	8500	13,000	W-784	13,600	20,800	28.76	8	28	53¾	70¾
S-884	9800	15,000	W-884	15,680	24,000	33.46	8	28	62	79
S-984	11,100	17,000	W-984	17,760	27,200	38.16	8	28	70¼	87¼
S-1084	12,400	19,000	W-1084	19,840	30,400	38.16	8	28	78½	95½
S-1184	13,700	21,000	W-1184	21,920	33,600	42.86	8	28	86¾	103¾
S-1284	15,000	23,000	W-1284	24,000	36,800	42.86	8	28	95	112

Water Line: 23 series—45½ in.; 32 series—53 in.; 42 series—57 in.; 84 series—57 in.

Equipment Shipped with Boilers

Same as for Utica-Imperial SUPER-SMOKELESS Boilers, as given on previous page.

Capacities and Dimensions of Utica-Imperial SUPER-SMOKELESS Boilers

Boiler No. Steam	Steam Ratings, Sq. Ft.		Boiler No. Water	Water Ratings, Sq. Ft.		Grate Area Sq. Ft.	No. and Size of Outlets Inches	Diameter of Smoke Collar Inches	Length of Sections Only Inches	Length of Sections and Smoke Box Inches
	High Efficiency	High Output		High Efficiency	High Output					
S-245	1200	1600	W-245	1920	2560	5.00	1-4	12	37¼	48½
S-246	1500	2075	W-246	2400	3320	6.25	2-4	12	45½	56¾
S-247	1800	2550	W-247	2880	4080	7.50	2-4	14	53¾	63¼
S-248	2100	3025	W-248	3360	4840	8.75	2-4	14	62	71½
S-249	2400	3500	W-249	3840	5600	10.00	3-4	14	70¼	79¾
S-335	2000	3000	W-335	3200	4800	7.32	1-5	15	37¼	49½
S-336	2500	3750	W-336	4000	6000	9.10	2-5	15	45½	57¾
S-337	3000	4500	W-337	4800	7200	10.87	2-5	15	53¾	66
S-338	3500	5250	W-338	5600	8400	12.65	2-5	16	62	72½
S-339	4000	6000	W-339	6400	9600	14.42	3-5	16	70¼	80¾
S-3310	4700	6750	W-3310	7520	10,800	16.20	3-5	16	78½	89
S-405	2750	4125	W-405	4400	6600	9.68	1-5	18	37¼	49¼
S-406	3500	5250	W-406	5600	8400	12.03	2-5	18	45½	57½
S-407	4250	6375	W-407	6800	10,200	14.38	2-5	18	53¾	65¾
S-408	5000	7500	W-408	8000	12,000	16.73	3-5	18	62	74
S-409	5750	8625	W-409	9200	13,800	19.08	3-5	18	70¼	82¼
S-4010	6500	9750	W-4010	10,400	15,600	21.43	3-5	18	78½	90½
S-4011	7250	10,875	W-4011	11,600	17,400	23.77	3-5	20	86¾	97
S-4012	8000	12,000	W-4012	12,800	19,200	23.77	4-5	20	95	105¼
S-4013	8750	12,700	W-4013	14,000	20,320	23.77	4-5	20	103¼	113½
S-4014	9500	13,500	W-4014	15,200	21,600	23.77	4-5	20	111½	121¾
S-4015	10,250	14,250	W-4015	16,400	22,800	23.77	4-5	20	119¾	130
S-4016	11,000	15,000	W-4016	17,600	24,000	23.77	4-5	20	128	138¼
S-4017	11,750	15,750	W-4017	18,800	25,200	23.77	4-5	20	136¼	146½
S-4018	12,500	16,375	W-4018	20,000	26,200	23.77	4-5	20	144½	154¾
S-4019	13,250	17,000	W-4019	21,200	27,200	23.77	5-5	20	152¾	163
S-4020	14,000	17,600	W-4020	22,400	28,160	23.77	5-5	20	161	171¼
S-4021	14,750	18,150	W-4021	23,600	29,040	23.77	5-5	20	169¼	179½
S-4022	15,500	18,650	W-4022	24,800	29,840	23.77	5-5	20	177½	187¾
S-4023	16,250	19,100	W-4023	26,000	30,560	23.77	5-5	20	185¾	196
S-4024	17,000	19,500	W-4024	27,200	31,200	23.77	5-5	20	194	204¼

Capacities and Dimensions of Utica-Duplex SUPER-SMOKELESS Boilers

Boiler No. Steam	Steam Ratings, Sq. Ft.		Boiler No. Water	Water Ratings, Sq. Ft.		Grate Area Sq. Ft.	No. and Size of Outlets Inches	Diameter of Smoke Collar Inches	Length of Sections Only Inches	Length of Sections and Smoke Box Inches
	High Efficiency	High Output		High Efficiency	High Output					
S-827	8500	12,750	W-827	13,600	20,400	28.76	8	28	53¾	70¾
S-828	10,000	15,000	W-828	16,000	24,000	28.76	8	28	62	79
S-829	11,500	17,250	W-829	18,400	27,600	33.46	8	28	70¼	87¼
S-8210	13,000	19,500	W-8210	20,800	31,200	33.46	8	28	78½	95½
S-8211	14,500	21,750	W-8211	23,200	34,800	38.16	8	28	86¾	103¾
S-8212	16,000	24,000	W-8212	25,600	38,400	38.16	8	28	95	112
S-8213	17,500	25,400	W-8213	28,000	40,640	42.86	8	28	103¼	120¼
S-8214	19,000	27,000	W-8214	30,400	43,200	42.86	8	28	111½	128½
S-8215	20,500	28,500	W-8215	32,800	45,600	42.86	8	28	119¾	136¾
S-8216	22,000	30,000	W-8216	35,200	48,000	47.54	8	28	128	145
S-8217	23,500	31,500	W-8217	37,600	50,400	47.54	8	28	136¼	153¼
S-8218	25,000	32,750	W-8218	40,000	52,400	47.54	8	28	144½	161½

Height of water line: 24 series, 45½ inches; 33 series, 53 inches; 40 series, 57 inches; 82 series, 57 inches.

Equipment Shipped with Boilers

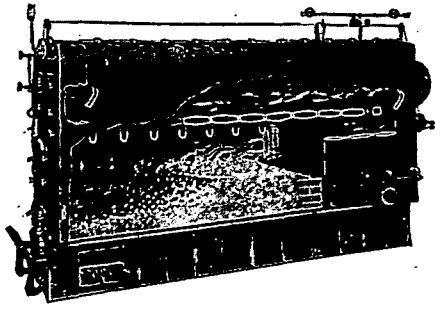
All Utica SECTIONAL Boilers are provided with equipment of the best type. Steam Boilers are equipped with water column with gage glass and compression cocks; Retard Steam Gage with Bourbon brass tube spring, Non-Glare Dial, syphon and cock; All-brass Pop Safety Valve, *A. S. M. E.* Standard, and Automatic All-metal Damper Regulator suitable for low pressure. Every boiler is furnished with a complete set of firing tools, consisting of shaker handle, hook, hoe, slice bar and flue brush with handle. Duplex Steam Boilers are equipped with Steam Header, Return Yoke, and Equalizer fitted with Hartford Connection which may be used or not, as desired.

Weil-McLain

SCIENTIFIC COMBUSTION

BOILERS

WEIL-McLAIN COMPANY—Michigan City, Ind.—Chicago, Ill.



Smokeless Type

Weil-McLain Long Firing Period Smokeless Boilers are now making smokelessness popular with everyone—for three primary reasons:—

First: They require considerably less firing attention than smokeless boilers in general.

Second: They are simple to fire.

Third: They are not limited to free burning types of soft coal for effective operation.

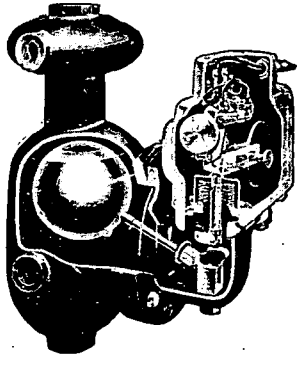
STEAM		WATER		Area Complete Firebox at Grate Sq. Ft.	Net Area of Fuel Grates Sq. Ft.	Water Line Height Inches	Outlets and Inlets Number and Size Each Inches	Overall Length Including Trimmings Inches
Size	Rating Sq. Ft.	Size	Rating Sq. Ft.					
722-S	1810	722-W	2990	7.03	4.88	46	2-3½	65
822-S	2105	822-W	3475	8.11	5.96	46	3-3½	72
922-S	2400	922-W	3960	9.19	5.96	46	3-3½	79
1022-S	2695	1022-W	4445	10.26	7.03	46	4-3½	86
752-S	2460	752-W	4060	8.10	5.70	51	2-3½	65
852-S	2995	852-W	4940	9.30	6.90	51	3-3½	72
952-S	3530	952-W	5825	10.50	6.90	51	3-3½	79
1052-S	4065	1052-W	6710	11.70	8.10	51	4-3½	86
1152-S	4565	1152-W	7530	12.90	9.30	51	4-3½	93
782-S	4210	782-W	6950	11.47	7.97	55	2-4	81
882-S	5060	882-W	8350	13.22	9.72	55	3-4	90
982-S	5800	982-W	9570	14.97	11.47	55	3-4	99
1082-S	6550	1082-W	10,810	16.72	13.22	55	4-4	108
1182-S	7250	1182-W	11,960	18.47	13.22	55	4-4	117
1282-S	7900	1282-W	13,035	20.22	14.97	55	4-4	126
863-S	6300	863-W	10,400	17.00	12.50	58	3-4	93
963-S	7100	963-W	11,700	19.75	14.75	58	3-4	102
1063-S	7900	1063-W	13,000	21.50	17.00	58	4-4	111
1163-S	8650	1163-W	14,275	23.75	17.00	58	4-4	120
1263-S	9400	1263-W	15,500	26.00	19.25	58	4-4	129
1363-S	10,150	1363-W	16,750	28.25	19.25	58	4-4	138
844-S	8480	844-W	13,990	20.85	15.35	58	3-5	96
944-S	9605	944-W	15,850	23.60	18.10	58	3-5	105
1044-S	10,730	1044-W	17,700	26.35	20.85	58	4-5	114
1144-S	11,855	1144-W	19,550	29.10	20.85	58	4-5	123
1244-S	12,980	1244-W	21,400	31.85	23.60	58	4-5	132
1344-S	14,105	1344-W	23,275	34.60	23.60	58	4-5	141
1444-S	15,230	1444-W	25,125	37.35	23.60	58	5-5	150
1544-S	16,225	1544-W	26,770	40.10	23.60	58	5-5	159
1644-S	17,125	1644-W	28,250	42.85	23.60	58	5-5	168

McDonnell & Miller

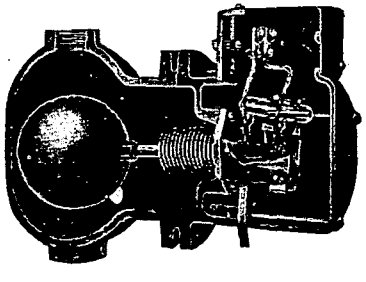
General Office:
Wrigley Building
CHICAGO

Eastern Warehouse Stock
Grand Central Terminal
NEW YORK

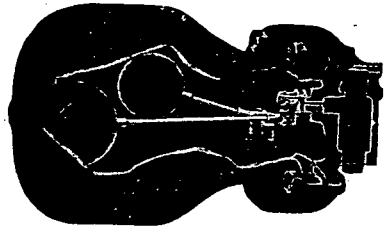
"Doing One Thing Well"



The Duplex Switch.—A combined low water cut-off and pressure control for oil fired steam boilers. Suitable for all boiler pressures up to 10 lb. Low water cut-off point is fixed. Pressure cut-off point may be varied from 9 oz. to 10 lb. Differential adjustment from 7 oz. to 5 lb. 8 oz. Installed in gage glass tappings. Makes and breaks main line motor current.

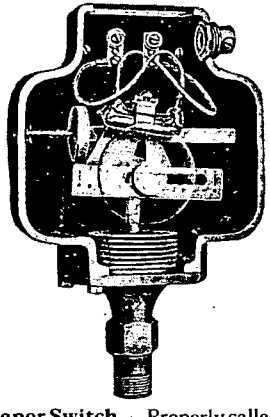


The Low Water Cut-Off.—A cut-off for industrial or non-recycling oil burner control systems. Installs in gage glass tappings. Suitable for 25 lb. steam pressure. Electrical capacity, 1 hp.



The Duplex Water Feeder.—This instrument is *not* an electrical control but a means of actually admitting make-up water to the boiler as necessary. It also disposes of excess condensate that may be returned from the system in sufficient quantities to flood the boiler. Suitable for steam pressures up to 15 lb. and city water pressures up to 120 lb.

"If you keep the boiler water line where it belongs there can be no burned boilers or cracked sections."



The Vapor Switch.—Properly called "The Aristocrat of Vapor Controls." Pressure range 0 to 2 lb. Capable of differential adjustment as low as 3 oz. Furnished in two types—for 110 and 220 volt or three wire 12 volt. This instrument is made especially for vapor heating systems that operate on pressures too low for satisfactory operation of other instruments.

The Vinco Company, Inc.

75 Vesey Street, **New York, N. Y.**

TELEPHONE—Cortlandt 1995 CABLE ADDRESS—Vincomp, New York

Vinco for Cleaning New, Remodeled and Old Heating Systems

Copyright, 1926, by The Vinco Company, Inc.

What Vinco Is

VINCO (Latin, "I conquer"), an insoluble powder, is a simple, safe, inexpensive and sure cleanser for new, for remodeled and for old systems.

What Vinco Does

VINCO stops foaming, priming, surging, sluggish steaming, clicking of pipes, incomplete circulation and poor radiation by removing oil, grease, scale and dirt from the internal surfaces, *without having to blow boilers over the top.*

Prevents cracking of boiler sections which often results from priming and sudden slugs of cold water.

TRADE-MARK
Reg. U. S. Pat. Off.

How Vinco Works

The minute particles of VINCO powder extend throughout the boiler water. These particles attract, absorb and hold the oil, rust and dirt in the boiler, uniting to form flocculent masses of the arrested impurities. These masses settle when the fire is banked at night and are easily removed by drawing off a pail of water, than refilling to restore the level, for six mornings. The unused VINCO remains in the boiler water.

A few hours after VINCO is applied the foaming is checked, enabling the boiler to deliver dry steam to the radiators and piping. *Dry steam* entering these parts of the system *emulsifies the Oil* adhering to the surfaces, carrying it back to the boiler through the return piping. The rust and dirt having lost the oil binder cannot adhere and are carried back to the boiler to be disposed of by VINCO.

Vinco for New and Remodeled Systems

Is simple to use, gives sure results. *No more blowing boilers over the top.* A great time and labor saver. For the Initial "Breaking In" VINCO gives the heating system a clean bill of health from the start. It assures positively that the internal surfaces are not and will not quickly become fouled.

Treatment with VINCO puts every well-engineered system into first class operating condition before turning over to the owner, for it quickly develops the best performance permitted by the design.

The conspicuous success of VINCO comes from its ability to *permanently* remove causes as well as effects, completely, at insignificant cost and without the slightest harm to any part of the system. A first demonstration of VINCO proves that its use should be standard practice.

Vinco for Old Systems

Annual cleaning of the old system prolongs boiler life and maintain original efficiency; prevents rust deterioration; scale and dirt insulated boilers—therefore saves your client fuel and fire attendance. *For old systems use only one half quantities given in table.*

Vinco Distributors

VINCO is stocked by the foremost jobbers in the United States and may be ordered direct from the manufacturers.

Our Guarantee

VINCO meets every performance claim; is a big money saver; contains no potash, lye, soda of any kind, oil, acid or other harmful ingredient.

Purchase price refunded if results are not entirely satisfactory. Patents are pending upon the product and method of application. Unlawful imitation will be prosecuted.

Vinco Specifications for Steam and Vapor Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method to remove oil, grease, rust and dirt from the boiler, using, *.....lb. of VINCO, in exact accordance with manufacturer's directions.

This compound must remain in the boiler for 36 actual steaming hours, which corresponds to six or seven days average operation. At the end of this period, boiler must be thoroughly drained and flushed before refilling with clean water.

1½, 3, 5, and 10 lb. cans only

*In writing specification, insert in this space number of pounds of VINCO to be used in accordance with the following schedule. For systems having:

Up to	350	sq. ft. of	*radiation		3 lb.
351 "	600	"	"	"	5 "
601 "	1100	"	"	"	8 "
1101 "	1400	"	"	"	10 "
1401 "	1800	"	"	"	13 "
1801 "	2100	"	"	"	15 "
2101 "	2700	"	"	"	18 "
2701 "	3100	"	"	"	20 "
3101 "	3700	"	"	"	23 "
3701 "	4200	"	"	"	26 "
4201 "	4600	"	"	"	28 "
4601 "	5000	"	"	"	30 "

Above 5000 sq. ft. use an additional pound of VINCO for each additional 300 sq. ft. of radiation.

*In determining amount of VINCO to be used all radiation may be taken at actual rating.

Vinco Specifications for Hot Water Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method using **.....lb. of VINCO in exact accordance with manufacturer's special directions for hot water systems, given on their cans.

**Only one half above quantities required for hot water systems.

For safety and full benefits specify by name and see that the material comes from 1½, 3, 5 or 10 lb. lithographed cans bearing our name and registered trade-mark as shown.

SEND FOR COMPLETE LITERATURE

Aladdin Utilities Corporation

157 N. Michigan Ave., **Chicago, Ill.**

QUIET **Aladdin**

***Uniform* Fuel-Oil Heat**

General Description

Aladdin is an atomizing type of oil burner. It is not restricted to special grades of volatile oil, but will satisfactorily burn a wider range of oil of heavier gravity. It is equally satisfactory for steam, hot water or warm air furnaces.

Compressed Air Atomizations

Aladdin admits the oil into a stream of compressed air which produces a fine spray that lights instantly and burns cleanly. No high speed mechanism or small orifices. Nozzle is automatically cooled and scoured clean. Aladdin's compressed air atomizer will give no trouble.

Uses a Centrifugal Fan

To accurately measure the supply of air, Aladdin uses a centrifugal fan.

Circulating Oil System

A positive pressure circulating pump draws direct from main storage tank and supplies burner, returning surplus oil to storage. This eliminates hand pumping and the uncertainty of gravity feed.

Fire Brick Combustion Chamber

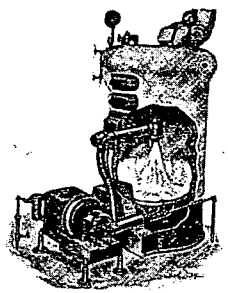
To maintain an oil flame of sufficient temperature for efficiency, Aladdin uses a fire brick combustion chamber.

Lubricated Under Pressure

The air compressor of Aladdin is automatically oiled with lubricating oil circulated under pressure. This assures long life and quiet operation of motor unit.

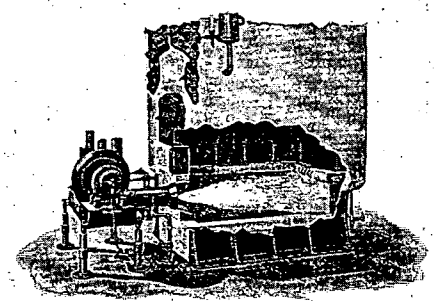
Newest Mercoid Controls

Aladdin uses Mercoid equipment—the last word in safety control. These appliances illustrate the high standard of engineering which characterizes Aladdin throughout.



Model K—Down Draft

Radiation up to 2000 sq. ft. Aladdin Down Draft forces flame down into boiler. Long flame travel and heat applied to bottom of fire pot, where coal boiler does about 76 per cent of its work. Secondary application of volume air results in not only an effective flame but quiet combustion. Safety control is Mercoid type "S. A." Stack Safety.



Models G and H

Horizontal projection is provided for horizontal boilers. Radiation, Model G up to 2500 sq. ft., Model H up to 4200 sq. ft. Mercoid Visaflame type "L" Safety Switch—the latest development in safety appliances.

Listed as standard by the Underwriters' Laboratory. Approved by the New York Board of Standards and Appeals. Approved by the Massachusetts Department of Public Safety.

The American Nokol Co.

4200 Schubert Ave., Chicago, Ill.

Facts about

New Silent NO COAL Nokol

REG. U.S. PAT. OFF.

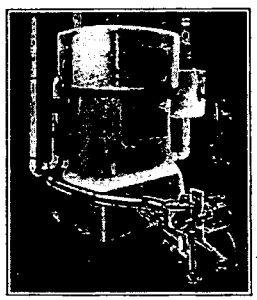
AUTOMATIC OIL HEATING FOR HOMES

Fully automatic oil heat—for residences and other buildings—large or small

General Description.—Nokol was the first automatic oil burner practical for heating homes—perfected 9 years ago. It provides fully automatic heat—governed by thermostatic control with maximum variation of 2 deg. above or below desired temperature. Atomization is by combination of venturi and nozzle—suction provided by blower fan, motor driven.

Combustion.—Since oil can only burn completely in high temperature zones, Nokol has a combustion chamber independent of furnace or boiler. By this means necessary temperatures for complete, clean combustion almost instantly reached—and maintained.

Cost.—In more than 35,000 homes—for periods up to 9 years—Nokol heating costs have been found no higher than for hard-coal; usually less. The **lowest-cost,** fully automatic oil heat **known.**



Typical Nokol Installation, heating 14-room house, Chicago, Ill.

Efficiency.—Orsat tests show an average of 12 per cent carbon dioxide in flue gas—almost instantaneously after starting, and during whole period of Nokol operation. This indicates combustion efficiency of at least .85 per cent.

Ignition.—Nokol has either gas or remarkably efficient electric ignition—the latter for use where gas is not available. The gas "pilot" light is constantly ready for operation. Expanded momentarily as combustion begins and ends—to avoid puffing out.

Noise.—The new Silent Nokol—by simple, effective softening of flame—cuts noise to the vanishing point.

Safety.—Nokol was the first domestic oil burner listed as standard by The Underwriters' Laboratories; approved by all leading safety boards. Equipped with double safety controls—positive in character.

Sizes.—Nokol is made in eight basic sizes—providing the correct burner for most efficient operation in any size boiler with total tax up to 4700 feet of steam radiation and equivalent for hot water or hot air. Two or more burners installed in larger heating plants.

A concise file of data on Nokol—covering every question of installation and operation—sent upon request. It is in convenient form for reference and filing.

Automatic Burner Corporation

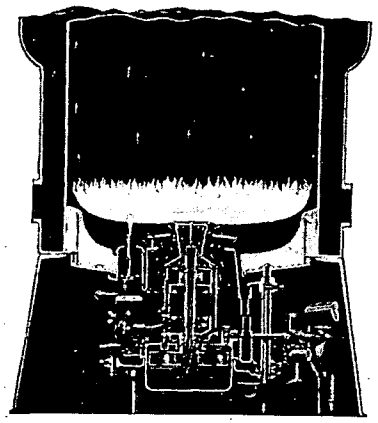
312 North May Street - - CHICAGO, ILL.

How ABC Heats

Your thermostat, placed in one of your living rooms, is set at 70 deg. The temperature in your home drops to 68 deg.—automatically ABC starts.

The lowering of the oil in the burner reservoir drops the float, unseating the three check balls. As the oil flows in from the wall float, which holds one pint of oil, the lowering of the float in its container automatically starts the pump. The pump draws oil from an underground tank.

When enough oil has been admitted into the reservoir the dependable three balls set, stopping



the automatic pump and checking the flow of oil. Observe this: At no time do you have more than one quart of oil in your basement.

The armature shaft by centrifugal force draws the oil through a taper hole up to the atomizing cup. Air is taken in—always the proper amount—through holes in the bottom of the cup.

The oil and air, thoroughly mixed and broken up, are thrown into the boiler, noiselessly, as a fine atomized, instantly inflammable mist. Ignited by the pilot light, the mist of oil burns with a clean, soft flame of circular form.

Twelve Reasons Why A B C Appeals to Engineers

1. **Converts coal boiler into oil burning boiler:** ABC is designed so that it retains the natural functions of a coal heating boiler. All boilers were designed to burn coal—and not to absorb heat traveling at a high velocity. The ABC horizontal circular flame heats from the grate on the water legs. Result: quick heat; low stack temperature; saving in oil.
2. **Oil burned in suspension:** This is the first law of efficient oil burning.
3. **Longer boiler life:** Burners with a concentrated flame in time destroy a boiler. The ABC circular flame, evenly applied all around the boiler, adds to its life.
4. **No carbon or soot:** Engineers know what an immense advantage this is.
5. **No fan or blower:** Heat is not forced up the chimney and wasted.
6. **Less oil required:** Unique means of atomization assures complete combustion. Every particle of oil is burned. The heat rises slowly and is maximumly absorbed by the boiler.
7. **Simple:** The life and amount of service of a piece of machinery is in ratio to the number of moving parts. ABC has only one moving part subject to wear. It is simple. It has no complicated or delicate adjustments.
8. **Burns low-priced oils:** 32–36 gravity oil is recommended.
9. **Odorless:** An ABC heated home is odorless.
10. **No unsightly parts outside of boiler:** The burner is entirely enclosed in the boiler out of the way.
11. **Automatic:** Heat when you want it—as you want it.
12. **Quiet:** The importance of quietness in a domestic oil burner cannot be overestimated. ABC is really quiet.

Full Information will be Sent You Gladly

No.	Maximum Steam Radiation	Max. Hot Water Radiation	Approximate Floor Space Required	Shipping Weight	Price
Type E	3000	4500	Enclosed in Boiler	110 lbs.	$600 to $1,000

ABC OIL BURNER

no noise - no carbon

Ballard Oil Equipment Co.

Oil Burning Engineers and Contractors

NEW YORK **WASHINGTON** **PHILADELPHIA** **NEWARK**

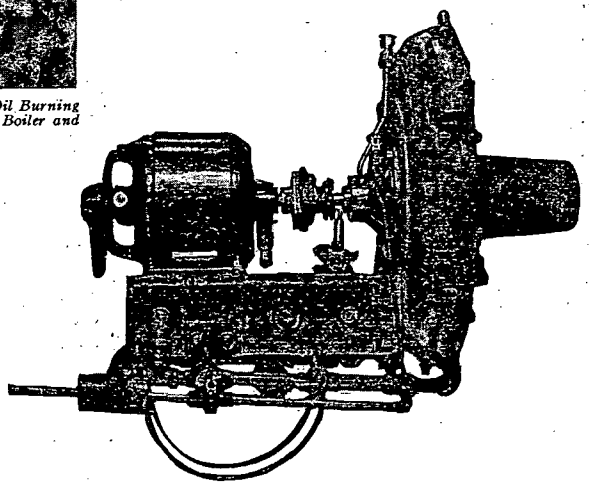
And Agencies Throughout the United States

The Ballard Oil Equipment Company offers a complete line of oil burning equipment for industrial and domestic installation. Its organization centers about its engineering service and its long experience in the field. To the architect, heating engineer and contractor this service is available in the form of expert engineering advice and the sale and installation of equipment which is perfectly adapted to the requirements of the individual job.

Installation of Ballard Type H Rotary Mechanical Burners in two 150-H. P. Simplex Boilers

Ballard Type A, Automatic Oil Burning System Installed in Heating Boiler and Hot Water Heater

Ballard equipment includes: high pressure mechanical burners, steam atomizing burners, the Ballard Type H rotary low pressure mechanical burner for fuel of 12-16 degrees Baumé, the Ballard Type H rotary low pressure mechanical burner and pump unit combined for fuel of 24 degrees Baumé and higher, the Ballard Type A automatic domestic and semi-industrial system, and automatic residence systems. Descriptive literature sent upon request.



Ballard Type H, Rotary Mechanical Burner

Hardinge Brothers, Inc.

Factory Branches:
CHICAGO
549 N. Michigan Ave.
BOSTON
843 Beacon Street

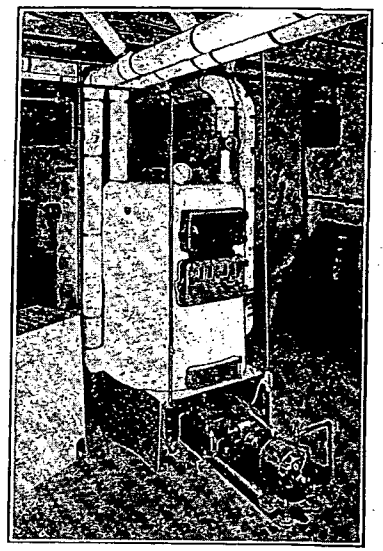
"The Oil Heat Machine with a Ten-Year Guarantee"

Main Office and Factory

4149 Ravenswood Avenue Chicago, Ill.

Branches and Dealers in Principal Cities throughout the United States

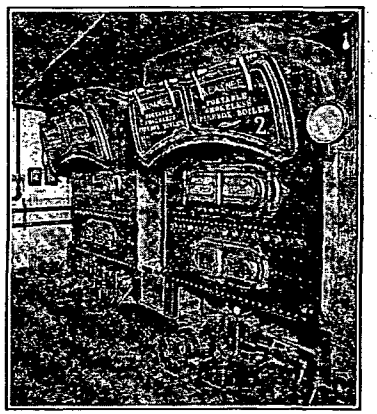
Manufacturers of HARDINGE Domestic and Industrial Oil Heating Equipment, Cataract Precision Lathes, Watchmakers and Opticians Tools and Supplies

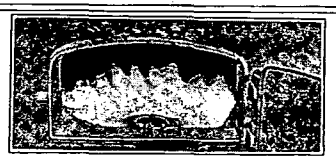


Hardinge Brothers, Inc., manufacture a range of Oil Heating Equipment adaptable to Heating Boiler with steam radiation loads of 500 to 25,000 sq. ft. per unit. It has been the aim of this organization not just to put an Oil Burner on the market, but to build into the HARDINGE the kinds of material, workmanship and design that ample capital and more than one-third century of Precision experience could build. Architects, Heating Engineers and Contractors should feel free to call upon our Engineering Department for information of any kind on Oil Heating problems anywhere—for medium sized and fine homes, apartment houses, where quietness is essential, churches, halls, business houses and industrial plants.

Features:—

1—Mechanical Atomization without the use of fans, blowers, compressors or steam.
2—Applies heat at grate level, scrubbing insulating gases from water legs.
3—It is a self contained unit independent of the Combustion Chamber and not attached to the boiler in any way.
4—Burns automatically any commercial fuel oil available between 28 and 40 deg. A.P.I. Burns manually fuel oil between 18 and 40 deg. A.P.I.
5—Pump—an involute gear type pump which develops a 27 in. vacuum (mercury) at only 80 r.p.m. *Slow Speed* means quietness and *long life.*
6—Fuel Feeding Valve *self cleaning* in its operation.
7—Motor—Standard, horizontal, constant speed (1750 r.p.m.) motor operating under normal temperature conditions.
8—Approved by the *National Board of Fire Underwriters;* Tested and Approved by the New York City Board of Standards and Appeals.
9—Tested over a period of ten years by the ultimate judge of Oil Heat—the User Public who also approve. A book of users and testimonials sent for the asking.



Ratings			HARDINGE ATOMIZER-SIZES	Ratings		
Diam. Inches	Capacity in Sq. Ft. Steam	Motor H. P.		Diam. Inches	Capacity in Sq. Ft. Steam	Motor H. P.
3	500	1/4		6	4200	1/2
3 1/2	800	1/4		6 1/2	5000	3/4
4	1200	1/4		7	6500	3/4
4 1/2	2000	1/4		8	9500	1
5	2800	1/3		9	14,000	1 1/2
5 1/2	3500	1/3	"FROM BUNGALOW TO SKYSCRAPER"	10	25,000	1 1/2

Factory Branch Offices:
SAN FRANCISCO
SACRAMENTO
PHILADELPHIA

S. T. JOHNSON CO.

OIL BURNERS

TRADE MARK REGISTERED

Distributors and Dealers Throughout the United States and in Foreign Countries

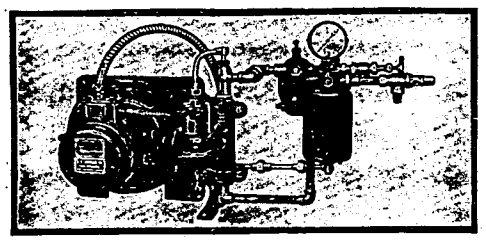
Exclusive Manufacturers of Oil Burners for 22 Years

Main Office and Factory:

948 Arlington Avenue **Oakland, California**

Products

A complete line of oil burning equipment, including Rotary Oil Burners; Oil Pumping Sets; Low Pressure Air-Oil Pump Sets; Johnson's Whirlwind Oil Burners and Oil Storage Systems.

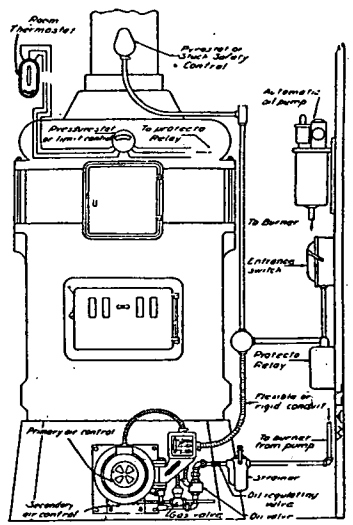


Rotary Oil Burner—Manual or Automatic Control

Rotary Oil Burners: Manual or full automatic control. Five sizes—600 to 20,000 sq. ft. steam radiation. Adapted to all kinds of boilers, using fuel oil from 14 to 34 deg. Baume. Efficient built-in oil pump, supplying oil from underground tank. Approved by Underwriters' Laboratories, the New York Board of Standards and Appeals and Fire Prevention Bureaus in principal cities.

Low Pressure Air Burners and Equipment—For any kind of oil. Unusual efficiency, economy, simplicity. Designed to vaporize heavy crude fuel oil with air pressure 1 to 5 lb. per square inch. Especially recommended for large industrial installations. Largely used for bakers' ovens, cooking ranges, incinerators, etc.

Rotary Oil Burners for Small and Medium-Sized Homes—The new model Johnson Rotary Oil Burner, known as the *Johnson Cub*, is designed for homes of from five to twelve rooms. Simplicity is the keynote in construction, but ruggedly built for long, lasting service. It is easy to install and economical in operation. It has full automatic controls (Minneapolis Heat Regulator). An unusually attractive Oil Burner with its highly polished, dust-proof aluminum casing. For details, write for Bulletin 32.



Note simplified construction of the JOHNSON CUB, *assuring easy installation and freedom from ordinary Oil Burner troubles*

May Oil Burner Corporation

Baltimore, Md.

QUIET MAY

AUTOMATIC OIL BURNER

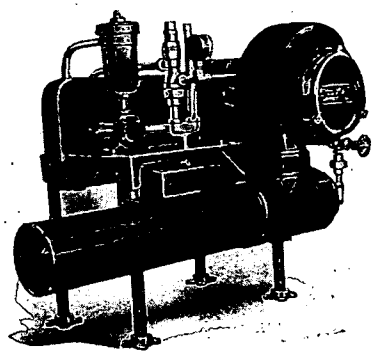
Definite electrical, mechanical and combustion engineering effort brought about the Quiet MAY Automatic Oil Burner. It was built to meet definite, listed requirements. Quiet operation, combustion efficiency and economy in fuel consumption, as well as complete safe automatic control, were sought.

Thousands of Quiet MAY installations testify to the success of the effort. Sizes for any domestic heating boiler.

Economy in Operation.—Quiet MAY burners will operate with any kind of fuel oil approved for domestic use. In communities where the cheapest grade of fuel oil is available Quiet MAY owners effect a considerable economy.

Simple Construction.—The Quiet MAY has only two moving parts—the pump and the motor-blower shaft. This simple construction makes the need for service less likely.

Complete Combustion.—Of course it is easy to say that an oil burner burns the oil completely. And every engineer knows that it is not difficult to arrange special tests that show efficient combustion. It is much harder to make every installation as good as a test installation. But this is what factory training has taught Quiet MAY dealers to strive for. The list of satisfied owners of Quiet MAY burners is proof that the Quiet MAY dealers have succeeded.



Ignition.—The Quiet MAY has electric ignition. Electric ignition has proved its worth conclusively in the automobile and it is this sure ignition that is used in the Quiet MAY.

Control.—The control system on the Quiet MAY insures safe automatic operation. There is thermal control that guards against ignition failure. There is a limiting control that prevents the heating plant from developing excessive temperatures. The thermostat is unusually sensitive.

The whole Quiet MAY unit, whether for homes, apartment buildings, stores, churches, hospitals or schools, is a sound engineering development. It is the kind of equipment engineers like to endorse.

Further information will gladly be supplied through either our local dealer or our central office.

Williams Oil-O-Matic Heating Corporation

Manufacturers of Automatic Oil Burners

Bloomington, Illinois

NEW YORK, N.Y., 101 Park Avenue — CHICAGO, ILL., 185 N. Michigan Avenue

Authorized Dealers and Factory Trained Installation and Service Organization in all Principal Cities of the United States and Canada, also in 75 other large Cities throughout the Civilized World

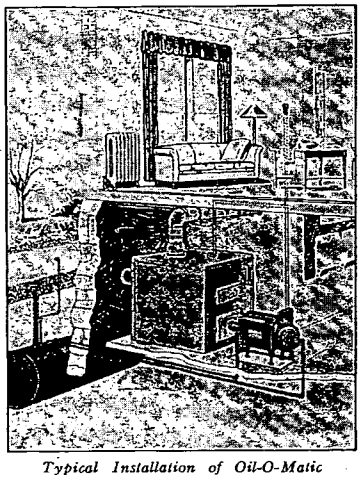
Oil-O-Matic Automatic Oil Burners

Advantages—To burn oil efficiently: (1) Oil must be atomized, not vaporized. (2) Oil must be mixed with a fixed minimum quantity of air. (3) Oil must burn in suspension. (4) Oil must burn in the presence of a refractory material.

OIL-O-MATIC operation complies strictly with these well-known natural laws governing the combustion of liquid fuel, as outlined in Dyson's "Naval Engineering," and the reference works of Harding and Willard Kent, and other like authorities.

The patented exclusive OIL-O-MATIC metering pump permits burning cheap 28 to 30 deg. Baume fuel oil, but will handle equally well, all lighter furnace oils. Change in fuel does not necessitate a change in burner adjustment. OIL-O-MATIC method of atomization eliminates all high pressure and needle valve atomization. OIL-O-MATIC air control permits use of a low velocity air blast, adjustable over a wide range of service, to meet the requirements of all existing types of heating plants. Continuous gas pilot is not used. Automatic intermittent spark and gas ignition operates for about ten seconds only, when burner starts. Room thermostat controls on and off operation of burner. Controls safeguard heating plant temperatures and pressures. Wear is automatically adjusted.

Domestic Hot Water Supply—The mechanically fired, automatically controlled heating plant has permitted the development of a practical and inexpensive, fully automatic domestic hot water supply system, which provides an inexhaustible supply of hot water at a very low cost.



Typical Installation of Oil-O-Matic

Complete description will be found in "Oil Heating—What It Means to the Architect." (See Catalogues).

Operating Efficiency—Combustion efficiency in domestic heating systems, the equal of industrial power plant operation, is obtainable with OIL-O-MATIC. A test run by A. H. Hansen, Engineer, Metropolitan Utilities, Omaha, reads:

"Burner was tested for fuel consumption, gas consumption for ignition, and flue gases were analyzed for combustion efficiency.

"Atmosphere was 29 deg. fahr., house was maintained at 72 deg. fahr. Burner operated 22 per cent of the time. Flue gas analysis—CO_2 12.2 per cent; O, 4.4 per cent; CO, none. Flue and combustion chamber was entirely free of soot."

Details of this and many other tests on request.

WILLIAMS OIL-O-MATIC HEATING

Models—Type 1200 is designed for steam heating system serving 1500 sq. ft. direct steam radiation or less; hot water system serving 2400 sq. ft. direct hot water radiation or less; hot air furnace of 36 in. grate diameter or less.

Type 1800 designed for heating systems larger than the model 1200. Will handle up to maximum of 4000 sq. ft. direct steam radiation; 6400 sq. ft. direct hot water radiation, or hot air furnace with maximum grate area of 14 sq. ft.

Additional load in larger boilers carried by installation of two or more burners.

Model I, industrial, manually controlled oil burner. Capacity same as Type 1800 or for any furnace operation requiring not more than 14 gallons of oil per hour.

OIL-O-MATIC oil burners operate on standard 110- and 220-volt, 60-cycle A.C. or D.C. current, or other usual electrical service.

The New OIL-O-MATIC Junior—becomes available for specifying, approximately January 15, 1928.

Burns cheap oil with the simplicity of gas. Highly efficient.

Perfected especially for the high class, well planned smaller homes. No pressure or noise.

For any type furnace or small boiler.

Range of Service—OIL-O-MATIC oil burners are heating every type of building:

HOUSES	SCHOOLS
BANKS	THEATERS
STORES	HOSPITALS
HOTELS	CHURCHES
GARAGES	CLUBS

APARTMENTS

Where questions arise regarding details of OIL-O-MATIC installations, counsel of OIL-O-MATIC engineers is available.

Installation—Grates and ash pit door are removed. Ash pit door is closed with fire brick after OIL-O-MATIC draft pipe is inserted, as illustrated.

Contractor should also figure oil storage, consisting of a 60-gallon tank, or other capacity, installed to comply with local ordinance; to be installed in basement; or a 1000 or 2000-gallon outside tank, buried not less than 3 ft. below grade and not more than 100 ft. from OIL-O-MATIC; bottom of tank to be not more than 12 ft. below suction pump on burner.

Installation must be made in accordance with Fire Underwriters rules, city ordinances and fire department regulations.

Specification—**1**—The oil burner must be approved by the National Board of Fire Underwriters' Laboratory to burn 28 deg. Baume fuel oil.

2—The oil burner must mechanically control, regulate or meter the flow of oil to the atomizing assembly, so that 28 deg. Baume fuel oil or any lighter oil may be burned, at will, without a change in burner adjustments.

3—The oil burner must mechanically atomize oil and be ignited and burned in suspension, before coming in contact with any surface; in the presence of a refractory material.

4—The oil burner installation must be provided with complete automatic controls, approved by the National Board of Fire Underwriters that—automatically operate the oil burner so as to safely maintain the desired room temperature; control maximum temperatures and pressures in the heating plant; immediately stop the oil burner and the flow of oil to the oil burner, in the event of any irregularities in operation, such as failure or oil supply or failure of oil to ignite in boiler.

5—The oil burner installation must comply strictly with all the National Board of Fire Underwriters' regulations and all local ordinances and must meet available electric current requirements.

6—The oil burner installation must be complete in every respect, tested and ready for service.

7—The contractor shall agree that the oil burner will be of sufficient capacity to operate the boiler (or furnace) continuously, at the manufacturer's full rated capacity.

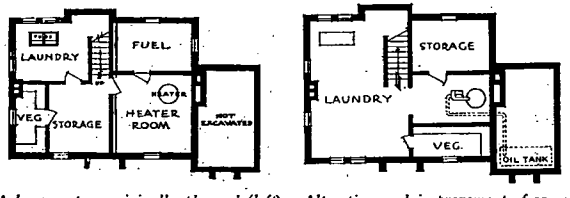
For outline of specification covering oil storage tank installation see "Installation."

Detailed OIL-O-MATIC specification is contained in "Oil Heating—What It Means to the Architect." (See Catalogues).

Catalogues

"Oil Heating—What It Means to the Architect."

"Oil Heating At Its Best."

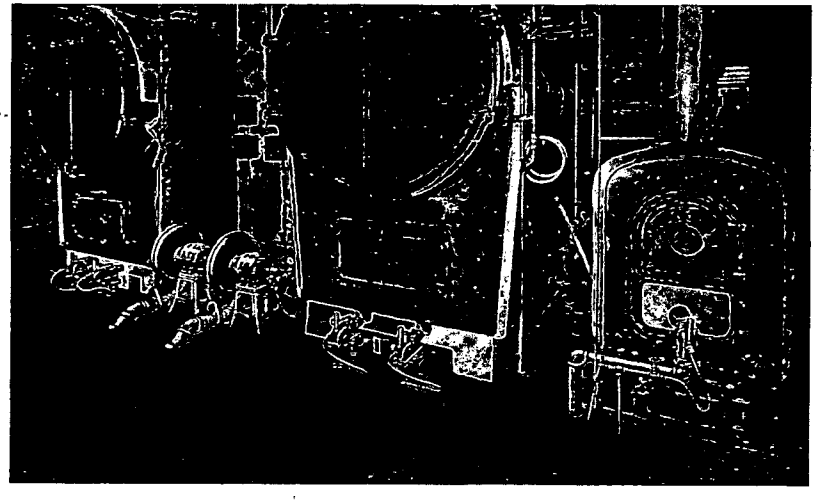


A basement as originally planned (left). Alteration and improvement of same basement plan, permitted by Oil Heating (right).

Winslow Boiler & Engineering Co.

Builders of Oil Burners

CHICAGO	NEW YORK	GALESBURG
844 Rush St.	SHOW ROOM: 46 E. 41st St.	Illinois



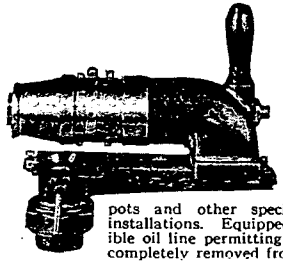
A WINSLOW INDUSTRIAL BURNER installation consists of a motor-blower unit and a burner nozzle assembly.

The motor blower unit may be located at any convenient point near the boilers and connected to the burner assembly, in front of the boilers, by oil and air piping of correctly proportioned sizes.

The pump pulls the oil from the storage tank and delivers it at from 7 to 10 lb. pressure to the burners. At the same time the blower is supplying the required air at low pressure, measured in ounces, to effect a thorough atomization of the oil. This burner is complete with a strainer, pressure gage, check valve, oil relief valve, motor, blower and pump unit.

Single motor blower units handle a variety of burner assemblies. Where dual units are twinned the capacities are not only doubled but the plant is insured against any shut down. There are several sizes of motor blower units and also of burners.

In specifying burners determine whether the boilers are to carry an overload. Ordinarily, steel boilers can be provided with burners rated at the boiler rating unless overloads are contemplated. On the other hand, cast iron boilers can usually be provided with burners rated at about 70 per cent of the boiler rating. This is due to the different methods of rating steel and cast iron boilers.



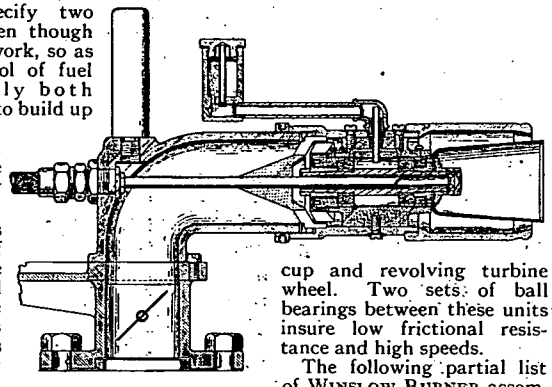
Sliding Type

The sliding type burner is particularly adapted to bake ovens, lead melting pots and other special industrial installations. Equipped with a flexible oil line permitting burner to be completely removed from slide base.

Wherever possible specify two smaller burner nozzles even though one large one will do the work, so as to assure an easier control of fuel consumption. Frequently both burner nozzles will be used to build up steam pressure and then one can be cut off entirely. Where loads are apt to be variable the double burner nozzle is ideal.

The cut to the right shows the efficient method of attaining atomization. The oil travels down the central tube and impinges onto the rotating disc. It whirls centrifugally and strikes the heel of the revolving cup in a thin film. It then travels along the inner wall of the cup to the rim where it is whirled off at tremendous speed, mixing with the air from the barrel and entering the boiler perfectly atomized.

The cut also shows the balanced rotating cup and revolving turbine wheel. Two sets of ball bearings between these units insure low frictional resistance and high speeds.



The following partial list of WINSLOW BURNER assemblages will be of assistance in determining correct sizes for a large scope of work. The ratings in column five are based on 100 sq. ft. of steam radiation per horsepower and represent the total load the burner can handle.

Designation	Motor Blower Unit	No. and Size Burners	Maximum Steam Radiation	Approximate Motor Unit Floor Space	Approximate Shipping Weight	H. P.	Pump	Air
Alexander	B-60	1 T 10	3500	24″ x 24″	290 lbs.	½	⅜″	2″
Amos	B-60	2 T 10	5000	24″ x 24″	265 lbs.	½	⅜″	2″
Anthony	B-60	1 T 30	5000	24″ x 24″	280 lbs.	½	⅜″	2″
Austin	B-60	2 T 30	7500	24″ x 24″	285 lbs.	½	⅜″	2″
Barney	B-90	3 T 10	9500	24″ x 24″	300 lbs.	1	⅜″	2″
Benjamin	B-90	3 T 30	11,000	24″ x 24″	315 lbs.	1	⅜″	2″
Bernard	B-90	2 T 30	10,000	24″ x 24″	290 lbs.	1	⅜″	2″
Blaine	B-90	2 T 40	12,000	24″ x 24″	305 lbs.	1	⅜″	2″
Carl	B-120	1 T 70	10,000	24″ x 24″	310 lbs.	1½	⅜″	2½″
Charles	B-120	4 T 10	11,000	24″ x 24″	320 lbs.	1½	⅜″	2½″
Curtis	B-120	3 T 30	14,000	24″ x 24″	330 lbs.	1½	⅜″	2½″
Daniel	B-180	5 T 10	14,000	28″ x 28″	365 lbs.	2	½″	2½″
David	B-180	4 T 30	20,000	28″ x 28″	355 lbs.	2	½″	2½″
Dean	B-180	3 T 40	22,000	28″ x 28″	370 lbs.	2	½″	2½″
Delbert	B-180	2 T 70	22,000	28″ x 28″	365 lbs.	2	½″	2½″
Earl	B-300	8 T 10	20,000	28″ x 28″	400 lbs.	3	½″	3″
Edward	B-300	6 T 30	24,000	28″ x 28″	425 lbs.	3	½″	3″
Elmer	B-300	5 T 40	30,000	28″ x 28″	455 lbs.	3	½″	3″
Eugene	B-300	4 T 70	34,000	28″ x 28″	460 lbs.	3	½″	3″
Frank	B-500	1 T 250	25,000	28″ x 28″	550 lbs.	5	½″	3″
Fred	B-800	2 T 250	50,000	28″ x 28″	650 lbs.	5	½″	3″

In addition to the WINSLOW INDUSTRIAL burner described here the Winslow Boiler & Engineering Company manufacturers a complete line of fully automatic, residential and apartment house burners.

The electric ignition KLEEN-HEET burners, with the vacuum oil feed eliminating the usual basement auxiliary tank, are built in several sizes and are thus suitable for a great range of work.

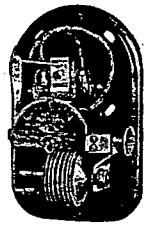
The KLEEN-HEET GJ gas ignition burners, without the vacuum feed but completely automatic in operation, are in four sizes. The No. 10 is rated at one thousand feet hot water and is suitable for the average home. The No. 6 is especially adapted to Arcolas and small domestic water heaters.

Inquiries to the INDUSTRIAL DIVISION of the WINSLOW BOILER AND ENGINEERING COMPANY, 844 Rush Street, Chicago, Illinois, will be promptly answered.

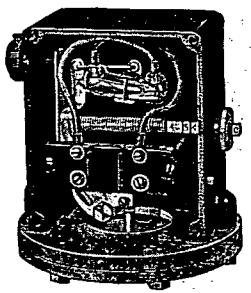
ABSOLUTE CON-TAC-TOR CORPORATION

ELKHART, INDIANA

Manufacturers of Temperature and Pressure-Operated Automatic Electric Controls, Mercury Switches and Safety Devices for Oil and Gas Burners

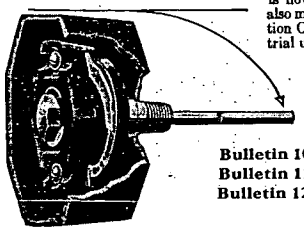


No. 64 Thermoswitch



No. 88 Pressureswitch

No. 26AR Convoswitch



No. 117 Plugswitch

CON-TAC-TORS (Mercury Switches) and Contactor Quality Controls are available for the temperature or pressure regulation of almost any type of heating or ventilating installation or heating device. These switching devices, using Con-Tac-Tors, will be found long of life because of the non-deteriorating contact points which are enclosed within the hermetically sealed gas filled tube and because the switching action is obtained through rolling mercury. In addition, Con-Tac-Tor instruments are designed for simplicity, dependability, accuracy and ease of installation.

Oil Burners

A complete line of operation and safety devices, Listed as Standard by Underwriters' Laboratories and widely used because of their reliability and easy installation, are available to manufacturers, distributors and dealers of full automatic or semi-automatic oil burners. This line includes room temperature controls, boiler controls, safety devices, dry boiler protection and gas and oil valves.

Gas and Coal Burners

Motor and valve controls operated from room temperature, boiler pressure, hot water temperature, or hot air temperature, may be selected to meet each individual application on forced draft coal burners, forced feed coal burners or gas burners.

Unit Heaters

Automatic operation of unit heaters adds materially to their value in the industrial and public building field in which this type of heating device is rapidly gaining popularity. Con-Tac-Tor Controls will make these systems fully automatic, efficiently and economically.

Fan Controls

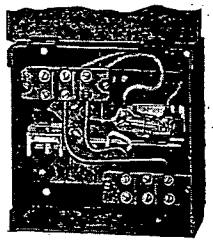
With exhaust fans or forced draft fan control which is dependent on temperature, Con-Tac-Tor automatic regulating appliances, including the room temperature controls and Furnaceswitches, will be found ideal. Submit your fan control problems to Con-Tac-Tor for solution.

Industrial Installations

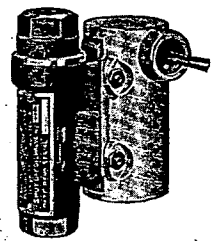
Special wide range temperature controls are available for industrial installations where temperatures lower than those of domestic installations are demanded.

Other Applications

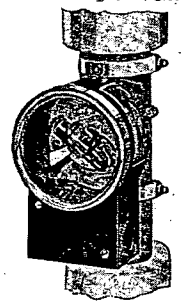
Con-Tac-Tor is prepared to furnish various types of mercury switches for application to almost any type of switching mechanism to provide longer life for the unit. Many mechanisms so adapted may be made to automatically control equipment that is now functioning manually. Con-Tac-Tor also manufactures a complete line of Refrigeration Controls for both commercial and industrial units.



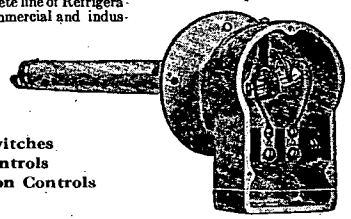
No. 111 Warpswitch



No. 110 Shut-off Oil Valve



No. 56 Aquaswitch



No. 68R Furnaceswitch

Send for

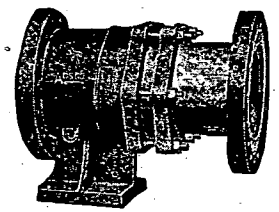
Bulletin 100—Mercury Switches
Bulletin 110—Heating Controls
Bulletin 120—Refrigeration Controls

AMERICAN DISTRICT STEAM COMPANY

GENERAL OFFICES AND WORKS
NORTH TONAWANDA, N.Y.

Branches and Agents in Principal Cities

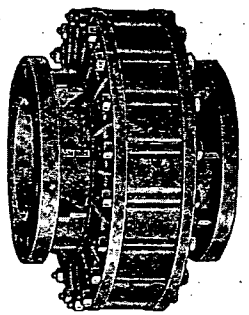
A few of the many types of ADSCO Expansion Joints



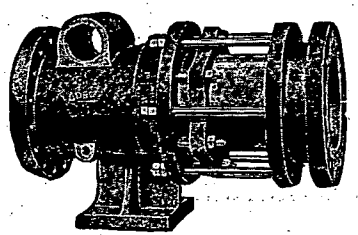
S-2

(At Left)
ADSCO 125 lb. Single Semi-Guided Expansion Joint. With anchor. No service. Traverse 4, 6, 8, 10 and 12 in.

(At Right)
ADSCO Double Variator. For pressures up to 125 lbs. Total traverse 2 in. Not furnished with service outlets or anchorage.



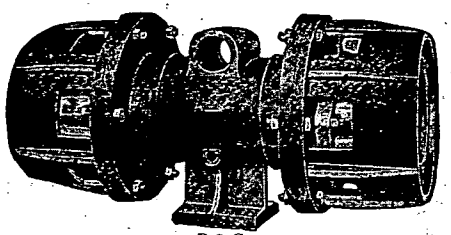
P-1



S-4 T

(At Left)
ADSCO 125 lb. Single Semi-Guided Expansion Joint. With Tie Rods. With anchor. With service. Traverse 4, 6, 8, 10 and 12 in.

(At Right)
ADSCO 250 lb. Double Externally-Guided Expansion Joint. With anchor. With service. Traverse 4, 6, 8, 10 and 12 in. Per Slip.



D-8 G

ESTABLISHED 1841

E. B. Badger & Sons Co.

Manufacturers of Expansion Joints for High and Low Pressure

OFFICE AND WORKS
63-75 Pitts Street, BOSTON, MASS.

SALES OFFICE
101 Park Avenue, NEW YORK

Badger Self-Equalizing Expansion Joints

Made of seamless copper tubes, corrugated and fitted with cast iron or steel rings to control the expansion and provide equal distribution over each corrugation. One piece corrugated construction effectively absorbs vibration and expansion without the use of sliding surfaces which require packing. Space required is usually only that of any flanged fitting. Maintenance is negligible.

Built in Standard and Extra Heavy patterns, furnished with standard flanges for pressures up to 125 lb. and extra heavy flanges for all pressures from 125 to 200 lb., also flangless design for welding into welded lines. Monel metal sleeves are used inside of the corrugations, to protect the copper, when used with super-heated steam and other high temperature fluids.

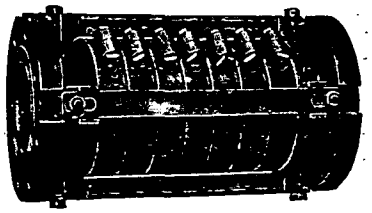


Fig. 1

This type of Joint is furnished in 4 in. and 5 in. sizes, with four and eight corrugations to take 1 in. and 2 in. of expansion. For smaller sizes, we furnish a 4-in. joint with companion flanges, bolts and gaskets, tapped for the size required.

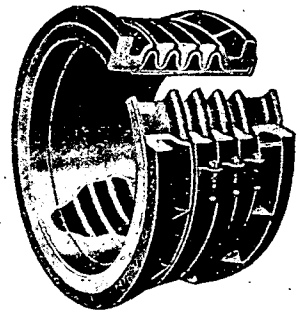


Fig. 3

Flanged Expansion Joint with Monel metal sleeve for super-heated steam.

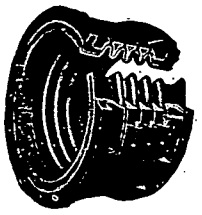


Fig. 2

This type of Joint is made in sizes from 6 to 20 in. inclusive, with two, three, four or five corrugations, 2¼ in. deep, each corrugation taking ½ in. of expansion.

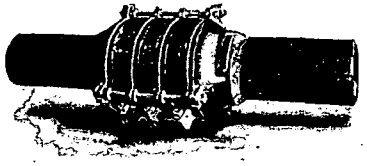


Fig. 4

Welding Expansion Joint.

Self-Equalizing Expansion Joints

Where welded joints are preferred BADGER SELF-EQUALIZING EXPANSION JOINTS are now furnished with steel or wrought iron pipe ends, for welding directly into the pipe line itself.

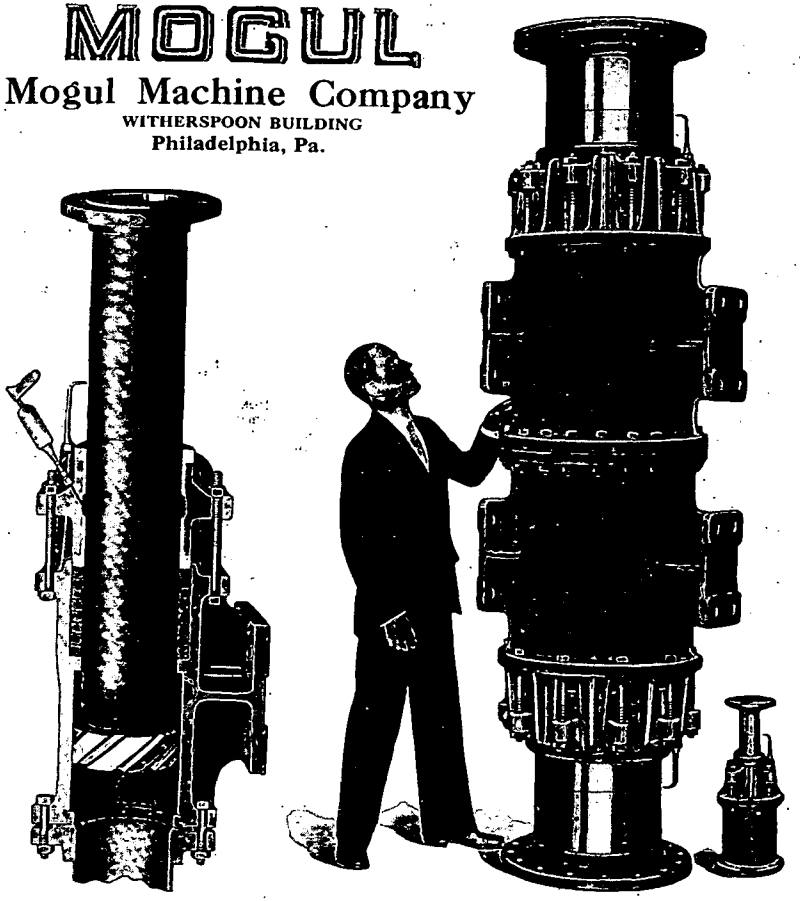
The same leakless one piece deeply corrugated copper expansion element is retained, with the heavy cast iron equalizing rings that distribute the stresses uniformly throughout the length of the joint.

Guaranteed for 200 lb. working saturated steam pressure. Sizes 5 in. and larger.

MOGUL

Mogul Machine Company

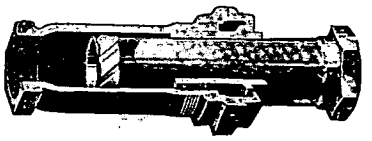
WITHERSPOON BUILDING
Philadelphia, Pa.



"MOGUL" DOUBLE-END-GUIDED, TYPE F. L. J. (FLANGED) EXPANSION JOINTS

Built in all pipe sizes from 1½" to 6' diameters, for extremely high or low pressures and temperatures, for saturated steam, superheated steam, hot or cold water, oil or gas and other fluids.

They are Double-End-Guided, have extremely deep packing chambers and unusually long packing-gland take up. They have built-in Traverse Stops and large graphite lubricating chamber. They may be packed while the line is hot and in an expanded condition. *Write for Bulletin with complete description and dimensions.*



"MOGUL" DOUBLE-END-GUIDED, TYPE R. S. J. (RISER) EXPANSION JOINTS

Built with screwed ends, in all pipe sizes from ¾" to 4" pipe diameters. *Write for Bulletin and dimensions.*

American Blower Company

General Offices: Detroit

Branches and Sales Offices

City and Address	Telephone
Atlanta, Ga., Bona Allen Bldg.	Walnut 5643
Baltimore, Md., Munsey Bldg.	Plaza 3774
Birmingham, Ala., American Trust Bldg.	Main 1278
Boston, Mass., 10 High St.	Liberty 8347
Buffalo, N.Y., White Bldg.	Seneca 2668
Charlotte, N.C., 208 Piedmont Bldg.	Phone 1254
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	VAndike 4838
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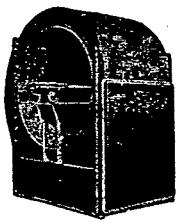
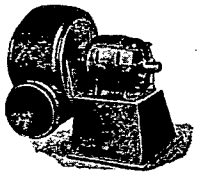
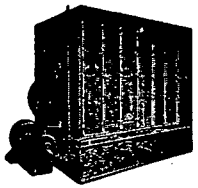


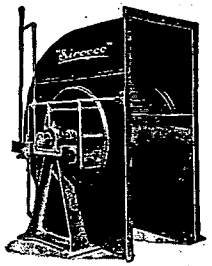
"Sirocco" Fans and Blowers for heating, ventilating, cooling, drying and mechanical draft.



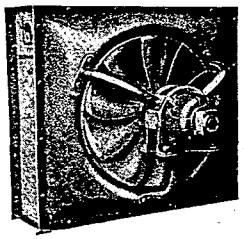
"Sirocco" Utility Blower—a compact, durable ventilator for installation with ducts.



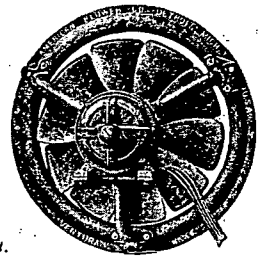
"Sirocco" Air Washer — for purifying and humidifying air for dehumidifying and cooling.



"ABC" Air Washing and Cooling Fan—an automatic, highly effective and durable unit that provides for purification, humidification and cooling.



Venturafin Unit Heater—one small unit is equal to 500 feet of direct radiation—occupies only one-fourth the space and has only one-tenth the weight.



"Ventura" Disc Fan for operation under free air delivery conditions — a complete ventilation system in itself.

Descriptive Catalogues sent upon request.

Bayley Blower Company

730 Greenbush Street — **Milwaukee, Wisconsin**

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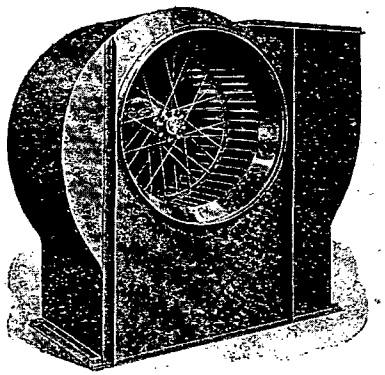
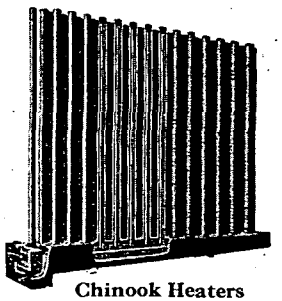
Heating, Ventilating, Air-Washing, Exhaust and Drying Equipment



Plexiform Fans

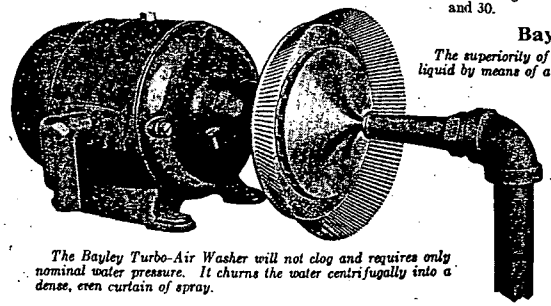
A well-balanced fan for ventilating public, office and industrial buildings, mines, tunnels, etc., and for heating, drying and air washing systems. Space and power economy are some of the advantages it offers. Complete information in Bulletin No. 26.

Separate bulletins are issued on Air Washers, B.t.u. Heaters, Dryers, Chinook Heaters, Plexiform Fans, Exhaust Fans, Disc Fans. These will be furnished on request. The Company also furnishes engineering information in connection with the application of any of the products manufactured.



Chinook Heaters

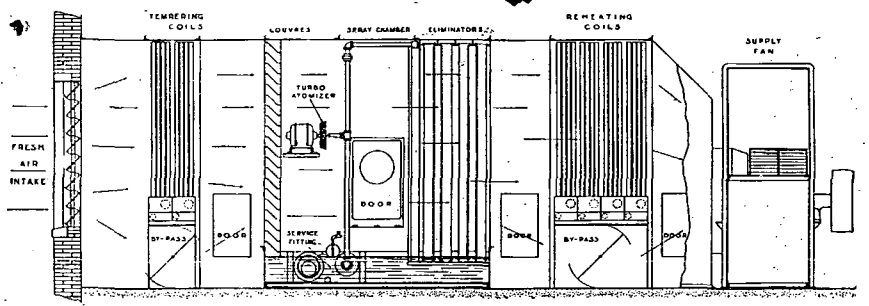
The Bayley Chinook Heater is a tube-within-a-tube radiator without return bends, elbows or nipples. Circulation is established from the steam chamber through the inner tube, and back through the outer tube to the return chamber. Used in connection with the Plexiform fan, also for indirect radiations, and for cooling water. Complete information in Bulletins Nos. 24 and 30.



The Bayley Turbo-Air Washer will not clog and requires only nominal water pressure. It churns the water centrifugally into a dense, even curtain of spray.

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. As distinct from all other types of washers, it will not clog because it operates on the principle of centrifugal force breaking the water into a finely atomized spray—the water is delivered to the revolving cone through a large or fice nozzle and at low pressure. This revolutionary non-clogging feature assures a steady, uniform spray with intimate contact between air and spray. No screen in pump intake requiring cleaning and no fine orifice nozzles to require attention because of clogging. The Bayley Atomizer fits any air washer. Washers made in various sizes for washing air or gases and for use in chemical plants. Complete information in Bulletin No. 25.



Buffalo Forge Company

Buffalo, New York

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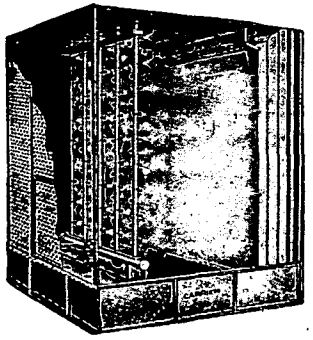


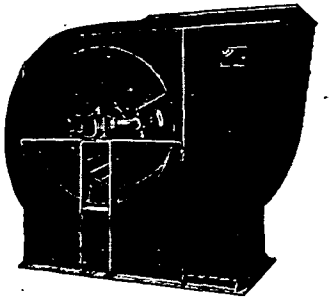
Carrier Air Washers

One-piece eliminators and scrubbers that are easily assembled in a few minutes and give great cleaning effect. Spray nozzles prevented from clogging by tank-width screen. Original efficiency is maintained indefinitely by a few minutes flushing out each week.

Buffalo Niagara Conoidal Fans handle large quantities of air at high efficiency under big overloads in industrial plants. Low speed and great capacity well suited to belt drive.

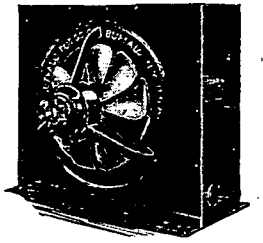
Buffalo Breezo-Propeller Fans are very successfully used for removing steam, odors or foul air in shops, mills and factories. Belted or direct motor driven types.

Buffalo Duplex Conoidal Fans, shown below, maintain steady pressures and good efficiency over a greater range of air demand than is possible with any other construction. Best adapted to schools, public buildings, offices, etc. Moderate speed for direct connection to motor.



Buffalo Unit Heaters

Made in four types to suit every kind of building. BREEZO-FIN Heaters (shown here), Vento Heaters, Hi-Pressure Pipe Coil Heaters, suitable for pressures up to 150 lb., and direct fired units. Catalog 466 describes all types and sizes. Write for it today.



Buffalo Products

Conoidal Multiblade Fans
Carrier Air Washers
Pipe Coil Heaters
Ventilating Sets
Disc Fans
Humidifiers
Generators Coolers
Gas Scrubbers
Stoker Fans
Induced Draft Fans
Planing Mill Exhaust Fans
Unit Heaters
Dust Collectors
Pressure Blowers
Drying Apparatus
Spray Nozzles

Forge Shop Equipment

Clarage Fan Company

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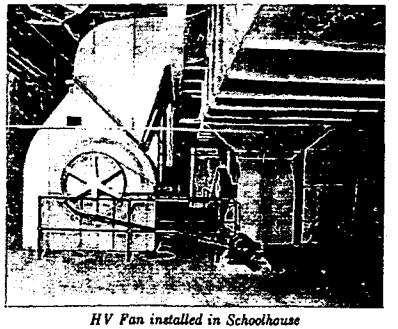
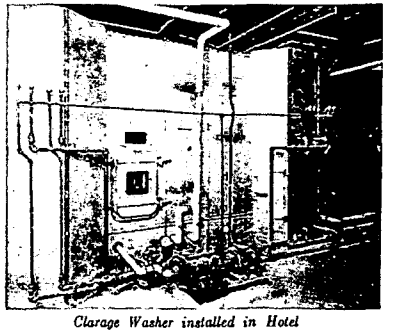
Consult Telephone Directory for Street Address of any Clarage Branch Office

PRODUCTS—Heating, Ventilating, Air Conditioning Equipment and Allied Apparatus: HV Multiblade Fans, Air Washers, Exhaust Fans, Unit Heaters, Steam Engines, Etc.



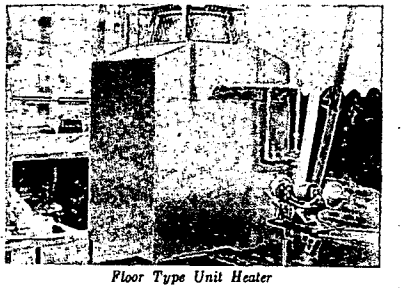
HV Fan installed in Schoolhouse

Type HV Fan—for heating, ventilation, air conditioning, drying, etc. High maximum efficiency of 77 per cent saves 15 to 20 per cent in power required for drive. Complete range of sizes with capacities from 500 to 236,000 c.f.m. Furnished with dust-proof, oil-tight bearings. Suitable for direct connection or belt drive.

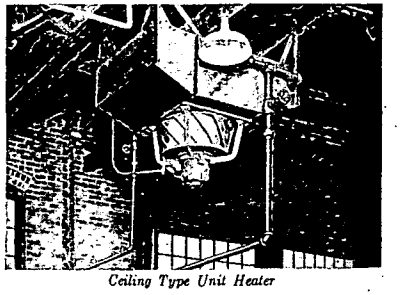


Clarage Washer installed in Hotel

Type V Air Washer—for air conditioning of all kinds. Spray nozzles so perfected that dense mist screen is obtained at lower pump pressures, saving as high as 25 per cent in horse power for operating pump. Spray nozzles cannot clog. New design of eliminators greatly simplifies erection. Sizes to meet all requirements. Performance fully guaranteed.



Floor Type Unit Heater



Ceiling Type Unit Heater

Clarage Unit Heater—for heating all types of industrial plants, garages, etc. The only unit heating equipment delivering heat direct from fan radially in all directions in horizontal plane. Furnished with centrifugal fan that cannot overload motor. Sturdy, compact, light-weight and shipped ready to run. Rated at five times efficiency of equal amount of direct radiation. Built for both floor and ceiling installation as shown, in sizes to meet all requirements.

CATALOGS ARE AVAILABLE ON EVERY CLARAGE PRODUCT—WRITE FOR THEM

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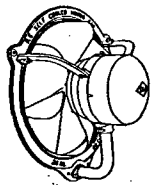
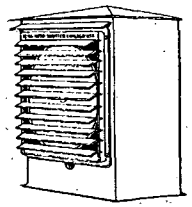
ILG Ventilation

for Offices, Stores, Restaurants, Factories, Theatres, Homes, Etc.



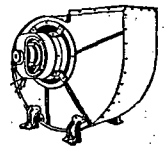
ILG Electric Ventilator

The only propellor fan made with a fully enclosed, self-cooled motor. Manufactured and carried in stock in all sizes—12 to 72 in., for any current or voltage. Guaranteed as a complete unit.



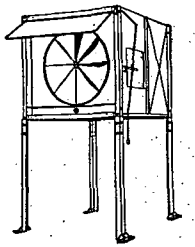
ILG Power Roof Ventilator

One ILG Power Roof Ventilator is equal to three ordinary gravity or natural ventilators. Moreover, provides positive ventilation, winter or summer, in any kind of weather. Recommended for one, two and three story buildings. Sizes 12 to 72 in.



ILG Direct Connected Blowers

The motor is a built-in feature—no pedestal or support required. Shipped from factory completely assembled ready to bolt in place. Sizes ranging from 25 to 90 in.



ILG Unit Heaters

More than 10,000 in use. Recommended for spacious warehouses, factories, garages, halls, etc. A new method of blast heating using steam or hot water heat. Made for ceiling and floor installation.

Ask for any or all of these New Pictorial Bulletins

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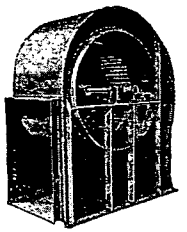
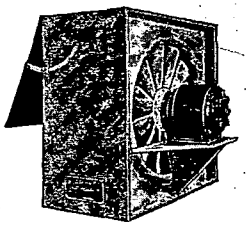


Type ME Fan

Type ME Fans cover a wide range of capacities from 100 c.f.m. to 300,000 c.f.m. Sizes up to and including No. 39 made with cast iron inlet stands and are reversible, the larger sizes made non-reversible. Fans deliver large quantities of air at high efficiency. Cone Back Multi-Blade Wheels with forward curved floats used exclusively. Fans are regularly made either with overhung pulley or overhung wheel of all hands and discharges.

We also manufacture Fans for mechanical draft, conveying systems, foundries, gas plants and stokers.

Write for Catalog No. 100 containing complete data.

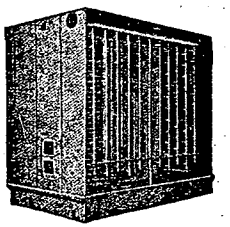


Comet Unit-Heaters

For use with steam. Made in two sizes, as shown in table. A Heavy Duty Disc Fan direct connected to motor drives air over copper heating coils. Unit-Heaters using pipe coil and vento made in convenient sizes.

Write for Bulletin 85 which gives complete data including B.t.u. capacities under various conditions.

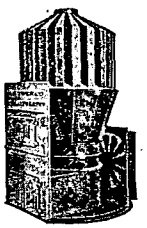
Size Heater	Cu. Ft. per Minute	Cu. Ft. per Hour	Fan			Dimensions			Heater	Wt. Complete
			Size	R. P. M.	H. P.	Height	Width	Depth	Sq. Ft.	
24	2400	144,000	18	850	¼	24	24	10	91	180
60	6000	360,000	30	550	½	34	34	12	190	485



Air-Washers and Humidifiers

Peerless Air-Washers and Humidifiers, Type "D" and "E," with capacities ranging from 3600 c.f.m. to 112,000 c.f.m. of value for washing, drying, humidifying and cooling. Also for special processes as paper, textiles, tobacco, glue, leather and wood.

Write for more detailed descriptive literature.



Thermair Fan Furnace

Complete heat machine ready to operate, made in one size only, 6000 c.f.m. with 600,000 B.t.u.'s per hour under ordinary fuel consumption. Will heat any building with 10,000 sq. ft. floor area. Furnace has a 30 in. fire pot, self-cleaning all steel radiator with 290 sq. ft. of prime heating surface and requires floor space 6 ft. square with 9 ft. overall height. Is furnished with a direct connected Heavy Duty Disc Fan. Easy to install as no duct work is needed.

Bulletin No. 90 gives complete data.

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STURTEVANT PRODUCTS

The wide application of Sturtevant Products can hardly be discussed here; so for the convenience of the architect, engineer and contractor the publications listed below have been prepared to aid in the selection of proper equipment for industrial, public, and private buildings of all types and sizes. We will gladly send you any of these publications on request.

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Each office, address shown above, maintains a force of trained engineers who are always ready to analyze the conditions of any prospective installation and make recommendations for suitable equipment.

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Heating and Ventilating Equipment

No. 215 Heating and Ventilating Treatise.
227 Heating and Ventilating Layouts.
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271 Multivane Fans.
279 Disc and Propeller Fans.
283 Autoforce Ventilators.
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No. 344 Unit Ventilator
345 Carbon Monoxide Asphyxiation and Its Prevention.
347 Tubular Air Heater.
1011 Heating and Ventilating Picture Book, Factory Section.
1012 Heating and Ventilating Picture Book, School Section.
1013 Heating and Ventilating Picture Book, Public Building Section.
1014 Heating and Ventilating Picture Book, National, State and County Building Section.
1016 Heating and Ventilating Watervliet, Shops D. & H. Railroad.

Power Plant Equipment

No. 222 Fuel Economizers in Paper Mills.
236 Forced Draft Apparatus.
275 Gear Transmissions.
288 Forced and Induced Draft with Mechanical Stokers.
301 Cindervane Fans.
311 Steam Turbines, Type 12.
322 Coal Burning Blowers.
330 Turbovane Fans, Design 4 and 5.
331 Air Economizers.
334 Lead Coated Extended Fin Economizers.
346 Propeller Type Forced Draft Fan.
348 Turbovane I. D. Fan.
309 Turbo-Transmissions.

Vacuum Cleaning Equipment

No. 320 Stationary Vacuum Cleaners.
324 Vacuum Cleaners, Heavy Duty.
342 Vacuum Cleaner, Furnace and Boiler Cleaning.

L. J. Wing Mfg. Co.

Branch Offices in Principal Cities

663 Hudson St., New York
PHONE: CHELSEA 0027-0030

Factory: NEWARK, N. J.

Manufacturers of Wing Featherweight Unit Heaters, Wing Turbine and Motor Driven Blowers, Wing-Scruplex Fans, Exhausters, Fog Eliminators

Wing Featherweight Unit Heaters

The Wing Featherweight Unit Heater, expressly designed for overhead installation, makes available for any industrial building a heating system that leaves all floor and wall space absolutely unobstructed. The success of this system has been proven by the satisfactory operation of several hundred units in industrial buildings of every kind and description.

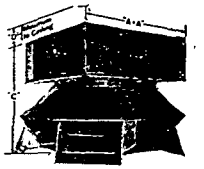
The installation of Wing Featherweight Unit Heaters is extremely simple, due to their light weight and small dimensions. For instance, a unit equal in heating effect to 12,000 sq. ft. of direct radiation, weighs only 332 lbs. A few advantages attending the installation of Wing Featherweight Unit Heaters may be briefly summarized as follows:

The heated air from the units, located at or near the ceiling or roof, is delivered directly downward toward the floor, heating the working level first. Chilled areas, caused by opening of doors, are almost instantly brought back to normal temperature by this downward method of heating.

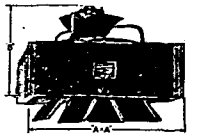
Since the air recirculated by the heaters is taken from the upper spaces and delivered to the lower levels, it is evident that an active circulation of air from the ceiling to the floor is continuously maintained and that, therefore, excessive heat is not allowed to accumulate in the upper spaces, as is the case with any system of heating that allows the heat to rise to the ceiling immediately, as it does in the case of direct radiation.

The steam and return lines are carried entirely overhead, eliminating costly pipe trenches which are necessary when radiation is placed at or near the floor.

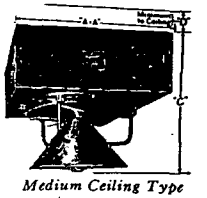
All vertical type heaters are furnished with ball bearing motors that do not require attention more than once a heating season.



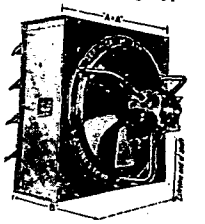
Low Ceiling Type



High Ceiling Type

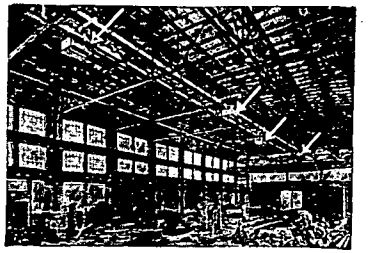


Medium Ceiling Type



Horizontal Type

Low Ceiling Heater in Furniture Factory

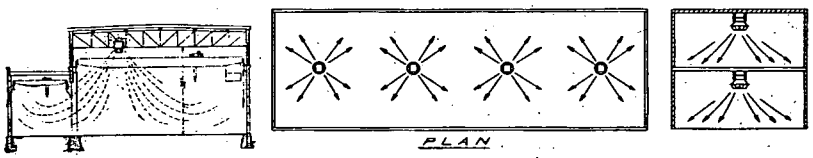


High Ceiling Heaters in Car Repair Shop

Methods of Installation

The drawings below show a typical high ceiling and low ceiling installation, together with a plan view illustrating the general distribution and diffusion of the heated air from the unit heaters. The first illustration shows the high ceiling type heater installed 30 or more feet from the floor, above the travelling crane, the heater arranged so that the left, the lower portion of the building is also heated. The third illustration shows a typical multi-story building heated with Wing low-ceiling type Unit heaters. The column of heated air leaves the heater with sufficient velocity to strike the floor with considerable force from this point, but by the aid of adjustable diffusers the column is divided and directed so that no objectionable velocity is felt at the head line. The best and most economical installation of Wing Featherweight Unit Heaters is when they are placed close to the roof or ceiling.

Five Wing Heaters in this Shop



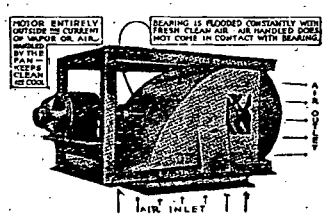
Condensed Table of Engineering Data

Unit Size	"A x A" Inches	B Inches	C Inches	D Inches	Air C.f.m.	Motor Hp.	Temperature		B.t.u. per Hour Available	Approximate Shipping Weight Lb.
							Room	Leaving		
13-4-12	19¾	25	25	6	1150	⅛	60	110	69,500	185
17-3-12	22¾	27½	27½	6	1950	¼	60	110	96,900	212
22-3-12	27¾	27¼	27¼	6	3200	⅓	60	112	162,000	270
22-4-12	27¾	27¼	27¼	6	2800	⅓	60	122	169,000	280
22-5-12	27¾	27¼	27¼	6	2600	⅓	60	133	180,000	288
25-4-12	32¾	28¾	28¾	7	4800	½	60	122	289,500	320
25-5-12	32¾	28¾	28¾	7	4500	½	60	133	311,400	332
30-4-85	40⅛	37¼	37¼	8	6900	1	60	122	416,000	360
30-5-85	40⅛	37¼	37¼	8	6500	1	60	133	450,000	365
36-4-85	46⅛	39⅞	39⅞	8	9600	2	60	122	579,000	504
36-5-85	46⅛	39⅞	39⅞	8	9000	2	60	133	623,000	528

Space does not permit complete table for other room temperatures but this data will be gladly furnished on application.

Wing Fog Eliminators

Wing Fog Eliminators supply tempered fresh air to completely de-fog dyehouses, bottling, preserving and pasteurizing plants, paper mills, and in general any building or room where steam, fog or fumes are liberated in manufacturing processes.



Wing-Scruplex Exhauster

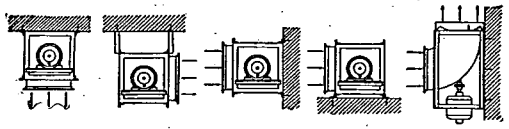
Wing-Scruplex Exhausters

Wing Scruplex Exhausters consist of the highly efficient "screw propeller" fan encased in appropriate manner with a motor on the outside where it is clean, cool and easy of access. They are used in duct work where the resistance is low and being designed in the form of an elbow fit snugly in any line. The accompanying diagrams show the methods of installation.

(continued on next page)

Proper Selection of Exhausters

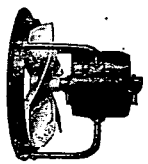
Where particularly quiet operation is desired, as in offices, residences, hospital wards, churches, theatres, etc., use lowest speeds in all sizes. For toilet rooms, laboratories, motion picture booths, stockrooms, etc., use any speed in sizes 1 and 2; low and medium speeds in all other sizes. In industrial plants, hotel and restaurant kitchens, engine-rooms, workshops, etc., use any speeds.



Bolted directly to Ceiling — *Hung from Ceiling* — *Bolted directly to Side Wall* — *Bolted to Floor or Foundation* — *Vertical Bolted to Side Wall*

"WING-SCRUPLEX" EXHAUSTERS

The accompanying table gives performances at static pressures up to ½ in. Complete table up to 1 in. static on request.



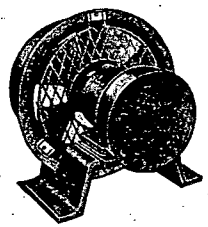
Wing-Scruplex Fan

Size	Inlet Sq. In.	Outlet Round. In.	Speed R. p. m.	Free Air		.15 in.		.25 in.		.40 in.		.50 in.	
				Cu. f. m.	Hp.	Cu. f. m.	Hp.	Cu. f. m.	Hp.	Cu. f. m.	Hp.	Cu. f. m.	Hp.
1-A	10	10½	1750	850	0.052	630	0.054	330	0.060	.....	.....	.....	.....
2-A	13½	14⅛	1150	1440	0.060	950	0.069	395	0.090	.....	.....	.....	.....
2-B	13½	14⅛	1750	2050	0.195	1895	0.208	1695	0.216	1155	0.248	750	0.285
3-S	16¾	17⅜	850	2130	0.090	1250	0.110	.....	.....	.....	.....	.....	.....
3-A	16¾	17⅜	1150	2700	0.180	2150	0.195	1550	0.221	.....	.....	.....	.....
3-C	16¾	17⅜	1750	4000	0.600	3720	0.635	3510	0.655	3150	0.700	2810	0.720
4-S	21	21¾	850	2850	0.100	2200	0.125	1610	0.150	.....	.....	.....	.....
4-A	21	21¾	1150	3575	0.170	3150	0.200	2775	0.220	1950	0.245	1550	0.280
4-C	21	21¾	1750	5400	0.540	5160	0.600	4990	0.650	4670	0.710	4440	0.750
5-A	25	25	1150	5200	0.330	4720	0.380	4250	0.440	3300	0.530	2610	0.600
5-B	25	25	1750	8000	1.330	7740	1.360	7540	1.400	7175	1.480	6900	1.540
6-A	30	30	600	5500	0.210	3725	0.250	2375	0.330	.....	.....	.....	.....
6-B	30	30	850	7400	0.550	6280	0.600	5450	0.740	4000	0.830	3400	0.960
6-C	30	30	1150	10250	1.500	9520	1.550	8950	1.570	8000	1.620	7340	1.760

Wing-Scruplex Fans

Wing-Scruplex Fans are built in the following sizes: 10 in., 13 in., 17 in., 22 in., 25 in. 30 in., 36 in., 42 in., 54 in., and 60 in. Capacities from 950 c.f.m. to 33,000 c.f.m. Up to 25 in. diameter, propellers are made of cast aluminum alloy while the larger sizes are of pressed steel.

Wing Type E M Motor-Driven Blowers



Wing E M Blower

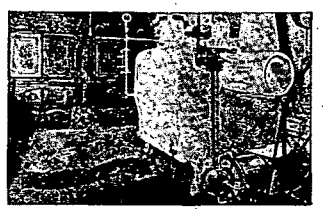
Wing motor-driven Blowers are installed in heating boilers so that low cost Buckwheat coal can be burned with great savings in fuel bills and with better heating results. They are also used in industrial plants where motor drive is preferred to turbine drive.

The Wing E M Blower is a simple compact unit of motor, fan, and casing, of the same general design as the Wing Turbine Blower, the first individual forced draft fan-blower ever built. Wing units are either set directly in the boiler brick base or are equipped with mounting feet or base and connected to the ashpit by a short duct in the case of cast iron boilers.

Motors are fully enclosed and dustproof. Because of this feature they stand up for years in the dusty atmosphere of boiler rooms without repair. Another feature is variable speed control; this permits of regulation without the use of dampers and saves power.

Wing Blowers are cutting down fuel bills in hundreds of schools, apartment houses, lofts, hotels, churches and institutions throughout the country. Booklet 46 describes Wing motor-driven units.

Information on Wing turbine-driven units in Bulletin 87.



The Wing Blower in foreground supplies forced draft to hot water supply heater; while blower in background serves two return tubular heating boilers

Armstrong Cork & Insulation Company

Pittsburgh, Pa.

Offices

Albany	Cleveland	Indianapolis	New York
Atlanta	Columbus	Jacksonville, Fla.	Omaha
Birmingham	Dallas	Kansas City	Pittsburgh
Boston	Denver	Louisville, Ky.	Rochester
Buffalo	Detroit	Memphis	St. Louis
Charlotte, N.C.	Grand Rapids, Mich.	Milwaukee	Tulsa, Okla.
Chicago	Hartford, Conn.	Minneapolis	Montreal, Que., Can.
Cincinnati	Houston		Toronto 2, Ont., Can.

Representatives

Baltimore	John R. Livezey	San Francisco	Van Fleet-Freear Company
Los Angeles	Gay Engineering Corp.	Seattle	D. E. Fryer & Company
New Orleans	H. T. Steffee	Spokane	D. E. Fryer & Company
Philadelphia	John R. Livezey	Tacoma	D. E. Fryer & Company
Portland	Gillen-Cole Company		

Detailed information, samples, and descriptive literature may be obtained on application to any of these offices or representatives.

Armstrong's Cork Machinery Isolation is a special grade of corkboard for absorbing noise and vibration under moving machines such as fans, motors, etc.

The natural resilience of cork and the fact that it does not "set" under pressure, nor harden with age make it especially suitable for this use.

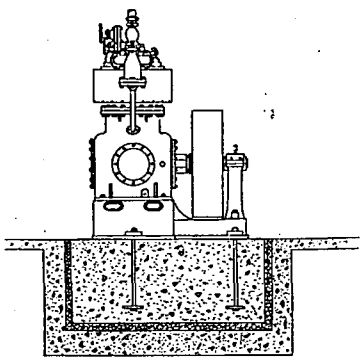
Another advantage of Armstrong's Cork Machinery Isolation is that, being a manufactured product, its density can be varied to suit different conditions. Armstrong's is made in six grades, or densities, from 1.1 to 1.66 lb. per board foot. By adapting the grade to weight and type of machine, much better results are obtained than by using a single grade for all installations.

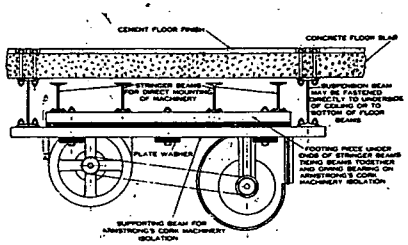
Armstrong's Cork Machinery Isolation is made in boards 12 by 36 by 1, 1½, 2, 3, 4, 5 and 6 in. thick. The standard boards may be sawed or cut into the desired shape or size as readily as lumber, and where large pads are required, they can be made in sections and cemented together.

The density and thickness to be used cannot be determined accurately until such factors as the weight, speed and character of the machine to be isolated are known. Generally speaking, the grades which should be used under different classes of machines are as follows:

Small fans, motors, generators, etc.	1.10 to 1.20
Large fans, medium size motors and generators, light machines and machine tools, etc.	1.25 to 1.33
Heavy motors and generators, large machines and machine tools, engines, etc.	1.50 to 1.66

Two methods of installing Armstrong's Cork Machinery Isolation are usually followed. In the first, the foundation pits are lined with Armstrong's Cork Machinery Isolation on the bottom and sides. The foundation proper is then poured in on top of the cork. In the second, the cork is placed between the base of the machine and the foundation, floor or ceiling, to which it is fastened. See figures below.





Langenberg Manufacturing Co.

4549 No. Euclid Ave. :-: St. Louis, Mo.

FRONT RANK

TRADE NAME REGISTERED

Dealers in all parts of the United States

A Quality Combination

A FRONT RANK FURNACE; Twin Sirocco Fan with S K F Bearings; New Design Casing. All assembled into the

FRONT RANK
UNIT HEATER

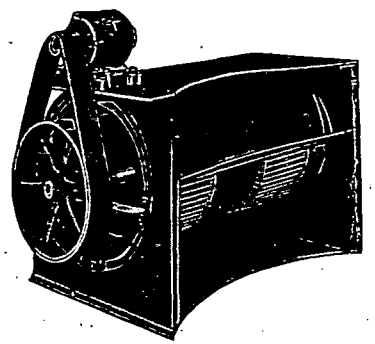
Fuels—

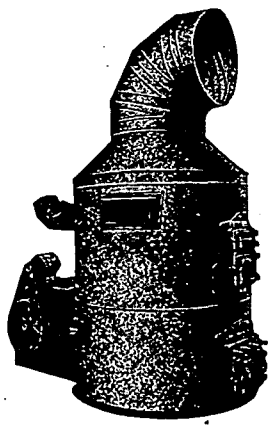
Any coal, coke or oil.

Operates by fan or gravity. No by-pass dampers necessary.

Churches, schools, stores, auditoriums, small factories, residences and garages where these plants have been installed and now operate successfully are our best references.

We design and install our own systems anywhere in the United States or Canada.





Fan Data

Diameter of Wheel	24″
Diameter Inlet	29″
Height	37″
Length	38″
Width	48″
Size of Outlet	23½ x 45
Cu. ft. per min.—¼ in. static	7000
R.p.m.	275
Hp. of Motor	1

Lewis M. Ellison

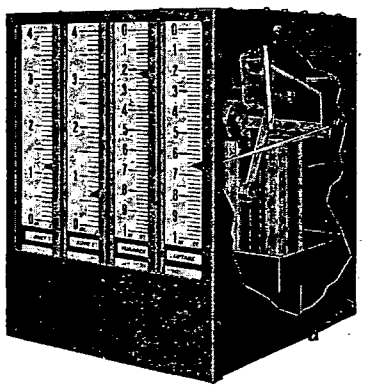
214 West Kinzie Street :-: **Chicago, Ill.**

Products:

ELLISON POINTER DRAFT GAGES, INCLINED DRAFT GAGES, VERTICAL DRAFT GAGES, INCLINED-VERTICAL DRAFT GAGES, INCLINED PITOT TUBE GAGES, INCLINED AIR FILTER GAGES, SATURATOR PRESSURE GAGES, AND STEAM CALORIMETERS. DESIGNED AND MANUFACTURED BY LEWIS M. ELLISON.

Ellison Pointer Draft Gage:

STRAIGHT-LINE VERTICAL: *This improved pointer draft gage, converting an arc into a straight line, is of remarkable accuracy and repeats precisely. It is of unusual substantial construction and is made in 1 to 12 readings with color code system of drafts. It has a powerful bell of 10 cu. in. displacement. The bell and fulcrum knife edges are*

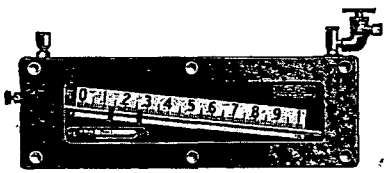


secured against displacement with straps. The fulcrum knife edges are of hardened steel, ¼ in. long. The bells have a common pan, with drain, and the liquid used is kerosene. The pan is filled thru a large tube, combining a filler and liquid level indicator. It is made for wall and panel mountings—panel projection 1 in.

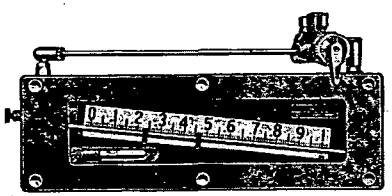
The scales are of unusual visibility, 10 in. long, of uniform spacings, and are illuminated from the back with a standard 15 watt bulb, one for nine pointers, which, with the casing white enameled inside, makes a most efficient lighting system.

Ellison Tube Draft Gages:

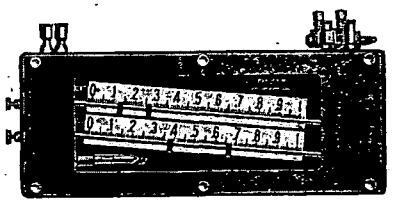
The famous Ellison Inclined Tube Gage, the recognized standard of accuracy in draft gages, was introduced in 1896. Water having a variable movement, a petroleum oil is used. Nearly all the gages have sliding scales for setting zero, requiring no refilling for several years. The stationary gages have white enameled scales, and the open type inclined gages are equipped with micrometer levelers.



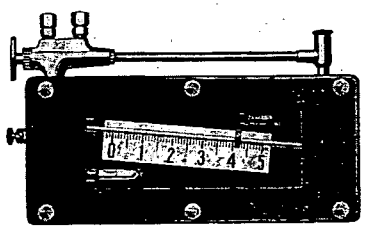
INCLINED DRAFT GAGE: *Made in .3 in. range for domestic furnaces and in ½, 1, 2, 3, 4, 5, 6 and 7½ in. range, and in mm., for power boilers, suction, pressure or differential.*



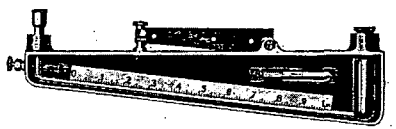
COMBINATION INCLINED DRAFT GAGE: *By turning the handle, this gage reads furnace, flue or differential draft in 1 and 1½ in. range, and in mm.*



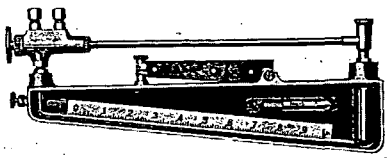
MULTI-TUBE INCLINED DRAFT GAGE: *Made in 2, 3 and 4 tubes in 1 to 7½ in. range, and in mm. suction, pressure or differential.*



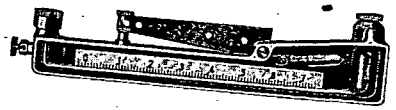
INCLINED AIR FILTER GAGE: *Indicates differential thru air filters and the time for cleaning filters, by setting the pointer at the highest reading that will clean the air properly. Made in ½ and 1 in. range, and in mm.*



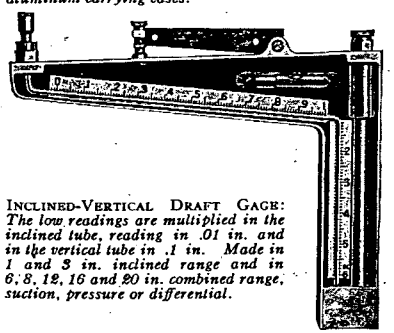
INCLINED DRAFT GAGE—OPEN TYPE: *For technical institutions and power plant testing. With sliding scale and micrometer leveler. Made in 1, 1½, 2, 3 and 5 in. range, and in mm., suction, pressure or differential.*



DIFFERENTIAL SYSTEM: *For Pitot tubes and differential readings, preventing the liquid from blowing out in static pressures in excess of the scale range. Applied to any of the inclined gages.*

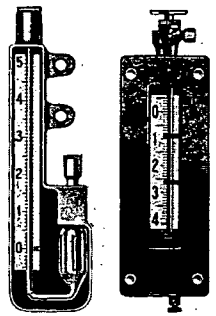


PORTABLE INCLINED DRAFT GAGE: *For traveling engineers, light and compact. Made in ½, 1, 1½ and 2 in. range, with attachments and pressed aluminum carrying cases.*



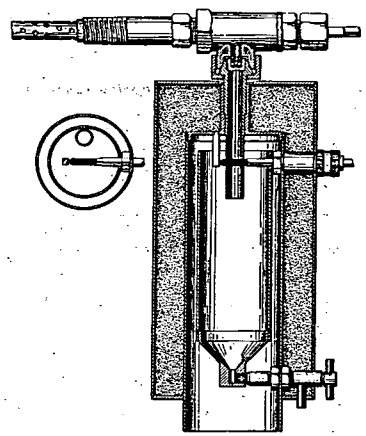
INCLINED-VERTICAL DRAFT GAGE: *The low readings are multiplied in the inclined tube, reading in .01 in. and in the vertical tube in .1 in. Made in 1 and 3 in. inclined range and in 6, 8, 12, 16 and 20 in. combined range, suction, pressure or differential.*

VERTICAL DRAFT GAGES: *The open type is for portable use and is made in 5 and 10 in. range, and in oz. The single tube cover type is for stationary use and is made in 4, 7, 12 and 20 in. range, and in cm. and oz. In multi-tube it is made in 7 and 10 in. range, in 2 to 12 tubes, with back connections and with casing around the frame for panels.*



Ellison U Path Steam Calorimeter:

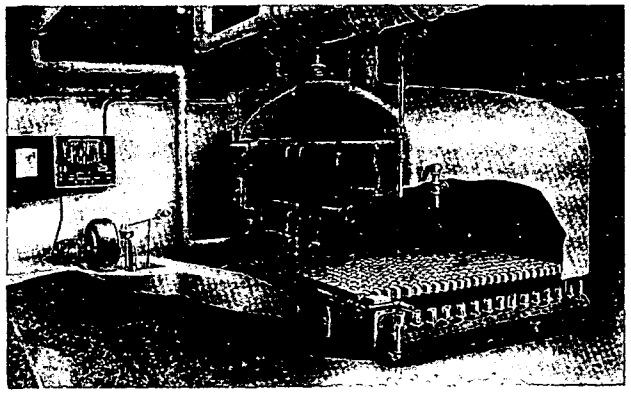
In this recently improved steam calorimeter, a remarkable performance of 2 degrees within the theoretical temperature is obtained.



Steam enters and escapes at the top of the steam chamber, forming a U path. Momentary excess moisture is separated and re-evaporated by the superheated steam, lowering the temperature on the superheat thermometer in direct proportion. This cycle forms a throttling, separating and re-evaporating calorimeter in a single steam chamber, which is steam jacketed by the down-flow escaping steam. The jacket steam is protected against chilling by a 1 in. insulating jacket on the sides and 1½ in. on the top of the jacket, which is filled with lamp black and encased by a bright nickel plated casing.

Economy Grate & Equipment Company, Inc.

General Offices
410-412 East 34th Street, New York, N. Y.
TELEPHONE, VANDERBILT 3397



A Typical Economy Water-cooled Grate Installation

PRODUCTS.—Economy Water-Cooled Grates and Equipment for high and low pressure steam boilers and hot water boilers is an apparatus for reducing heating costs by burning the cheapest grades of coal, such as No. 3 buckwheat and anthracite screenings (which contains as many heat units per pounds as the larger sizes); will satisfactorily burn any of the coal substitutes such as screenings, coke breeze, dust or culm.

Construction.—The Economy Equipment is made of indestructible water-cooled grate bars, 4 in. wide, 3 in. deep, and of the length required for the boiler furnace. The sides of the grate bars have vertical semicircular grooves extending from the top to the bottom. The grate bars are placed side by side, in an abutting position, so that the adjoined grooves form tubular channels and in each of these channels is placed an air distributor. The grate bars are cast with tongue and groove so that, when snugly fitted together, no air can come through the grate except through the air distributors which are perforated radially, causing the air to sweep across the grate instead of blowing straight up. Thereby the fire burns evenly over every inch of grate surface eliminating dead spots at the end and sides.

The grate bars are hollow, forming a waterway which is so shaped as to entirely surround each distributor, thus preventing it from ever burning out. Each grate bar has a screw head opening at either end, and is connected with manifolds by extra heavy wrought iron connections. By this means the water from the boiler circulates through each grate bar. All pipe connections are outside of the firebox. This prevents leakage from expansion and contraction.

The ashpit of the boiler is sealed, making an airtight chamber into which air is forced by an electric motor driven blower from whence it passes upward through the air distributors.

Guarantees.—If at any time within a period of ten years from date of installation, the Economy Grate Bars shall burn out, or prove defective or faulty in workmanship, they are to be replaced without charge to purchaser.

If at any time within a period of one year the motors shall prove defective, they shall be replaced without charge.

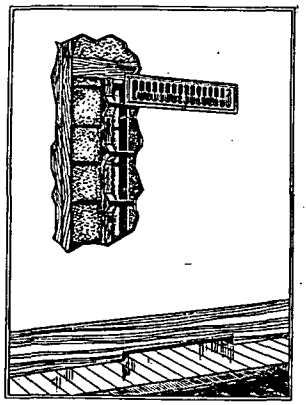
It is further guaranteed, ton for ton, to deliver as much heat from a good grade of No. 3 buckwheat coal as was previously received from the larger sizes of anthracite coal.

(See Trane Heating Specialties on pages 624 and 625; Trane Pumps on pages 564 and 565; and Unit Heaters on page 503.)

The Trane Company

La Crosse, Wis.

Heat Cabinets and Concealed Heaters



Trane Heat Cabinets and Concealed Heaters take the place of exposed radiators on all types of heating systems.

The Heat Cabinets are installed in the room and finished to match the furniture. The Concealed Heaters are entirely hidden in the wall with the exception of an air inlet at the baseboard and a grilled heat outlet in the wall.

The Heating Unit

The heating unit consists of two copper tubes to which a multiplicity of copper sheets are connected by a special process to increase the heating surface. There are no soldered or welded joints in the entire heating unit and it will stand extremely high pressures.

Heat By Convection

Both the Heat Cabinet and Concealed Heater operate on the principle of convection. Cold air enters at the floor under the heater and is drawn up over the heating unit by the chimney effect of the cabinet or wall stack. The temperature of the room is controlled by a damper arrangement that regulates the amount of air flowing over the heater.

Capacities

Capacities vary with height of wall stack or cabinet and length of heater.

The Heat Cabinets are made in two widths—Standard and Double Capacity. The Standard is 6½ in. wide the Double Capacity is 12 in. Capacities range from 17 sq. ft. to 125 sq. ft. of equivalent direct radiation. Both are furnished in four heater lengths and three cabinet heights.

The Concealed Heaters are furnished in four lengths and four widths— 4, 6, 8 and 12 in.

Heat Cabinets are furnished complete. Concealed Heaters are furnished with shutter-grille, boot for connecting wall stack and grille, and heater. The Wall Stack is made up on the job from sheet metal according to specifications furnished.

The Heating Unit

COMPLETE DETAILS AND CATALOGS WILL BE FURNISHED ON REQUEST

Circulair Heat, Inc.

215 Central Avenue
Louisville, Ky.

50 Church Street
New York

1916 Builders Building
Chicago

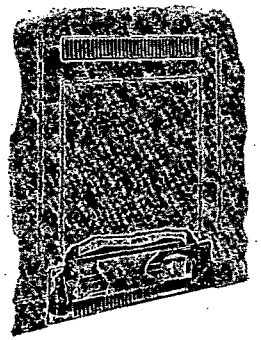


Fig. 1

CIRCULAIR

We announce a new **Method of Heating** which economically achieves uniform, comfortable, healthful warmth by scientifically utilizing Induced Circulation of Air. CIRCULAIR!

A Concealed Type which does not intrude upon the Decorative Scheme nor usurp Floor Space.

Cabinet Types which afford all the advantages of the Scientific Method and readily lend themselves to any Decorative Treatment desired.

We announce, coincidentally, the development, under the direction of Willis H. Carrier, of highly-perfected **equipment** which realizes the full possibilities of the **method.**

CIRCULAIR is now available in heater lengths from 12 to 48 in. in increments of 6 in., representing heating capacities, in equivalent square feet of cast iron "radiation" of from 8 to 105 per Unit; in the Concealed Type, Figs. 1 and 2; the tall shallow Cabinet Type (which extends but 4 in. from the wall), Fig. 4; or the short, deeper Cabinet Type, Fig. 5.

CIRCULAIR Method

By housing the heat-element in the base of a stack a strong upward convection current is induced. The stream of warmed air from the upper grille is deflected horizontally into the room, moving gently across it, to be reversed and drawn back into the lower grille. This effects a continuous draftless **circulation** which warms the zone of occupancy above the floor and avoids excessive overhead overheating. The result is **uniform** comfort throughout the room.

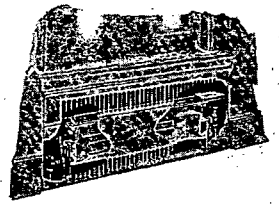


Fig. 2

Above the heater is an easily adjustable air-tight damper (See Figs.) which regulates the volume of air passing through the CIRCULAIR and thus **flexibly** and **instantaneously** regulates the quantity of heat admitted to the room. Real heat

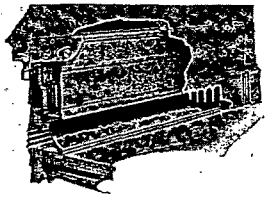


Fig. 3

control at last, independent of the heating **medium,** *infinitely* variable at will, between none and full capacity, and **instantly responsive.** Contemplate the manifold advantages of this—in comfort, health, convenience and economy!

Then note, Fig. 3, that CIRCULAIR provides means of introducing Fresh Air, through any desired Unit, without drafts, without opening windows, without disturbing the uniform temperature of the room! (Patents pending.)

Note, further, Fig. 4, that CIRCULAIR provides a tall, shallow Cabinet (Patents pending) which makes available to existing buildings all the advantages of the Concealed Type itself, salvaging most of the space heretofore **occupied** by a "radiator," not only, but **all of the adjacent space** which the "radiator" rendered untenable. This is a boon to those forced to sit or stand near a "radiator," as in an office, a small room of any description, or in a restaurant, since the tall CIRCULAIR Cabinet, replacing the "radiator" discharges its warmed air overhead and does not "radiate" from its front panel.

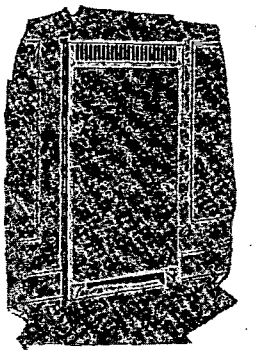


Fig. 4

CIRCULAIR Equipment

The heat-element, a scientific **conductor,** rather than a "radiator," since air is heated almost wholly by conduction, is designed for maximum heat transmission and built to outlast the enclosing structure. It is entirely non-corrosive and absolutely freeze-proof. The Figures afford some conception of its many advanced features and of the care and study expended in the design of the grilles and cabinets. Figs. 6 and 7 show dimensions of heater units. Stack heights vary from 15 to 85 in. The largest CIRCULAIR Heater Unit, capacity 105 sq. ft. equivalent cast iron "radiation" weighs but 53 lbs.!

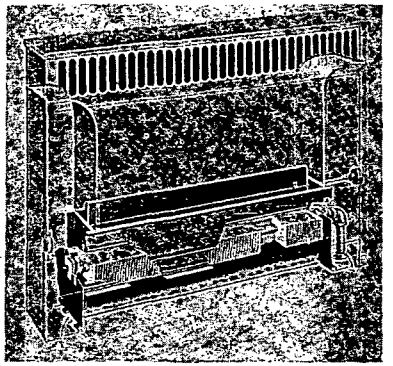


Fig. 5

Complete Information
is contained in a beautifully illustrated Booklet (A.I.A. File 30c4) which will be mailed gratis upon request.

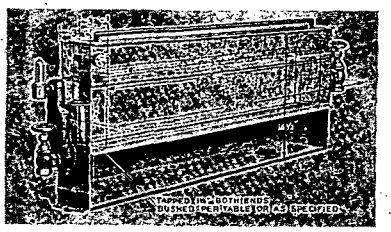


Fig. 6

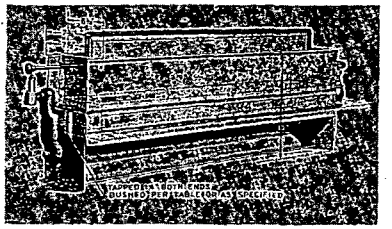


Fig. 7

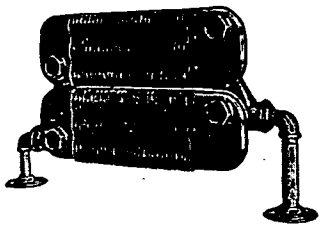
ROME BRASS RADIATOR
CORPORATION

1 East 42nd Street, New York City

BOSTON PHILADELPHIA PITTSBURGH CHICAGO

ROBRAS 20-20

A welded brass radiator 20 per cent the size and 20 per cent the weight of cast iron radiators.



What It Is:

Each section of the Robras 20–20 is made up of two pressed sheets of brass welded together over two shouldered nipples, one at each end.

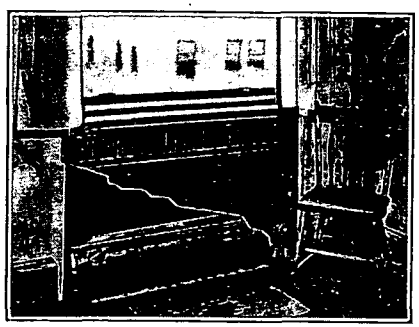
Flat brass fins are attached at right angles to both sides. The sections are fastened together by hexagonal spacers into which are threaded the shouldered nipples.

The usual traps and fittings for hot water, steam and vapor are used.

How It Works:

Because of this high conductivity of brass, hot water, steam or vapor heat is rapidly changed into room heating by this Robras 20–20.

The fins on both sides of each section accelerate the speed of this heat transferred because they offer unobstructed surface. The arrangement of these fins form numbers of tiny flues, between the sections through which the hot air rises rapidly, thus speeding up the room heating.



One method of installing Robras 20–20 in the walls.

How They Are Installed:

Robras radiators can be had in any number of sections in lengths ranging from 18 to 70 inches.

They can be had connected laterally or tiered.

An 18 inch section contains 5.5 sq. ft. A 70 inch section contains 25 sq. ft.

This allows almost any desired amount of radiation to be installed in almost any given space.

In walls, in base boards, under stairs and in any sort of cabinets.

Where The Saving Lies:

The saving in installing Robras 20–20 radiators is in the installation cost.

A steamfitter and helper can in a day, set up three times as many feet of this radiator as they can cast iron radiators.

The light weight makes carrying and handling charges so much less.

Robras 20–20 never needs painting.

It can not be harmed by freezing and it is practically indestructible.

Our trained engineers are competent to send proper information on any heating or ventilating problem.

We will send Robras dimensions, ratings, prices and discounts.

C. C. Shipp & Company

Indianapolis, Indiana, U. S. A.

AUTOMATIC

Trade Mark **D-I** Reg. U. S. Pat. Office

SANITARY

VENTILATING AND HUMIDIFYING UNITS*

for

SCHOOLS, HOSPITALS AND OTHER PUBLIC BUILDINGS

Three vital and important factors are assured by the use of any Standard Column Legless Radiator when equipped with Automatic D-I Sanitary Ventilating and Humidifying Units

HEAT.....Distributed properly and automatically to every corner of the room.

MOISTURE.....In just the proper percentage assured automatically and without noise.

VENTILATION.....Controlled automatically by the temperature within the room, without drafts and without the use of mechanical appliances of any kind, or the services of an expert operating engineer.

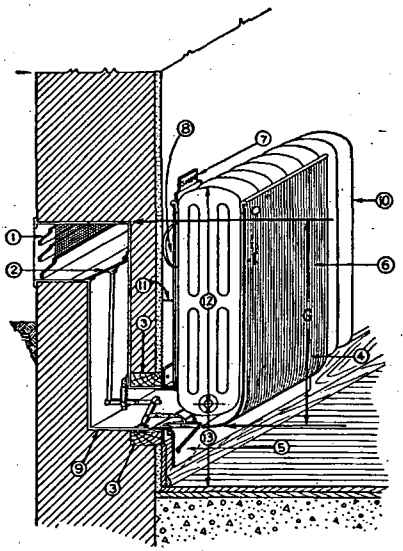
Thus it will be seen that the D-I System is a natural, easy, simple, efficient and economical way of obtaining heat, ventilation and humidity for old and new buildings

See Pages 490, 491, 492, 493.

*Copyrighted, 1927, C. C. Shipp & Company

CAPACITIES OF THE AUTOMATIC D-I SANITARY VENTILATING UNITS

No. of Series	Size of D-I Wall Box Inches	Cu. Ft. Air per Min.	C.f.m. Air per Pupil	Sections of Radiators Covered
1	8 x 20	180	30	8
2	8 x 24	240	30	10
3	8 x 30	300	30	12
4	10½ x 20	270	30	10
5	10½ x 24	330	30	12
6	10½ x 30	420	30	14



Model B

Patented August 23, 1921
Patented December 15, 1925
Patented March 9, 1926

Automatic D-I Sanitary Ventilating Unit for Legless Radiator showing Air Recirculating Feature

Furnished for any standard make or height, one,- two-, three- or four-column radiators, covering as many sections as required, not including two sections at each end.

NOTE.—(G) When requesting quotations, this measurement should be given overall, together with thickness of finished wall.

(1) D-I Ventilating Wall Box with Storm Louvers, Insect Screen, Special Adjustable Extension Sleeve and Adjustable Controlling Fresh Air Damper with dust-proof and non-corroding hinges.

(2) D-I Adjustable Controlling Fresh Air Damper.

(3) 2 x 4-inch Wood Frame around ends, top and bottom of Sleeve, room side —Edge to set flush with finished plastering.

(4) D-I Adjustable Sanitary Ventilating Box Base.

(5) Recirculating Air Damper.

(6) D-I Adjustable Air Diffusers with Removable Rolls.

(7) D-I Adjustable Fresh Air Damper Indicator.

(8) D-I Automatic Fresh Air Damper Control.

(9) Bottom of Sleeve to set not less than 8 in. from the finished floor.

(10) Three-Column 38 in. D-I Legless Radiator, bracketed from wall.

(11) Back of radiator to set 1¾ in. from finished wall to provide sufficient space for D-I Automatic Fresh Air Damper Control.

(12) From center of tapping to extreme top of radiator—33½ in.

(13) From finished floor to center of radiator tapping—11¼ in.

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C. C. Shipp & Company — Heating and Humidifying Unit, Air

CAPACITIES OF THE AUTOMATIC D-I SANITARY VENTILATING UNITS

No. of Series	Size of D-I Wall Box Inches	Cu. Ft. Air per Min.	C.f.m. Air per Pupil	Sections of Radiators Covered
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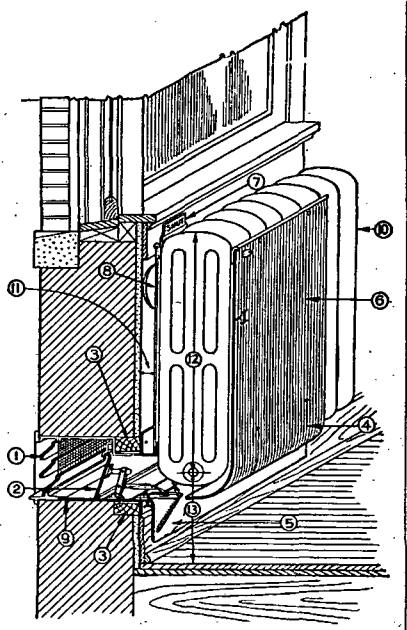
3	8 x 30	300	30	12
4	10½ x 20	270	30	10
5	10½ x 24	330	30	12
6	10½ x 30	420	30	14



Model S

Patented August 23, 1921
Patented December 15, 1925
Patented March 9, 1926

Automatic D-I Sanitary Ventilating Unit for Legless Radiator showing Air Recirculating Feature

Furnished for any standard make or height, one,- two-, three- or four-column radiators, covering as many sections as required, not including two sections at each end.

NOTE.—When requesting quotations, thickness of finished wall should be given.

(1) D-I Ventilating Wall Box with Storm Louvers, Insect Screen, Adjustable Extension Sleeve and Adjustable Controlling Fresh Air Damper with dust-proof and non-corroding hinges.

(2) D-I Adjustable Controlling Fresh Air Damper.

(3) 2 x 4-inch Wood Frame around ends, top and bottom of Sleeve, room side —Edge to set flush with finished plastering.

(4) D-I Adjustable Sanitary Ventilating Box Base.

(5) Recirculating Air Damper.

(6) D-I Adjustable Air Diffusers with Removable Rolls.

(7) D-I Adjustable Fresh Air Damper Indicator.

(8) D-I Automatic Fresh Air Damper Control.

(9) Bottom of Wall Box to set not less than 8 in. from finished floor.

(10) Three-Column 38 in. D-I Legless Radiator, bracketed from wall.

(11) Back of radiator to set 1¾ in. from finished wall to provide sufficient space for D-I Automatic Fresh Air Damper Control.

(12) From center of tapping to extreme top of radiator—33½ in.

(13) From finished floor to center of radiator tapping—11¼ in.

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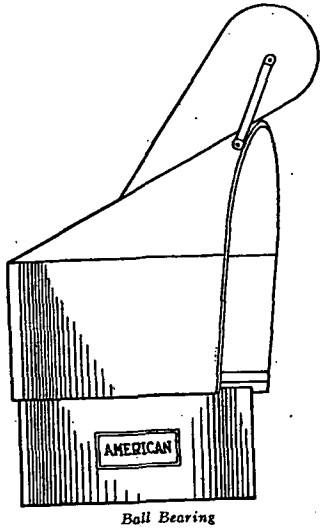
AMERICAN AUTOMATIC VENTILATORS

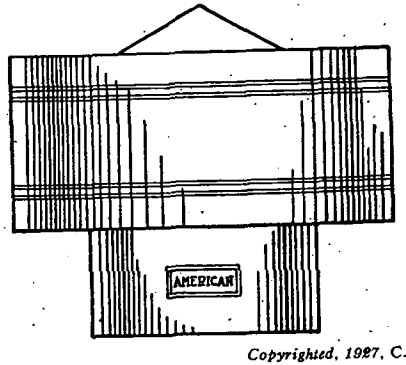


Ball Bearing

Diameter Inches	Area in Sq. In.	Shipping Weight	List Price
10	78	20	$23.24
12	113	25	28.24
14	153	35	33.74
16	201	45	43.74
18	254	48	45.00
20	314	60	46.88
22	380	70	51.24
24	452	78	54.38
26	530	94	61.24
28	615	110	65.00
30	706	140	68.74
32	804	155	81.24
34	907	165	87.50
36	1017	197	92.50
38	1134	225	112.50
40	1256	250	125.00
42	1385	275	130.00
44	1520	300	142.50
46	1661	350	152.50
48	1809	378	162.50
50	1963	400	175.00
52	2123	425	187.50
54	2290	450	200.00
56	2463	500	217.50
58	2642	575	230.00
60	2827	660	245.00

NOTE.—Furnished in galvanized iron only unless otherwise ordered. Base extra.

AMERICAN STATIONARY VENTILATORS



Diameter Inches	Area in Sq. In.	Shipping Weight	List Price
12	113	40	$ 7.12
14	153	50	10.24
16	201	60	15.74
18	254	70	19.36
20	314	90	25.00
24	380	100	31.24
30	706	150	42.50
36	1017	210	67.50
42	1385	350	90.00
48	1809	450	115.00
54	2290	570	137.50
60	2827	700	168.74

NOTE.—American Ventilators are received by all transportation companies under Classification One, double rate.

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METHOD OF CALCULATION FOR D-I SANITARY VENTILATING AND HUMIDIFYING UNITS

The following method of calculation for amount of air required is based on State requirements of Indiana, and will naturally vary in states where the requirements are different: However, the general principles of the method will apply to all cases.

1. The amount of Direct Radiation installed, which is not enclosed with the Air Diffusers, is that required for the exposed wall and glass. This Radiation is determined in the following manner:

2. Multiply square feet of glass surface in room by 89, if from zero to 70 deg., or by 99 if from −10 deg. to 70 deg.

3. Multiply the net wall by 27, if from zero to 70 deg., or by 37 if from −10 deg. to 70 deg.

4. Add results of 2 and 3, and divide by 250. This will give you the square feet of direct radiation necessary to overcome heat losses through glass and walls, which in the average school room is 120 to 140 sq. ft. Add 10 per cent to above figures for north or west exposures.

5. To determine the number of Wall Boxes required, first determine the number of pupils for the room. This can be obtained by dividing the cubical contents of the room by 225 (allowing 225 cu. ft. of contents per pupil).

6. Multiply the number of pupils by the amount of air required for each pupil per minute, which, for Indiana, is 30. This gives the total amount of the air required for the room per minute.

7. Divide the total amount of air required per minute by the capacity of the Wall Box to determine the number of boxes required.

8. *Example:* Assemble a room designed for 34 pupils; then, 34 × 30 (cu. ft. of air per minute per pupil) equals 1020 cu. ft. per minute; 1020 c.f.m. divided by 300 (capacity of 8 x 30 in. Wall Box) equals 3.4, or it will be necessary to use four 8 x 30 in. Wall Boxes.

9. Therefore, there will be required in the room four radiators, with a Wall Box for each radiator. Since, when using an 8 x 30 in. Wall Box, twelve sections of 3-column 38 in. radiator are enclosed by the air diffusers, there will be 60 sq. ft. of radiation enclosed in each radiator, or a total of 240 sq. ft. for ventilation.

10. To the preceding amount must be added the direct radiation required for wall and glass. Assume this to be 120 sq. ft. There would then be a total of 240 sq. ft. plus 120 sq. ft., making 360 sq. ft. in the room.

11. In designing the boiler, take special notice that the 240 sq. ft. of indirect radiation, or those sections enclosed in the Air Diffusers will condense two and one-half times as much steam as ordinary direct radiation. Therefore, the four radiators in the room will be equivalent to $2\frac{1}{2} \times 240 = 600 + 120$, or a total of 720 sq. ft. of direct radiation.

12. If the building is an eight-room school house, it will require 8×720 plus whatever direct radiation there may be required in the halls, toilets, offices, etc.

13. Say there are 500 sq. ft. of radiation in the halls, etc. Then $8 \times 720 = 5760$ sq. ft.; 5760 sq. ft. + 500 sq. ft. = 6260 sq. ft.

The size of the boiler, together with the supply and return piping, should be based on an equivalent of 6260 sq. ft. of radiation, making due allowances for mains and risers.

We recommend, on account of better air distribution, the use of four Wall Boxes for the ordinary class room, the size depending, of course, upon the requirements.

Do not use tube radiation.

Do not use radiation less than 26 in. high.

All Ventilating Radiators should be legless.

Ventilating Radiators for one pipe steam should be tapped $1\frac{1}{2}$ in. up to 70 sq. ft., inclusive, all above 70 sq. ft. 2 in.

Ventiiating Radiators for two-pipe steam should be tapped $1\frac{1}{2}$ in.

Each class room should be provided with a suitable foul air vent-flue, constructed on the opposite side of the room from the ventilating radiators. The size of this foul air vent-flue is based upon the number of pupils in the room. The State of Indiana requires 16 sq. in. in the foul air vent-flue for each pupil. Aspirating Radiators should be installed in each foul air vent-flue, allowing $\frac{5}{8}$ sq. ft. per pupil on the first floor and $\frac{7}{8}$ sq. ft. on the second floor.

All Foul Air Ventilating Flues should be connected to a foul air collecting chamber or chambers constructed in attic. The size of collecting chamber or chambers should be 10 per cent larger than the combined free area of all ventilating flues connecting into same. The foul air collecting chamber or chambers should be connected to a revolving automatic ventilator on the roof of the building of sufficient size and capacity to meet all requirements.

In determining size of American Automatic Ventilator one-half sq. in. free area in ventilator should be allowed to each one sq. in. of free area in foul air vent-flue.

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Skinner Bros. Mfg. Co., Inc.

Home Office 1490 S. Vandeventer Avenue, St. Louis, Mo.

Eastern Office 1013 Flatiron Bldg., New York, N. Y.

BALTIMORE	2 E. Lexington Street	INDIANAPOLIS	621 Illinois Bldg.
BOSTON	723 Little Bldg.	KANSAS CITY	Mutual Bldg.
BUFFALO	310 Walbridge Bldg.	PHILADELPHIA	1011 Pennsylvania Bldg.
CHICAGO	1701 Fisher Bldg.	PITTSBURGH	715 Magee Bldg.
CLEVELAND	612 Marshall Bldg.	SEATTLE	929 Dexter Horton Bldg.
DETROIT	Eaton Tower Bldg.	SPOKANE	409 First Avenue
WASHINGTON	312 Tivoli Bldg.		

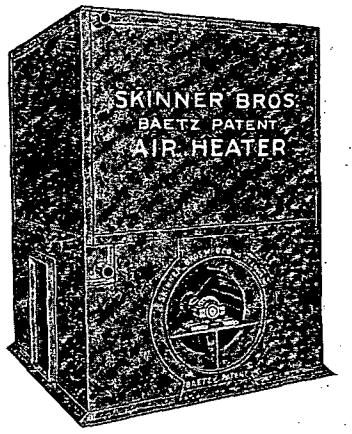
Sales Offices in Principal Cities

Factories at ST. LOUIS, MO. and ELIZABETH, N. J.

Sole and exclusive manufacturers of Skinner Bros. (Baetz Patent) Air Heater, Skinner Bros. Direct Fired Heater, Skinner Bros. Lightweight Copper Heater, Skinner Bros. Revolving Siphon Ventilator, Skinner Bros. Slow Speed Low Power Dust Collecting System, Skinner Bros. Patent Fan Blast Dryer Outfit, and exhaust heads, blow piping, slow speed fans, buffing and emery wheel systems, machine guards.

SKINNER BROS. STEAM COIL HEATER

Recommended for heating, ventilating, air conditioning industrial buildings, regardless of size, whether of permanent or temporary construction, sawtooth or monitor, single or multistory. In paper and pulp mills, dyehouses, packing plants, laundries, dairies and buildings in which steam vapor, condensation and drippage are troublesome, Skinner Bros. Steam Coil Heaters are installed to eliminate these conditions. Installations in thousands of buildings throughout the country demonstrate their versatility and ability to heat buildings of any type of construction.



The New Skinner Bros. Two-Fan Four-Inlet Steam Coil Heater

Skinner Bros. Steam Coil Heaters are built in eight standard sizes and three models delivering from 75,000 to 4,630,000 B.t.u. per hour, and ranging in floor space occupied from 2 x 2 ft. to 7 x 7 ft. However, they are constructed in sizes and dimensions to fit the requirements they are called upon to fill in capacity and space occupied. For use where floor space is at great premium we supply an inverted type for overhead suspension.

Outlet hoods are designed to accommodate the conditions found in the buildings, one-, two-, three-way, round or rectangular, being supplied.

Skinner Bros. Steam Coil Heaters function equally well with either live or exhaust steam, and high or low pressure may be used. The coils of every heater are tested with 150 lbs. of hydraulic pressure before leaving the factory. Whatever power is available may be used to propel the fans.

The performance of the heaters is guaranteed when they are installed as directed by our engineers.

DIMENSIONS AND CAPACITIES
Skinner Bros. Two-Fan Four-Inlet Steam Coil Heaters

Heater Designation	Height*	Floor Space Covered	H. P. Motor	R. P. M.	C. F. M.	B.t.u per Hour, Air Entering at 0° F. 5 lbs. Steam	B.t.u per Hour, Air Entering at 0° F. 100 lbs. Steam
224†	5′ 3½″	2′ 4″x2′ 4″	½	490	1,850	125,000	206,000
			1	635	2,450	159,000	265,000
336	5′ 8½″	3′ 4″x3′ 4″	1	490	4,500	352,400	589,000
			2	620	5,800	460,000	770,000
336B	6′ 6½″	3′ 4″x3′ 4″	1	490	4,500	429,000	716,000
			2	620	5,800	544,000	910,000
448	6′ 3″	4′ 4″x4′ 4″	1½	544	5,200	612,500	935,000
			2	600	6,000	668,000	1,020,000
448B	7′ 0½″	4′ 4″x4′ 4″	2	600	6,000	736,000	1,125,000
			2½	730	7,000	803,000	1,230,000
560	7′ 2″	5′ 5″x5′ 5″	2	525	8,300	995,000	1,538,000
			3	600	10,000	1,166,300	1,825,000
672	7′ 6″	6′ 6″x6′ 6″	3	400	12,000	1,453,000	2,222,800
			5	480	14,400	1,727,000	2,560,400
784	8′ 2″	7′ 6″x7′ 6″	7½	460	26,000	2,780,000	4,400,000
			10	500	28,500	2,960,000	4,630,000

*Not including outlet which is made to fit requirements.
†Made in 1 fan, 2 inlet style only.

SKINNER BROS. DIRECT FIRED HEATERS

Designed for use in buildings in which steam is not available. A heater that burns bituminous or anthracite coal, coke, wood, gas or oil. It is the pioneer of its type and not only has proved performance in factories, mills, shops, garages and industrial buildings of all kinds, but has been widely recommended by contractors for preventing the freezing of concrete, plaster and other materials during winter construction.

Skinner Bros. Direct Fired Heaters are built in sizes, delivering from 150,000 to 1,000,000 B.t.u.

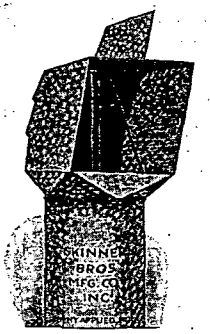
SKINNER BROS. REVOLVING SIPHON VENTILATORS

A roof ventilator designed to embrace the last word in efficiency and at the same time be so simple in construction that the possibilities of getting out of order are entirely eliminated. Skinner Bros. Revolving Siphon Ventilators, therefore, have shown themselves to require no attention whatsoever, once they are installed.

Operation: The slightest movement of air exerting pressure on the vane at the top moves the ventilator head to a position in which the open face is at right angles with the direction of the wind. In this position the air passes through the immovable shutter or louvres putting into operation the siphon principle which causes the foul air or fumes in the room below to be siphoned up the stack and out through the face of the ventilator.

Rain falling directly downward runs off the top, and when the rain or snow is blown in a slanting direction the face of the ventilator is automatically turned from the windward. Ball bearings and a hardened steel pivot bearing minimize all possible friction. A counter-balanced damper in the stack closes the ventilator when desired. Stocked in galvanized iron in 26 standard sizes, and made of sheet copper on order.

The following table is based upon the capacities of Skinner Bros. Revolving Siphon Ventilators operating in the average wind velocity of the ten largest cities in the United States. The wind velocities used are those reported by the U. S. Weather Bureau. Therefore, these figures are accurate for normal weather conditions in various parts of the country.



Skinner Bros. Revolving Siphon Ventilator

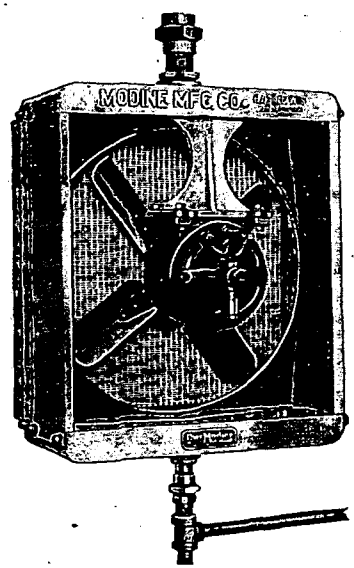
Size	Gauge	Cu. Ft. per Hr.
10	24	29,040
12	24	41,400
14	24	56,460
16	22	73,920
18	22	93,240
20	22	115,200
22	22	139,380
24	22	165,840
26	20	194,400
28	20	225,720
30	20	259,200
32	20	294,840
34	20	332,880
36	20	373,200
38	20	415,800
40	20	460,800
42	18	507,960
44	18	557,520
46	18	609,360
48	18	660,000
50	18	720,000
52	18	778,800
54	18	839,760
56	16	903,000
58	16	968,760
60	16	1,036,800

Modine Manufacturing Co.

Racine, Wisconsin

Sales Offices in Principal Cities

Manufacturers of Unit Heaters, Cabinet Heaters, Concealed Radiation



TherModine Unit Heaters

This heating unit is the result of years of effort to produce a heater combining great heat transfer capacity with minimum weight and simplicity. One TherModine Unit Heater weighing 125 lb. will deliver more effective heat than 5,000 lb. of ordinary cast iron radiation depending upon gravity circulation.

Construction—Consists of three major parts: the condenser assembly, manifold and frame assembly, and the fan and motor assembly. Condenser is of copper construction that cannot leak, rust or corrode. Is so attached to manifold and frame assembly that full allowance is made for expansion.

Flexibility—Exclusive directional advantage. Unit can be rotated in any direction on vertical axis after loosening union in feed and return connections. Vertical control is provided by adjustable deflectors. Will deliver a stream of heated air to the floor from a maximum height of 12 ft.

Light Weight—Easily Installed—Light weight makes it possible to suspend all models from steam main. A 2 in. main is sufficient to support it. No other brackets or rods are necessary.

CAPACITIES

Heat Deliveries in B.t.u. per Hour with 5 lb. Steam

Room Temperature Degrees	Model 101	Model 201	Model 301	Model 501	Model 701
50	26,800	43,700	66,700	139,100	178,800
60	24,900	42,400	61,300	131,300	167,000
65	23,900	41,200	60,000	126,000	160,000
70	22,800	40,500	57,000	121,900	153,100

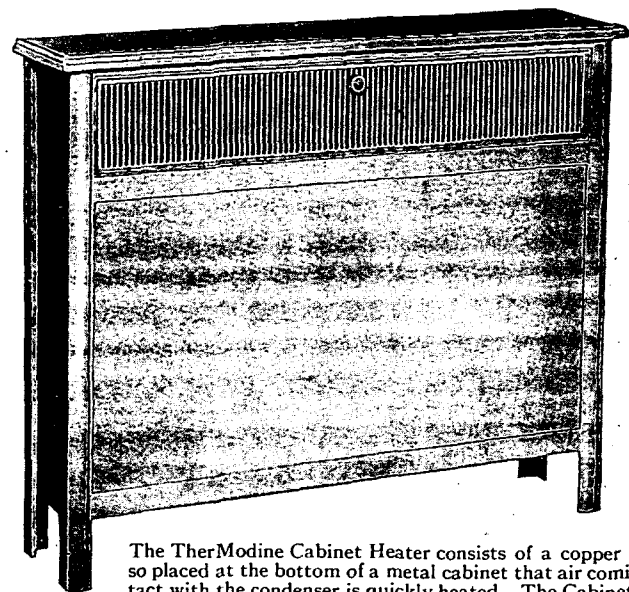
With Water at 170 deg. fahr. Average Temperature

Room Temperature Degrees	Model 102	Model 202	Model 302	Model 502	Model 702
50	14,800	28,300	35,600	79,500	99,100
60	13,400	26,000	32,100	70,900	89,700
65	12,300	24,700	30,000	68,000	82,500
70	11,800	24,000	28,600	64,000	79,500

OVERALL DIMENSIONS

Model	Height Inches	Width Inches	Depth Inches	Inlet Tapped Inches	Outlet Tapped Inches	Weight Lb.
701, 702, 501, 502	24⅝	20½	17	2	¾	125
301, 302, 201, 202	16¾	13⅜	11	1¼	¾	75
101,102	12	12	11	1¼	1¼	40

TherModine Cabinet Heaters



The TherModine Cabinet Heater consists of a copper condenser so placed at the bottom of a metal cabinet that air coming in contact with the condenser is quickly heated. The Cabinet acts as a stack causing the heated air to rise and be discharged through a grille near the top of the Cabinet. The TherModine Cabinet Heater is composed of two parts: the TherModine Heating Section Type **H**, and the Cabinet.

The Heating Section or condenser consists of a series of flattened copper tubes held rigidly in place by copper fins perpendicular to the tubes. Metal tanks or headers receive the ends of the tubes, acting as manifolds for the entering steam and returning condensation. The condenser is of unusual heat transfer capacity, cannot leak, rust or corrode and is built to outlast cast iron radiation.

The Cabinet, substantially constructed of auto body steel, sets over condenser, entirely free of any connections to condenser, floor or wall. Because of its light weight, Cabinet may easily be removed by simply lifting it from condenser. This greatly facilitates cleaning around the condenser. Cabinets are furnished with a priming coat and may be finished to harmonize with the decorative scheme of the room. As the top of the Cabinet never becomes excessively warm, it may be used as a shelf for books, bric-a-brac, etc.

TherModine Type **C** Humidifiers are furnished with all cabinets. The Humidifier is a water pan extending the full width of the Cabinet and is so arranged that there is a slight circulation of air over the surface of the water. Convenient means of filling are provided.

TherModine Cabinets are supplied with a close fitting damper for modulating the flow of heat into the room. The heat flow is controlled manually by setting the damper. The damper can also be operated by automatic temperature regulating systems. A radiator valve is not necessary but is advisable for the purpose of shutting off the steam.

The light weight of the TherModine Heating Section is best exemplified by a comparison with cast iron radiation. A TherModine Section weighing 11 lb. is equivalent to 50 sq. ft. of cast iron radiation weighing approximately 350 lb. The TherModine Cabinet for this section weighs about 25 lb.

TherModine Cabinet Heaters are manufactured in a wide range of sizes to meet the requirements of rooms of various dimensions.

ESTABLISHED 1894

John J. Nesbitt, Inc.

Manufacturers of

The Universal Heating and Ventilating Unit

Executive Offices and Factory

State Road and Rhawn Street, **Holmesburg Junction, Philadelphia, Pa.**

Branch Office, 405 Lexington Avenue, NEW YORK CITY

Sales and Service Through Offices of the American Blower Co.
In all Principal Cities of United States and Canada

Products

Manufacturers of the "UNIVERSAL" combined Heating and Ventilating Unit (Portable Unit Ventilators), also "UNIVERSAL" air filters.

"UNIVERSAL" Unit System of Heating and Ventilating

A mechanical system of ventilation for supplying fresh warm air directly from out of doors for use wherever good ventilation is required and particularly suitable for school house ventilation.

"UNIVERSAL" Combined Heating and Ventilating Unit

The Unit is built in sizes ranging from 500 to 4000 c.f.m.

Cabinet Size

Capacity C.f.m.	Height Inches	Length Inches	Depth Inches
400- 750	36	27	14
900-1500	36	43	14
2000	48	43	18

All sizes can be arranged for floor or ceiling mounting.

Motor

The motor of the "UNIVERSAL" Unit is supplied for quiet operation on any character of current. The use of a motor generator set is no longer necessary with this system, but will be furnished upon request.

Volume Control

When a fine adjustment is desired for obtaining either a larger or smaller volume of air than a given set of fans discharge from a given line voltage, air volume regulators will be furnished. Air volume regulators consist of curved plates, which may be readily adjusted to further open or close the fan discharge opening. The reduction of the air delivery results in a corresponding reduction of current consumed.

Radiator

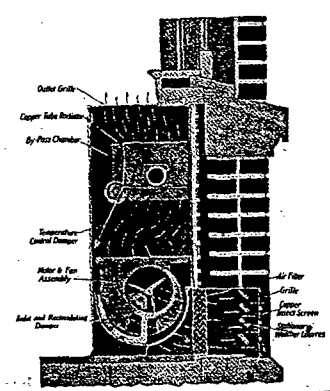
Standard "UNIVERSAL" Units are supplied with a radiator which consists of horizontal seamless copper tubes, the ends of which are connected to a cast iron header by means of ground joints. Over these tubes are hydraulically pressed thin copper plates or fins properly spaced. Hydraulic pressure insures absolute heat transfer from tube to fin, making the whole a highly efficient unit. This type is particularly sturdy and rigid and will give permanent service. Tested at 100 lb. pressure.

"UNIVERSAL" Air Filters

The use of air filters is especially recommended for buildings located in congested manufacturing districts, or where the air is heavily laden with dust or soot. "UNIVERSAL" air filters are the adhesive impingement type, designed to fit in the fresh air intake of the "UNIVERSAL" Unit. In this location the velocity of air over the entire surface of the filter is uniform with the result that an equal amount of work is imposed throughout its entire area. Combined with this ideal location is a set arrangement, which provides ease and simplicity of removal and replacement, when cleaning is necessary.

Fans

"UNIVERSAL" Fans are of the multi-blade low speed double inlet type, designed to operate at 800 r.p.m., plus or minus 5 per cent. The fans are rigidly constructed of aluminum with special care given to balance. Fans are mounted on double extended ends of the motor shaft.



Vertical section, end removed, UNIVERSAL UNIT. Series No. 14-3643. Fresh air intake through wall box and grille near bottom of Unit. This Unit can be recessed to depth of 4 in. as shown, recess must be 60 in. long by 36 in. high, or can be recessed 8 in. in 43 in. long recess 36 in. high. Standard practice places the Unit flush with the inside wall.

Three-Point Lead Mounting

The motor and fan assembly of the "UNIVERSAL" Unit is mounted in the cabinet on three steel ball points. These points rest on lead liners, supported by angles from the side of the casing. This three-point lead mounting has made possible the use of alternating current motors with a permanent and rigid supporting device.

Catalogue and Engineers' Data Book

A copy of our "Catalogue and Engineers' Data Book" containing complete engineering data, specifications, etc., on "UNIVERSAL" Unit Ventilation System, will be furnished upon request to our executive office.

Pecco Incorporated

Main Office and Factory

2957 North Market Street **St. Louis, Missouri, U. S. A.**

PECCO UNIT HEATERS
"They Keep The Whole Place Warm"

District Sales Offices

DAVENPORT, IOWA · CINCINNATI, OHIO · NEW YORK, N. Y. · CHICAGO, ILL.
COLUMBUS, OHIO · BALTIMORE, MD. · BOSTON, MASS. · PITTSBURGH, PA.

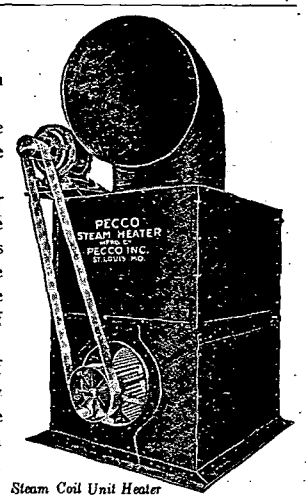
Pecco Steam Units

PECCO UNIT HEATERS are built in two types, Steam Coil and Direct Fired.

The advantage of these units as illustrated, is in the fact that they are designed to operate in accordance with natural laws.

The cooler air is drawn off the floor and the warm air discharged out in a horizontal direction above the working zone. In this way a constant circulation is maintained in the working zone which produces more uniform temperatures and keeps the heat down where it is wanted. This circulation prevents excessive loss of heat to the upper levels.

PECCO HEATERS are built to the highest kind of standards. The steam coils are guaranteed for any steam pressure up to 125 lb. and the fan units are of the very best design, carefully balanced and operating on ball bearings. Capacities range from 130,000 B.t.u. to 1,700,000 B.t.u. when recirculating air at 60 deg.



Steam Coil Unit Heater

Direct Fired Type

Direct Fired Type

The PECCO DIRECT FIRED HEATER, which burns either coal, coke, gas, wood or oil, is built on the same principle as the Steam Unit and is just as effective in maintaining proper temperatures near the floor over large areas.

We also manufacture a light weight copper tube fin type heater for smaller buildings or special conditions.

We maintain an organization of experienced heating engineers who are ready to serve you in working out your heating problems. Ask for catalogs or for the assistance of our engineers.

Peerless Unit Ventilation Company, Inc.

Heating and Ventilating Systems -:- Industrial Heating Units

718-34 Crescent Avenue, **Bridgeport, Conn.**

NEW YORK, N. Y., 369 Lexington Avenue
BOSTON, MASS., 100 Boylston Street
BUFFALO, N.Y., 135 University Avenue
HARRISBURG, PA., 705 Telegraph Building
} Sales Offices {
CLEVELAND, OHIO, 1836 Euclid Avenue
CHICAGO, ILL., 808 Monadnock Building
DETROIT, MICH., 1214 Lafayette Building
MINNEAPOLIS, MINN., 240 Seventh Avenue, S.
PORTLAND, ORE., 927 Board of Trade Building

CANADA: Darling Brothers, Ltd., 77 York Street, TORONTO, ONT.

Products

"PEERVENT" and "PEERLESS" HEATING and VENTILATING UNITS, for Schools, Hospitals, Libraries, Churches, Dormitories, Club Rooms, Theaters, Banks, Offices, Auditoriums and other Buildings where many people congregate.

"PEERLESS" INDUSTRIAL HEATING UNITS (used in place of cast iron radiators), for Factories, Garages and other Industrial Buildings.

"PeerVent" and "Peerless" Heating-Ventilating Units

This Company makes two types of heating and ventilating units—"PEERVENT" and "PEERLESS"—both intended for the same service but differing in design and construction. Only the PEERVENT Unit is illustrated in these pages. Information about PEERLESS Units will be sent on request.

Operation of "PeerVent" Units

The illustrations on the following page show clearly how the PEERVENT Heating and Ventilating Unit operates. The system consists of a series of units—one unit usually for each room requiring ventilation. Each unit operates independently and each room gets exactly the required amount of heat and fresh air—without waste of fuel.

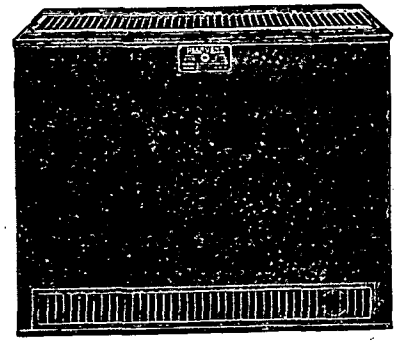
The standard unit is usually placed beneath a window—it is only 36 in. high and 14 in. deep—but many adaptions are available, including concealed and semi-concealed types, for a wide range of architectural requirements.

Units of various sizes and capacities are furnished. For schools, the usual standard of ventilation is 30 cu. ft. of air per minute for each pupil. A radiator large enough to heat this volume of incoming air to any desired degree, from very low outdoor temperatures, is provided in each PEERVENT Unit.

Ordinary direct radiation is commonly installed in addition to the PEERVENT Units, but the direct radiation is used only for extreme conditions—such as exceptionally cold weather.

Cold rooms can be heated quickly with PEERVENT Units, before being occupied, by means of recirculation. The recirculation damper (operated by hand at the unit or pneumatically from a remote point) shuts off the flow of incoming air from outdoors, and allows the fans to draw in air from within the room through a grille near the bottom of the unit. Thus the air in the room is recirculated through the unit until it is warmed to the required temperature. Then the recirculation and fresh air damper moves back to the position which allows fresh air to enter from outdoors.

When a room is unoccupied, the fresh air and recirculation damper can be closed and the radiator in the unit used for such limited heating as is then desirable. The motor and fans need not be operated



PeerVent Heating and Ventilating Unit

during periods of vacancy, or until shortly before the room is to be used, when the temperature can be raised to normal by starting the fans and recirculating the air in the room as explained above.

Advantages

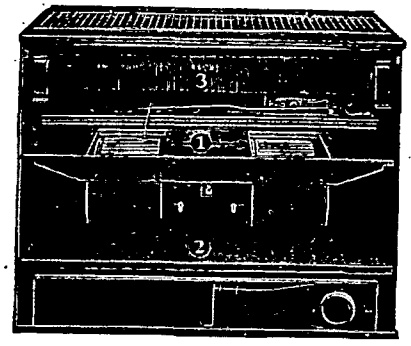
Each PEERVENT Unit is entirely independent, and the operating expense is **per room,** proportional to the demand of that room only, regardless of conditions in other parts of the building. Rooms which are naturally cold get the extra heat required. Opening windows in one room cannot affect any other room, and each unit can be operated at the lowest possible cost for the work to be done.

Because the discharge of heated air from the PEERVENT Unit is vertical, desks can be placed close to the Unit without discomfort. There are no drafts.

The motor and fans are wholly enclosed, and mounted in a way that eliminates vibration and insures noiseless operation.

There is nothing in the PEERVENT Unit to cause trouble. The only wearing parts are the motor bearings, which are of phosphor-bronze, sleeve type. All parts of the unit are easily accessible; in fact, it can be dismantled entirely and reassembled in a few minutes, without tools. No user has ever encountered mechanical trouble with PEERVENT Units.

PEERVENT Units occupy little more



PeerVent Heating and Ventilating Unit with Front Plate Removed

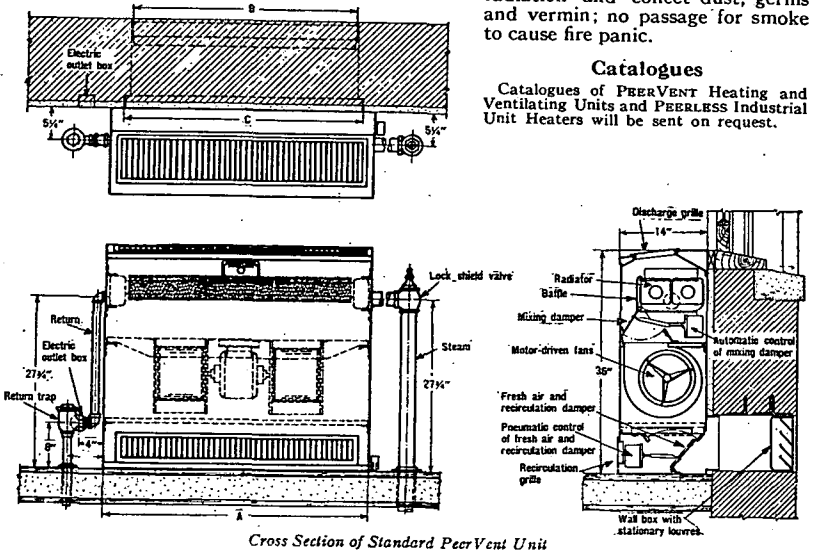
space than ordinary radiators. The unit system reduces structural costs, eliminates large and expensive apparatus and apparatus rooms, boiler pits, etc.

Ventilation can be stopped instantly when a unit-equipped room is unoccupied. One or two rooms used after hours can be ventilated separately and economically. The cost of ventilating rooms not used is completely eliminated.

The PEERVENT System requires no built-in or sheet metal ducts or warm air passages of any kind to waste heat through radiation and collect dust, germs and vermin; no passage for smoke to cause fire panic.

Catalogues

Catalogues of PEERVENT Heating and Ventilating Units and PEERLESS Industrial Unit Heaters will be sent on request.



Cross Section of Standard PeerVent Unit

Engineering Data—PEERVENT Heating and Ventilating Units

Unit No.	Maximum No. of Pupils	C.f.m. Delivered	Entering Air −10°					Entering Air 0°					Entering Air +10°				
			Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3	Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3	Final Discharge Temp.	Condensation, Lb. per Hour	B.t.u. Value (see note below) 1	2	3
36331	13	400	118.7	67.6	65500	5280 (61 Sq. Ft.)	25000	125	64.3	62400	14725 (58.9 Sq. Ft.)	27500	131.2	63.8	61700	14170 (56.6 Sq. Ft.)	32400
36332	16	500	113.7	81.2	78600		27700	120	77.3	74900		31200	126.2	73.5	71100		34400
36333	20	600	106.7	91.7	89000		28000	113	87.2	84500		32100	119.2	82.8	80100		37100
36334	23	700	100	101	97900		26700	106.3	96	92800		31700	112.5	89.7	87700		36300
36335	26	800	92.9	108	104600		23200	99.2	99	97800		27900	105.4	94.7	91700		33000
36336	30	900	80.7	108	104600		13100	87.1	99	97800		19200	93.3	94.7	91700		25700
36337	33	1000	72.1	108	104600		2800	78.4	99	97800		10400	84.6	94.7	91700		18300
36338	35	1050	.....	.....	.....		.....	72	99	97800		6100	78.2	94.7	91700		14600
36421	30	900	94.5	136.7	132600	19440 (77.75 Sq. Ft.)	41000	100.7	128.6	124500	18740 (74.96 Sq. Ft.)	45900	106.9	120.5	116600	18037 (72 Sq. Ft.)	50200
36422	33	1000	91	136.7	132600		30800	97.2	128.6	124500		37100	103.4	120.5	116600		43000
36423	35	1050	87.5	136.7	132600		25900	93.7	128.6	124500		32800	99	120.5	116600		39400
36424	36	1100	83.9	136.7	132600		20700	90.2	128.6	124500		28500	96.4	120.5	116600		35800
36425	38	1150	80.4	136.7	132600		15600	86.7	128.6	124500		24100	93.1	120.5	116600		32200
36426	40	1200	76.9	136.7	132600		10600	83.2	128.6	124500		19700	89.4	120.5	116600		28600
36427	41	1250	73.4	136.7	132600		5400	79.7	128.6	124500		15300	85.9	120.5	116600		25000
36428	43	1300	70	136.7	132600		....	76.2	128.6	124500		10900	82.4	120.5	116600		21400
36429	45	1350	66.4	136.7	132600		....	72.7	128.6	124500		6500	78.9	120.5	116600		17800
36511	40	1200	95.4	166.5	161000	23610 (94.4 Sq. Ft.)	38900	101.6	156	150900	22740 (90.9 Sq. Ft.)	46100	107.8	145.7	141000	21860 (87.5 Sq. Ft.)	52900
36512	43	1300	88.4	166.5	161000		28800	94.6	156	150900		37400	100.8	145.7	141000		45500
36513	45	1350	84.9	166.5	161000		23600	91.1	156	150900		33000	97.3	145.7	141000		41900
36514	46	1400	81.4	166.5	161000		18500	87.6	156	150900		28600	93.8	145.7	141000		38200
36515	48	1450	77.9	166.5	161000		13500	84.1	156	150900		24200	90.3	145.7	141000		34500
36516	50	1500	74.4	166.5	161000		8400	80.6	156	150900		19800	86.8	145.7	141000		30800
36517	51	1550	70.9	166.5	161000		3300	77.1	156	150900		15400	83.3	145.7	141000		27200
36518	53	1600	67.4	166.5	161000		....	73.6	156	150900		11000	79.8	145.7	141000		23600
36519	57	1700	60.4	166.5	161000		....	66.6	156	150900		.....	72.8	145.7	141000		16300

Note.—B.t.u. values are as follows:
1. With fans running.
2. With fans stopped.
3. B.t.u. available for heating purposes, over requirements for heating indicated c.f.m. to 70 deg.

Where values are not given, the discharge temperature is lower than we would recommend and we suggest the use of next larger size PeerVent.

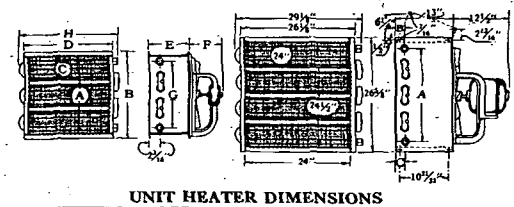
Unit No.	Maximum Number of Pupils	Maximum Cu. Ft. per Minute	Dimensions Height 36" Depth 14" — Length Overall Outside L	Fresh Air Intake 8½ x B B	Approximate Shipping Weight Lb.	Power Consumption in Watts	PIPING DATA — Steam and Return—5⅛ in. from Back of Unit — Height of Steam and Return Openings from Floor	Steam Size (see note) Gravity System	Steam Size (see note) Vacuum System	Return Size (see note) Gravity System	Return Size (see note) Vacuum System
36331	13	400				65		1½"	1¼"		
36332	60	500				75		1½"	1¼"		
36333	20	600				85		1½"	1¼"		
36334	23	700	33⅜"	27½"	300	100	27¾"	1½"	1¼"	1"	¾"
36335	26	800				113		1½"	1¼"		
36336	30	900				126		2"	1½"		
36337	33	1000				142		2"	1½"		
36338	35	1050				146		2"	1½"		
36421	30	900				115		2"	1½"		
36422	33	1000				132		2"	1½"		
36423	35	1050				141		2"	1½"		
36424	36	1100				150		2"	1½"		
36425	38	1150	42⅜"	36½"	350	159	27¾"	2"	1½"	1"	¾"
36426	40	1200				168		2"	2"		
36427	41	1250				177		2"	2"		
36428	43	1300				186		2"	2"		
36429	45	1350				195		2"	2"		
36511	40	1200				162		2"	2"		
36512	43	1300				178		2"	2"		
36513	45	1350				186		2"	2"		
36514	46	1400				194		2"	2"		
36515	48	1450				200		2"	2"		
36516	50	1500	51⅜"	45½"	400	208	27¾"	2"	2"	1"	¾"
36517	51	1550				215		2"	2"		
36518	53	1600				222		2"	2"		
36519	57	1700				230		2"	2"		

Note.—Peerfin Radiators are tapped 2 in. for both steam and return connections but can be reduced to sizes given in table. Eccentric reducers must be used. Peerfin Radiators can be connected with either right or left hand steam supply.

The Trane Company

La Crosse, Wis.

Manufacturers of Trane Heating Specialties, Pumps, Heat Cabinets, Concealed Heaters and Blast Heaters



Unit Heaters

The Trane Unit Heaters are of the extended surface type using a heating unit similar to that used in the Trane Heat Cabinets. No soldered or welded joints. Guaranteed for pressures up to 150 lb. Unit Heaters for higher pressures can be furnished.

UNIT HEATER DIMENSIONS

Unit No.	A	B	C	D	E	F	G	H
121	12¼"	15"	12"	15"	6"	⅞"	9¾"	16¾"
181	18⅜"	20¼"	18"	19⅛"	8⅜"	8"	15⅜"	22¾"
241	21⅝"	2⅛"	2½"	Pipe Tapping 1"				
242	22"	3⅞"	3⅞"	Pipe Tapping 1½"				
243	22⅝"	9"	2⅛"	Pipe Tapping 2"				

	Steam Pressure Lbs. per Sq. In.	Room Temperature 50° F. *B.t.u. Output	Cond. Lbs. per Hour	Final Temp.	Room Temperature 60° F. *B.t.u. Output	Cond. Lbs. per Hour	Final Temp.	Room Temperature 70° F. *B.t.u. Output	Cond. Lbs. per Hour	Final Temp.
HEATER No. 241	5	112,500	117	91	109,500	114	100	103,000	107	108
	10	126,000	132	96	119,500	125	104	113,000	119	112
	20	137,000	146	100	130,500	139	108	124,000	132	116
	30	145,000	156	103	138,500	149	111	132,000	142	119
	40	153,000	167	106	146,500	160	114	140,000	152	121
	50	162,000	178	109	155,500	171	117	148,000	162	124
	60	171,000	189	113	164,000	182	120	157,000	174	128
	70	180,000	201	116	173,000	193	123	166,000	185	131
	80	189,000	212	119	182,000	204	127	175,000	196	134
	90	197,000	223	122	190,000	215	130	183,000	207	137
	100	207,000	235	126	200,000	228	134	193,000	220	141
HEATER No. 242	5	169,000	177	116	160,500	167	123	151,000	158	129
	10	176,000	183	118	167,000	175	125	158,000	166	132
	20	191,000	204	125	181,500	193	131	172,500	184	137
	30	203,000	219	129	194,000	209	136	185,000	200	142
	40	216,000	235	134	207,000	225	141	198,000	216	147
	50	228,000	250	139	219,000	241	146	210,000	231	152
	60	240,000	266	144	231,000	256	150	222,000	246	157
	70	251,000	280	149	242,000	270	155	233,000	260	161
	80	264,000	297	153	254,000	285	159	245,000	275	166
	90	275,000	311	158	265,000	300	164	255,000	289	170
	100	285,000	324	162	275,000	314	168	265,000	301	174
HEATER No. 243	5	231,000	241	146	218,000	227	151	205,000	214	156
	10	250,000	263	155	237,000	249	159	224,000	235	164
	20	276,000	294	165	263,000	280	170	250,000	266	175
	30	297,000	320	174	284,000	306	179	271,000	292	183
	40	313,000	340	181	300,000	326	185	287,000	312	190
	50	329,000	361	188	315,000	346	192	302,000	332	196
	60	341,000	377	193	328,000	362	197	315,000	348	202
	70	354,000	395	198	340,000	379	202	327,000	364	207
	80	364,000	409	202	351,000	394	207	338,000	379	211
	90	376,000	425	207	362,000	408	211	349,000	394	216
	100	386,000	438	212	372,000	423	216	359,000	408	220

To find Unit Heater capacity in equivalent sq. ft. of direct radiation divide B.t.u. per hour by 240. Capacities for other sizes of Unit Heaters is contained in Trane Bulletin 23-A.

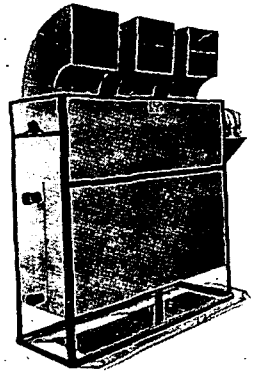
York Heating and Ventilating Corp.

1518 Locust Street, **Philadelphia**

Branch Offices and Representatives in All Principal Cities

York Heat-Diffusing Units for Heating Factories, Shops, Garages, Etc.

YORK HEAT-DIFFUSING UNIT



Operating Economies:

1. High-velocity heat diffusion holds heat in the working zone until its principal energy has been utilized.
2. Reduces overheating of upper areas.
3. Heats large floor areas quickly. Saves fuel by reducing time.
4. Rise in temperature in average building from floor to roof is less than one degree per foot of height.
5. A single Unit of correct capacity will heat uniformly a floor space up to 60 ft. by 200 ft. Comparatively few Units are required even for large plants.
6. The work of installation is reduced. Mains are shortened and fewer branches and fittings are needed.
7. Cost of complete installation ordinarily runs from 10 to 50 per cent below cost of direct radiation, pipe coils or central blower system.

Specifications:

Four sizes and capacities of Units are standard. No. 25 and No. 35 Units are but 18 in. wide, while the No. 50 and No. 55 are but 36 in. All Units are 7 ft. long in floor plan except No. 25, which is 3½ ft. All Units can be used on steam or water pressures from 0 to 200 lbs. All are tested to 1000 lbs. hydrostatic pressure.

Fresh air intakes and regulating dampers can be furnished at a slight extra charge. By their use the Units may be made to operate wholly on air drawn from outside, or on any proportion of outside and recirculated air.

NOTE.—Light weight suspended heaters can be furnished where it is impossible to use floor mounted heaters.

CAPACITIES

Size Unit	R.p.m.	C.f.m. at Temp. in the Fans	Hp. Motor	Recirculating Air at 60° F. Entering Unit and Steam at 2 Lb. Gauge Pressure on the heating Surface. (See footnote.)				Air at 0° F. Entering Unit and Steam at 5 Lb. Gauge Pressure on the Heating Surace.*			No. of Air Outlets	Pipe Connections	
				B.t.u. per Hr.	Final Temp.	Lbs. Cond. per Hr.	Equiv. Direct Rad.	B.t.u. per Hr.	Final Temp.	Lbs. Cond. per Hr.		Supply	Return
25	1750 1160	2780 1800	¾ ½	197,000 139,000	133° 141°	204 144	820	283,000 198,600	104° 116°	294 207	2	2½"	1½"
35	1750 1160	5480 3620	1½ ½	389,000 281,000	133° 141°	403 291	1620	555,000 401,000	105° 116°	579 418	4	3"	2"
50-S	1160 870	11,000 8400	3 1½	590,000 487,000	114° 118°	610 505	2460	842,000 696,000	77° 84°	876 725	3	3"	2"
	1160 870	10,250 7700	3 2	758,000 600,000	137° 142°	784 621	3160	1,081,000 858,000	110° 117°	1121 894	3	3"	2"

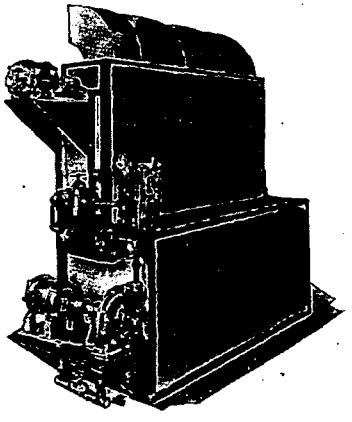
NOTE.—It is understood that the specified steam pressure is to be maintained on the heating surface. A suitable pipe line drop must be added in determining the pressure to be carried at the boiler. When air is to enter the unit at a temperature below freezing the steam pressure on the heating surface should be maintained at not less than 5 lb.

*See Chapter XI of this issue of the GUIDE for B.t.u. constants for other steam pressures and entering temperatures.

For 25-cycle speed and other ratings ask for complete Catalog.

York Air-Conditioning Units for Air Conditioning in Industrial Plants of All Kinds

YORK AIR-CONDITIONING UNIT



PRODUCTS—Air-Conditioning Units, Heat-Diffusing Units.

Unit System of Air Conditioning:

Complete air conditioning—heating and humidification in combination—is now available to Industry in a compact, highly-developed unit.

The basis of operation is the universally known York Heat-Diffusing Unit, amplified and developed to include the functions of scientific air conditioning.

The expensive, immobile distributing system such as is an essential part of a central air conditioning installation is entirely eliminated. Any floor, any partitioned department may now be controlled effectively as to atmospheric conditions, without reference to any other floor or department.

Operation:

The York Air-Conditioning Unit receives steam from the regular steam line, and water from a simple water pipe connection. The air passes through two spray chambers and a series of baffle plates, which humidify or dehumidify automatically according to the desired standard. It is then heated and blown out horizontally at high velocity above the heads of the workers.

Simple regulating controls, easily set, govern both temperature and degree of humidity. An effectively conditioned atmosphere results.

Advantages:

No expensive central system is needed. Awkward, bulky ducts are eliminated. Every Unit is mobile—can be shifted as needed in a few hours. The work of installation is as nothing compared with the setting up of a central system. Complete flexibility of operation is possible. The cost of the Unit System is but a fraction of what has been the accepted standard for air conditioning in the past.

Installation:

As these units are shipped completely assembled, the installation consists only in making ordinary connections to steam, water and electric lines. Installations are personally inspected by York experts.

Data Required:

Blue Prints and full information as to size and construction of building or department into which the Units are going; full information as to material to be conditioned and amount handled; available locations for Units and location of steam, water and electric lines.

Information:

Full information concerning York Air Conditioning Units in general, or for specific conditions, will gladly be sent on request. Cooperation with Heating Engineers, Contractors and others will gladly be given.

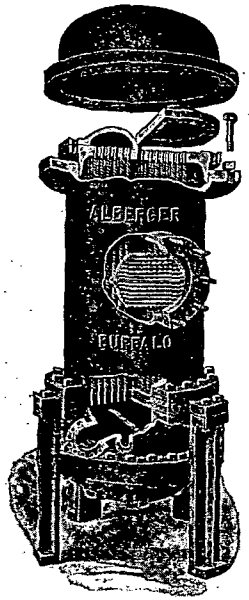
Alberger Heater Company

HOWARD IRON WORKS

218 Chicago St. :-: :-: :-: BUFFALO, N. Y.

REPRESENTATIVES IN PRINCIPAL CITIES

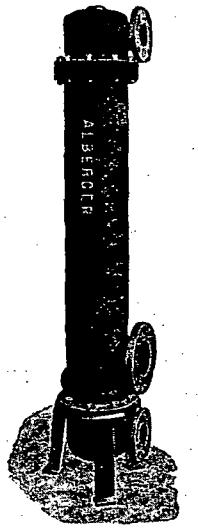
Heaters — Condensers — Coolers — Economizers — Expansion Joints



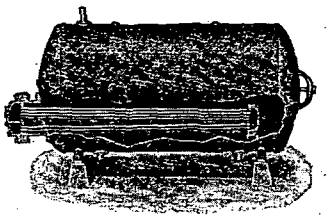
Instantaneous Water Heater Furnished in Vertical or Horizontal Type

Alberger-Buffalo Heaters are built in several types to meet a large range of standard and special water heating requirements. The standard instantaneous water tube type with floating heads is a highly efficient device embodying economy in space and maintenance cost. The storage water heater is used where the steam supply is intermittent or insufficient to take care of peak water demands. The swimming pool heater is especially designed for the purpose and is also extensively used with air washer equipment.

All of these heaters are built in either horizontal or vertical arrangement. **Alberger-Buffalo** equipment is widely used for many special requirements involving the heating or cooling of water and other liquids, and for the interchange of heat from one liquid to another.



Swimming Pool Heater Single Pass Furnished in Vertical or Horizontal Type

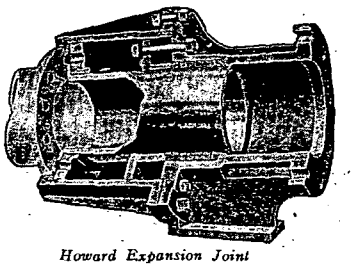


Storage Type Heater

ARCHITECTS ENGINEERS CONTRACTORS — **If you have not already done so, send immediately for a copy of the ALBERGER HEATER DATA BOOK which gives complete information regarding capacities and dimensions of our various types, as well as service and installation data. Also remember that our experience in designing and building special heaters and coolers is available to prospective clients.**

The Howard Guided Expansion Joint is a most satisfactory means for taking care of expansion in pipe lines because it is designed with only one object in view—100% service. The construction is mechanically correct—deep stuffing box—bronze sliding sleeve—totally enclosed construction to eliminate accumulation of dirt—exterior adjustment of packing gland—ready accessibility when packing is renewed. It is the most economical joint to use because it stays on the job and leaves a satisfied customer.

Send for—Bulletin XJ-3 for full details.



Howard Expansion Joint

Davis Engineering Corp.

90 West Street, New York, N. Y.

Cable Address: "PARACOIL, NEW YORK" Factory: ELIZABETH, N.J.

Manufacturers of Paracoil Steam Traps, Steam Specialties, Water Storage Heaters and other Heat Exchangers

Paracoil Products

STEAM TRAPS, FEED WATER HEATERS, FEED WATER FILTERS AND GREASE EXTRACTORS, STORAGE WATER HEATERS, OIL HEATERS, EVAPORATORS, EXHAUST GAS-STEAM GENERATORS, OIL COOLERS, DISTILLERS.

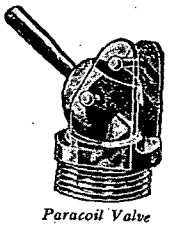
Paracoil Steam Trap

In this trap there is only one moving part, the solid recessed sphere which rotates over the valve seat. The trap is designed for all pressures, but 30 lb. steam pressure, 125 lb. and 200 lb., are carried in stock.

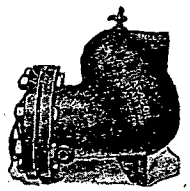
The oscillating action of the valve makes possible a constant flow of condensate and the gauging action of the recessed ball keeps foreign matter from lodging between the valve and its seat. Capacities up to 75,000 lb. per hour.

The Paracoil Trap is guaranteed free from repairs for two years, providing installation and operating instructions are followed.

Write for Catalogue A-12.



Paracoil Valve



Paracoil Steam Trap

Paracoil Steam Trap

Trap In.	Capacity Sq. Ft. Radiation	Height In.	Length In.	Width In.	List Price	Wght Lb.
½	800	8½	8	8	$15.00	24
¾	1800	8⅝	10⅛	4⅞	20.00	28
1						
special 1–1¼	.....	11½	11½	5½	25.00	36
1½–2	4800	12¾	12	6⅛	35.00	50
2½	8000	16⅜	16	10¼	68.00	112
3	12,000	18	19	11½	100.00	185
	23,000	20	20¾	11½	125.00	212

Larger size traps on application.

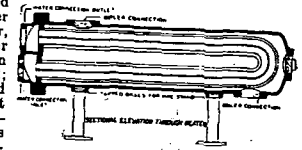
Paracoil Storage Water Heater

For heating and storing hot water for laundries, factories, hospitals, etc. The utilization of exhaust steam in this water heater effects a big fuel saving. Has steel plate shell for water and copper heating coils for steam. Pressures, 100 lb. standard and up. Sizes. 200 to 20,000 gallons per hour, heated to 180 deg. fahr. Fully described in Bulletin 74.

Paracoil Storage Water Heater

Paracoil Instantaneous Water Heater, U Tube Tank Heater, Preheater and Condensation Cooler

Connected below water level of boiler, heats water supply when fire is banked; Unexcelled for indirect heating of private garages and conservatories.



Paracoil Instantaneous Water Heater

No.	Diameter In.	Length In.	Water Inlet and Outlet In.	Steam Inlet In.	Drain In.	Capacity Gal./Hr. 40–180° F. Steam Atmos.	W'ght Lb.
200	14½	34	2	2	1	200	250
300	14½	34	2	2	1	300	260
400	14½	47	2	3	1½	400	290
500	14½	47	2	3	1½	500	300
600	16½	50	3	4	1½	600	480
750	16½	50	3	4	1½	750	500
1000	16½	62	3	4	1½	1000	560
1250	16½	62	3	4	1½	1250	580
1500	19½	70	3	5	2	1500	962
1750	19½	75	3½	5	2	1750	1010
2000	19½	80	3½	6	2	2000	1083
2500	21½	81	3½	6	2	2500	1252
3000	21½	87	4	7	2½	3000	1301
4000	21½	99	4	8	2½	4000	1400
5000	21½	110	4	10	2½	5000	1481
7500	26	95	5	12	3	7500	1915
10000	26	108	5	14	3	10,000	2126
12500	26	120	5	14	3	12,500	2241

Nos. 200 to 1250 cast iron shell, and Nos. 1500 to 12,500 steel shell.

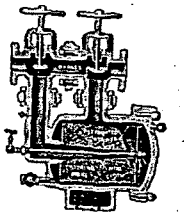
Paracoil U Tube Type Tank Heater

Size No.	Capacity, Gals. Below Water Level	Capacity, Gals. With Live Steam	Hot Water Radiation Sq. Ft.	Diam. In.	Length In.	Wght Lb.
1	350	650	260	7½	27½	90
2	700	1300	520	11¾	40¼	220
3	1050	1900	780	14½	47	375
4	1350	2500	1000	16½	50	500

Larger sizes on application. Capacity rating, 100 deg. temperature rise in 3 hours (40 to 140 deg.). Capacity rating with live steam based on ½ lb. steam pressure.

Paracoil Feed Water Filter and Grease Extractor

Utilizes the affinity of cocoa fiber for particles of oil, grease, scum and dirt for the removal of these floating impurities from exhaust steam condensation and raw make-up water. The filtering area is over twenty times the size of inlet and outlet connections. Filter body may be by-passed and removed without cutting off the boiler supply. A steam jet and blow-off permits steaming out and further efficient use of the fiber before removal for thorough cleaning. Sizes, 2 to 6 in. Fully described in Bulletin A-4.

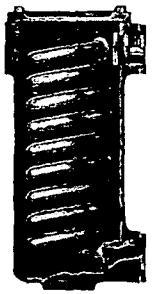


Paracoil Feed Water Filter and Grease Extractor

Excelso Products Corporation

65 Clyde Ave., BUFFALO, N. Y.

Excelso Indirect Water Heaters, Phaeton Heaters, Fire Pot Generators, Rotary Hack Saw Tools



EXCELSO INDIRECT WATER HEATERS

Dimensions—Price List—Capacities

	Single Coil						Double Coil				Triple Coil	
Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Length...In.	8½	10½	14	11½	15	19½	12½	15	19	23¼	21	25
Diameter...In.	5	5	5	6½	6½	6½	9	9	9	9	13¾	13¾
Shell Open'gs...In.	1	1	1	1½	1½	1½	2	2	2	2	3	3
Coil Open'gs...In.	¾	¾	¾	1	1	1	1½	1½	1½	1½	2½	2½
Weight Crated...Lbs.	11	13	16	29	37	42	65	73	88	106	185	210
List Price	$12.50	$30	$40	$50	$60	$70	$120	$150	$180	$210	$310	$400

Heating Water Below Water Line of Steam or Vapor Boilers

Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Tank Capacity	30	30	45	60	90	120	160	200	300	400	600	800

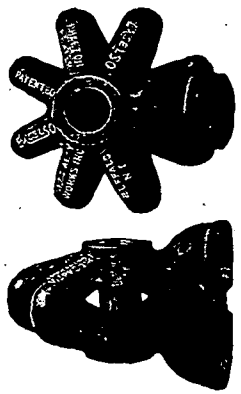
Temperature rise 100 deg. in 3 hours.

Heating Water With Live Steam

Size	Jr.	11	12	13	14	15	25	26	27	28	35	36
Tank Capacity	45	50	75	100	150	200	250	300	450	600	900	1200

Temperature rise 100 deg. in 3 hours at 5 lb. pressure.

Connect below water line of any Steam or Vapor Boiler, or use with live steam. Boiling water in the shell heats water circulating through copper coil.

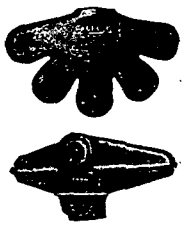


THE EXCELSO PHAETON HEATER

Dimensions—Price List—Capacities

Diameter...In.	6	8	10	12	15	18
Height...In.	3½	4½	5¼	6	7	8
Tappings...In.	1	1	1½	2	2½	3
Center to Center of Outlets...In.	2½	2½	3	3½	4½	5½
Capacity...Gals.	30	45	80	100	150	250
Sq. Ft. Direct Water Radiation...Ft.	40	75	100	150	250	400
Shipping Weight..Lb.	6	11	18	30	60	85
List Price...Iron	$7.50	$12.00	$20.00	$24.00	$50.00	$70.00
List Price...Brass	$15.00	$28.00	$45.00	$54.00	$115.00	$160.00

The highly efficient firepot heater, suitable for hot water supply or auxiliary radiation, transfers 80 per cent of heat to water.



Excelso Firepot Generator

Generator fits any type of hot water boiler or hot air furnace. Made in both cast iron and brass.

Size No. 1, up to 40 gals. capacity.

Size No. 2, over 40 gals. capacity.

Excelso Rotary Hack Saw Tool

Boilers may be quickly and easily tapped by means of the Excelso Rotary Hack Saw Tool. Each tool cuts three sizes: 1 in., 1½ in. and 2 in. Pipe Tap size.

Price $7.50 net, with six blades; two of each size.

O. E. Frank Heater and Engineering Co., Inc.

Associated with FARRAR & TREFTS, Inc.

BUFFALO, N. Y.

Branch Offices

New York, Philadelphia, Detroit, St. Louis, Tulsa, Birmingham, Indianapolis, Kansas City, Charlotte, N. C, Calgary, Alta., Baltimore, Toronto

Branch Offices

Boston Mass., Chicago, Pittsburgh, Cleveland, Halifax, Vancouver, Minneapolis, San Francisco, Washington, Harrisburg, Pa., Los Angeles, Portland, Ore.

O. E. F. Products.—U-Tube and Straight Tube Storage Heaters, U-Tube and Straight Tube Instantaneous Heaters, U-Tube and Straight Tube Feed-water Heaters, U-Tube and Straight Tube Swimming Pool Heaters, Bleeder Turbine Heaters, Domestic Service Heaters, Power Plant Heaters, Oil Coolers, Special Heat Exchange Equipment for Industrial Plants.

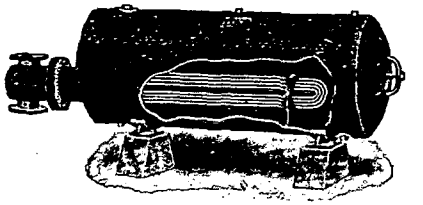
O. E. F. Storage Heaters are furnished in either the U-Tube or Straight Tube types to meet *your* requirements.

Tanks are made of high quality flange boiler steel. Tube Sheets of rolled steel, Castings of heavy gray iron, and Tubes of heavy gauge copper.

All Heaters, unless otherwise specified are constructed for a working pressure of 100 lb. Information for higher pressures furnished on request.

When it is necessary to use both high and low pressure steam, the steam chamber and tubes can be so arranged as to eliminate installation of a separate tube bundle.

All tube bundles or heating elements are removable from the tank for ease in inspection, cleaning, or repairing.



O. E. F. U-Tube Storage Heater

O. E. F. STORAGE HEATERS

For heating water from 50° to 180° F. with steam at 212° F.

Storage Capacity Gal.	80	141	220	294	370	476	576	720	940	1128	1204	1445	1469	2056	2115	2538	2961
Tank Size Inches	18 x 72	24 x 72	30 x 72	30 x 96	36 x 84	36 x 108	42 x 96	42 x 120	48 x 120	48 x 144	54 x 120	54 x 144	60 x 120	60 x 168	72 x 120	72 x 144	72 x 168
Gallons per Hour																	
100	A5	C5	F5	H5	K5	M5	O5	Q5	W5	Y5	AX5	CX5	GX5	*MX5*	*NX5*	*PX5*	*RX5*
150	*A8*	*C8*	*F8*	*H8*	*K8*	M8	O8	Q8	W8	Y8	AX8	CX8	GX8	MX8	NX8	PX8	RX8
200	A11	C11	F11	H11	H11	M11	O11	Q11	W11	Y11	AX11	CX11	GX11	MX11	NX11	PX11	RX11
250	A13	C13	F13	H13	K13	M13	O13	Q13	W13	Y13	AX13	CX13	GX13	MX13	NX13	PX13	RX13
300	A16	C16	F16	H16	K16	*M16*	O16	Q16	W16	Y16	AX16	CX16	GX16	MX16	NX16	PX16	RX16
350	....	C19	F19	H19	K19	M19	O19	Q19	W19	Y19	AX19	CX19	GX19	MX19	NX19	*PX19*	RX19
400	....	C22	F22	H22	K22	M22	O22	Q22	W22	Y22	AX22	CX22	GX22	MX22	NX22	PX22	RX22
450	....	C24	F24	H24	K24	M24	O24	Q24	W24	Y24	AX24	CX24	GX24	MX24	NX24	PX24	RX24
500	....	C27	F27	H27	K27	M27	O27	Q27	W27	Y27	AX27	CX27	GX27	MX27	NX27	PX27	RX27
600	....	C32	F32	H32	K32	M32	O32	Q32	W32	Y32	AX32	CX32	GX32	MX32	NX32	PX32	RX32
700	....	C38	F38	H38	K38	M38	O38	Q38	W38	Y38	AX38	CX38	GX38	MX38	NX38	PX38	RX38
800	....	C43	F43	H43	K43	M43	O43	Q43	W43	Y43	AX43	CX43	GX43	MX43	NX43	PX43	RX43
900	....	C47	F47	H47	K47	M47	O47	Q47	W47	Y47	AX47	CX47	GX47	MX47	NX47	PX47	RX47
1000	....	....	F54	H54	K54	M54	O54	Q54	W54	Y54	AX54	CX54	GX54	MX54	NX54	PX54	RX54
1250	....	....	F67	H67	K67	M67	O67	Q67	W67	Y67	AX67	CX67	GX67	MX67	NX67	PX67	RX67
1500	....	....	F81	H81	K81	*M81*	O81	Q81	W81	Y81	*AX81*	CX81	GX81	MX81	NX81	PX81	RX81
1750	....	....	F94	H94	K94	M94	O94	Q94	W94	Y94	AX94	CX94	GX94	MX94	NX94	PX94	RX94
2000	....	....	F108	H108	K108	M108	O108	Q108	W108	Y108	AX108	CX108	GX108	MX108	NX108	PX108	RX108
2500	....	....	....	H134	....	*M134*	*O134*	*Q134*	*W134*	*Y134*	AX134	CX134	GX134	MX134	NX134	PX134	RX134
3000	....	....	....	....	....	M162	O162	Q162	W162	Y162	AX162	CX162	GX162	MX162	NX162	PX162	RX162
3500	....	....	....	....	....	....	*O188*	Q188	W188	Y188	AX188	CX188	GX188	MX188	NX188	PX188	RX188
4000	....	....	....	....	....	....	O215	Q215	W215	Y215	AX215	*CX215*	GX215	MX215	NX215	PX215	RX215
4500	....	....	....	....	....	....	....	Q243	W243	Y243	AX243	CX243	GX243	MX243	NX243	PX243	RX243
5000	....	....	....	....	....	....	....	Q269	W269	Y269	AX269	CX269	GX269	MX269	NX269	PX269	RX269
6000	....	....	....	....	....	....	....	....	....	Y323	....	CX323	....	MX323	....	PX323	*RX323*
7000	....	....	....	....	....	....	....	....	....	....	....	....	....	MX377	....	....	RX377

NOTE.—The letter given in the above table of sizes indicates the size of the tank and the numerals, the square feet of heating surface.

EXAMPLE.—A G5 Heater consists of a 24 by 72 in. Storage Tank (length not including dished heads) and contains 5 sq. ft. of heating surface.

Write for information on sizes other than listed above, special conditions such as corrosion, and pressures

The Whitlock Coil Pipe Company

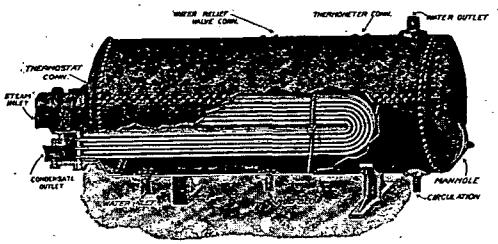
Manufacturers and Engineers

HARTFORD, CONN.

Baltimore, Md.	Dallas, Tex.		Memphis, Tenn.	San Antonio, Tex.
Boston, Mass.	Denver, Colo.		New Orleans, La.	San Francisco, Calif.
Buffalo, N. Y.	Detroit, Mich.	WHITLOCK HEAT TRANSFER PRODUCTS	New York, N. Y.	Seattle, Wash.
Charlotte, N. C.	Grand Rapids, Mich.		Omaha, Neb.	St. Louis, Mo.
Chicago, Ill.	Houston, Tex.		Philadelphia, Pa.	St. Paul, Minn.
Cincinnati, O.	Indianapolis, Ind.		Pittsburgh, Pa.	Tacoma, Wash.
Cleveland, O.	Kansas City, Mo.		Portland, Ore.	Troy, New York
			Rochester, N. Y.	Tulsa, Okla.

Darling Bros. Montreal, Manufacturers of Whitlock Heaters in Canada

See Telephone Directory for Local Address



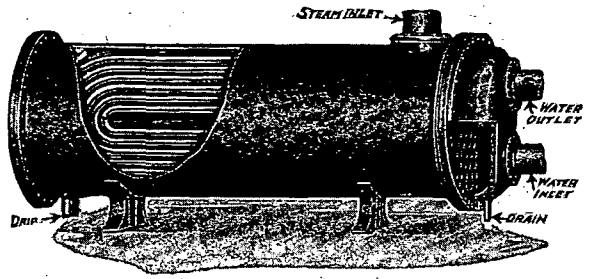
Whitlock type "K" storage heaters are manufactured in both horizontal and vertical types. The table shows sizes of the horizontal heaters only. We will gladly furnish dimensions of horizontal heaters and vertical heaters upon request. That this type of heater is of particularly sturdy construction is evidenced by the increasing number of prominent engineers and architects who are specifying their use in all types of buildings, including many of the largest and finest buildings constructed

Whitlock Type K Storage Heaters, Horizontal

SHELLS — To be used with Type K Heating Section. Shell Prices include Cradle. Manhole 11"x15"							HEATING SECTIONS — Capacity based on Heating from 40° to 180° with Steam at 0 lbs. pressure. For other temperatures and Steam Pressures see Bulletin No. 27				
Number	Gallons One Filling	Diameter of Shell	Length of Shell	Thickness of Shell	Thickness of Head	Weight of Shell	Number	Gallons per Hour	Maximum Size Steam Pipe Inches	Smallest Shell into which Section will Fit Inches	Weight of Entire Heating Section Lbs.
1	65	18	60	1/4	3/8	400	H 0	100	2	18x 48	75
2	80	18	72	1/4	3/8	450	H 1	150	2	18x 60	80
3	118	24	60	1/4	3/8	600	H 2	200	2	18x 72	90
4	141	24	72	1/4	3/8	700	H 3	250	3 1/2	18x 48	175
5	164	24	84	1/4	3/8	800	H 4	300	3 1/2	18x 48	185
6	185	30	60	1/4	3/8	750	H 5	350	3 1/2	18x 60	190
7	220	30	72	1/4	3/8	850	H 6	400	3 1/2	18x 60	200
8	255	30	84	1/4	3/8	950	H 7	500	3 1/2	18x 72	210
9	290	30	96	1/4	3/8	1050	H 8	550	3 1/2	18x 72	215
10	365	36	84	5/16	1/2	1300	H 9	600	3 1/2	18x 84	220
11	420	36	96	5/16	1/2	1450	H10	700	5	24x 60	300
12	475	36	108	5/16	1/2	1600	H11	800	3 1/2	18x 96	260
13	525	36	120	5/16	1/2	1800	H12	900	3 1/2	18x108	270
14	575	42	96	5/16	1/2	1850	H13	1000	3 1/2	18x120	285
15	720	42	120	5/16	1/2	2150	H14	1250	5	24x 84	370
16	860	42	144	5/16	1/2	2500	H15	1500	5	24x108	425
17	1000	42	168	5/16	1/2	2900	H16	1750	5	24x120	450
18	950	48	120	3/8	1/2	2850	H17	2000	6	30x 96	570
19	1140	48	144	3/8	1/2	3250	H18	2400	6	30x120	620
20	1310	48	168	3/8	1/2	3700	H19	2800	6	30x132	670
21	1480	48	192	3/8	1/2	4100	H20	3200	8	36x 96	860
22	1190	54	120	3/8	1/2	3250	H21	3600	8	36x108	920
23	1430	54	144	3/8	1/2	3700	H22	4000	8	36x120	950
24	1670	54	168	3/8	1/2	4200	H23	4400	8	36x132	1020
25	1900	54	192	3/8	1/2	4700	H24	4800	10	36x 96	1200
26	1420	60	120	7/16	5/8	4300	H25	5400	10	36x108	1300
27	1710	60	144	7/16	5/8	4900	H26	6000	10	36x120	1380
28	2000	60	168	7/16	5/8	5600	H27	7000	12	42x 96	1950
29	2300	60	192	7/16	5/8	6200	H28	8000	12	42x 96	2000
30	2460	72	144	7/16	5/8	5700	H29	9000	12	42x108	2300
31	2880	72	168	7/16	5/8	6400	H30	10000	12	42x108	2460

DIRECTIONS FOR USE—Select the size storage you require and combine its designating number with the number which designates the desired hourly output. Assuming a required storage of 1000 gallons (No. 17 shell 42 x 168) and a required hourly output of 1750 gallons (No. H16 Heating unit) you would specify a Whitlock Type K, No. 17H16.

WHITLOCK TYPE R INSTANTANEOUS HEATERS



This type of heater is used extensively as an instantaneous heater in connection with a separate storage tank, as a swimming pool heater, as a hot water convertor for use with a heating system as well as for various special conditions.

Standard sizes of the 2 and 4 pass heaters are shown in the table. Dimensions on multi-pass heater will be furnished on request.

Standard Sizes, Capacities, Dimensions and Weights

	2 PASS. TEMP. RANGE. 40° F. to 80° F.						4 PASS TEMP. RANGE 40° F. to 120° F.					
Size No.	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight
0	150	11 3/8	7	3/4	1 1/4	80	80	11 3/8	7	3/4	1	80
1	350	14 5/8	7	1 1/4	1 1/2	90	150	16 5/8	7	3/4	1 1/4	100
2	650	19 5/8	7	1 1/2	1 1/2	110	300	21 3/8	7	1	2	115
3	1100	23 5/8	7	2	2	130	480	26 3/8	7	1	2	135
4	1600	29 5/8	7	2	2 1/2	145	650	31 3/8	7	1 1/4	2 1/2	150
5	1900	34 5/8	7	2	3	170	800	38 3/8	7	1 1/4	2 1/2	170
6	2550	24 1/4	9 1/2	2 1/2	3	240	960	24 1/4	9 1/2	1 1/2	3	220
7	3200	30 3/4	9 1/2	2 1/2	3 1/2	270	1350	30 3/4	9 1/2	2	3	270
8	3800	35 3/4	9 1/2	2 1/2	4	300	1600	35 3/4	9 1/2	2	3 1/2	300
9	5100	43 3/4	9 1/2	3	5	360	2100	43 3/4	9 1/2	2	4	350
10	6350	55 3/4	9 1/2	3	5	420	2600	55 3/4	9 1/2	2 1/2	5	420
11	7950	45	12	4	6	610	3300	52	12	2 1/2	5	620
12	9550	52	12	4	6	670	4000	61	12	3	6	700
13	12700	67	12	4	8	810	5300	79	12	3	6	860
14	15900	51 7/8	15	5	8	930	6600	55 7/8	15	3 1/2	8	940
15	19100	59 7/8	15	5	8	1040	8000	65 7/8	15	4	8	1070
16	25600	59	17	6	10	1320	10500	71	17	5	10	1390
17	31700	71	17	6	10	1510	13300	83	17	5	10	1580
18	38200	61 7/8	20	8	12	1940	16000	72 7/8	20	5	10	2020
18 1/2	44400	70 7/8	20	8	12	2100	18500	82 7/8	20	5	12	2230
19	50700	78 7/8	20	8	12	2300	21000	92 7/8	20	6	12	2430
19 1/2	57100	59 5/8	26	10	14	2870	24000	62 5/8	26	6	12	2800
20	63450	64 5/8	26	10	14	3020	26700	67 5/8	26	6	12	3000
21	79300	76 5/8	26	10	16	3500	33300	82 5/8	26	6	14	3480
22	95100	66	30	12	18	4250	40000	73	30	8	14	4015
23	126900	83	30	12	20	4780	53300	92	30	8	16	4600
24	158400	78	36	14	24	6550	66700	83	36	10	20	6100
25	191000	89	36	14	24	7060	80000	95	36	10	22	6900
	Sizes 0 to 10 inclusive, have 3/4" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.						Sizes 0 to 10 inclusive, have 3/4" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.					

Whitlock Heat Transfer Products include the following types of apparatus in addition to the Storage and Instantaneous Heaters shown above: Feed Water Heaters; Heat Exchangers; Fuel Oil Heaters; Superheaters; Condensers and Coolers for all kinds of liquids; Also pipe coils of any kind of pipe or tubing and Air and Ammonia Receivers.

Additional information and quotations covering any of this apparatus will be gladly furnished upon request.

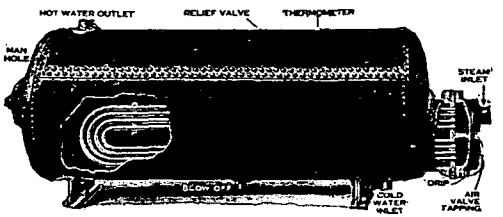
The Patterson-Kelley Co.

99 Park Avenue - New York City

Hot Water Heaters for all purposes. Pool Heaters and Converters. Preheaters, Heat Exchangers, Heaters for Chemicals, Gases, Oils. Coolers for Brine, Chemicals, Gases, Oil and Water.

The Patterson Combined Hot Water Service and Storage Heater, Type B, is for any service where requirements for hot water are not constant, or where a large volume must be stored for sudden heavy demands.

We guarantee to furnish heaters that will deliver the quantity of hot water called for. Without obligation our Engineering Department will be glad to give engineers the benefit of our 46 years' experience.



General Specifications

Constructed like a high grade boiler—of heavy steel plate. Steam inlet and outlet chamber is a heavy, grey iron casting. Tube head is a heavy, steel forging into which both ends of each tube are expanded. Tubes are of pure, cold drawn seamless copper and 'U' shaped to provide against contraction and expansion strains.

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.

Grinnell Company, Inc.

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices
PROVIDENCE, R. I.

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Albany, N. Y.	Dallas, Texas	Nashville, Tenn.
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GRINNELL COMPANY OF THE PACIFIC

Los Angeles, Cal. (Plant) Oakland, Cal. (Plant) San Francisco, Cal. (Plant) Seattle, Wash.

GRINNELL COMPANY OF CANADA, LTD.

Montreal, Que. (Plant) Toronto, Ont. (Plant and Foundry)
Vancouver, B. C. (Plant) Winnipeg, Man.

Cooperative Engineering and Contracting Service on Heating Systems—Seventy years' experience in piping installation puts Grinnell Company, Inc., in an especially advantageous position to render service of the highest order to heating engineers and their clients. This not only includes a cooperative advisory service which is frequently used by engineers who desire authoritative practical information when working on problems more or less out of the ordinary, but also a complete and expert contracting service as well.

Close contact with power and industrial piping enables Grinnell Engineers to approach questions of heating with full realization of their relationship to other factors. Information supplied by members of the Grinnell Staff regarding the utilization of waste heat through the agency of hot water systems, the utilization of exhaust steam, etc., has proved of invaluable assistance in working out more efficient heating.

Grinnell Engineering or Contracting Service is equally satisfactory on the remodeling of old heating systems—a type of work with which the Company is thoroughly familiar.

A Revolutionary Development in Forced Hot Water Heating—One of the chief difficulties in the way of a broader use of forced hot water heating systems with their many important advantages has been the determination of pipe sizes by the complex and arduous method of calculating frictional resistances. Failure to do this, plus easily possible installation mistakes has resulted in many unsatisfactory installations of this type of heating system.

This whole complication has now been simplified by the invention of the *Grinnell Equiflo Valve.*

The Grinnell Equiflo Valve for forced hot water heating *permits:*

1. The calculation of pipe sizes for this system by simple tables, similar to those commonly used in connection with the design of vacuum steam systems.
2. Change in locations of radiators or piping during installation to take care of local construction conditions without recalculation of pipe sizes.

The Grinnell Equiflo Valve for forced hot water heating *accomplishes*:

1. More perfect equalization of flow to every radiator than has ever been practical by even the most careful calculation of pipe sizes. Size or location makes no difference.
2. The introduction of sufficient frictional resistance to completely overcome that trouble so pronounced in most forced hot water heating systems which is due to the well-known war between pump head (a constant) and the gravity on temperature head (a variable). This insures absolutely equalized circulation at all temperatures.
3. Lower pumping costs.

The Grinnell Equiflo Valve:

1. Serves as the regular shut-off valve for each radiator. It is of the packless type.
2. Is so designed that after the installation is completed a multiple-orifice cartridge or tube, having a definite resistance pre-determined by Grinnell Co., is dropped into place in the valve.

In order to obtain all the advantages of this new development, it is only necessary for the Consulting Engineer to specify that *each radiator shall be equipped with a Grinnell Equiflo Valve*. This device is marketed through the regular heating trade, and proper results are guaranteed by the standing of Grinnell Company in the hot water heating field.

Power and Industrial Piping—The advantages of placing contracts for all necessary piping with one reputable company are obvious. Responsibility is centralized and a saving in cost is often effected. Grinnell Company, Inc. is prepared to submit bids and render expert, personally supervised construction service on all types of Power Plant and Industrial Piping including Automatic Sprinkler Systems, piping for Acids, Alkalis, etc., Compressed Air Cleaning Systems, Humidifying Systems. A contract placed with Grinnell Company is carried out to the satisfaction of all concerned. Materials of the highest quality are used. Grinnell Adjustable Hangers and Grinnell Fittings, for instance, save work in installation and make for cleaner, more satisfactory finished jobs and lower maintenance costs.

Pipe Bends, Welds, Etc.—Grinnell facilities for making Pipe Bends, Welds and Lap Joints are second to none. Three plants—Warren, Ohio, Auburn, R. I., Atlanta, Ga.,—equipped with special modern machinery and operated by the most skillful workmen make possible unusually prompt and efficient service on this important work.

Grinnell Fittings—After years of buying cast iron fittings on the open market Grinnell Company concluded that the best way to obtain clean accurate fittings of uniformly high quality was to cast them in Grinnell Foundries. Grinnell Cast Iron Flat Band Fittings made to conform to the American standard adopted by the Manufacturers Committee on Standardization of Fittings and by the N. F. P. A. can now be obtained by other users. Impartial purchasers agree that accuracy of threading, freedom from sand holes, and smoothness of core speed up installations and reduce replacements wherever Grinnell Fittings are specified.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Grinnell Adjustable Hangers

ONE of the chief advantages of Grinnell Adjustable Hangers is that they permit adjustment of pipe lines after installation, thus obviating the necessity of turn buckles or the removal of hangers. And their time and trouble-saving qualities during installation are equally exceptional. On this and the two following pages are shown a few Grinnell Hangers of particular interest to heating engineers. The Grinnell Hanger Blue Book, however, illustrates and describes the complete line and carries mechanical drawings and dimensional tables on practically every hanger shown. This feature alone makes the Grinnell Hanger Blue Book invaluable to Engineers, Architects and Draftsmen. As many copies as you require will be sent on request.

Fig. No. 101

Adjustable Swivel Ring—Solid Ring Type

(Patented October 4, 1921)

THIS Malleable Iron Adjustable Swivel Ring can be used with Coach Screw Rod or Machine Threaded Rod in connection with practically any type of Ceiling Flange, Expansion Case, Insert, etc.

The unusual feature of this ring is the Swivel Shank. An adjustment of at least 1½ in. is secured by simply turning the nut on the shank. No temporary support of the pipe line is necessary while making adjustments.

By means of a unique locking device the Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.

Fig. No. 104

Adjustable Swivel Ring—Split Ring Type

(Patented October 4, 1921)

THE Split Ring Type of the Adjustable Swivel Ring was also designed for use with Coach Screw Rod or with Machine Threaded Rod. The Swivel Shank allows the same adjustment as in Fig. No. 101, either before or after the hinged section is bolted in place.

The off-center hinging of the Ring provides sufficient seating to hold the pipe before closing the Ring.

By means of the same locking device as in Fig. No. 101, the Swivel Shank is automatically locked, preventing loosening due to vibration in the pipe line.

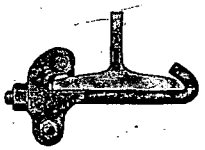


Fig. No. 225

Universal Side I-Beam Clamp

(Patented April 6, 1915)

ADAPTABLE to many uses, this Side I-Beam Clamp has ample strength for hanging ¾ to 12 in. pipe from I-Beams. This Clamp in different sizes will fit all sizes of Standard and Bethlehem I-Beams, and most sizes of Bethlehem Girder Beams.

Under conditions requiring vertical adjustment of the pipe line, this Side I-Beam Clamp is used with an Extension Piece or an Extension Eye Bolt.

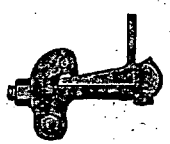


Fig. No. 226

Universal Channel Clamp

(Patented April 6, 1915)

DUE to the adjustability of the Grinnell Channel Clamp, three sizes of these clamps, with varying lengths of clamp rods, will meet most of the conditions encountered in practical installation work in connection with channels. We know of nothing else on the market which will obviate the necessity for the making of specials for Channel Iron work.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Adjustable Wall and Column Radiator Brackets

(Patents Pending)

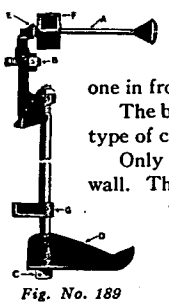


Fig. No. 189

THE bracket on the right, Fig. 190, is designed to support a single tier of wall radiation. A similar bracket, No. 191, is designed to support a double tier, one in front of the other.

The bracket on the left, Fig. 189, is designed to support the legless type of column radiation.

Only one bolt is necessary to securely fasten these brackets to the wall. This means low installation cost and it cuts drilling holes down to a minimum. Cost of installation can be further reduced by spacing these hangers farther apart than ordinary type of weaker construction, especially where hook bolts are set in the wall.

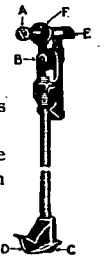


Fig. No. 190

When hook bolt is used, it can be set without extremely accurate measurements, due to the liberal range of vertical and horizontal adjustment, and as only three points of the bracket touch the wall, the difficulty so often experienced with rough brickwork is practically eliminated.

Adjustable Wall Coil Hangers

(Patented May 20, 1913)

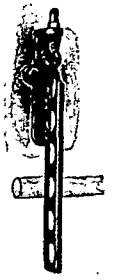
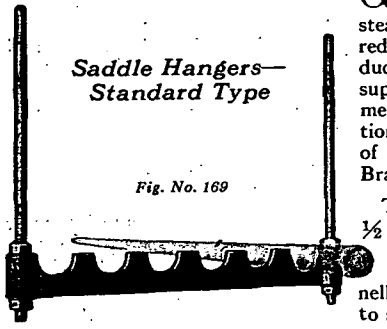


Fig. No. 160

THE Adjustable Wall Coil Hanger can be furnished with four separate brackets—two for single coils and two for double coils. The brackets locate the center of the coils 2¼ or 6¼ in. from back of bracket. Where double coils are used the second hangs 3½ in. in front of the first.

Besides the adjustable advantages of these hangers which permit the hanger plate to be raised or lowered to secure perfect pipe alignment, it is only necessary to fasten the individual bracket in place by two bolts. This saves labor.



Saddle Hangers—Standard Type

Fig. No. 169

GRINNELL Saddle Hangers are unique inasmuch as the hanger bar is of steel instead of cast iron. This feature not only reduces the weight of the hanger but also reduces its cost. Hex-nuts at bottom of rods support the hanger and allow liberal adjustment. These Saddle Hangers are exceptionally strong and will not sag. Labor cost of installation is considerably less than with Branch Rolls and Rods.

The Saddle Hanger is used in connection with ½ in. rods and hex-nuts on 2 to 8 branch hangers —⅝ in. rods and hex-nuts on 9 to 12 branch hangers—and with Expansion Cases, Grinnell Hanger Flanges, or with Side I-Beam Clamps to steel work, for supporting overhead coils.

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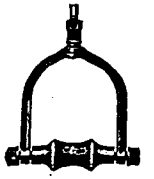


Fig. No. 174

Adjustable Swivel Pipe Roll

(Patented October 4, 1921)

THE Adjustable Swivel Pipe Roll supplies the need for any adjustable type of pipe roll hanger with single hanger rod. It is unique inasmuch as vertical adjustment can be made by use of the Swivel Shank at the top of the hanger. As in the Swivel Pipe Ring, Fig. No. 101, the Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.

Branch Pipe Rolls

GRINNELL Pipe Rolls are especially designed to take care of expansion and contraction. The rolls are made hollow so that only a small surface is in contact with the rod whereas the surface in contact with the pipe is made as large as possible. This allows the roll to take care of expansion and contraction properly.

Through a specially designed socket, vertical adjustment is allowed at the bottom of each vertical rod as well as at the Ceiling Flange. Furthermore, the nut at the bottom of the hanger rod fits into a recess of the socket preventing loosening or turning from vibration.

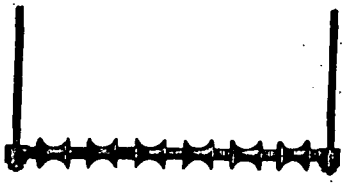


Fig. No. 172

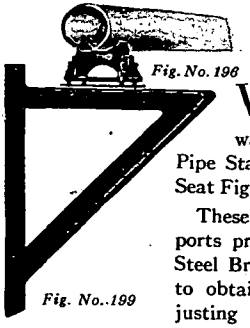


Fig. No. 196

Fig. No. 199

Adjustable Pipe Stand—Anchor Chair—Pipe Seat—used with Welded Steel Bracket

WELDED Steel Bracket Fig. No. 199 is light in weight as compared with the usual cast iron brackets. It was designed primarily for use with the Grinnell Adjustable Pipe Stand Fig. No. 196, Anchor Chair Fig. No. 197 and Pipe Seat Fig. No. 198, here illustrated.

These combine the strongest type of brackets and pipe supports procurable. The Adjustable Pipe Stand as used with the Steel Bracket has excellent adjustment features, it being possible to obtain vertical adjustment by simply adjusting bolts on the roll stand. A lateral adjustment or movement is possible with the Adjustable Pipe Stand and Pipe Seat by sliding the Stand or Seat on the bracket. With the Anchor Chair, lateral adjustment is also possible if Chair is moved before the nuts on the anchor yoke are tightened.

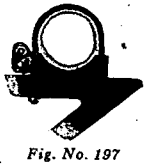


Fig. No. 197

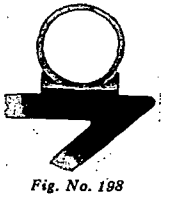


Fig. No. 198

AEROFIN CORPORATION

750 Frelinghuysen Avenue
Newark, N.J.
L. C. SOULE, Sec'y and Chief Engineer

Manufacturers of

AEROFIN

Fan System Heating and Cooling Surface

Aerofin

AEROFIN is a modern Fan System Heating Surface developed by Fan Engineers to meet the present-day requirements of this highly specialized field and to afford an adaptability which permits the new and advanced applications of tomorrow.

Low and High Pressure Aerofin

AEROFIN is built in two distinct types: Low Pressure AEROFIN, tube-plate construction, for pressures from 2 to 50 lbs. gauge; and High Pressure AEROFIN, continuous seamless tubes, for pressures from 25 to 350 lbs. gauge (Temp. 500° F.)

Design and Construction

The heat-transfer surface, in AEROFIN, is a plurality of seamless copper tubes about which is wound a helix of copper ribbon, crimped on its inner edge to permit winding and to afford maximum contact between tube and fin. The extended fin surface is applied, and tinned while held in position, by highly-developed automatic machines, being accurately crimped and spaced. The tinning of the tube and the extended surface makes them metallicly integral, affording maximum heat transmission and permanent effectiveness. The thickness and width (height) of the extended surface, the crimping and the pitch of the helix were determined by careful experiment, to afford maximum heat transfer, uniform air flow and minimum resistance thereto. The copper tubes and fins of AEROFIN transmit heat eight times as effectively as iron. So scientifically is AEROFIN designed that air is heated more in passage through a single row of its tubes, a travel of 1⅛ in., than in passage through an entire section of cast iron surface, a travel of 9 in.

In Low Pressure AEROFIN the tubes are set into flexible tube-plates by means of a highly developed joint which is tight and permanent. See Fig. 1.

Fig. 1

In High Pressure AEROFIN the seamless tubes, with their extended fin surface, are continuous. See Fig. 2.

Both Low and High Pressure AEROFIN are furnished as completely encased units, ready for pipe and duct connections. The casings are built of pressed steel and are exceptionally strong and rigid, protecting the unit from all the strains of pipe connection and expansion or contraction in service. The casings are flanged on both faces, top and bottom, and template punched for bolting together adjacent units, or for duct connection.

Standard Casings

The casings of all Low Pressure or High Pressure AEROFIN Units, whether comprising one, two or three rows of tubes, are **29 in. wide,** across tubes, from outer edge one flange to outer edge opposite flange, and **10 in. deep** in direction of air flow. **Length** of casing is tube length plus 8½ in.

Sizes of Low Pressure AEROFIN

Low Pressure AEROFIN is made in fifteen standard tube lengths, either one, two or three staggered rows of tubes per Unit. There are thus forty-five standard Units available, a range which adequately meets all requirements.

Tubes are furnished of any length between 2 ft. 0 in. and 6 ft. 0 in., in increments of 6 in., and between 6 ft. 0 in. and 12 ft. 0 in. in increments of 1 ft.

Complete Tables of Sizes and Capacities are shown in our Bulletin G7, mailed gratis upon request.

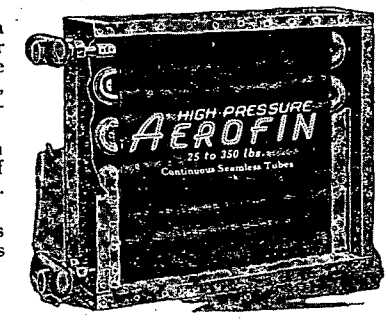


Fig. 2

Sizes of High Pressure AEROFIN

High Pressure AEROFIN is made in five standard tube lengths (i.e. length of straight section of tube, between the 180 deg. bends), 2 ft. 0 in., 2 ft. 6 in., 3 ft. 0 in., 3 ft. 6 in., 4 ft. 0 in., either one, two or three staggered rows of tubes per Unit. There are thus fifteen standard Units now available, meeting practically all requirements. Since the Supply and Drip Connections of High Pressure AEROFIN are located on the same end, Fig. 2, Units may be placed end-to-end thus affording battery widths of twice the Standard tube-lengths. Complete Tables of Sizes and Capacities are shown in our Bulletin GHP-1, mailed gratis upon request.

Steel Supporting Legs

Standard Steel Supporting Legs, 18 in. high, template punched to same bolt hole centers as standard casing, are furnished when ordered. These legs may be attached quickly and obviate necessity of any other foundation.

Advantages

AEROFIN weighs but 9 to 16 per cent as much as equivalent cast iron, and occupies but 35 per cent of the space required by equivalent cast iron (3-row units). Two men can easily carry any AEROFIN Unit. Expensive foundations are unnecessary, building reenforcement is not required and the Units may readily be suspended from beams or roof trusses, or installed snugly in any out-of-the-way corner. The light weight and remarkable compactness of AEROFIN permit design heretofore impossible, bringing a new era in Fan Engineering,—enabling the Engineer or Architect to exercise his highest skill, undeterred by the weight and bulk which have limited him in the past.

The **encasing** of AEROFIN, complete, ready for pipe and duct connections, is the most important advance in Heating Surface since the inception of Fan Engineering. It avoids all the old familiar uncertainties and delays, insuring installation in the shortest possible time and at the lowest possible cost. Best of all, the cost of installing encased AEROFIN may be **calculated** with great accuracy. It isn't necessary to "guess at it" as of yore,—and probably discover that the "guess" was low enough to wipe out the profit on the job. The cost of installing AEROFIN is usually about one-fifth that for equivalent cast iron or "pipe-coil."

Whatever you've wished for in a Fan System Heating Surface you'll find in AEROFIN!

Publications

For complete Data on Low Pressure AEROFIN ask for Bulletin G7, containing eighteen Piping Diagrams in four colors, representing the coordinated experience of the foremost Engineers in America.

Bulletin GHP-1 covers High Pressure AEROFIN and contains large Temperature Effects Chart on linen.

Either or both Bulletins will be mailed promptly upon request.

Sales

AEROFIN is sold *only* by Manufacturers of nationally advertised Fan Heating Apparatus.

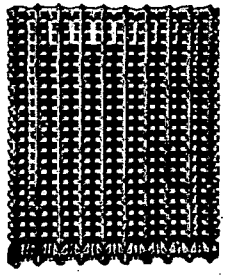
AMERICAN RADIATOR COMPANY

VENTO DIVISION

40 West 40th Street
New York City

816 S. Michigan Avenue
Chicago, Illinois

VENTO
Cast Iron Heaters



VENTO
Cast Iron Heater

Twenty-five years of successful operation of VENTO Heaters in thousands of installations in private and public buildings throughout America, Europe and Australia, disclose no failure of any kind.

VENTO has a unique construction which breaks up the air currents and assures rapid steam circulation, both of which features insure full heating efficiency of all the surfaces of the heater.

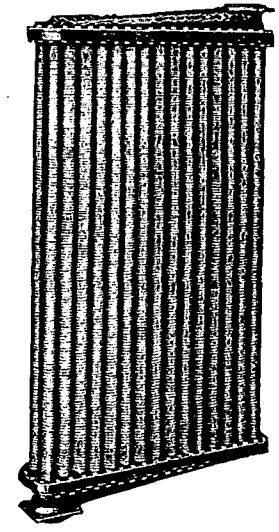
Being made up into stacks which are easily handled, and having far less joints per hundred square feet than pipe-coils, there is less liability to leaks. VENTO requires less labor to install, and calls for about 15 per cent less space. VENTO is made of cast iron, which does not rust by action of air, gases, water or summer dampness, and is much more durable than pipe-coils. VENTO Heaters do not freeze, split or corrode, nor is there any effect from electrolysis.

VENTO does not call for any new or special conditions in either housing or steam supply and drip connections. Both live and exhaust steam may be used at the same time.

In blast and plenum chamber work the *net installed* cost of VENTO is less than that of lighter forms of heaters.

A copy of the new revised edition of Engineer's Data on VENTO Heating will gladly be sent on request.

IDEAL ARCOBLAST HEATERS
For Unit Heater Work Only



IDEAL ARCOBLAST HEATER
For Unit Heater Work Only

The ARCOBLAST Heater, designed to meet the most exacting demands of the Heating Engineer, presents the following commendable features:

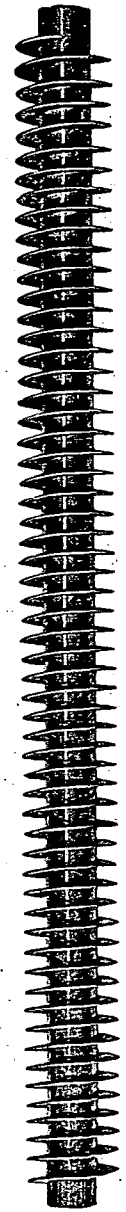
1. **Rugged Unit Design.**
2. **No soldered Steam-backed Joints.**
3. **Non-corrosive.**
4. **Ample Tube Steam Carrying Capacity.**
5. **Minimum Weight without Impairing Strength.**

The heater is composed of staggered rows of metallicly attached fin-wound copper tubes expanded into two cast iron tube sheets which, with the tapered design cast iron header bodies flange-connected to the tube sheets, form the supply and return headers.

The copper tubes are three-quarter inch outside diameter with a copper, helical-wound, flat, continuous fin three-eight inch in depth, metallicly attached to each tube. The materials of construction, copper for tubes and fin and cast iron for headers, offer a product which is non-corrosive.

A new Catalog containing complete technical data on IDEAL ARCOBLAST Heaters will be gladly sent on request.

40 West 40th St., **New York, N.Y.** 816 S. Michigan Ave., **Chicago, Ill.**



The Rome-Turney Radiator Co.

Rome, N. Y.

Exclusive Manufacturers of
ROME HELICALFIN COPPER RADIATION
High Efficiency Extended Surface Type Blast Heaters, Unit Heaters, Radiators, Condensers, Coolers, Etc.

Products

Standard Heater Units complete with steel casings for fan type heating and ventilating systems, ready for installation.

Standard and Special Heater Cores without Casings for manufacturers of Heating and Ventilating Apparatus.

Standard Copper Radiators for concealed direct radiation.

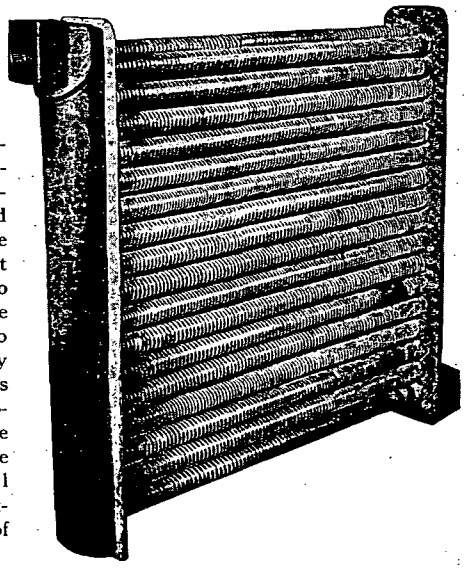
Condensers for Electric Refrigerators.

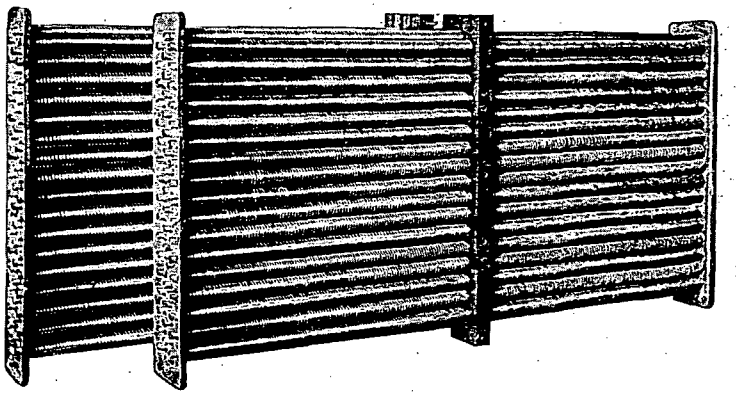
HELICALFIN Seamless Copper Tubes in all sizes from $\frac{5}{16}$ in. O.D. to $1\frac{1}{4}$ in. O.D. for any type Heat Transfer Equipment.

Cooling Systems and Radiators for Diesel Electric Locomotives, Gasoline Engines, Heavy Duty Trucks and Aeroplanes.

Construction

HELICALFIN Products are made of heavy gauge Seamless Copper Tubes which are encircled with a continuous flat copper radiating fin, free of corrugations, which is formed under power around the tubes so tightly that there is a copper to copper contact. The tubes are joined to brass header plates by improved methods which insure an absolutely tight union. The headers or tanks are made of a special quality of brass suitable for this type of work.





Heater Sections before assembly with Headers or End Tanks. Note trouble proof type of stiffening element used in heaters with long tubes

Engineering Data, Capacities, Etc.

Reliable performance data covering tests made with Rome HELICALFIN Heaters has been prepared by a nationally known test engineer. Complete tabulation of this data is available upon request.

Advantages

Rome HELICALFIN Heaters offer great advantages in high efficiency extended surface Copper Radiation. Rome HELICALFIN Heaters are compact and sturdy. Considerable saving in installation costs may be made over costs of handling and installing cast iron radiation.

High Pressure Heaters

Special sizes of Rome HELICALFIN Tubing are now manufactured for assembly into coils and heaters for high pressure work, drying equipment, etc.

Direct Radiation

Rome HELICALFIN Tubing in sizes suitable for direct Radiation, Radiator Cabinets and Concealed Radiation, available for prompt shipment.

For modern heating equipment in schools, factories, and homes

Specify

ROME HELICALFIN COPPER RADIATION

THE ROME-TURNEY RADIATOR CO.
ROME, N. Y.

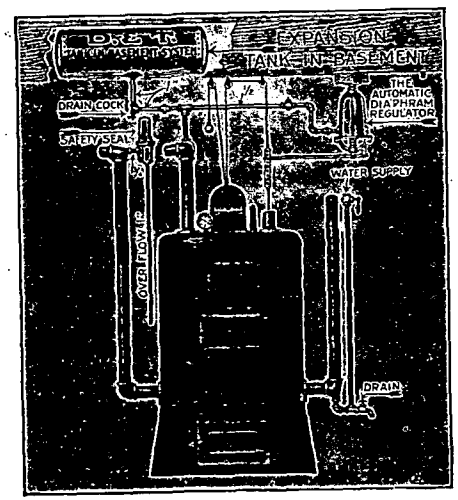
Good Radiators since 1905

D. & T. Manufacturing Company

3001 La Salle Street

St. Louis, Mo.

ORIGINAL TANK IN BASEMENT SYSTEM



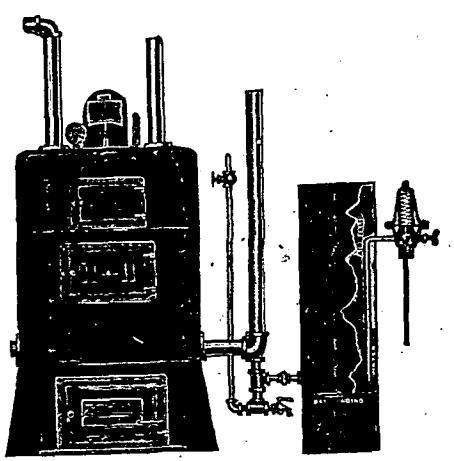
Placing the expansion tank in the basement on hot water installations is destined to become the one general method. WHY NOT GET INTO THE GAME?

Eleven years' experience and upwards of 100,000 D. & T. Tank-in-the-Basement Systems in successful operation throughout the United States and Canada, should be sufficient proof of the success of this system to the most skeptical heating engineer or contractor.

The D. & T. System is efficient, simple and foolproof.

Send for booklet entitled, "Progress in Hot Water Heating."

As a logical sequence to the development of the tank-in-basement idea, came the growing demand for a specialization of this tested and proved idea—for a basement expansion tank to be used in buildings where extreme simplicity and economy are of paramount importance. To supply this need, we offer and guarantee the Simplex Air-Sealed Tank-in-Basement Equipment.



The Simplex Air-Sealed Tank-in-Basement Package Equipment consists of:

1 Specially Constructed Airtight Expansion Tank

1 Relief Valve

1 Thermometer

1 Gauge

1 Vacuum Breaking Valve for automatically charging Tank with air.

MUELLER CO.

Decatur, Ill.

BRANCHES

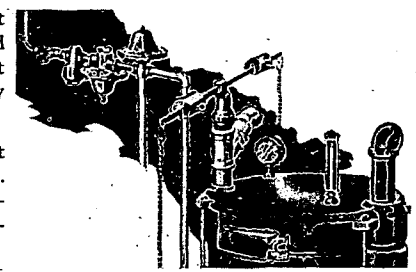
E. 135th St. and Walnut Ave., Bronx, New York 1072-76 Howard St., San Francisco 2468 Hunter St., Los Ang
901 McKinney St., Dallas, Texas

PRODUCTS

Mueller Automatic System of Hot Water Heat Control

Reducing and Regulating Valves for water.
Reducing and Regulating Valves for steam.
Relief Valves. Water Strainers.

Complete line of High Grade Plumbing Brass Goods



Mueller Automatic System of Hot Water Heat Control—This is a closed system operating automatically without an expansion tank. It can be quickly installed on either new or old jobs.

The water in the system is always kept fresh. This promotes good circulation. Just enough water is admitted by the reducing valve to supply the amount released by the relief valve.

A very considerable saving in fuel is effected due to the automatic control of dampers and rapid circulation.

Perfectly safe as both reducing valve and relief valve are operated by the pressure of the water in the system. These valves are especially constructed and tested for use on this system.

The reducing and relief valves are positive in action and durable, the working parts being made of bronze with phosphor bronze diaphragms.

Boiling point of water raised to higher point than with open system.

The damper regulator is a very important part of this system as it is not only a fuel saver but also is a safety feature, checking the fire when the desired temperature is reached.

The Mueller System can be readily used with a thermostatic control, operated by a motor in the basement. Mueller positive control of pressure in the system assures permanent safety.

Reducing and Regulating Valves—For steam, water, air, gas, oil, etc. All are diaphragm operated and positive in action. Their reputation for sustained accuracy is known wherever regulating valves are used.

Brass Goods—Everything in the line of brass faucets, stops, etc., for lavatory and bath room, and also complete line of laboratory faucets adopted and approved by leading universities such as the Massachusetts Tech.

Relief Valves—Mueller Relief Valves are absolutely dependable. They have been approved by the National Board of Boiler and Pressure Vessel inspectors and correspond to the code of the American Society of Mechanical Engineers. Tests in the Underwriters' Laboratories have proved the Mueller Relief Valve safe.

Mueller Co. has been in business from 1857 and has an acknowledged reputation for quality goods.

Specific information regarding any Mueller product will be cheerfully given upon request.

Neptune Meter Company

50 East 42nd Street, NEW YORK

Branch Offices

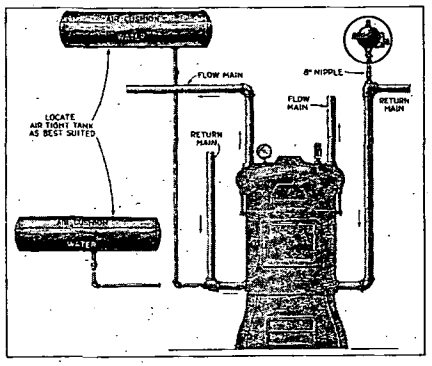
ATLANTA, GA.	1173 Virginia Avenue, N.E.	DENVER, COLO.	1700 Fifteenth Street
BOSTON, MASS.	141 Milk Street	LOS ANGELES, CAL.	701 East Third Street
CHICAGO, ILL.	130 North Jefferson Street	SAN FRANCISCO, CAL.	320 Market Street
ST. LOUIS, MO.	1912 Pine Street	PORTLAND, ORE.	474 Glisan Street

NEPTUNE METER CO., LIMITED, 345 Sorauren Avenue, Toronto, Ontario

RED TOP PRESSURE SYSTEM OF HOT WATER HEATING

This type of heating system is proving increasingly popular throughout the country. It is easily installed at a price which attracts the owner, builds good will for the heating engineer and allows a worthwhile profit.

Owners appreciate the high efficiency and the economy effected by the **Red Top Pressure System.**

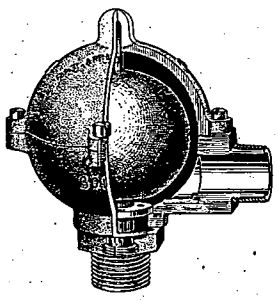


RED TOP RELIEF VALVE MODEL No. 2

This valve and an airtight expansion tank, to be located in the basement near the apparatus, are the only special pieces of equipment needed for the Red Top System.

Red Top Relief Valves act on the dead weight or gravity principle, and are approved by the Underwriters' Laboratories, Inc.

In the **Model No. 2** a special nickel weighted piston is forced off the seat when pressure reaches 30 pounds. Non-corrosive metal is used throughout, and there are no springs, levers or other complicated parts to get out of order. They are 6½ inches high, 5¾ inches wide, with inlet threaded for standard 1 inch fitting and male outlet threaded for 1 inch fitting.



Sectional View, Red Top Relief Valve Model No. 2

RED TOP MODEL No. 1 protects domestic hot water supply, and prevents range boiler explosions and other ruptures. It is made with inlet threaded for standard ½ inch pipe fitting and outlet drilled and tapped for ½ inch connection. It may be adjusted to relieve automatically at 50, 75, 100 and 130 lbs. pressure. Its measurements are 4½ inches high and 4 inches wide.

Thrush Differential Pressure Relief

H. A. Thrush & Company

Makers of Thrush System

Factory and Offices

Peru, Ind.

Thrush Automatic Damper Regulator

Thrush System comprises equipment to be added to any unregulated gravity hot water heating plant to make it a "Closed System" operating under slight added pressure and with automatic control of dampers.

Thrush Differential Pressure Relief Valve

A large flexible diaphragm which places a thrust against the Valve member making it certain that the Valve will open. Valve seat is at all times submerged in water, won't corrode because it has no contact with atmosphere. Dirt and sediment will not collect at the valve seat. Design is such that heavier solids fall away from seat. Regularly set to open at 26 lb. pressure for 1, 2 and 3 story buildings. For higher buildings, adjustments made at factory. Non-adjustable and not easily tampered with. No small restricted openings.

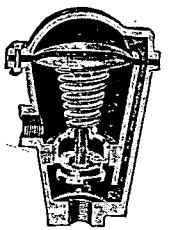


Fig. 1

Thrush Automatic Temperature Damper Regulator

Its operation depends upon the temperature change of the water circulating through the heating system and not upon pressure. Maintains different water temperatures by simple adjustment of sliding weights on lever. Multiple disc thermostat sets in dry well permitting easy inspection. A fuel saver. Easily connected with one short nipple as shown in Fig. 6.

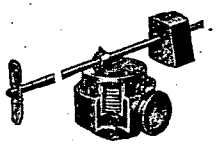


Fig. 2

Thrush Pressure Tank

Serves two purposes—conserves hot water and returns it to system—and being closed to the air, it maintains pressure on the system by compression and expansion of the air in the tank. **Thrush Tanks** are made of copper bearing steel, welded and tested, coated with enamel. Connect as shown in Fig. 6.

Fig. 3 Thrush Pressure Tank

Fig. 4

THRUSH THERMOMETER and SPECIAL GAUGE furnished with **Thrush System** simplify operation.

Fig. 5

Benefits of Thrush System of Hot Water Heating

Thrush Pressure System actually increases rate of heat transmission,—faster circulation and hotter radiators. Therefore lower water temperatures may be carried.

Installation is easy, requiring but 6 ft. of ¾ in. pipe and eight fittings. A further reduction of pipe sizes makes for lower cost and higher efficiency.

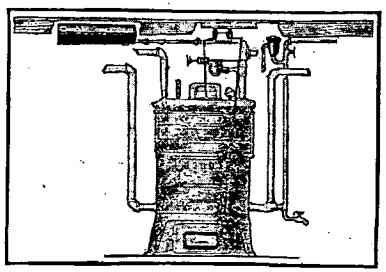


Fig. 6

DATA AND SPECIFICATIONS

CLASS "A" EQUIPMENT

Consists of *Thrush Automatic Temperature Damper Regulator, Differential Pressure Relief, Air Tight Pressure Tank, Special Gauge and Thermometer.*

CLASS "B" EQUIPMENT

Consists of *Thrush Differential Pressure Relief, Air Tight Pressure Tank, Special Gauge and Thermometer.*

SIZES

Size No. 0 up to 350 sq. ft. of radiation
Size No. 1 up to 750 sq. ft. of radiation
Size No. 2 up to 1250 sq. ft. of radiation
Size No. 3 up to 2000 sq. ft. of radiation

For larger job use additional pressure tanks of proper capacity.

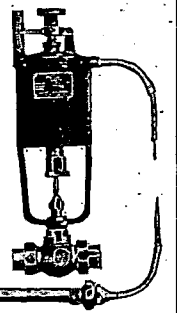
American Schaeffer & Budenberg Corp.

338 Berry Street, Brooklyn, N. Y.

Atlanta, Ga	Cleveland, Ohio	Minneapolis Minn.	San Francisco, Cal.
Boston, Mass.	Detroit, Mich.	Philadelphia, Pa.	St. Louis, Mo.
Buffalo, N. Y.	Houston, Texas	Pittsburgh, Pa.	Seattle, Wash.
Chicago, Ill.	Los Angeles, Cal.	Salt Lake City, Utah	Tulsa, Okla.

Manufacturers of Indicating and Recording Gauges; Draft Gauges; Indicating and Recording Thermometers; Tachometers; Pressure and Temperature Controllers; Pop Safety and Water Relief Valves; Gauge Testers; "U" Gauges; Steam Traps; Engine Indicators; Counters; Calorimeters; Locomotive and Engine Room Clocks; Barometers; Steam Whistles; Hydraulagraphs; Gauge Boards

American Temperature Controller



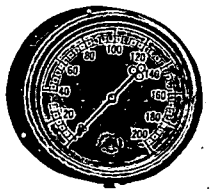
American (formerly Honeco) self-operated Temperature Controller, type 2205, is exceptionally well adapted for maintaining any desired temperature of the water in hot water tanks.

It has a wide range and close control at the setting point, giving a 50 per cent safety factor even at the maximum point of range without damage. Adjusting device locks the controller against unauthorized interference.

No expensive pipe lines, compressed air or auxiliary force is required for operation. The motive power needed to open and close valve is supplied by the controller itself. The patented motor is unusually strong and durable and the instrument itself is extremely rugged throughout.

The American Controller is guaranteed to accurately perform its function for the purpose sold when properly installed.

Write for Catalog R-59.



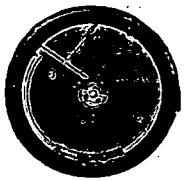
American Indicating Gauges

A complete line of American pressure, vacuum and draft gauges for all purposes.

Write for Catalog A-59.

American Recording Gauges and Thermometers

The recording systems of American (formerly Columbia) Recording Gauges and Thermometers are interchangeable. A separate recording system can be kept in stock at small cost and quickly inserted while the old one is being repaired, should repairs be necessary due to accident.



Instructions are lithographed on the chart plate, so they can not be lost. Time punch shows when and how often readings are taken. Any slight inaccuracies due to rough handling can be quickly corrected by means of the adjusting device. The chart is held in place by a non-removable clamp, preventing loss of clamp. Automatic pen release lifts pen arm away from chart automatically when the door is opened, preventing arm from being strained. Fitted with an inverted Monel metal pen arm with tension adjusting device and non-corrosive glass pen. Has 10-in. chart with extra large recording area.

Write for Catalogs E-59 and H-59.

American Air Duct Thermometer

Designed especially for both warm and cold air ducts. Fitted with polished brass or nickel plated "V" shaped case, glass front. Furnished with 9-in. or 12-in. scale graduated 0-160 deg. fahr.

Write for Catalog F-59.

American Pop Safety and Water Relief Valves

Complete line for all applications. Modern design. Finest construction. Each valve guaranteed to properly perform its function. Send for Catalogs U-59 and V-59.

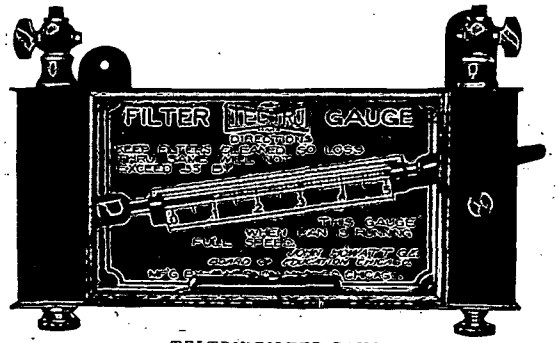
American Ideal Steam Trap

Built on extremely rugged lines and guaranteed for all pressures. Valve discharge orifice is much larger than in ordinary traps, which means larger capacity. Valve seat can be renewed without disconnecting trap. The heavy float is made of seamless, non-corroding copper. It resists pressures up to 600 lbs. per sq. in. and is guaranteed for life of trap. Valve seat is under continuous water seal, thus cannot leak live steam.

Send for Catalog S-59.

EVERNON HILL AEROLOGISTS

121 North Clark Street **Chicago**



TELTRU FILTER GAUGE

A New Product

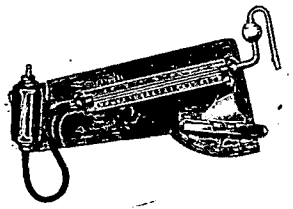
that has every desirable feature of other gauges, and several new ones.

An **unbreakable glass** front.

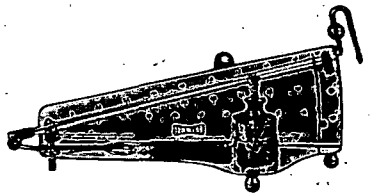
Removable and replaceable gauge glass.

All parts **accessible** by the removal of one thumb screw.

A display card back of the scale, bearing the filter manufacturer's name and *his* directions.



TELTRU SLANT GAUGE
for chimney draft determinations. Complete with static tip and carrying case.



TELTRU PITOT TUBE GAUGE
The standard portable gauge and tube outfit for general air velocity determinations.

Write for descriptive circulars of other gauges and air testing instruments

No obligation

TELTRU

A TRADE MARK WITH A MEANING

Insulating Products Corporation

280 Madison Avenue at 40th Street,
New York

Insulating Products Company

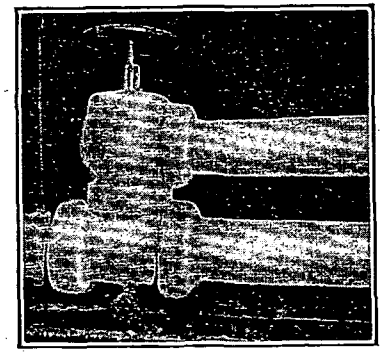
1553 West Madison Street,
Chicago
Factory—AURORA, ILLINOIS

Webers No. 48 Insulating Cement

A recently invented Heat Insulation involving an entirely new principle of manufacture, producing a material of exceptional insulating value as proven by results of actual, practical installations.

Webers No. 48 Insulating Cement is dielectric and unaffected by acid fumes, therefore adaptable for use in chemical and manufacturing plants where conditions are unfavorable to other insulations.

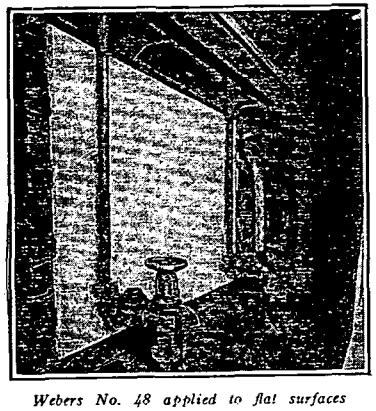
Webers No. 48 Insulating Cement is easily applied to hot or cold surfaces, is exceptionally adhesive and requires no reinforcement under normal conditions.



Webers No. 48 applied to pipes, valves, etc.

—is reclaimable for re-mixing without loss of insulating value.
—withstands vibration.
—responds to normal expansion.
—in actual service, is the most durable of any insulation on the market.
—is extremely economical to install.
—readily takes a paint or waterproof finish.

The covering capacity is approximately 1000 sq. ft., one inch thickness, per ton.



Webers No. 48 applied to flat surfaces

Webers No. 48 Insulating Cement is especially suitable for insulating the following types of equipment:

Accumulators	Flanges
Boilers	Fittings
Breechings	Furnaces
Ducts	Heaters
Evaporators	Tanks
Economizers	Valves

Shipped in bags weighing 50 lbs. net.

Our engineering service is at all times available for consultation and we are equipped to undertake installations of any description.

Johns-Manville Corporation

Miners of Asbestos, Manufacturers of Asbestos and Allied Products

EXECUTIVE OFFICES

292 Madison Avenue, at 41st Street - NEW YORK, N. Y.

Branches in all large cities

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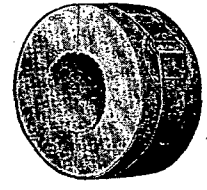
CHICAGO, ILL., Michigan Avenue at 18th Street
CLEVELAND, OHIO, 6300 Euclid Avenue
NEW YORK, N. Y., 292 Madison Avenue at 41st Street (Executive Offices)
PHILADELPHIA, PA., 1315-1317 Race Street
ST. LOUIS, MO., Locust Street at Seventeenth
SAN FRANCISCO, CAL., 159 New Montgomery St.
TORONTO, ONT., Canadian Johns-Manville Co., Ltd., 19 Front Street, East

Please Communicate with Nearest Division Sales Office

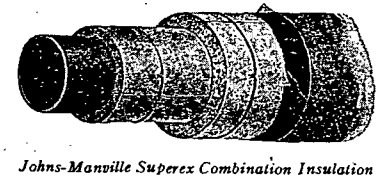
INSULATION SPECIFICATIONS
(Abbreviated Form)



Johns-Manville 85% Magnesia

High Pressure and Intermediate Pressure Steam Lines—All high pressure and intermediate pressure steam lines indoors, and high pressure drip piping, including connections to all engines, turbines, pumps, auxiliaries, water columns, safety valves, superheaters and soot blowers, shall be insulated with Johns-Manville 85 per cent Magnesia of the following thickness:

Steam Pressure or Condition	Temperature Deg. Fahr.	Thickness of Insulation		
		Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
25 to 100 lbs.	267 to 338	1½"	Std.	Std.
100 to 200 lbs.	338 to 388	2"	1½"	Std.
Low Superheat	388 to 500	Dbl. Std.	2"	1½"
Superheat	500 to 600	3"	Dbl. Std.	2"

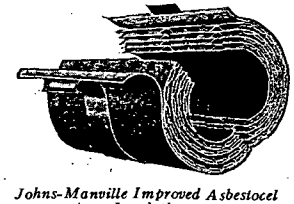


Johns-Manville Superex Combination Insulation

Superheated Steam Piping (Temperatures above 600 deg. fahr.)—All superheated steam piping shall be insulated with Johns-Manville Superex Combination Insulation of thicknesses shown below:

Steam Condition	Temperature Deg. Fahr.	Thickness of Insulation		
		Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
High Superheat	600 to 700	3½"	3"	2"*
High Superheat	700 to 800	4"	3½"	2"*

*Single layer Superex Insulation on lines 1½ inch and smaller.



Johns-Manville Improved Asbestocel Insulation

Low Pressure and Exhaust Steam and Feed Water Piping—All low pressure, exhaust steam and feed water piping shall be insulated with 4-ply Johns-Manville Improved Asbestocel Sectional Insulation.

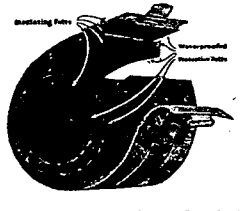
Steam Heating Supply and Return Mains, Risers and Radiator Branches—All steam heating supply and return mains and branches, and all risers, shall be insulated with 4-ply Johns-Manville Improved Asbestocel Insulation. All concealed radiator branches shall be insulated with 3-ply Johns-Manville Improved Asbestocel Insulation.

Johns-Manville Asbesto-Sponge Felted Insulation

High Pressure Steam Lines in Manufacturing Buildings—All high pressure steam piping and high pressure drip piping used in connection with distribution of steam for manufacturing purposes shall be insulated with Asbesto-Sponge Felted Sectional Insulation of the following thicknesses:

Steam Pressure or Condition	Temperature Deg. Fahr.	Thickness of Insulation		
		Pipes Larger than 4 in.	Pipes 2 in. to 4 in.	Pipes Smaller than 2 in.
0 to 25 lb.	212 to 267	1"	1"	1"
25 to 100 lb.	267 to 338	1½"	1½"	1"
100 to 200 lb.	338 to 388	2"	1½"	1"
Low Superheat	388 to 500	2½"	2"	1½"
Superheat	500 to 600	3"	2½"	2"
High Superheat	600 to 700	3½"	3"	2"

Fittings, Valves and Flanges—All pipe fittings, valves and flanges shall be insulated with block and plastic insulation to the same thickness as the adjacent pipe insulation. Block insulation shall be of the same material as the adjacent pipe insulation and plastic material used shall be hard finish Asbestos Cement. Block insulation may be omitted on pipe sizes smaller than 4 in., or where total thickness of insulation is less than 1½ in. and the entire thickness of insulation in such cases may be made up of hard finish Asbestos Cement.

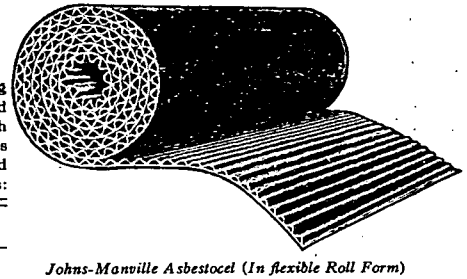


Johns-Manville Anti-Sweat Insulation

Cold Water Piping—All cold service water piping, including risers and concealed fixture connections or exposed soil or waste lines, shall be insulated with Anti-Sweat Insulation 1 in. thick applied in two layers with all joints broken, fittings with Hair Felt and hard finish Asbestos Cement to the same thickness.

Finish of Insulation—All insulation on pipes, fittings, valves and flanges which is exposed to view shall be enclosed in an extra jacket of 8-oz. canvas sewed over rosin sized paper.

Where insulation is concealed the light canvas furnished in manufacture is to be pasted down over the joints and the insulation additionally secured by means of brass lacquered bands applied at least two to a section.



Johns-Manville Asbestocel (In flexible Roll Form)

Warm Air Ducts—All warm air ducts, flues, heater casings and fan housings in the ventilating system shall be insulated with 4-ply Improved Asbestocel sheet insulation finished with hard finish Asbestos Cement ⅛ inch thick, applied over hexagonal wire reinforcement. The cement finish shall be troweled to a smooth and uniform surface. Where this insulation is exposed to view it shall be finished with a jacket of 8-oz. canvas, glued to the insulation and sewed in place.

Painting—All insulation exposed to view and enclosed in a jacket of 8-oz. canvas is to be painted with one coat of glue sizing and two coats of first quality lead and oil paint of a color selected by the architect.

Underground Lines—All high and low pressure steam lines and hot water lines running under ground outside of buildings shall be installed in Johns-Manville System of Underground Insulation. This system shall be installed in accordance with the manufacturer's specifications.

All of the above insulation is to be furnished and applied by the manufacturer of the materials used, or by his approved contractor, in accordance with the manufacturer's standard specifications.

Johns-Manville is prepared to furnish detailed standard specifications on any of the above items, as well as on the following and many others:

Boilers,
Boiler Settings,
Tube Doors,
Breechings and Smoke Flues,
Stack Lining, Stack Insulation,
Feed Water Heaters,
Pump Cylinders,
Hot Water Piping,
Ice Water Piping,
Refrigeration Piping,
Pipes Exposed to Freezing.

Space limitations do not permit the insertion of complete efficiency tables, pipe sizes, insulation thickness, etc. If you do not find the size you want, write to the nearest Johns-Manville Division sales office.

JOHNS-MANVILLE 85 PER CENT MAGNESIA INSULATION

An efficient insulation for steam lines to 600 deg. fahr.

EFFICIENCIES

Pipe Size Inches	Nominal Insulation Thickness Inches		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100° / Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	200° / 275°	300° / 375°	400° / 475°	500° / 575°
			Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation				
1	0	Bare Pipe Loss, B.t.u.	74.0	183.4	337.4	555.2	891.0
	Std.	Efficiency %	68.7	73.7	77.7	81.1	84.0
	2	" %	78.4	82.0	84.8	87.3	89.5
	3	" %	81.4	84.6	87.0	89.1	90.9
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1611.0
	Std.	Efficiency %	76.7	80.5	83.3	85.7	88.2
	2	" %	83.3	85.9	88.2	90.2	91.7
	3	" %	86.2	88.5	90.2	91.9	93.3
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2375.0
	Std.	Efficiency %	78.8	82.3	84.8	87.1	89.3
	2	" %	85.2	87.7	89.6	91.4	92.9
	3	" %	88.2	90.2	91.7	93.0	94.2
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	3051.0
	Std.	Efficiency %	81.7	84.5	86.9	89.1	90.8
	2	" %	86.4	88.7	90.5	92.1	93.4
	3	" %	89.3	91.1	92.4	93.7	94.8
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4488.5
	Std.	Efficiency %	82.7	85.4	87.6	89.7	91.3
	2	" %	87.8	89.8	91.3	92.8	94.0
	3	" %	90.4	92.1	93.3	94.4	95.3
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5845.6
	Std.	Efficiency %	83.7	86.2	88.4	90.2	91.9
	2	" %	88.4	90.3	91.8	93.1	94.3
	3	" %	91.1	92.7	93.7	94.8	95.6
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2590.0
	1	Efficiency %	82.36	85.20	87.60	89.64	91.48
	2	" %	90.16	91.85	93.12	94.27	95.31
	3	" %	93.22	94.37	95.25	96.06	96.75

JOHNS-MANVILLE ASBESTO-SPONGE FELTED INSULATION

For insulating high pressure and superheated steam lines to 750 deg. fahr.

EFFICIENCIES

Pipe Size Inches	Nominal Insulation Thickness Inches		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100° / Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	200° / 275°	300° / 375°	400° / 475°	500° / 575°
			Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation				
1	0	Bare Pipe Loss, B.t.u.	74.0	183.4	337.4	555.2	891.0
	1	Efficiency %	76.5	79.9	82.6	85.2	87.4
	2	" %	80.7	83.6	85.8	87.8	90.0
	3	" %	83.5	86.1	88.0	89.8	91.5
2	0	Bare Pipe Loss, B.t.u.	133.9	331.5	608.3	1003.9	1611.0
	1	Efficiency %	80.4	83.3	85.5	87.6	89.3
	2	" %	85.1	87.2	89.0	90.6	92.1
	3	" %	87.7	89.6	91.0	92.4	93.7
3	0	Bare Pipe Loss, B.t.u.	197.3	488.8	896.8	1480.0	2375.0
	1	Efficiency %	82.2	84.9	86.8	88.8	90.3
	2	" %	86.8	88.8	90.3	91.7	93.2
	3	" %	89.5	91.2	92.3	93.5	94.6
4	0	Bare Pipe Loss, B.t.u.	253.5	627.9	1152.1	1901.3	3051.0
	1	Efficiency %	83.3	85.8	87.6	89.5	90.9
	2	" %	87.9	89.7	91.1	92.4	93.7
	3	" %	90.5	92.0	93.0	94.1	95.1
6	0	Bare Pipe Loss, B.t.u.	371.9	923.7	1694.9	2797.1	4488.5
	1	Efficiency %	84.2	86.5	88.3	90.1	91.4
	2	" %	89.1	90.7	91.9	93.1	94.3
	3	" %	91.5	92.9	93.8	94.8	95.6
8	0	Bare Pipe Loss, B.t.u.	485.7	1203.0	2207.3	3642.8	5845.6
	1	Efficiency %	84.8	87.0	88.7	90.4	91.7
	2	" %	89.6	91.2	92.4	93.4	94.6
	3	" %	92.1	93.4	94.2	95.1	95.9
Flat Surface	0	(Bare Surface) B.t.u.	215.2	533.0	978.0	1614.0	2590.0
	1	Efficiency %	84.17	86.50	88.38	90.10	91.73
	2	" %	91.32	92.61	93.61	94.55	95.44
	3	" %	94.02	94.90	95.59	96.23	96.85

JOHNS-MANVILLE IMPROVED ASBESTOCEL INSULATION

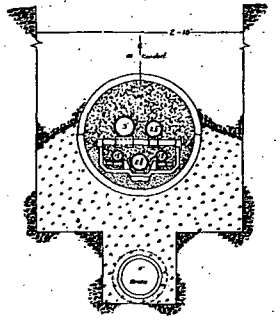
For insulating pipes conveying hot water or steam at medium and low pressure.

EFFICIENCIES

Pipe Sizes Inches	Ply		Temperature Difference Between Pipe and Surrounding Air, Deg. Fahr. 100°	150°	200°	250°	300°
			Temperature of Pipe, Deg. Fahr. (Temperature of Surrounding Air, 75 Deg.) 175°	225°	275°	325°	375°
			Heat losses per linear foot of bare pipe per hour and efficiencies of insulation				
1		Bare Pipe Loss, B.t.u.	74.0	123.8	183.4	253.7	337.4
	2-ply	Efficiency %	57.8	59.8	61.6	63.2	64.8
	3-ply	" %	62.9	64.8	66.6	68.2	69.7
	4-ply	" %	66.4	68.1	69.7	71.2	72.6
2		Bare Pipe Loss, B.t.u.	133.9	223.9	331.5	458.7	608.3
	2-ply	Efficiency %	64.5	66.1	67.6	68.9	70.1
	3-ply	" %	69.7	71.3	72.6	73.9	75.1
	4-ply	" %	73.0	74.5	75.7	76.9	78.0
3		Bare Pipe Loss, B.t.u.	197.3	330.1	488.8	676.3	896.8
	2-ply	Efficiency %	67.2	68.7	70.0	71.2	72.3
	3-ply	" %	72.6	74.0	75.3	76.4	77.4
	4-ply	" %	75.9	77.2	78.3	79.4	80.3
4		Bare Pipe Loss, B.t.u.	253.5	424.2	627.9	868.8	1152.1
	2-ply	Efficiency %	68.6	70.0	71.3	72.4	73.4
	3-ply	" %	74.0	75.3	76.5	77.6	78.6
	4-ply	" %	77.4	78.5	79.6	80.6	81.5
6		Bare Pipe Loss, B.t.u.	371.9	623.9	923.7	1278.1	1694.9
	2-ply	Efficiency %	70.0	71.4	72.6	73.7	74.7
	3-ply	" %	75.6	76.8	77.9	79.0	79.9
	4-ply	" %	79.0	80.1	81.1	82.0	82.8
8		Bare Pipe Loss, B.t.u.	485.7	812.5	1203.0	1664.5	2207.3
	2-ply	Efficiency %	70.9	72.2	73.3	74.4	75.3
	3-ply	" %	76.4	77.6	78.6	79.6	80.5
	4-ply	" %	79.8	80.9	81.8	82.7	83.5

JOHNS-MANVILLE UNDERGROUND SYSTEM OF INSULATION

A specially salt glazed and highly vitrified tile conduit is used as a waterproof envelope to protect the insulation—Johns-Manville Asbesto-Sponge Conduit Filling, is packed around the piping to be insulated and completely fills the conduit.



Section of Trench

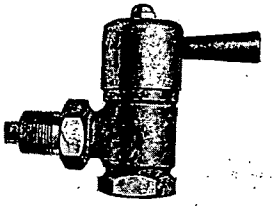
The cast iron roll frame used is installed in a mortar or concrete bed and is set at the proper elevation from an overhead batter-board line. This method prevents uneven alignment of the pipes by irregularity in the manufacture of the conduit, etc.

The insulation used to surround the pipe is made of asbestos fibre and material of a sponge-like nature, which when properly mixed with the asbestos, forms the most efficient and durable insulation for underground work.

The underdrain laid with open joints carries away the water that rapidly filters away from the system through the broken stone or gravel in which the lower half of the system and the underdrain itself is laid.

Shutters for sealing the ends of the system, manhole and anchor pits are incidental but necessary, and are placed according to conditions and requirements as recommended by our engineers.

JOHNS-MANVILLE RADIATOR CONTROL VALVE



Hot Water Heating With Steam

The Johns-Manville Radiator Control Valve is used for controlling radiator temperature and thereby obtaining, with steam, the desirable effects heretofore only obtained from hot water heating systems.

The Johns-Manville Radiator Control Valve, on account of new and unique patented design, not only gives positive control or regulation of radiator temperatures, but causes complete circulation of the heating medium and uniform distribution of temperature over the entire surface of the radiator, heating coils, etc.

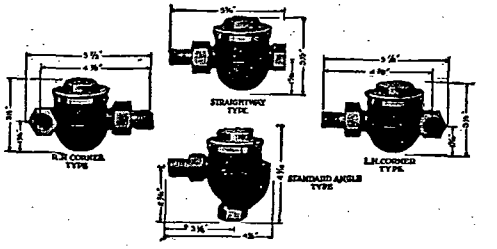
It is intended for use in vacuum and atmospheric return line systems of heating.

RADIATOR TRAPS (Bronze and Nickel Finishes)

For steam pressures to 10 lbs.—on open (atmospheric) or vacuum return line heating systems. For use on cast iron heating radiators only.

WEIGHTS

Style	Pipe Connection ½"	¾"
Standard	2 lb., 5 oz.	2 lb., 7 oz.
Straight-way	2 lb., 3 oz.	2 lb., 6 oz.
Corner	2 lb., 4 oz.	

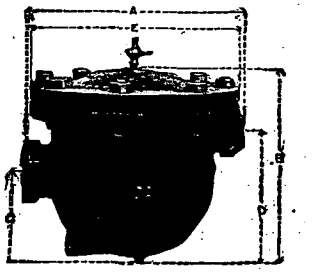


JOHNS-MANVILLE STEAM TRAPS

Type A (Cast Iron)

The simplicity of the Johns-Manville Steam Trap practically eliminates all possibility of its getting out of order. It has and requires no adjustments, and consists of only three parts—the body, discharge bushing and rolling ball, the latter being the only part that moves.

Trap No.	Pipe Size Inches	Capacity Pounds of Water per Hour	Dimensions in Inches (See Diagram) A	B	C	D	E	Weight Lbs.
2-A	¾	700	7⅝	6	2⅞	3¾	6¾	14¼
3-A	1	1000	8¼	7⅞	3½	4½	8	23
4-A	1¼	1700	10⅜	8¾	4⅛	5¼	10¼	47
5-A	1½	3500	12¾	11¼	5⅝	7½	12½	85
6-A	2	6000	14½	13	6⅞	8⅛	14¼	126



Cast Iron Model

JUNIOR MODEL (Bronze)

For steam pressures to 50 lbs. ½ in. inlet and outlet pipe connections. Bushings for pressures from 1 to 10 lbs. and 10 to 50 lbs.

Trap	Pipe Size, Inches	Pressure Range Pounds	Capacity, Pounds of water per Hour
Junior	½	1–10 10–50	250

4¼ inches long by 3⅝ inches high; weight, 2 pounds, 6 ozs.

Telephone
Main 1736

Established 1910

The Ric-wiL Company

UNDERGROUND CONDUIT SYSTEMS FOR HEATING PIPES

Union Trust Building **CLEVELAND, OHIO**

AGENTS IN PRINCIPAL CITIES—REFER TO LOCAL TELEPHONE DIRECTORY

Products—RIC-WIL Conduit, which includes Base Drain, Pipe Supports, insulation and other accessories for underground steam, hot water and fuel oil pipes. Cast iron conduit for extra heavy duty.

Ric-wiL Conduit—Hard burned and glazed tile, bell and spigot type, which splits on the job for easy installing. Special Loc-Lip Side joints seal top and bottom halves together again after pipes and insulation are installed, a strong water-tight joint. Sections 2 ft. long, sizes I. D. 4 to 24 in.

Ric-wiL Base Drain—Hard burned and glazed tile designed to be a base for supporting and lining up conduit and drain for carrying away moisture. Slotted sections interlock with conduit bells to form a strong construction. No concrete foundation necessary in solid ground. Three sizes: No. 1 for 4 and 6 in. conduits, No. 2 for 8 to 15 in., No. 3 for larger sizes.

Ric-wiL Pipe Supports—Planned to carry one to five or more pipes and ordinarily spaced 12 ft. apart. Made of cast-iron, rust proofed, and interlocked with the base drain, imposing no load on the conduit itself.

Ric-wiL Conduit Systems for All Uses—*Type SPC* system for steam heating and power pipes and superheated steam. Insulation provided by standard pipe covering applied directly to pipes.

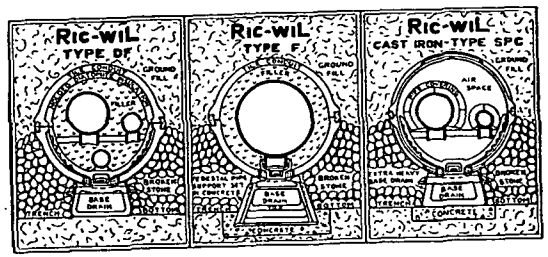
Type F system for steam heating and power pipes. Unlined RIC-WIL conduit with filler packed around pipes. DRY-PAC Waterproof Filler if desired.

Type DA system for hot water, fuel oil and condensation returns. Sil-o-cel insulation moulded to inside of tile and keyed in. Pipes insulated from outside earth but not from each other.

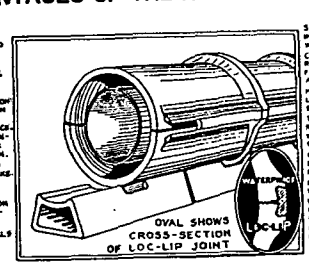
Type DF system for steam heating and power pipes. Type DA with addition of RIC-WIL Conduit filler packed around pipes. DRY-PAC Waterproof Filler if desired.

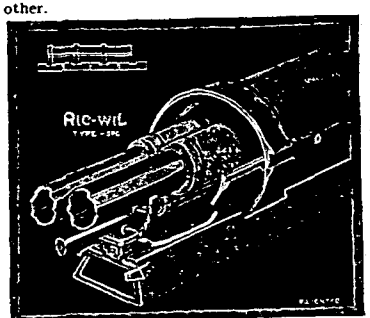
Cast Iron Ric-wiL Conduit—For extra heavy duty under railroads or other places where conduit is subject to abnormal strain. Similar in design to tile RIC-WIL. Special reinforced base drain.

Engineering Service—Maintained for the convenience of customers. Inquiries answered promptly. Catalogs and special information on request.

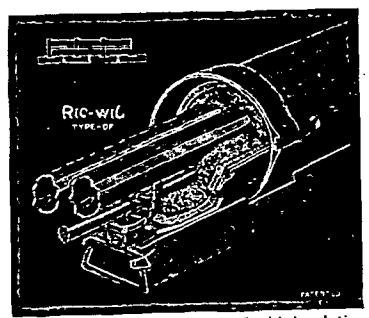


ADVANTAGES OF THE RIC-WIL SYSTEM





Ric-wiL Type F is an unlined conduit like this SPC, insulation being a loose filler packed around the pipes.



Ric-wiL Type DA is like this DF with insulation moulded to tile but without loose filler.

Samuel Cabot, Inc.

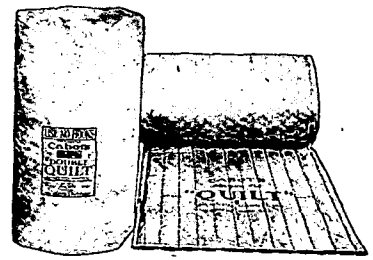
141 Milk St., **Boston, Mass.**

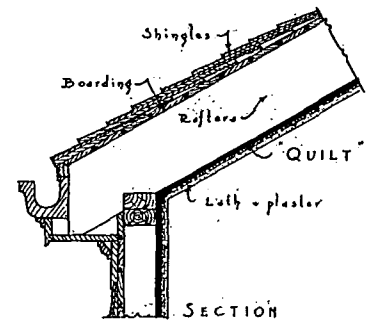
101 Park Avenue, **New York** 5000 Bloomingdale Avenue, **Chicago**

PHILADELPHIA KANSAS CITY MINNEAPOLIS LOS ANGELES SAN FRANCISCO PORTLAND

CABOT'S HEAT-INSULATING "QUILT" (Trade-mark)

Cabot's "Quilt" is the original flexible insulator. It is made in three thicknesses—single, double and triple—is 36 in. wide and shipped in rolls covering 250 sq. ft. each. It is made of cured eel-grass, and will not rot, will not burn and will not harbor insects or vermin.





"Quilt" Insulation in Roof and Wall Construction

U. S. Government Bureau of Standards Letter Circular No. 227, reporting tests of numerous Insulating Materials, gives Cabot's "Quilt" a Thermal Conductivity rating of 0.25 which was equalled by only two other insulators, regardless of cost.

Tests conducted by Prof. Gordon B. Wilkes, of the Massachusetts Institute of Technology, show the following savings in heat leakage in different methods of construction:

WALL CONSTRUCTION	Conductivity Uninsulated "H"	Conductivity Insulated "H1"	Percentage Saving
Clapboard, studding	0.70	0.26	63
Clapboard, studding, lath, plaster	0.44	0.21	52
Clapboard, sheathing, studding, lath, plaster	0.28	0.16	43
8 in. brick	0.40	0.20	50
8 in. brick, furring, lath, plaster	0.27	0.16	41
4 in. tile, stucco, outside, plaster inside	0.40	0.20	50
12 in. concrete	0.46	0.21	54
Corrugated iron	1.50	0.32	79
12 in. stone	0.49	0.22	55
12 in. concrete, furring, lath, plaster	0.40	0.20	50
Stucco, studding, plaster	0.45	0.21	53

ROOF CONSTRUCTION	Conductivity Uninsulated "H"	Conductivity Insulated "H1"	Percentage Saving
Tar, gravel on 4 in. concrete	0.60	0.24	60
Metal on tongue and groove sheathing	0.42	0.20	52
Corrugated iron on wood frame	1.80	0.32	82
Tile or slate on wood sheathing	0.82	0.27	67
Tar, gravel, tar paper, 2 in. wood plank	0.26	0.16	39
Shingles, sheathing, studding, lath, plaster	0.30	0.17	43
Wood shingles on shingle lath	0.64*	0.24	63

*Average value from JONES' tables, *The Heating and Ventilating Magazine.*

The cost of Cabot's "Quilt" is so low, for material and application, that reduction in Heating Equipment warranted by above figures more than pays for entire insulation. The annual fuel saving is pure velvet.

Fire-resistant: "Quilt" is a *real* fire-resistant. It will not smoulder or carry fire.

Will not Rot: "Quilt" will not rot. It will last as long as the house.

Flexible: "Quilt" will fit any surface, or around corners or jogs. Lowest labor cost.

Armstrong Cork & Insulation Company

Pittsburgh, Pa.

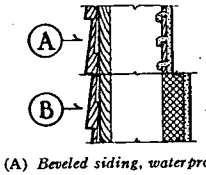
Branches and Representatives

See Complete List on Page 480, Under Section "Foundation, Cork"

Something over 50 per cent of the heat supplied to an uninsulated residential building is lost by conduction and radiation through the walls and roofs. But when the house is insulated with the recommended thicknesses of Armstrong's Corkboard this loss is so materially reduced that it can be heated comfortably with a smaller plant and on less fuel.

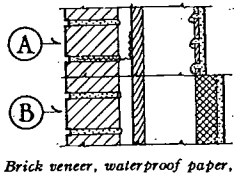
The following figures for heat transmission through standard wall constructions are accurate and can be depended upon as a basis for heating capacity calculations.

Heat transmission through insulated and uninsulated construction expressed in B.t.u. per hour, per square foot, per degree difference in temperature.



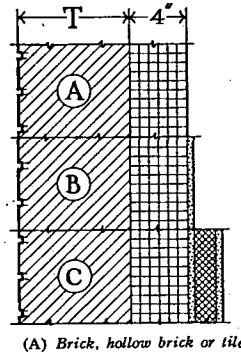
Not Insulated	B-INSULATED with Corkboard	
A	1½ inches	2 inches
.218	.105	.090

(A) *Beveled siding, waterproof paper, sheathing, studding, lath and plaster.*
(B) *Beveled siding, waterproof paper, sheathing, studding,* ARMSTRONG'S CORKBOARD, *plaster.*



Not Insulated	B-INSULATED with Corkboard	
A	1½ in.	2 in
.200	.101	.087

(A) *Brick veneer, waterproof paper, sheathing, studding, lath and plaster.*
(B) *Brick veneer, waterproof paper, sheathing studding,* ARMSTRONG'S CORKBOARD, *plaster.*

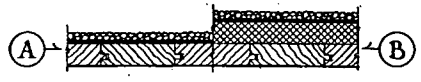


THICKNESS T	NOT INSULATED A	NOT INSULATED B	C-INSULATED with Corkboard 1½ inches	C-INSULATED with Corkboard 2 inches
8 in.	.234	.222	.105	.090
12 in.	.197	.189	.097	.084
16 in.	.170	.164	.090	.078
20 in.	.150	.145	.084	.074
24 in.	.134	.130	.079	.070

(A) *Brick, hollow brick or tile (4 in.).* (B) *Brick, hollow brick or tile, plaster*
(C) *Brick, hollow brick or tile, Portland Cement mortar backing,* ARMSTRONG'S CORKBOARD, *plaster.*

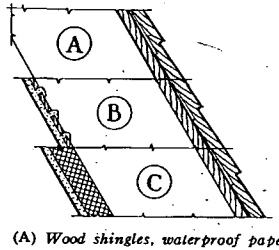
The heat loss through roofs is even greater than through walls for the reason that roofs are generally thinner in construction and more exposed to extremes of temperature. Moreover, in many buildings where high humidity is maintained, condensation, or sweating, on the ceilings is a serious problem. Excessive heat loss and sweating are eliminated by insulating the roof with the proper thickness of Armstrong's Corkboard.

The figures below show the heat loss and the effect of insulation on several types of standard roof construction.



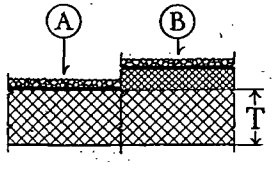
Not Insulated	B-INSULATED with Corkboard	
A	1½ inches	2 inches
.262	.114	.097

(A) *Standard built-up roofing, mill construction plank roof.*
(B) *Standard built-up roofing,* ARMSTRONG'S CORKBOARD, *plank roof.*



NOT INSULATED A	NOT INSULATED B	C-INSULATED with Corkboard 1½ inches	C-INSULATED with Corkboard 2 inches
.384	.224	.108	.091

(A) *Wood shingles, waterproof paper, roof boards, rafters.*
(B) *Wood shingles, waterproof paper, roof boards, rafters, lath and plaster.*
(C) *Wood shingles, waterproof paper, roof boards, rafters,* ARMSTRONG'S CORKBOARD. *plaster.*



THICKNESS T	Not Insulated A	B-INSULATED with Corkboard 1½ inches	B-INSULATED with Corkboard 2 inches
2 in.	.400	.135	.110
3 in.	.376	.132	.108
4 in.	.356	.129	.106
5 in.	.336	.126	.105
6 in.	.319	.124	.103
7 in.	.303	.121	.101
8 in.	.290	.119	.100

(A) *Standard built-up roofing, reinforced concrete slab.*
(B) *Standard built-up roofing,* ARMSTRONG'S CORKBOARD, *reinforced concrete slab.*

The Celotex Company

Branches in Principal Cities

General Office
645 N. Michigan Avenue
Chicago, Ill.

Mill
New Orleans, La.

CELOTEX
INSULATING LUMBER

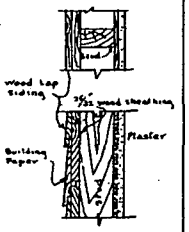
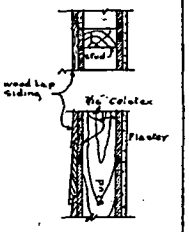
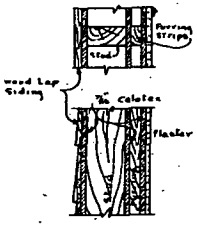
CELOTEX is a structural material made from the tough fibres of cane. Its physical properties give it a remarkable resistance to the passage of heat, and because of its strength it replaces other building materials in most of its uses while providing effective insulation.

All materials provide some measure of insulation, but unless the ability to resist the passage of heat is present in a sufficient degree, the material is not an effective insulation. Celotex has a conductivity of 0.33 B.t.u. per hour, per square foot, per deg. fahr., per inch of thickness, which ranks it among the best of commercial insulating materials.

Celotex has made practical the insulation of all types of structures. Used throughout in combination with other materials its cost is seldom more than 1 or 2 per cent of the total cost of the building. In fact, Celotex is an actual economy, for a smaller heating plant and less radiation is required when Celotex has been built into roof and walls. Properly used, it can save from 25% to 35% of the fuel expense.

Fuel and Radiation Savings; also Percentage of Heat kept out in Summer by Walls Insulated with Celotex

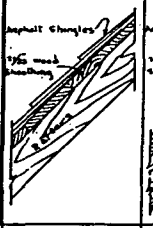
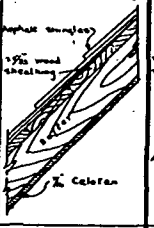
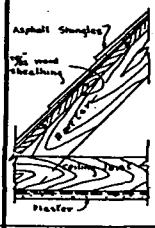
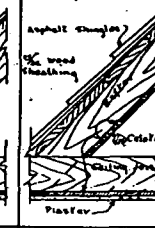
(Based on Net Wall Area of 1000 Sq. Ft.)

		WOOD SIDING WALLS		
		ORDINARY WALL	WALL INSULATED WITH CELOTEX (2 LAYERS)	WALL INSULATED WITH CELOTEX (3 LAYERS)
				
Heat Transmission (B.t.u. per Hr. per sq. ft. per °F.)		0.227	0.167	0.114
Annual Fuel Saving*	Cu. Ft. of Gas		26,500	50,000
	Tons of Coal		0.88	1.66
	Gallons of Oil		117	220
Radiation Saving** (Sq. Ft.)	Hot water Heat		28	52.6
	Steam Heat		18.7	35.1
	Vapor Heat		21.5	40.4
Percentage of Heat Kept Out by Celotex in Summer	†		26%	50%

*Based on heating season of 210 days and average temperature difference of 35 deg. fahr.
**Based on temperature difference of 70 deg. fahr.
†Compared with wall not insulated with Celotex.

Fuel and Radiation Savings; also Percentage of Heat kept out in Summer by Roofs Insulated with Celotex

(Based on Net Roof Area of 1000 Sq. Ft.)

		ASPHALT SHINGLE ROOFS			
		a HEATED ATTICS		b UNHEATED ATTICS	
		ORDINARY ROOF	ROOF INSULATED WITH CELOTEX (1 LAYER)	ORDINARY ROOF	ROOF INSULATED WITH CELOTEX (2 LAYERS)
					
Heat Transmission (B.t.u. per Hr. per sq. ft. per °F.)		0.518	0.211	0.231	0.119
Annual Fuel Saving*	Cu. Ft. of Gas		136,000		49,500
	Tons of Coal		4.51		1.65
	Gallons of Oil		597		218
Radiation Saving** (Sq. Ft.)	Hot water Heat		71.3		26.1
	Steam Heat		47.7		17.4
	Vapor Heat		54.8		20
Percentage of Heat Kept Out by Celotex in Summer	†		59%		46%

*Based on heating season of 210 days and average temperature difference of 35 deg. fahr.
**Based on temperature difference of 70 deg. fahr.
†Compared with roof not insulated with Celotex.

The advantages of Celotex may be obtained in houses already built, as well as new houses, by lining attic and basement with Celotex. Since a large percentage of the heat loss in most houses is through the roof, lining the attic with Celotex gives protection where it is most needed.

The U. S. Bureau of Standards has this to say about insulation applied to walls and roofs of dwellings: "The application of insulation results in a certain absolute saving which is independent of heat loss through windows and doors. The approximate fuel saving in dwelling houses with half inch insulation may be 20 per cent (or over) and with one inch insulation from 30 to 40 per cent."

The broad strong boards of Celotex are used instead of wood sheathing under wood siding, brick veneer, stucco or shingles; under plaster replacing lath; as roof sheathing; as interior and exterior finish, as attic and basement lining. For best results, at least two layers of Celotex should be used in walls and roof and in some instances a greater thickness will prove economical. These should preferably be distributed, one layer on each side of the framing.

The charts reproduced here show typical savings of fuel and radiation and the percentage of summer heat kept out when Celotex *has been properly used* in walls and roof. Figures are given for one and two layers in roofs and two and three layers for walls on the basis of 1000 sq. ft. of wall or roof area.

We will be glad to send you special literature that will be very helpful to the heating and ventilating engineer—"Coefficients of Heat Transmission." "Roof Insulation with Celotex," "Radiation Saving with Celotex," "Fuel Saving with Celotex" and the Celotex Building book containing the general story of this product. Write for any or all of these pamphlets.

Flax-li-num Insulating Company

Chicago Office
228 North La Salle

Home Office and Factory
St. Paul, Minnesota

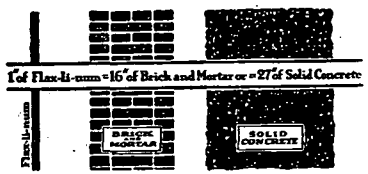
New York Office
ARCHITECTS BUILDING,
101 Park Avenue

Manufacturers of FLAX-LI-NUM

Flax-li-num is a thermal insulation and sound control material used for many years in various industries to meet existing insulation requirements. FLAX-LI-NUM is a semi-rigid board felted from the long tough fibres of the flax plant and naturally FLAX-LI-NUM is durable and assures the user that the insulation will last as long as the building stands.

Flax-li-num is vermin and rodent proof and is guaranteed by the manufacturers *never to fall down or become displaced* in a building wall. As the material is of *semi-rigid* type it cannot warp, break or crack, and it should not be considered as a substitute for ordinary wood or metal lath, sheathing or other parts of a building construction.

The FLAX-LI-NUM insulation method has been developed for roofs and walls of frame, brick, hollow tile or veneer constructions, and to give the user the full benefit of its heat insulation and sound proofing qualities.



Flax-li-num was introduced in 1909, first, to insulate railroad refrigerator cars, and has extended its application in the past fifteen years to a variety of insulating services in residences and industrial buildings and in many specialty markets, such as iceless shipping containers and kindred products.

The use of FLAX-LI-NUM in buildings, brings definite economies in fuel and radiation required, as well as the production and maintenance of healthful conditions. Heat transmission coefficients are given for various types of walls and roofs.

To get the best service from FLAX-LI-NUM specify the exact place where insulation is to go. The effectiveness of insulation is increased if applied between studdings, midway between the sheathing and lath and plaster for frame construction, or furred out on masonry construction. FLAX-LI-NUM for walls should be at least ½ in. thick and for roofs 1 in. thick.

The FLAX-LI-NUM method of application of insulating material to all types of construction is fully covered in our booklet, "Heat Insulation for Houses"—A. I. A. File 37-b-1. There is also contained in this booklet the FLAX-LI-NUM radiation chart which greatly simplifies the accurate computation of radiation where heat loss factors are known. A copy of this publication should be in the files of every engineer and architect, and will be sent on request.

Heat Loss factors for various insulated and uninsulated walls of stucco, brick and frame construction are fully covered in the publication "Heat Insulation for Houses."

These walls are listed below with their *K* values, showing how these values are substantially reduced by the addition of FLAX-LI-NUM in accordance with our standard specification which calls for ½ in. FLAX-LI-NUM in side walls and 1 in. ceilings or roofs.

Stucco Walls

A-1. Standard frame construction furred out over sheathing, metal lath and stucco. Lath and plaster inside..... .242

B-1. Same as above but with ½ in. Flax-li-num added..... .146

C-1. Standard frame construction with Byrkett sheathing. Stucco directly on sheathing. Lath and plaster inside..... .287

D-1. Same as above with ½ in. Flax-li-num added..... .161

E-1. Frame construction. Metal lath directly on studs. Stuccoed outside and back-plastered. Lath and plaster inside..... .357

F-1. Same as above with ½ in. Flax-li-num added..... .181

Brick and Tile Walls

A-2. Standard frame construction. Lath and plaster inside. Face brick veneer..... .210

B-2. Same as above with ½ in. Flax-li-num added..... .133

C-2. 8 in. hollow tile. 4 in. Face Brick, plastered directly on tile .255

D-2. Same as above, but furred inside with 1 by 2 in., plastered on Flax-li-num Keyboard..... .141

E-2. Standard 13 in. solid brick wall, furred inside, lath and plaster .191

F-2. Same as above with Flax-li-num Keyboard as plaster base..... .146

Frame Walls

A-3. Standard frame construction. Sheathing, paper and siding outside. Lath and plaster inside..... .255

B-3. Same as above with ½ in. Flax-li-num added..... .151

C-3. Standard frame construction, same as A-3, except plastered on lumber substitute..... .216

D-3. Same as above with ½ in. Flax-li-num added..... .136

E-3. Standard frame construction, same as A-3, except lumber substitute used for sheathing.... .229

F-3. Same as above with ½ in. Flax-li-num added..... .141

Roofs and Ceilings

A. Standard frame construction. Wood shingles, attic floor. Lath and plaster..... .179

B. Same as above, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster .104

C. Standard frame construction, same as A, without attic floor. .284

D. Same as B, without attic floor. .132

E. Standard frame construction, attic floor, tile roof..... .163

F. Same as E, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster..... .098

One of the fields in which FLAX-LI-NUM finds extensive use is in the insulation of industrial roofs, where it serves to reduce heat losses, secures greater comfort for workers and corrects condensation difficulties which hamper production in many instances. It is also extensively used for sound control and acoustical correction.

All details pertaining to the above uses are covered in the aforementioned publication, "Heat Insulation for Houses."

MacAndrews & Forbes Company

200 Fifth Avenue, New York, N.Y.

MAFTEX

PRODUCTS:

MAFTEX Structural Insulating Board.
MAFTEX Roof Insulating Board.

The Company:

MAFTEX is made by MacAndrews & Forbes Co., of Camden, N.J., whose business was established in the U.S.A. in 1870, and for many years makers of Fiberlic Wall-Board and other licorice root products, nationally known for toughness, strength and rigidity.

Properties of MAFTEX:

MAFTEX is the result of twenty years development. Fig. 1 shows a section of experimental board fabricated from roots of licorice. After nineteen years it shows no trace of disintegration, no inherent change, no loss of tensile strength. Note the "cleanness" of the saw cut.

Fig. 2. shows the ripple side (approximately one-tenth actual size) of a typical MAFTEX board, ready for roof or side wall sheathing and insulation, or as a base for plaster to take the place of lath—or as interior finish.

MAFTEX is made from the roots of licorice toughened by five-year root growth through stubborn soil. When prepared and processed these form a mass of densely interlaced, reinforcing and stiffening fibres.

MAFTEX affords effective thermal non-conductivity, because it is composed of millions of "dead air" cells that become a barrier to the passage of thermal units.

MAFTEX may be applied without the supplementary use of roof or side wall sheathing. It has the strength and resiliency that withstands windstrain, vibration, atmospheric change and other conditions to which construction is subjected after completion.

MAFTEX undergoes no change in inherent structure. It will not buckle, crack, warp, nor disintegrate after application.

MAFTEX forms a solid base for gypsum plaster in place of lath. It is easily and quickly applied. It requires no forcing of ground coats through to key. The float of the surface forms a bond that resists 1000 lb. pull to the square foot without being budged.

MAFTEX does not attract rats, ants and other vermin. Though thousands of tons of licorice root waiting to be made into MAFTEX boards—and thousands of finished boards awaiting shipment—are stored in the Company's warehouses, no rats or vermin are ever seen there.

MAFTEX is handled easily and swiftly. It has the structural qualities desired, saws and nails cleanly, and reduces construction time, effort, and cost.

General Uses:

MAFTEX is used as: Structural sheathing and insulation for exterior walls; Structural sheathing and insulation for sloping roofs; Sound deadening for floors and walls; Plaster base to replace interior lathing; Interior finish when not plastered; Exterior finish when left exposed; and Thermal-Insulating sheets for flat roofs.

Sizes, Thickness and Weight:

MAFTEX Structural Insulating Board is $\frac{7}{16}$ in. in thickness, 4 ft. wide and 8, 9, 10 and 12 ft. long. Weight is approximately 750 lb. per 1000 sq. ft.

MAFTEX Roof Insulating Board is made in 4 ft. by 4 ft. sizes, approximately ½ in. in thickness.

Figure 1

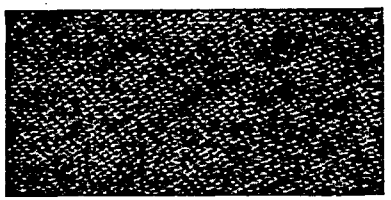


Figure 2

Lengths and widths are cut scant to obviate "crowding" of the joints between boards.

Processing of the Root Fibre:

In the manufacture of MAFTEX Insulating Board, the root is first "cured" and then shredded. It is next given a prolonged and vigorous boil, which serves a double purpose. First, the boiling removes ingredients which are not fibrous. Second, the boiling effectively sterilizes the fibres.

Following this the fibres are thoroughly washed with two hundred times their weight of water. Any sand or fine particles which might lessen the strength of the board are thus screened out. There remain then only the long fibres—tough, elastic, reinforcing, durable, clean, sterile.

Fabricating the Sheets:

The fibres are next waterproofed and felted, and the mass is passed through many presses and formed, in one process, into a single-ply continuous sheet without laminations. When given the MAFTEX texture, cut to standard sizes and dried in kilns there results a staunch board composed of interwoven tough root fibres which enclose millions of minute dead air-pockets, upon which the thermal insulating properties, the strength and the durablity of the board so largely depend.

Authoritative Results of Tests:

THERMAL-CONDUCTIVITY—The coefficient of heat transmission of MAFTEX is expressed as 0.326 B.t.u. per hour per square foot, per degree Fahrenheit difference in temperature per inch thickness. As illustrative of the fact that the lower the conductivity the better the insulating value, such well and favorably known species of wood as Yellow Pine and Maple have, respectively, thermal conductivities of 1.045 B.t.u. and 1.10 B.t.u. The thermal conductivity of concrete is 6 to 9 and that of granite 13 to 28. The value of MAFTEX for its lack of heat and cold transmission can be readily recognized from these figures.

STRUCTURAL STRENGTH—Distortion Tests clearly indicate the strength of MAFTEX for sheathing compared with wood as ordinarily used for the same purpose. Similar panels, each 8 ft. by 8 ft., sheathed respectively with two sheets of MAFTEX and with $\frac{7}{8}$ in. by 12 in. wood sheathing, tested by tightening a turnbuckle between the panels show MAFTEX to be only $2\frac{5}{16}$ in. out of plumb when the wood panel is 12½ in. from the perpendicular. This extreme resistance to twisting and distortion enables the architect to secure insulation plus structural strength in one material.

Sheathing for Walls and Roofs:

MAFTEX is not only a waterproofed insulating material of high type but its structural strength adds to its desirability in place of the usual sheathing for frame walls and sloping wood rafter construction. The large sheets 4 ft. wide by 8, 9, 10 and 12 ft. long, provide a stiffening action to the framework, resisting twisting and distortion whether clapboarded, shingled or stuccoed as in the best work, or left exposed. As a roof sheathing on rafters under any type of roofing material, the large sheets of MAFTEX afford added rigidity plus high insulating value. Ordinarily the roof is one of the most pronounced places at which occurs heat infiltration in the summer and heat leakage in the winter.

Insulation for Roofs:

On flat roof slabs of concrete, hollow-tile or other materials, including roof decks of wood planking or steel forms, MAFTEX Roof Insulating Board, in the 4 ft. by 4 ft. sheets, laid in one or two layers in combination with bituminous or asphaltic compounds, makes a base for any type of roof covering that insures insulation against heat or cold, prevents condensation, conserves fuel, lessens radiation and size of heating plant, and reduces contraction and expansion of the supporting roof construction.

Base for Interior Plastering:

The use of MAFTEX as a plaster base, or lathing, for gypsum plaster adds insulation to the structure and at the same time provides a plaster bond stronger than with ordinary lath. So firm is the bond formed between the MAFTEX and gypsum plaster that, in tests conducted, a load of about 1000 lb. per sq. ft. has been necessary to cause rupture, and even then the tearing apart did not occur at the contact of the plaster with the MAFTEX face.

Finished Interiors Without Plastering:

For decorative effects without plaster, the distinctive MAFTEX surface places at the disposal of the designer possibilities in texture practically unobtainable heretofore. The surface may be painted, Kalsomined, left natural, or treated with one coat of special preparations for textural effects.

Sound Deadening:

As a sound-deadening material MAFTEX is most effective, for the same intrinsic qualities which provide thermal insulation guarantee its sound-absorbing value.

UNIVERSAL GYPSUM & LIME CO.

NEW YORK, N. Y.
JACKSONVILLE, FLA.

Offices
Chicago, Ill.

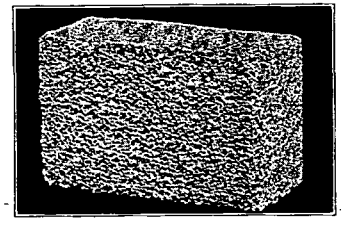
FORT DODGE, IOWA
KANSAS CITY, MO.

MILLS—AKRON, N. Y., FORT DODGE, IA., ROTAN, TEXAS

INSULEX
GYPSUM INSULATION

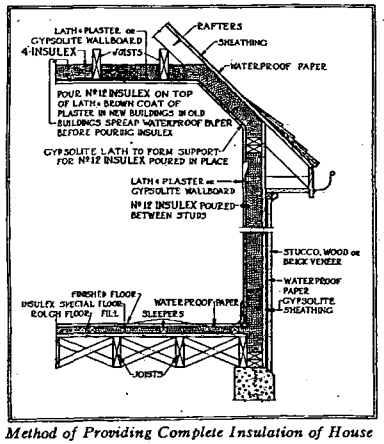
Reg. U. S. Patented Office

Insulex is a gypsum insulating material for building construction and is used to prevent the passage of heat, cold and sound. When mixed with water **Insulex** expands and hardens into a cellular mass in partitions, floor and ceiling spaces. It is especially adapted for use in homes, apartment houses, schools, commercial and industrial buildings where the saving of heat is a vital necessity.



A Block of INSULEX *Showing Cellular Structure*

The use of **Insulex** reduces the size of heating plants and amount of radiation installed so that in estimating the heating requirements of a building using **Insulex** insulation special conductivity factors are required.



Method of Providing Complete Insulation of House

Complete A. I. A. Specifications, reports of tests and engineering data on **Insulex** will be furnished on application. Our staff of heating engineers will help solve your problems on reduced radiation.

BUILDING CONSTRUCTION*

SIDE WALL (FRAME)	UNINSULATED		INSULATED By Filling Stud Space With No. 12 INSULEX	
			Lath and Plaster	Gypsolite Plaster Board and Plaster
Clapboard, Stud, Lath and Plaster	....	.345	.082	.079
Clapboard, Paper, Sheathing, Stud, Lath and Plaster	....	.263	.076	.073
Brick Veneer, Paper, Sheathing, Lath and Plaster	....	.251	.075	.073
Cement Stucco, Paper, Sheathing, Lath and Plaster	....	.255	.075	.073
SIDE WALL (MASONRY)			By Using 2-Inch Furring Strips and Filling Space with No. 12 INSULEX	
	No Furring Strips	With Furring Strips	Lath and Plaster	Gypsolite Plaster Board and Plaster
Brick Wall—Plastered Inside:				
8-inch	.379	.272	.111	.105
12- "	.296	.228	.103	.098
16- "	.243	.196	.096	.091
Terra-Cotta Wall—Stucco Exterior—Plastered Inside:				
8-inch	.291	.224	.102	.096
12- "	.225	.183	.093	.088
16- "	.184	.155	.095	.081
CEILING			Filling Space Between Joists 4-Inches With No. 12 INSULEX	
			Lath and Plaster	Gypsolite Plaster Board and Plaster
Ceiling Joists, Lath and Plaster	....	.692	.082	.079

***New Heating Constants**—For use in determining house heating radiation requirements when insulated with **Insulex**, according to UNIVERSAL GYPSUM & LIME CO.'s specifications.

The Armour Institute of Technology, Chicago, Illinois, have prepared the above figures based on tests and years of experience showing the amount of heat lost through various kinds of construction. Prepared by Professor J. C. Peebles.

The figures given are in B.t.u.'s per square foot per hour per degree temperature difference and show heat loss or conductivity. These figures can be used in figuring reduced size of heating plants and radiation required in an **Insulexed** home.

United States Gypsum Company

General Offices 300 West Adams Street
Chicago

Description:

Thermofill is a combination of specially processed gypsum and short pulp fibre. The gypsum is forced into the fibre by a rolling and shredding process, making the Thermofill light, fluffy and fire-resisting in addition to the splendid insulating value which it has.

It provides bulk insulation at low cost. These two properties are of first importance in considering an insulating material. Other desirable properties of Thermofill are its high fire, moisture, and vermin resistance and its permanence. Thermofill fits tight against joists, studs, and rafters to form the most effective barrier to heat and cold it is possible to obtain.

In the side walls of a house Thermofill is placed between the studs 3⅝ in. thick. Over the ceiling, with side walls fully insulated, Thermofill is placed 4 in. deep. Or, it may be filled between the rafters when the attic space is finished off in rooms. It is put in place as it comes from the mill without cutting, fitting or mixing, to form the most practical type of insulation.

THERMOFILL
The Dry Fill Insulation

INSULATING EFFICIENCY ON TYPICAL CONSTRUCTION

Description

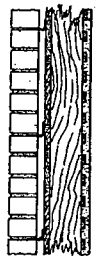
Siding.
Paper—(Water-proof.)
Sheathing.
2 by 4 in. studs.
Wood lath.
3 coats plaster.

Description

Stucco-cement.
C2-14 wire mesh.
Building paper (Water-proof.)
Yellow Pine sheathing.
2 by 4 in. studs.
Wood lath.
3 coats plaster.

Description

Brick, 4 in.
1 in. air space.
Building paper.
¾ in. wood sheathing.
2 by 4 in. studs.
Wood lath.
3 coats plaster.



USE CONSTANTS SHOWN BELOW FOR ESTIMATING RADIATION

	"U" Calculated	"U" Actual Test	"U" Calculated	"U" Actual Test	"U" Calculated	"U" Actual Test
Uninsulated	.26	.32	.27	.36	.24	.30
Insulated 3⅝ in. Thermofill	.085	.13	.09	.14	.08	.13

NOTE.—"U" (Calculated) is B.t.u.'s per hr.—per sq. ft.—per degree difference in temperature F. They are calculated from Surface and Conductivity factors of each material making up the construction.

"U" (Actual Test) is B.t.u.'s per hr.—per sq. ft.—per degree difference in temperature F. as obtained by actual tests, using equipment and method as recommended by a committee of the *American Society of Heating and Ventilating Engineers* and conducted under the supervision of Prof. J. C. Peebles of Armour Institute, Chicago, Ill.

INSULATING EFFICIENCY ON CEILINGS

Description	Uninsulated		Thermofill Insulated		
	"U" Calculated	"U" Actual Test	"U" Calculated		"U" Actual Test
Joist—Lath and Plaster (no flooring)	.60 .60	.76 .76	2" 4"	.13 .07	.24 .12

Wood Conversion Company

General Office and Factory at Cloquet, Minnesota

District Sales Offices:

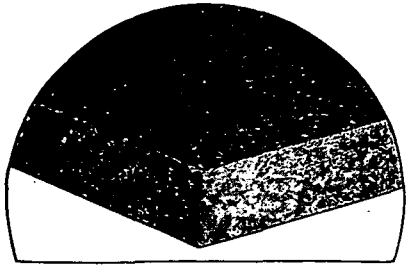
CHICAGO, ILL., 1320 London Guarantee Bldg.
DETROIT, MICH., 503 Stephenson Bldg.
NEW YORK, N.Y., 101 Park Avenue
ST. PAUL, MINN., 1955 University Avenue

Manufacturers of

Balsam-Wool

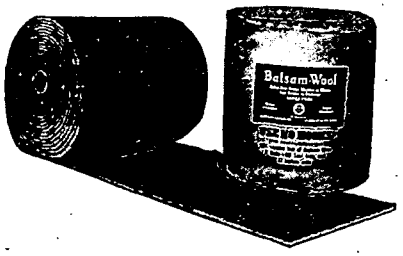
House Insulation
Sound Absorbent

Steel Car Insulation
Refrigerator Car Insulation



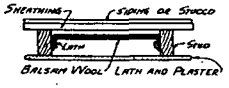
Section of BALSAM-WOOL Insulation

Showing wood fibres re-arranged into a fleecy substance, matted together in blanket form, packed, without stitching, between two coverings of tough kraft paper lined with waterproof films of asphalt coating. BALSAM-WOOL is a fire resisting, rot and vermin proof insulation.

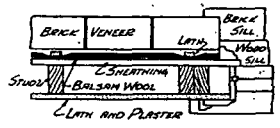


Balsam-Wool comes in three widths, 17, 25 and 33 in., wrapped in rolls. These widths are available in both ½ and 1 in. thicknesses. The latter thickness is recommended for roof and ceiling insulation. Half-inch Balsam-Wool weighs 200 lbs. per 1,000 sq. ft.

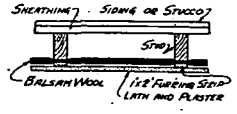
Details of Application



17 in. Balsam-Wool flanged between studding.



33 in. Balsam-Wool outside of sheathing—brick veneer.



33 in Balsam-Wool on inside face of studding.

The illustrations above show the method of placing BALSAM-WOOL in the walls of a building. BALSAM-WOOL acts as a blanket around a house and will hold in the heat and keep out the cold.

Thermal Conductivity

The following hot plate test by Professor J. C. Peebles gives the thermal conductivity of BALSAM-WOOL per square foot, per inch thickness, per degree difference in temperature, per hour, and shows the extremely high insulating value of the material.

Material	Thickness Inches	Density Lbs. Cu. Ft.	Conductivity	
			Per Inch Thick	Thickness as Tested
Balsam-Wool Plain Paper	0.63	3.62	.229	.364

Radiation Reduction

In a building properly insulated with BALSAM-WOOL, 25 per cent less radiation and boiler capacity as well as relatively smaller pipe sizes will be required and the saving is usually enough to pay for the cost of the insulation.

In computing the heat losses from a building and the radiation required, the following coefficients of wall sections should be used.

TYPE OF WALL	B.t.u. Transmission per Sq. Ft., per Hour, per 1 deg. fahr. Difference in Temperature.		
	Uninsulated	Insulated with ½ Inch Balsam-Wool	Insulated with 1 Inch Balsam-Wool
Frame Wall	.25	.127	.10
Stucco on Metal Lath	.26	.13	.10
Brick Veneer	.23	.125	.095
8 In. Brick Wall with Furring Strips	.27	.132	.102
Ceiling, Lath and Plaster, no Floor	.60	.18	.129
Ceiling, Lath and Plaster, Single Floor	.34	.15	.11
Roof, Wood Shingles on Sheathing	.43	.163	.120
Asphalt Shingles on Sheathing	.55	.175	.127

Chamberlin Metal Weather Strip Company

Incorporated

General Offices: **Detroit, Mich.**

Factories

Detroit, Mich. — **Peru, Illinois**

Over 100 Sales-Service Branches Throughout the United States

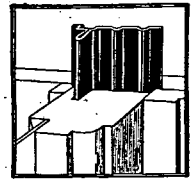
In figuring radiation for a building it is imperative that you investigate the heat saving effected by weather strips and calking. Consider, for example, this one fact alone. An unstripped window of average size will leak 124 cu. ft. of air per hour per foot of crack when the wind is blowing only 15 miles an hour. The uncalked cracks around door and window frames leak an additional 22.6 cu. ft. of air per hour per foot of crack at the same wind velocity. Rigid air leakage tests on ten to thirty-three year old Chamberlin installations have proved that Chamberlin Weather Strips and Calking prevent over 90 per cent of this infiltration and consequent heat loss.

This means that when computing the B.t.u. delivery of your heating plant you can make considerable reduction and effect substantial economies both for the building owner and future occupants if you can prevail upon those most interested to include Chamberlin equipment in the building plans.

Many heating and ventilating engineers are today recognizing the relationship of weather stripping equipment to heating efficiency and are insisting that for economical and efficient heating a building must be weather stripped. Naturally the preferred weather stripping is Chamberlin —the standard for over thirty-four years.

Chamberlin furnishes complete weather stripping equipment for every type of opening. This equipment includes Chamberlin Weather Strips for window and door cracks, In-Dor-Seals for sealing cracks at bottom of interior doors, Sill-Dor-Seals for sealing cracks at bottoms of exterior doors, Pulley Covers for stopping inleakage of air at pulley holes of sliding windows, and Plasti-Calk for sealing cracks around window and door frames.

CHAMBERLIN WEATHER STRIPS
"SINCE 1893-THE STANDARD"



Weather stripped windows should be practically airtight yet easy to operate. Chamberlin covers entirely the runways of sliding windows but raised track-like corrugations reduce sliding friction to a minimum.

Chamberlin Weather Strips

These Weather Strips are furnished in zinc, cold-rolled bronze or spring bronze. Thirty-four years of performance and over 20,000,000 Chamberlin equipped doors and windows have demonstrated their efficiency and the correctness of their design. These Weather Strips seal the cracks around doors and windows thereby barring out rain and the inleakage of cold or dust laden air at these vulnerable points.

Chamberlin In-Dor-Seals

This outstanding Chamberlin equipment effectively seals the cracks at the bottoms of inside doors thereby preventing the spread of cold air from bed rooms or other unheated rooms throughout the remainder of the building. Chamberlin In-Dor-Seals are ingeniously hidden in the bottoms of inside doors. A thick but soft felt strip rises automatically to clear rugs or runners the instant the door is opened and lowers snugly to the floor, sealing the under-door crack an instant before the door is entirely closed. In-Dor-Seals are essential in preventing heat loss particularly at night when bed room windows are open.

Chamberlin Sill-Dor-Seals

Chamberlin Sill-Dor-Seals effectively seal the cracks beneath entrance doors and prevent rain and air leakage at this junction. They are made of extruded brass, highly polished and artistically formed and are anchored securely to wood, stone or metal sills. The effect of their presence is quickly noticeable in halls or corridors.

Chamberlin Pulley Covers

These Pulley Covers cover pulley holes in lower sash runways and fit snugly around the cord, thereby practically stopping any air leakage at these points.

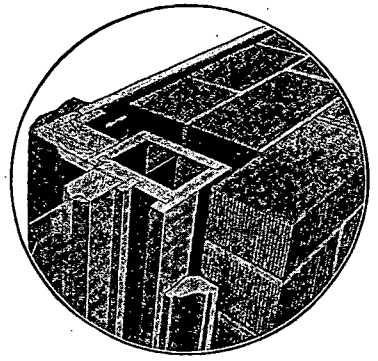


Illustration above shows how cracks around window and door frames in masonry walls are effectively sealed with Chamberlin Plasti-Calk. It adheres perfectly and will not chip or crumble.

Chamberlin Plasti-Calk

Chamberlin Plasti-Calk permanently seals the cracks between window or door frames and the surrounding masonry. Plasti-Calk does not crack or crumble away but remains semi-plastic and adheres to metal, wood or stone. Cracks between frames and masonry constructed walls are always present despite the most expert workmanship, and are too often neglected. Yet they allow considerable infiltration of air and dust, and a considerable loss of heat when the weather is cold.

Since 1893 Chamberlin equipment has been considered the leading Weather Stripping equipment. Tests show that Chamberlin equipment continues to give as good service as when first installed. A Chamberlin installation involves a scientific and complete weather stripping service. It is sold only through Chamberlin factory branches and installed exclusively by Chamberlin mechanics trained and supervised to work to the rigid Chamberlin standard. And as final assurance of permanent satisfaction, Chamberlin positively guarantees and services its equipment "for the life of the building."

The following is a brief summary of why Chamberlin equipment will best serve the interests of heating efficiency, why you can safely recommend Chamberlin equipment and why you will gain the lasting good will of your clients by doing so.

Ten Reasons Why Chamberlin Should Be Your Choice As An Aid To Heating Efficiency

1. Complete line of weather proofing equipment.
2. High Quality of heavier gauge materials.
3. All Installations factory supervised and made by Chamberlin's own Trained Craftsmen.
4. Exacting Attention to Installation Details.
5. Proved by Test of Time.
6. Product and Guarantee nationally advertised and therefore dependable.
7. Ranked as Standard for thirty-four years.
8. Specialists in Weather Strip Development to meet all requirements.
9. Installations freely Serviced-Guaranteed "for Life of the Building."
10. Nation Wide Service Organization—an established million dollar corporation with more than one hundred factory branches.

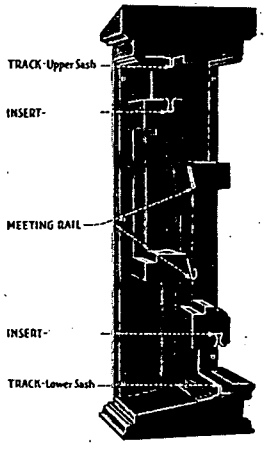
The Higgin Manufacturing Co.

Newport, Ky.

Manufacturers of Metal Weather Stripping for Windows and Doors

Representatives in Principal Cities

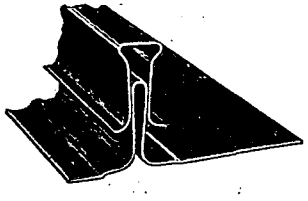
HIGGIN ALL METAL Access Panel



A double hung window model is illustrated. Note rib track and insert at sides, head and sill and interlocking strips at the meeting rail.

Higgins All Metal Weatherstrip Equipments efficiently reduce to a minimum infilteration losses around windows and doors.

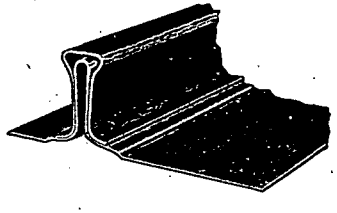
The Higgins rib track and spring tempered bronze insert for double hung windows, forms a metal to metal contact that drafts will not pass. The efficiency of this two member equipment is not affected by shrinkage of the sash. If the sash should draw away from the frame the insert will snugly contact with the rib at any point of its projection. Air leakage through the pulley holes is prevented by the insert dividing as it does into a separate chamber the cut out for sash cord.



(At Right) Note how snugly the spring tempered insert hugs the rib, even though the sash has shrunk since installation.

There is also an All Metal equipment for every type of casement window and for doors, too.

Higgin Weatherstrips are installed by only thoroughly trained mechanics, assuring the proper functioning of the sash and a perfectly fit job.



The metal to metal contact insures a perfectly tight fit, yet an easy sliding sash.

Write for Complete Literature.

The Higgin Manufacturing Co.

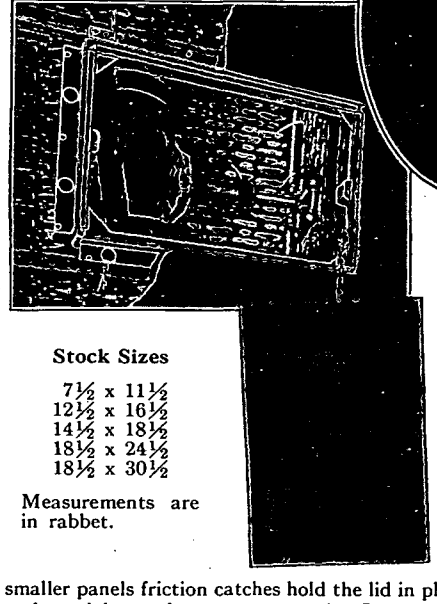
Newport, Ky.

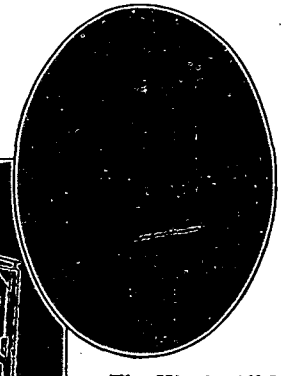
Manufacturers of Metal Access Panels for Heating and Plumbing Systems

Representatives in Principal Cities

HIGGIN ALL METAL Weatherstrips

Illustration below shows panel used for access to concealed valve. Plaster is shown broken to expose metal lath and method of fastening. Lid is shown hanging below frame well out of the way. Note how frame provides ground for plasterer.





(In Oval) Lid is shown in place. Note how inconspicuous the panel is.

Stock Sizes

7½ x 11½
12½ x 16½
14½ x 18½
18½ x 24½
18½ x 30½

Measurements are in rabbet.

The Higgin All Metal Access Panel was designed to meet a pressing need for an inconspicuous flush panel for access to critical places in Heating, Plumbing and Refrigerating systems. The panel is entirely of metal.

They are made as a unit. No assembling at the job.

Installation is simple and no special framing or grounds are necessary. The panel is composed of a frame and lid. The frame is in one piece with a continuous angle on the inside, forming a rabbet for the lid. Perforated angles are spotwelded to outside of frame for fastening and plaster key. On the smaller panels friction catches hold the lid in place. For the larger sizes, retaining clips and special cam fasteners are used. Concealed hinges may be provided if desired in place of the retaining clips. Panels may be installed in walls faced with plaster, tile or marble. They can be painted, decorated or papered over.

Higgin All Metal Access Panels are ideal for use in Hospitals, Apartment Houses, Hotels, Residences, Offices and other Buildings.

Write for Complete Descriptive Literature

GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y.

Sales Offices in Principal Cities

Motor Drive and Control

For Heating, Ventilating and Air Conditioning Systems

Methods of Drive

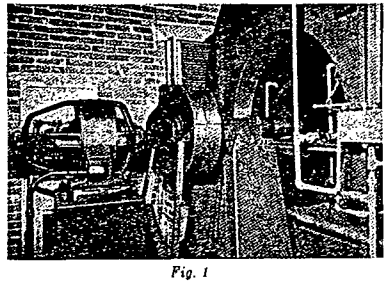


Fig. 1

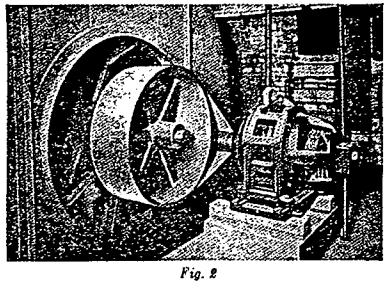


Fig. 2

Fig. 1. Silent chain drive can frequently be employed to advant ge, with a lowering of the motor cost as compared with direct-connected drive. The illustration shows a 25 hp., 500/900 r.p.m.. Type CD, adjustable speed, motor driving an American Blower Fan at the Portland (Oregon) Journal Building. The chain drive is enclosed in an oil-tight housing.

Fig. 2. "Texrope" drive makes possible the placing of the motor very close to the fan pulley, and saves space. The ill stration shows a 50 hp., 850 r.p.m. motor driving a Buffalo fan. The maximum an speed is 140 r.p.m.

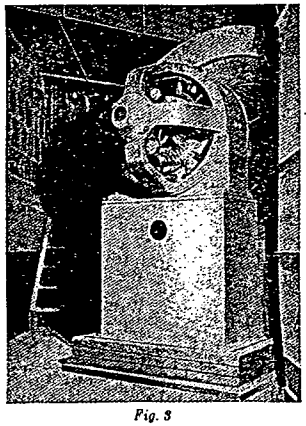


Fig. 3

Fig. 4. With fans of moderate size driven by alternating-current motors, the simple belt drive is efficient and economical. This illustration shows a Type KT, 3 hp., 860 r.p.m., constant speed motor controlled by a CR7005 magnetic switch, operating a Buffalo fan in the Plaut Store, Newark, N. J.

Fig. 5. The center distances on a belt drive can be shortened by using the "Lenix" idler to insure a larger arc of contact at the motor pulley. The illustration shows a 10 hp., Type MT, slip-ring induction motor driving a fan at the Washington High School, New Rochelle, N.Y.

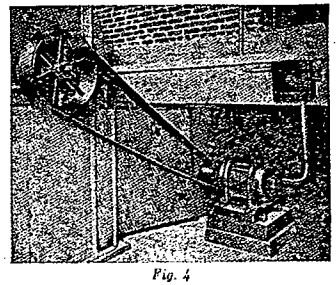


Fig. 4

Fig. 5. The direct-connected, slow-speed direct-current motor has long been a standard drive for ventilating and exhaust fans in large buildings. It is quiet and compact in operation, and has the lowest possible maintenance for a long period of years. The illustration shows a Type CD, 15 hp., slow-speed, adjustable speed motor driving an American Blower fan at the Detroit Masonic Temple.

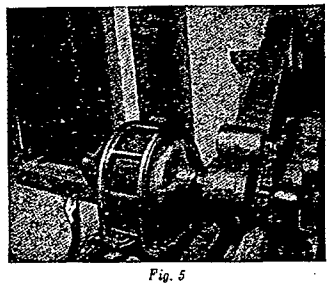


Fig. 5

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

Motor Drive and Control

For Heating, Ventilating and Air Conditioning Systems

Controllers for Use with Varying Speed, 3- or 2-phase, Alternating-Current, Slip-Ring Motors for Driving Fans

Remote Indicating Control

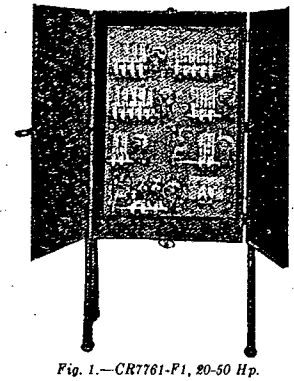


Fig. 1.—CR7761-F1, 20-50 Hp.

H.P.	Dimensions in Inches (Approx.)			Net Weight in Lb. (Approx.)
	Height	Width	Depth	
5- 7½	*67½	36	37	360
10–15	*67½	36	37	375
20	*67½	36	37	475
25	*67½	36	37	575
30	*67½	39½	37	650
40	*67½	39½	37	725
50	*67½	39½	37	850

*All sizes mounted on 64-in. angle supports.

Equipment includes one CR7761-F1 control panel, one BS-15-F four-speed indicating station, one BS-31-A start-safe-run station and one CR1924, 3-pole, fused switch. Dimensions of BS-15-F are 8 in. by 15¼ in. Sizes 5–15 hp. have self-contained resistors. Larger sizes have separate resistors.

Four Speeds—CR7761-F1

Remote indicating control, four speeds, operated by remotely located push-button station with bull's-eye lights of different colors indicating speed selected or attained. 5–15 hp. CR7761-F1 and BS-15-F.

CR7761-F1 enclosed contactor panel includes four speed-controlling or accelerating contactors with three relays. Remote located push-button station BS-15-F has four speed buttons marked (1) Slow Speed, (2) Second Speed, (3) Third Speed, (4) Full Speed, and one "stop" button. On pressing any "speed" button the motor accelerates automatically to that speed and the corresponding bull's-eye is illuminated. Speed can be changed while running to any other value by pressing button corresponding to speed desired. An additional control station BS-31-A with three buttons, "start," "safe," and "run," may be provided adjacent to the motor to start the equipment at the motor for test purposes. When the "safe" button is pushed the equipment is not only stopped but cannot be started from the remote indicating station. The "run" button on the BS-31-A station adjacent to the motor is pressed to release the "safe." When started by the BS-31-A station adjacent to the motor, the motor can be run at slow speed only. If it is desired to arrange this controller so that the motor can only be started in the fan room, add a CR7002 and a BS-79-J Start-Stop station. With this arrangement the BS-31-A station will not be required. Speed control and stopping may be secured from the remote station as before.

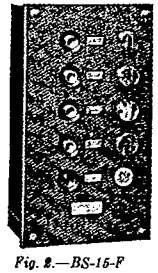


Fig. 2.—BS-15-F

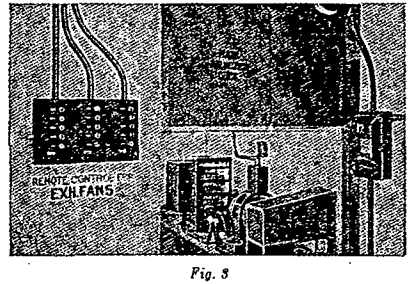


Fig. 3

Installation of 3 BS-15-F, Remote Indicating Control Stations for CR7761-F1 Controllers operating Exhaust Fans in the Pent House of the Salaam Temple, Newark. At right is shown a Type MT Motor belted to Supply Fan and Controlled by a CR7764 Controller

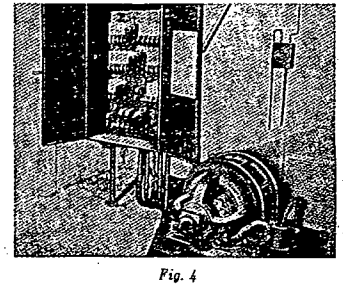


Fig. 4

Installation of Type MT Motor belted to Exhaust Fan at Salaam Temple, Newark. Motor is controlled by a CR7761-F1 Remote Indicating Control Panel operated from a Remote Point by one of the Control Stations shown in Fig. 2

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

The Westinghouse Electric & Manufacturing Company

EAST PITTSBURGH, PA.

WESTINGHOUSE SALES OFFICES

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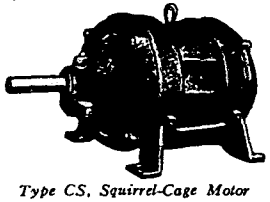
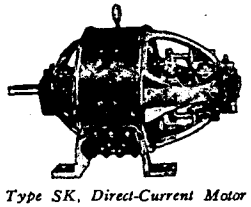
*Warehouse located in this city.

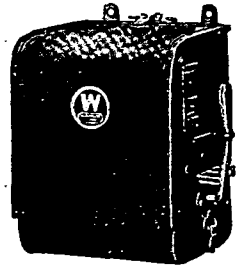
MOTORS AND CONTROL FOR HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS



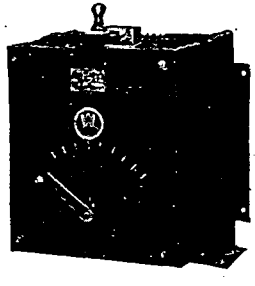
Type CS, Squirrel-Cage Motor



Type SK, Direct-Current Motor



Class 10700 Auto Starter



Class 7810-B Regulator

Motors—Westinghouse motors and control can be supplied for practically all demands within the heating and ventilating engineer's field of activity. Noiseless operation, close speed regulation, and dependability in service are their recognized characteristics.

Motor Control—Westinghouse Electric manufactures manual and magnetic starters and speed regulators to control motors in all applications. By specifying Westinghouse starters and regulators to operate Westinghouse motors, the responsibility for the successful operation of the installation is placed upon one manufacturer.

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Complete Ionizing and Ozone producing Plants for all Purposes

Service

We maintain well equipped Chemical Laboratories for the scientific solution of problems, both of a general and specific nature. Our Research Staff and Engineers will gladly consult with you. This service entails no obligations.

For General Ventilation

we provide two types of assembly. The Type TU, United States Ionizer is a self-contained unit, all apparatus being mounted on one base, and is built for requirements up to 120,000 c.f.m.

Where there is a multiplicity of fans, all operated quite independently, we provide our type TM Assembly, which comprises a number of Ionizer units mounted on a common base and employing a common blower and dehydrator.

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we provide United States Ozone Apparatus for maintaining the air pure, and fresh, oxidizing odors and inhibiting mold growth, etc.

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we provide United States Ozone and other Apparatus for treating potable waters, destroying all pathogenic bacteria, odors and tastes, particularly the odor and taste of chlorine. Special attention is given to SWIMMING POOLS.

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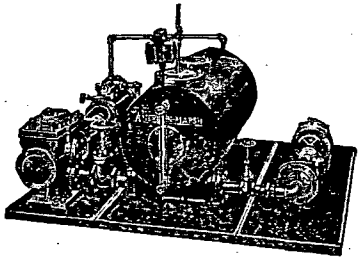


Automatic Combination Unit

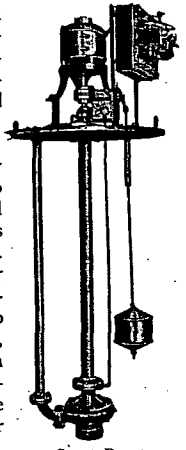
American-Marsh Condensation Units:—Combination unit shown above is patented development extensively used on heating systems where there is wide variation in steam pressure between day and night service. When pressure falls below 15 lb., motor driven pump starts automatically and keeps lines open until enough pressure is again generated to operate steam pump. Economical unit insuring rapid heating on cold mornings. Bulletin 58.

Condensation units equipped with either steam or centrifugal pumps are also furnished in sizes covering all needs. Bulletins 27, 32 and 52.

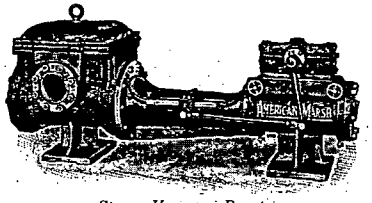
Multistage Centrifugal Pump

American-Marsh Centrifugal Pumps:—Built single or multistage, single or double suction, with split or solid cases. Adaptable for air washer service, pressure boosting, boiler feed, as fire pumps, etc. Designed for any type of drive. Dependable and highly efficient. Many sizes. Bulletins 33, 38, 44 and 53.

American-Marsh Sump Pumps:—Designed for automatic operation, elevating sewage and drainage to sewer levels, for cellar drains, etc. Current used only when pump runs; pump always submerged ready to start. Sizes to handle all jobs. Simple design for faithful service without attention. Also built as duplex units, similar in construction except that two complete pumps are mounted on one cover plate. Bulletin 41.



Sump Pump



Steam Vacuum Pump

American-Marsh Vacuum Pumps:—Standard equipment includes bronze fittings throughout. Designed for all vacuum heating needs with sizes to handle up to 200,000 sq. ft. radiation. Motor driven if desired. Bulletin 24.

Guarantees and Engineering Service:—Every pump is rigidly tested and guaranteed to meet conditions specified. It is further guaranteed against any defects in material and workmanship. Write for the co-operation of our engineers. Our forty years' experience is at your disposal.

Buffalo Steam Pump Co.

Buffalo, N. Y.

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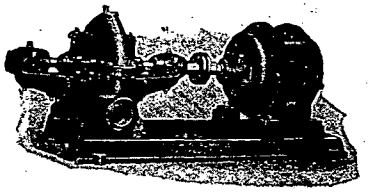
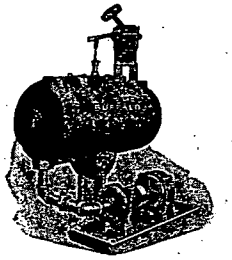
Products

Centrifugal Pumps For All Purposes—Single and Double Suction, Single and Multistage, Horizontal and Vertical. Steam Pumps—Duplex and Simplex, Inside Packed and Outside Packed. Vacuum Pumps and Condensers.



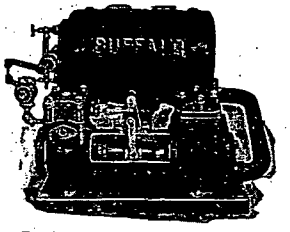
Class S Double Suction Centrifugal Pump

Horizontally divided casing. Extensively used with air washers, and for circulating systems and booster service.



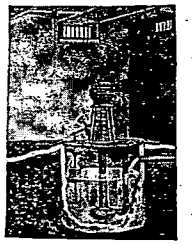
Centrifugal Condensation Return Pump and Receiver

Also built vertical with receiver pit. Especially adapted for low pressure boilers. Automatic in operation.



Duplex Steam Pump and Receiver

Entirely automatic. Can be furnished for high or low boiler pressure.



Automatic Sump Pump

Self contained. Ball bearing thrust with automatic oil lubrication.

Complete Catalogs Will Be Furnished Upon Request

Economy Pumping Machinery Co.

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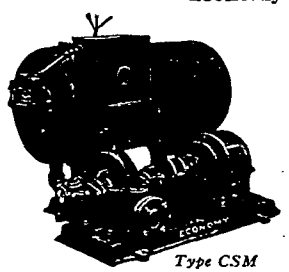
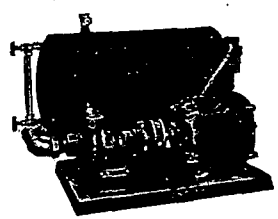
Economy Pumps

Economy Pumps and Receivers



Type CSM



Type CSS

Economy pumps and receivers are made in a variety of types for every pressure and capacity conditions. The present line is the result of a long study and improvement by this Company which was one of the pioneers in the manufacture of Electric pumps and receivers.

The use of these pumps to improve circulation with a reduction in boiler pressure usually results in large fuel economies. The savings are particularly striking in the case of medium pressure plants where it is desired to work at low pressure during dull periods of the day.

The table below gives a partial list of sizes which are available in either solid shell or horizontally split case designs. Complete specifications and descriptions will be found in Bulletin No. 405.

All Economy pumps are substantially mounted on cast iron bases with machined pads. Either cast iron or steel receivers are used. The automatic control is assembled as a unit and is easily accessible for inspection at all times. The most important features of individual standard designs are given below.

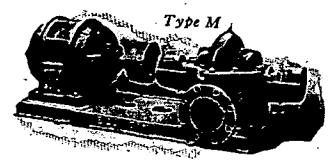
Type CSS—A single suction solid shell unit with oil-less stand bearing and outboard ring oiling or radial ball bearing. The most popular of all Economy pumps and receivers; a thoroughly dependable unit at a moderate price.

Type CSM—A double suction horizontal split case unit with enclosed bronze impeller with ring oiling bearings. This unit has been designed for use where the service is unusually severe as where equipment of the highest grade is desired.

Type CST—Multi-Stage Pumps for pressures above 40 lb. They are bronze fitted with ring oiling bearing at the driving end and radial ball bearing at the outboard end.

No. of Unit	Capacity in Sq. Ft. Direct C. I. Radiation	Pump Capacity G.p.m.	Receiver Capacity Gals.	Motor Horsepower				
				10 lb.	15 lb.	25 lb.	60 lb.	100 lb.
6	2000	7½	13	¼	..	..	..	..
6½	3500	12	16	½	..	..	..	..
7	5000	15	20	½	¾	1½	3	5
7½	7500	20	26	½	¾	1½	3	5
8	10,000	25	33	½	1	1½	3	5
8½	15,000	37	41	¾	1	2	5	5
9	25,000	60	49	1	2	3	5	10
9½	35,000	80	57	1½	2	3	7½	10
10	50,000	110	82	2	2	5	7½	15

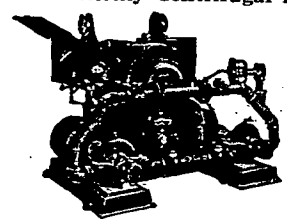
Economy Double Suction Pump



Type M

Economy Double Suction Single Stage Pumps, for hot water circulation, brine circulation, water supply, etc., are made in a complete range of capacities up to 3500 g.p.m. They embody the newest hydraulic developments which give them an unusually high efficiency over a broad range. The mechanical design is rugged and simple so that reliable performances and long life is assured. A head capacity table is given in Bulletin No. 408.

Economy Centrifugal Return Line Vacuum and Boiler Feed Pumps



Type 2234

Economy Vacuum Pumps have been designed for the rapid removal of air and water from heating systems and discharge of the water to the boiler. They are made in a wide range of sizes, a partial list of which is given below:

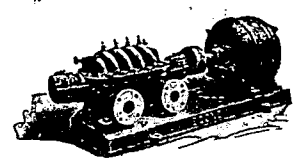
Bronze Fitted Pumps, Air Eliminator, Vacuum Receiver and Automatic Control are standard equipment. Sizes over 5000 sq. ft. capacity are of a double suction horizontal split case construction. Standard units are supplied with bronze suction strainer and scale pocket. Entire apparatus is shipped completely assembled and wired in accordance with National Electric Code.

Economy Centrifugal Vacuum Pump

Unit No.	Capacity in Sq. Ft. Direct C. I. Radiation	Motor Horse Power	Cubic Feet Air per Min.	Size Discharge to Boiler	Size Return Inlet	Shipping Weight
CV-1	2,500	¾	1¾	¾	1½	650
CV-2	5,000	1	4	1	2	750
CV-3	8,000	1½	6	1	2½	900
CV-4	16,000	2	10	1¼	3	1,025
CV-5	20,000	3	15	1¼	3	1,150
CV-6	27,500	5	19	1½	3½	1,300
CV-7	40,000	5	24	1½	4	1,550
CV-8	65,000	7½	40	2	5	1,800
CV-9	100,000	10	60	2½	6	3,100
CV-10	150,000	15	90	2½	6	.....

Duplex Units consisting of single tank, two pumps, motors and control can be furnished in any size. A test with calibrated orifices is made on each unit before shipment.

Standard Pumps are designed for operation against 20 lb. pressure but reasonably prompt delivery can be made on units for discharge pressures up to 150 lb.



Type EMF

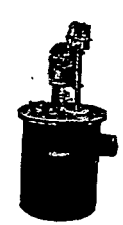
Economy Multi-Stage Pumps

Made in the horizontal split type in sizes 2½ and larger, smaller sizes are vertically split. In these pumps the head per stage has been limited to a figure at which high efficiency and long life is obtained. Distinctive features of *Economy* Horizontally Split design are solid one piece bronze diaphragms, the volute in every stage and the hydraulic balancing device. The table shows maximum head at 1750 r.p.m. Higher pressures are obtained with 3600 revolution units. Specifications are given in Bulletin No. 406.

Multi-Stage Pumps for High Pressure House Supply Boiler Feeding, Etc.

Capacity, gallons per minute	25	50	100	160	250	350
Pump number	1	1½	2½	2½	3	3
Horsepower for each 100 ft. head	2.5	3.75	5.5	7.0	11.0	17.0
Maximum head at 1750 r.p.m.	300	400	600	750	750	550

Economy Underground Pumps and Receivers—Type CU



Type CU

Underground pumps and receivers are designed for use where radiation is placed on the floor with returns underground or in any other places where it would otherwise be necessary to install horizontal pumps in a pit.

The underground pump consists of special vertical pump which is bronze fitted and controlled by a special mechanism which prevents binding and sticking of float rod. Lower bearing is of the oil-less type which has given such excellent service in these pumps for the last twelve years.

When necessary to use an underground pump on high pressure jobs we recommend the use of a low pressure underground pump discharging into the receiver of a high pressure horizontal pump. Our engineering department will be pleased to work out the details of such installations.

Type CU. Underground Pumps and Receivers

Capacity Sq. Ft.	Hp., 10 lb. Discharge Pressure	Motor Hp. 20 lb.	Pump Capacity G.p.m.	Receiver Capacity Inches	Disch. Size Inches	Capacity Sq. Ft.	Hp., 10 lb. Discharge Pressure	Motor Hp. 20 lb.	Pump Capacity G.p.m.	Receiver Capacity Inches	Disch. Size Inches
2000	¼	¾	7½	24 x 30	1	10,000	½	1½	25	24 x 36	1½
3500	¼	¾	12	24 x 30	1	15,000	¾	1½	37	30 x 36	1½
5000	½	1	15	24 x 30	1¼	25,000	1	2	60	30 x 48	2
7500	½	1	20	24 x 36	1¼	50,000	3	5	110	36 x 48	2½

Chicago Pump Company

Office and Works

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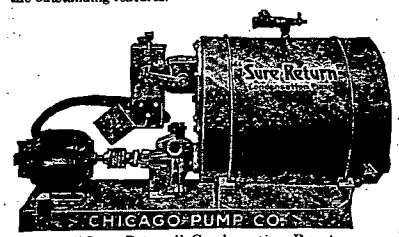
Representatives in Principal Cities

Quality Centrifugal Pumps—{Condensation, Vacuum, Sump, Sewage, House Circulating, Fire

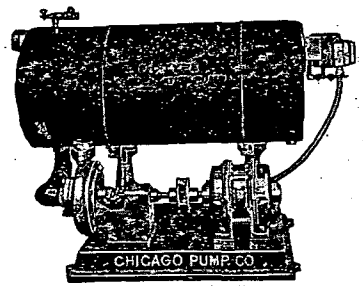
HORIZONTAL CONDENSATION PUMP AND RECEIVER

Horizontal condensation pumps and receivers are designed for capacities up to 150,000 sq. ft. of direct radiation and boiler pressures to suit any job. All units are mounted on one base and are assembled at the factory. Simple construction, quiet operation, and low operating costs are a few of the outstanding features.



"Sure Return" Condensation Pump

The "Sure Return" condensation pump and receiver is especially designed for low and medium capacities and boiler pressures up to 10 lbs. All parts are standard and interchangeable. Delivery can be made on this unit in 24 hours. Bulletin 131.



F. C. Condensation Pump

The F. C. or Float Controlled type condensation pump and receiver is designed for low, medium and high boiler pressures and capacities up to 150,000 GPM. Bulletin 129.

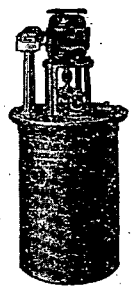
Horizontal Condensation Pump Capacities, Horsepower and Floor Space

Unit No.	Maximum Sq. Ft. Direct Radiation	Horsepower Motor	Approximate Floor Space Required Inches	Highest Water Level in Receiver from Floor Line Inches
H. 650	3,000	1/4	43x28	26
H. 651	6,000	1/2	43x30	26
H. 652	10,000	1/2	55x30	30
H. 653	15,000	3/4	57x32	30
H. 654	20,000	3/4	59x32	30
H. 655	25,000	1	59x32	35
H. 656	35,000	1	61x34	39
H. 657	50,000	1 1/2	65x36	41

VERTICAL CONDENSATION PUMP AND RECEIVER

The vertical condensation pump and receiver is designed particularly to collect the return from heating coils, etc., that come back below the floor level. No concrete pit is required, the unit being adaptable to ground installation, thus using a minimum of floor space. ASK for BULLETIN 133.

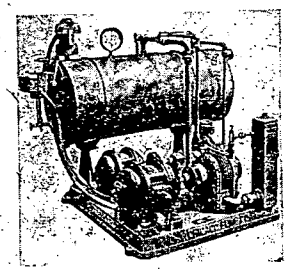
Unit No.	Maximum Sq. Ft. Direct Radiation	Lbs. Press. Pump will Disch. Against	Horsepower Motor Furnished	Capacity Pump in Gals. per Min.	Dia. Receiver, In.; also Floor Space
1650	3,000	10	1/2	5	24
1651	"	17	3/4	"	"
1652	"	22	1	"	"
1654	6,000	10	1/2	10	24
1655	"	17	3/4	"	"
1656	"	22	1	"	"
1658	10,000	10	1/2	15	24
1659	"	17	3/4	"	"
1660	"	22	1	"	"
1662	15,000	14	3/4	21	24
1663	"	18	1	"	"
1665	25,000	12	3/4	35	30
1666	"	16	1	"	"
1668	40,000	10	3/4	55	30
1669	"	14	1	"	"
1670	"	21	1 1/2	"	"



Vertical Condensation Pump

RETURN LINE VACUUM HEATING PUMP AND RECEIVER

The "Condo-Vac" return line vacuum pump and receiver for maintaining a vacuum on the return line of a heating system and collecting and returning the condensation to the boiler, is constructed with separate motors and individual automatic control. The entire outfit is mounted on one base. Units for capacities from 5000 to 6500 sq. ft. of direct radiation, low and high boiler pressures. Bulletin 137.



Return Line Vacuum Pump

ENGINEERING SERVICE

The cooperation and advice of skilled engineers will be gladly given to Engineers, Architects, and Contractors in the solution of their pump problems. Complete data are available in bulletins on all types of pumps.

The Nash Engineering Company

South Norwalk, Conn., U. S. A.

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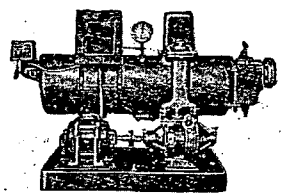


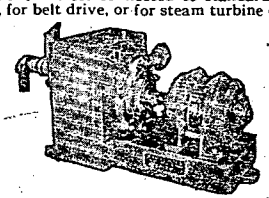
Motor-Driven Return Line Vacuum Pump

Jennings Vacuum Pump and Receiver for Return Line Heating Systems

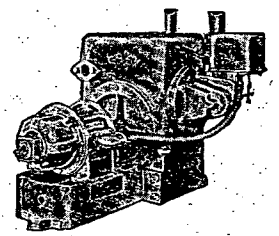
This pump removes air and water from the heating system, discharges the air to the atmosphere without back pressure, and automatically returns the water under pressure to the boiler or hot-well. Air and water are handled independently, often resulting in a 50% saving in horsepower required for pump operation. Occupies one-third the space of other apparatus of equivalent capacity.

Interior parts bronze. Moving parts revolve without metal-to-metal contact and are supported on radial ball bearings mounted outside casing.

Furnished direct connected to standard electric motors, for belt drive, or for steam turbine drive.



Motor-Driven Return-Line Vacuum Pump, Size M



Motor-Driven Condensation Pump

Jennings Condensation Pump and Receiver, Unit Type

No piping between the pump and receiving tank is necessary. The only connections are main return, water discharge, and air vent. Companion flanges are furnished.

The pump has an integral cast bronze impeller mounted on motor shaft supported by large motor bearings.

Literature, Recommendations and Proposals on Request

Bulletin 37—Return Line Vacuum Heating Pump.
Bulletin 25—Return Line Vacuum Heating Pump Size M.
Bulletin 63—Condensation Pump.
Bulletin 17—Air-Line Vacuum Heating Pump.
Bulletin 10—Air and Gas Compressors.
Bulletin 11—Air and Gas Vacuum Pumps.
Bulletin 52—Centrifugal Pump.
Bulletin 67—Sewage Ejector

STANDARD SIZES AND CAPACITIES, JENNINGS VACUUM PUMPS

Size	Square Feet equivalent direct radiation surface	Air Capacity cubic feet per min. at 10 in. vacuum	Water Capacity gals. per min. against 10 lbs. pres. 180 F.	R. P. M.	Horse Power of Motor for 10 lbs. Discharge
M	5,000	3	8	1800	3/4
A	8,000	5	11	1800	1
B	16,000	9	22	1800	1 1/2
C	26,000	15	35	1800	2
D	40,000	19	60	1200	3
E	65,000	34	90	1200	5
F	100,000	52	140	1200	7 1/2
G	150,000	90	200	1800	10
H	300,000	180	400	1800	15

TRANE PUMPING EQUIPMENT

(See Trane Heat Cabinets on page 485; Unit Heaters on page 503; and Trane Heating Specialties on pages 624 and 625.)

The Trane Company

La Crosse, Wis.

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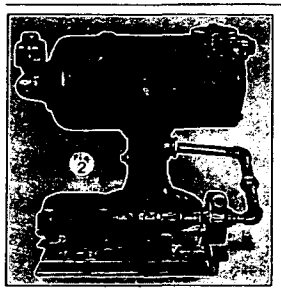
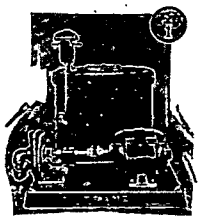




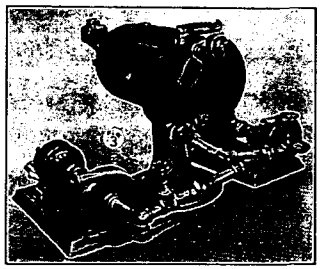


Fig. 1. (Center) Cast Iron Tank Style Condensation Pump *Fig. 2. (Left) Pedestal Tank Style Condensation Pump*
Fig. 3. (Right) Duplex Type Condensation Pump with Pedestal Tank

THE TRANE LINE

Trane Vacuum Pumps

Trane Vacuum Pumps are furnished in capacities ranging from 6000 to 100,000 sq. ft. There are at this time over three hundred and fifty (350) sizes, styles, and combinations of Trane Vacuum Pumps, divided into the following general classifications:

The Two-Motor Trane Return Line Special.

The Four-Motor Trane Duplex Special.

The Trane Air Line Vacuum Pump.

Trane Condensation Pumps

(Boiler Feed)

Trane Boiler Feed Pumps are furnished in capacities ranging from 4000 to 100,000 sq. ft. There are 101 standard sizes, divided into two classifications:

Single Units. Duplex Units.

Trane Multistage Pumps

Trane Multistage Pumps were particularly designed for use on high pressure boiler feed service and pneumatic water supply systems. They are built with from one to six stages, each directly connected to the other.

Trane General Service Pumps

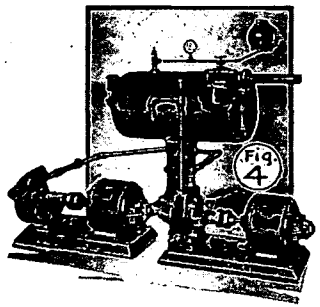
Trane General Service Pumps are the standard Trane centrifugals used with or without receiving tanks. Capacities range between 5 and 5000 g.p.m. against pressures ranging from 0 to 200 lb. There are many sizes, divided into two broad classifications:

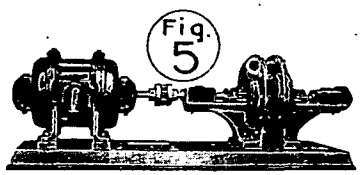
Circulating Pumps. Booster Pumps.

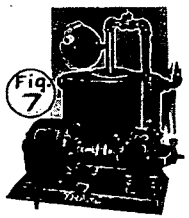
Special Air and Gas Pumping Apparatus

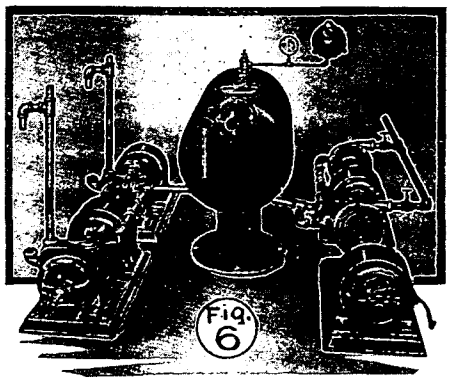
Trane Air and Gas pumps handle from 3 to 125 c.f.m. They are classed as

Compressors	Exhausters
Agitators	Gas Pumps
Core-Suckers	Priming Pumps









TRANE VACUUM PUMPS

Fig. 4. Two-Motor Return Line Style.
Fig. 6. Four Motor Duplex Return Line.
Fig. 6. Multistage Pumps.
Fig. 7. Air Line

BOOSTER AND CIRCULATING PUMPS

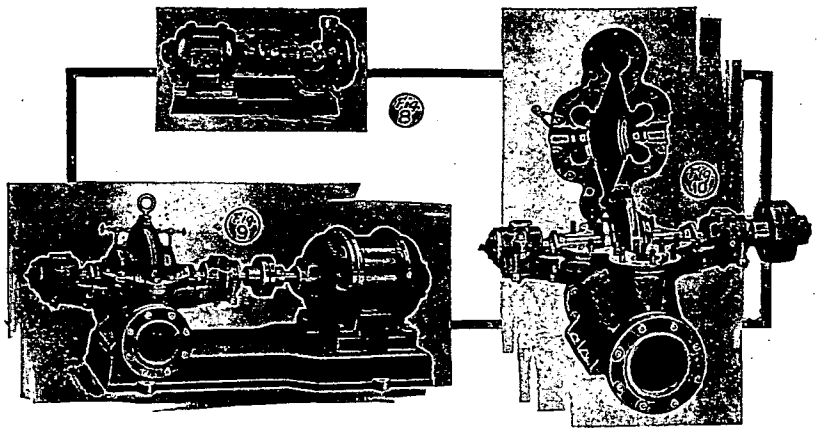


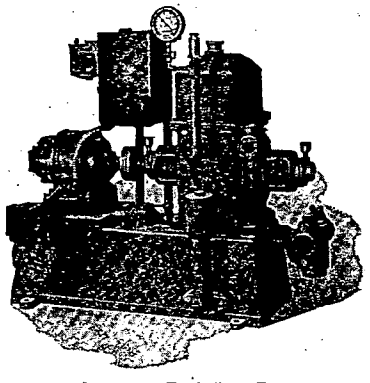
Fig. 8. Trane Vertical Split Shell Pump, Capacities available up to 1500 g. p. m.
Fig. 9. Trane Horizontal Split Shell Pump, Capacities available between 100 and 5000 g. p. m.
Fig. 10. Interior of Trane Horizontal Split Shell Pump.

GUARANTEE

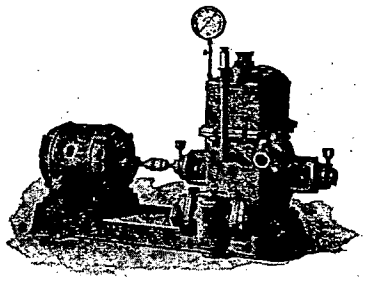
Every Trane Pump is guaranteed to deliver its rated capacity against the head or pressure for which it is sold. In addition it is guaranteed against all mechanical defects for a period of one year.

Skidmore Corporation

General Offices and Factory: 1535 Dayton Street, **Chicago, U.S.A.**



Interceptor Tank Base Type
Furnished when vacuum and float control is desired



Standard Type
Furnished for continuous service or when vacuum control only is desired

The pump in its construction, materials used and operation remains the same as shown for our standard type.

The object of the design is to have a unit compact in arrangement, combining the vacuum pump with an interceptor tank, thereby saving floor space, and securing a low water line in the system when operating on float control.

In the arrangement shown a hollow base has been used on which the pump, motor and electrical equipment are mounted. A float operated switch is installed in the base to control the pump from water level in same. All wiring between the starter, vacuum switch and float switch will be installed at the factory.

With this construction the unit arrives complete, ready to set in place, and by simply connecting the return and discharge pipes to flanged openings and wiring to starter the pump is ready to run.

The use of a cast iron tank as a base eliminates the necessity of a concrete base for mounting.

We feel sure that the low operating water line secured in this design will appeal to Architects and Engineers as it will in many installations eliminate the placing of the pump in a pit to secure drainage of low radiation and returns.

The operating point on these units will be from 10 in. on the smaller sizes to 12 in. on the larger, from floor level.

Where a self-contained unit reliable and quiet in operation is desired the Skidmore will be found.

Positive removal of air and water from the heating system and the return of water to the boiler.

A unit of pleasing design of large capacity and maintained efficiency, occupying less than half the floor space of pumps for similar service, self-contained all on one base with return connections close to floor with strainer arranged so that connections can be made to one or both sides as desired. Furnished with direct connected motors for 10 and 20 lb. pressure, or up to 60 lb. if desired. For continuous service or with automatic vacuum control.

A strictly high grade product, bronze rotors and bronze fitted throughout, shaft carried on oversize ball bearings, no close clearances or rubbing parts.

CAPACITIES FOR 10-in. VACUUM—10 and 20 lb. Pressure

Size of Pump	Capacity Sq. Ft. of Radiation	Gallons of Water per Minute	Motor Horsepower		Size of Companion Flanges for Returns	Size of Discharge to Boiler	R.p.m.
			10 lb.	20 lb.			
0	5000	8	¾	1	1½″	1″	1800
1	8000	11	1	1½	2″	1¼″	1800
2	16,000	22	1½	2	2″	1¼″	1800
3	26,000	35	2	3	3″	1½″	1800
4	40,000	60	3	5	3″	2″	1800
5	65,000	90	5	7½	4″	2″	1800
6	100,000	150	7½	10	5″	2½″	1800

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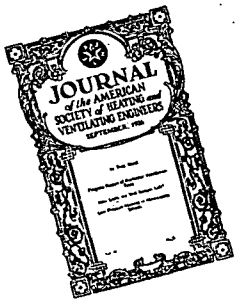

THE JOURNAL

of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is the official organ of the Society, whose purpose is to promote the art of heating and ventilating, to act as a medium for the exchange of engineering experience, to standardize the industry by means of codes of design and testing, and to conduct research investigations for ascertaining the uncertain factors in the art.

The JOURNAL appearing monthly, is read by 3,000 consulting engineers, architects and contractors actively engaged in heating and ventilating work. It gives them technical articles on important subjects, makes a permanent record of discoveries, experiments and other developments in the industry and thereby keeps them in constant touch with the best thought in the profession. The Society's meetings, news of the local Chapter events, and other happenings in the heating and ventilating field are also reported.

An exclusive service to JOURNAL readers is the presentation of the reports, made by the Society's Research Laboratory, reference data which is invaluable to the engineer, contractor and manufacturer in his daily work.

The JOURNAL offers manufacturers the opportunity of placing their equipment before a large group of discriminating buyers at a minimum cost. The fact that it is devoted exclusively to heating and ventilating engineering in all its branches makes it a most desirable advertising medium and especially so because of its class circulation. In addition to its proven merit as an advertising medium, its use by manufacturers indicates their desire to cooperate with the Society in advancing the interest of heating and ventilating.

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St. Paul, Minn.

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Manufacturers of E-Z Radiator Hangers Write 791 Hampden Avenue

E-Z RADIATOR HANGERS are designed to hang all Wall and Column Radiation of any make including all new types of radiators. They have both vertical and horizontal adjustments, and are designed to anticipate the use of temperature control valves.

Only one bolt per hanger. No accurate placing of anchor bolts required. Hanger absolutely invisible, including washer at top.

Style "R", shown below, places radiator 1½ in. from wall, but is not adjustable for baseboard. Convertible, with parts No. 5 and No. 8, into Style "H", which places radiator 2½ in. from wall and provides for baseboard adjustment.

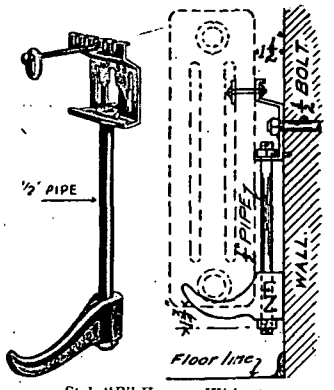
TYPICAL SPECIFICATIONS

Where Baseboards Are Used

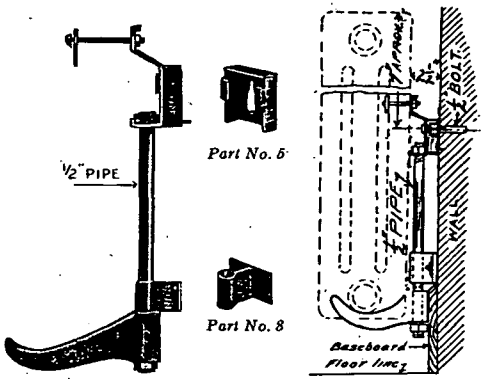
All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style "H" as manufactured by the Healy-Ruff Co., St. Paul, Minn., or equal and approved in writing by the Architect arranged to support the radiator 2½ in. from the wall and with baseboard adjustment.

Where Baseboard Adjustment is Not Desired

All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style "R," as manufactured by the Healy-Ruff Co., St. Paul, Minn., or equal and approved in writing by the Architect, arranged to support the radiator 1½ in. from the wall.



Style "R" Hanger, Without baseboard adjustment



Style "H" Hanger, with baseboard adjustment

Shaw-Perkins Manufacturing Company

Works: West Pittsburgh, Lawrence County, Pa.
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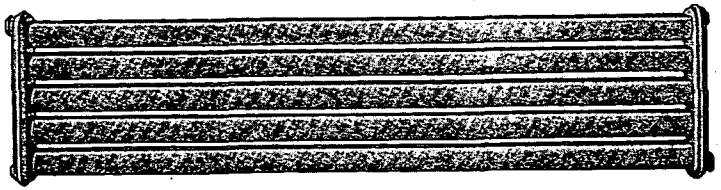
HIGH CONVECTION
Radiators

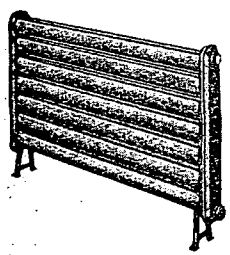
For Steam and Hot Water Heating, Cooling, Drying and Industrial Application



Shaw-Perkins Radiation is an original and distinctive type of heat exchanging surface, containing desirable features not found in other forms of radiation. It is neither experimental nor new, as SHAW-PERKINS radiation has been manufactured for the past twelve years. During this period large quantities have been furnished throughout the United States and foreign countries, all of which is giving entire satisfaction.

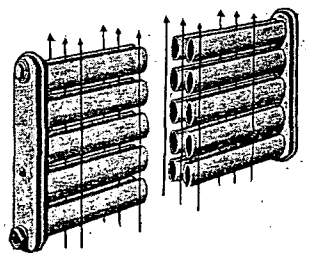
Shaw-Perkins Radiation is made from heavy gauge iron of great durability. The use of this highly refined iron; the design, which provides for tube drainage; the welded construction which eliminates mechanical joints and produces a solid, one-piece radiator; are important factors which contribute to the many years of perfect service built into every SHAW-PERKINS radiator.

All of the surface of a SHAW-PERKINS radiator is prime heating surface and the oval tube is employed which presents a most effective form of heat exchanging surface for radiator purposes. The ingenious arrangement of oval tubes in the SHAW-PERKINS radiator allows the air to pass freely over the tubes, unimpeded by fins, baffles or top and bottom hub connections, consequently the SHAW-PERKINS radiator has a high heat emission by convection.



Above view shows a 14 tube Shaw-Perkins radiator on legs.

Shaw-Perkins Radiation is made in radiators from 4 to 14 ft. in length and in several heights and tube arrangements. They are light in weight, heat and cool quickly, occupy less space than conventional types of radiation, and are absolutely sanitary. They are especially suitable for installation upon walls, under windows, in recesses, upon ceilings, columns or pilasters, in greenhouse heating systems, etc.



Above view illustrates the high convection feature. Arrows indicate air travel. Note absence of any impediments to free air circulation.

Radiators can be furnished with legs or brackets for floor, wall or ceiling installation.
All radiators are furnished in gray, dull gloss finish, subject to change without notice.
Shaw-Perkins radiation is particularly adapted to various drying and cooling purposes. Inquiries are invited upon its application to various industrial requirements.

Catalog and complete information gladly sent upon request

Tuttle & Bailey Mfg. Co.

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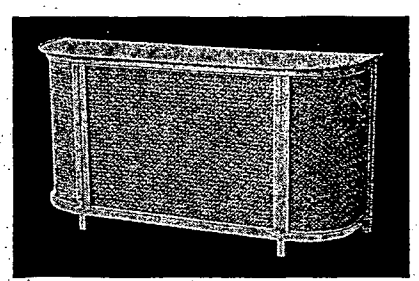
The logical and rapidly growing demand for radiator concealment should have the sympathetic attention of Engineers and Architects.

T & B Radiator Cabinets are designed to overcome the frequently expressed objections to covering radiators. Circulation can be readily controlled with the adjustable tops, and the full heating efficiency of the radiator assured by opening them during extreme weather.

These Radiator Cabinets are made entirely of fine furniture metal and expertly finished to simulate the different woods, or furnished in priming coat. Backs and tops are solid to prevent the usual radiator soiling of walls and curtains. Tops open up on hinges, giving easy access to radiator, valve and humidifying pan.

The strong and rigid construction permits all styles to be used for seats and consoles.



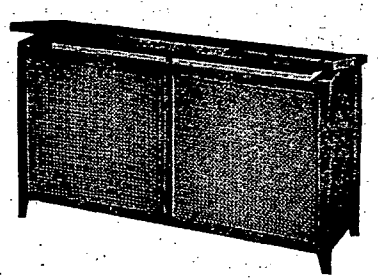
The Raleigh

Villa and Gramercy styles have square ends, the Raleigh has curved ends.

Frames of these three styles are of re-inforced steel tubing, with mitre joints. Tubing and moulding around panels are slotted to hold securely the grilles, ends and back—and all welded together.

Antoinette style is made of heavy sheet steel, the ends being formed to give pilaster and panel effect. Sufficiently strong and rigid to make practical seat. Construction allows of lower prices than for styles above.

Cut shows hinged top held part-way open by "catch" and humidifying pan—important features of all our styles.



The Antoinette

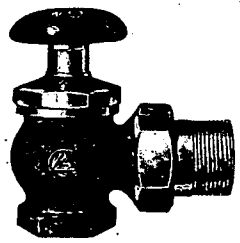
AMERICAN RADIATOR COMPANY

General Sales and Eastern Executive Office
40 West 40th Street, New York

Western Executive Office and Accessories Division
816 South Michigan Avenue, CHICAGO, ILLINOIS

Manufacturers of Ideal Boilers, American Radiators, and other Heating, Ventilating, and Refrigerating Products

PACKLESS VALVES

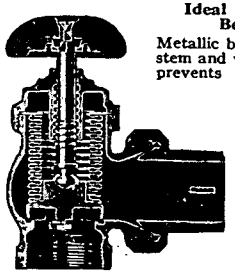


No. 988

Arco Packless Valves Quick Opening

Leakless feature consists of special moulded ring with metallic core held under compression by a spring. Requires no repacking. Opens or closes with one turn. Does not stick or bind. Furnished with either round or lever composition handle.

No. 988 Angle. No. 955 R.H. Corner. No. 960 L. H. Corner. No. 970 Globe. No. 968 Fractional Type with indicator and graduated dial.



No. 850

Ideal Packless Valves Bellows Type

Metallic bellows surrounds the stem and working parts, which prevents passage of steam, water or air around the stem opening. Equipped with round composition handle.

No. 850 Angle. No. 851 R. H. Corner. No. 852 L. H. Corner. No. 860 Globe.

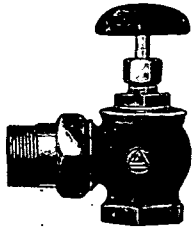
Also furnished in Quick Opening type —one turn. Nos. 878, 879, 880, 870.

PACKED VALVES

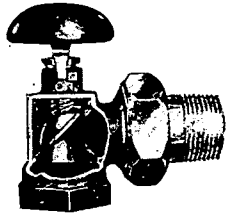
Detroit Steam Valves

Metal well distributed —strong and heavy where strength is needed. Regularly equipped with composition handle, black hard rubber finish.

No. 72 Angle. No. 32
R. H. Corner, No. 37
L. H. Corner. No. 57
Globe. No. 373 Gate.



No. 72



No. 101

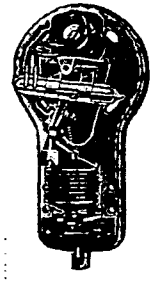
Detroit Hot Water Valve

The No. 101 Hot Water Valve will not stick or turn hard. The narrow edge of the plate presents a small area of contact so that corrosion is easily broken away. Concave plate gives true elbow shape when valve is open, reducing friction of water flow. Made in Angle pattern only.

Union Elbow, No. 132.

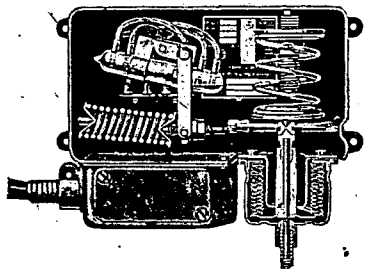
MERCOID CONTROLS

PATENTS PENDING

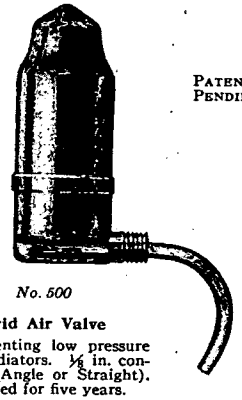


No. 845 Thermostat

All Mercoid Controls employ the Mercoid Switch which carries the full line current at 110 or 220 volts without arcing or corrosion of contacts. Mercoid instruments give automatic control of temperature, pressure or vacuum. The various models provide a wide field of application. The No. 845 Mercoid Thermostat is especially adapted for use with Unit Heaters—starting or stopping the fan as the air temperature changes. The No. 847 Arco Motor Valve, for high or low pressure steam, water, air, etc., can be used with any Mercoid Control. Write for full details of this complete line.



No. 848 Type
For temperature, pressure, or vacuum



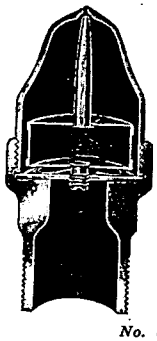
PATENTS PENDING

No. 500

Airid Air Valve

For venting low pressure steam radiators. ⅛ in. connection (Angle or Straight). Guaranteed for five years.

FOR VACUUM JOBS.—No. 510 Vac-Airid is self-sealing against the return of air.



PATENT PENDING

No. 815

Ideal Quick Vent

All metal. Very sensitive. For venting mains, long runs of pipe, indirect stacks, drop risers, etc.

No. 815—¾ in.; No. 820—⅜ in.

PATENT PENDING

No. 821

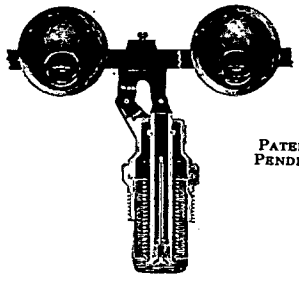
Ideal Float Quick Vent

For free venting mains, indirect stacks, Vento, etc. Closes against water.

No. 821—¾ in.

FOR VACUUM HEATING.—No. 822 Vac-Vent is self-sealing against the return of air.

No. 822—¾ in.



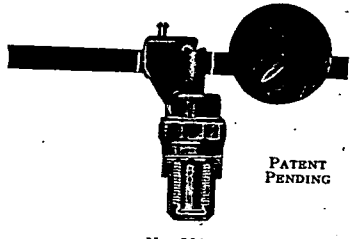
PATENTS PENDING

No. 800

Arco Water Regulator

For damper control on hot water heating boilers. Adjustable for temperature between 100° and 220°. All metal.

Length of Bulb, 2⅞ in. Connections, 2 in.

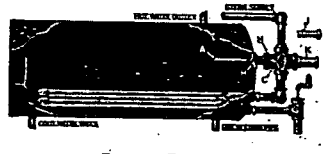


PATENT PENDING

No. 801

Arco Junior Water Regulator

For damper control on Hot Water Supply Boilers. Temperature range 130°-180°. Length of Bulb, 2 in. Connection, 1½ in.



PATENT PENDING

No. 825

Arco Tank Regulator

For temperature control of liquids heated by steam. (Also made in flexible tube type No. 826). Range 140° to 180° F. For use on steam pressures up to 15 lbs.

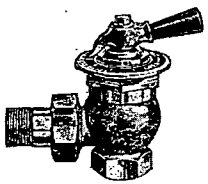
Send for complete catalog of Ideal Heating Specialties

Barnes & Jones

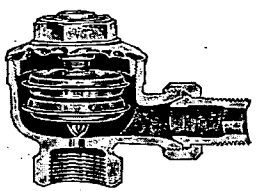
128 Brookside Avenue, **Jamaica Plain, Boston, Mass.**

New York Office: 126 East 44th Street

Modulating Vapor and Vacuum Steam Heating Apparatus—Modulation and Thermostatic Return Valves—Condensators, Blast Traps, and Vent Traps



Barnes & Jones modulation systems, either pressure or vacuum, are applicable to every heating problem from the smallest house to the largest office building. They have many special advantages in construction and design which have been developed as a result of our 25 years of experience with steam heating problems.



Barnes & Jones Modulation Valve

Barnes & Jones modulation valve completely controls the heat of each radiator, allowing it to be heated wholly or partially, independently of every other radiator.

It can be opened in less than a full revolution of the handle, and can be forcibly closed to the seat so as to be tight under any operating condition. It does not require repacking. Has renewable disc seat.

Sizes and Models—Made in the angle type, in sizes from ½ to 1½ in. Standard model has lever handle. Other models include:

Wheel Handle—With indicating dial.

Extension Stem—With indicating dial, for use with enclosed or concealed radiators.

Chain Operated Type—Modulation valves on radiators and coils located overhead on walls, ceilings, and in skylights can be equipped with chain extensions to permit operation from floor.

Lock Shield Model—For corridors, toilets, etc.

Barnes & Jones Thermostatic Radiator Trap

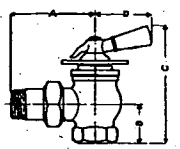
The successful operation of open return line vapor systems and vacuum systems depends on the efficiency of the radiator traps. These must be sensitive, so as to close in the presence of steam and open as soon as air or water of condensation begins to accumulate. Their action must be independent of pressure conditions.

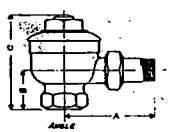
Barnes & Jones radiator trap is of the Thermostatic diaphragm type, its moving power being obtained by the expansion and contraction of a volatile liquid enclosed in a hermetically sealed diaphragm. Its double diaphragm of tempered phosphor bronze allows wide range of travel with minimum strain. Each trap is factory adjusted and tested to rigid standards.

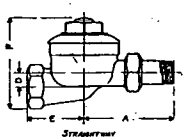
Types and Sizes—This valve is made in ½", ¾", 1" and 1¼" sizes. The ½" and ¾" sizes are made in four types—angle, straightway, right hand corner and left hand corner patterns. The 1" and 1¼" are made in the angle pattern only. The ½" size, unless otherwise specified, is made with ¾" outlets, thus avoiding the use of all ½" pipe and reducing fittings.

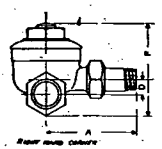
Construction Details

Both valves made of best grade cast composition throughout. Cover and trimmings are highly polished. Tail piece and union nut extra heavy to prevent breakage; tail piece made long for easy connection. Lugs located under threads.









Modulation Valve

DIMENSIONS					Capacity in square feet of cast iron radiation
Size Valve	A	B	C	D	
¾"	2¾	1¼	3½	1⅞	60
1"	3	1⅜	3⅝	1⅞	100
1¼"	3½	1½	3⅞	1⅞	180
1½"	3¾	1½	4⅛	1⅞	250

Thermostatic Radiator Trap

CAPACITIES			
Size Valve	Lbs. water per hour	Sq. feet C.I. Rad.	Sq. feet Coils
½"	30	125	100
¾"	80	320	240
1"	200	800	600
1¼"	400	1600	1200

DIMENSIONS						
Size Valve	A	B	C	D	E	F
½"	3⅛	1⅜	3⅜	½	2	3⅛
¾"	3⅜	1⅜	3½	⅝	2⅛	3½
1"	3⅝	1½	3⅜	¾	2⅜	3⅝
1¼"	4⅛	1⅝	4⅛			

The Bishop & Babcock Sales Co.

General Offices

4901-4915 Hamilton Avenue, N.E., **Cleveland, Ohio**

ATLANTA, GA., The Bishop & Babcock Sales Co., 230 Mitchell, S.W.
AMSTERDAM, N. Y.....F. E. Dwyer, 447 Guy Park Ave.
BALTIMORE, MD.....Building Service Co., 404 St. Paul St.
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CHICAGO, ILL., The Bishop & Babcock Sales Co., 112 W. Austin Ave.
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DETROIT, MICH., Wolley Eng. Sales Co., 506 Donovan Bldg.
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NEW YORK, N. Y., The Bishop & Babcock Sales Co., 444 Lafayette St.
OKLAHOMA CITY, OKLA., Federal Steam Specialty Co., 120-2 E. Main St
PHILADELPHIA, PA., Alexander & McDevitt, 1725 Sansom St.
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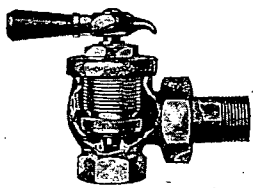
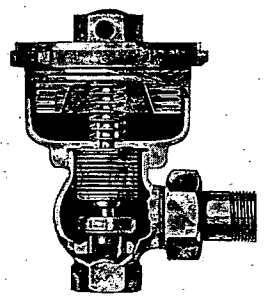
SAN FRANCISCO, CALIF., Walter S. Leland. 532 Natoma St.
SPOKANE, WASH., R. L. Nelson, 507 Empire State Bldg

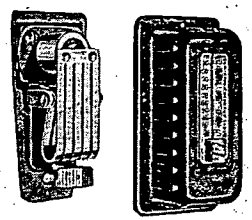
Heating Specialties—Temperature Control—Ventilating Equipment—Unit Heaters



Special Modulation Valve



Multiflex Pneumatic Radiator Valve

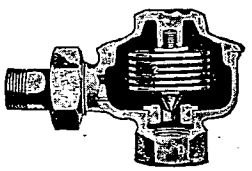


All Metal Thermostat

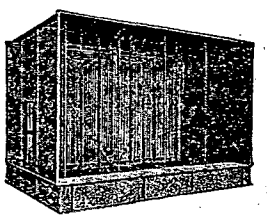
Bishop & Babcock manufactures a complete line of Heating and Ventilating Equipment. Its products comprise all devices and apparatus used in up-to-date vacuum and vapor Heating Systems, Temperature Control and Ventilating Systems. It is entirely practical for an engineer and architect to standardize with **Bishop & Babcock** apparatus, thus insuring a uniformity in design and operation not to be found in equipment of varied manufacture.

Bishop & Babcock has been manufacturing heating, ventilating and temperature control apparatus for many years, its installations including many of the most prominent buildings in all parts of the country.

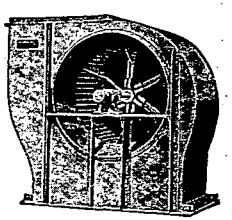
Our Engineering Data Book, pocket edition, will be mailed upon request.



B. & B. Multiflex Trap No. 6



Type B Massachusetts Air Washer



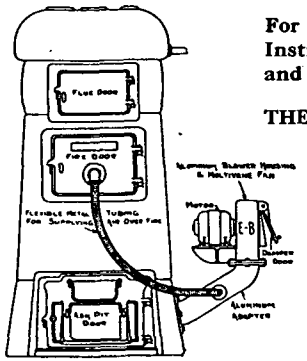
Single Width Squirrel Cage Fan

Combustion Specialties Corporation

250 West 54th St., New York

Manufacturers of

DRAFT BALANCERS for Burning Buckwheat **and** **COMBUSTO** Coal Gas Burner



The Draft Balancer

For all types of heating plants in Homes, Stores, Institutions, Garages, Churches, Schools, Buildings and Apartments.

THE DRAFT BALANCER—

The Draft Balancer is a device that utilizes and increases present draft facilities with a resultant increase in efficiency and economy.

It enables you to *burn lower priced fuels with no more attention* than with Egg, Stove or Nut anthracite and thereby effect a 50 per cent *saving* (at least); if you're now burning buckwheat coal, it will *save between* 10 *and* 20 per cent on your fuel cost. It produces a quicker and hotter heat and a more even temperature—a finer, lighter ash to eliminate the back-breaking "ash days"—and the reduction of clinkers to a minimum.

This unit is unique in that it creates a balanced air supply over the fire as well as under it. It is because of this feature, together with the carefully studied-out engineering principles which assure positive, accurate, quiet operation, that the saving in money, time and labor is so great . . . and so certain.

TECHNICAL ADVANTAGES: All aluminum—consequently absorbs vibration and sound; G. E. Motors—unquestionably superior; Fans are multivane American Sirocco type; blowers mounted on the ash pit in such a way that they can't be blocked with ashes; motor is high—away from dust, dirt and dampness, and more convenient for oiling, cleaning, etc; unit is available with or without automatic control; the flexible steel tubing from the blower to the device in the fire door doesn't interfere with the operation of the door. It is this tubing which introduces the proper amount of air over the fire for consuming the monoxide gases distilled out of the coal.

PROMINENT USERS

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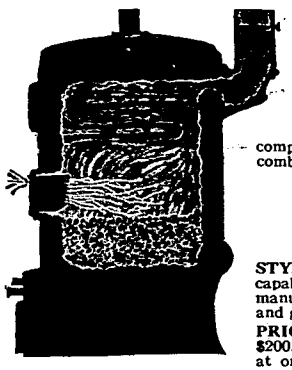
Weinstein & Feinstein, Jersey City (Apts.)
S. Bernstein, Newark (Apts.)
Stonehorn Realty Co., New York (Apts.)
Van Kannel Revolving Door Co., New York



COMBUSTO
Saves coal and labor—maintains even heat with less draft

WHAT COMBUSTO IS: To quote Walter S. Timmis, past president of the *American Society of Heating & Ventilating Engineers.* "COMBUSTO is a system carefully studied, tested and developed for each individual different case and provides means for supplying the necessary diffused and heated air (oxygen) over the fire to properly complete in the second stage the combustion begun in the fuel bed by distillation of gases."

WHAT COMBUSTO DOES: "COMBUSTO is of cast iron cellular structure, the air is heated on passing through this structure and is then discharged through a large number of small apertures over the fire bed. The amount of air thus admitted having been carefully computed for the required conditions, the result is practically perfect combustion, which to the user of COMBUSTO results in—

Economy of fuel
Fewer firings
Complete combustion of fuel, hence—
A finer ash and reduction of clinker
Elimination of coal gases
Means for producing a steady even heat."

STYLES: COMBUSTO is manufactured in 28 basic styles—each style is capable of adjustment to meet specified conditions. Suitable styles are manufactured for practically any type of heating plant and for all sizes and grades of fuel.

PRICES: Prices range from $25.00 on small house-heating plants to $200.00 on largest low pressure heating boilers. Definite estimates can at once be submitted if manufacturer's name and number of boiler is sent to us.

NOTABLE INSTALLATIONS

Daniel Guggenheim Estate
Clarence H. Mackay Estate
Otto Kahn Estate
U. S. Department of Labor
D. L. & W. R. R., 40 installations
Bank of Manhattan Co., 26 inst.

G. M. Davis Regulator Company

407 MILWAUKEE AVENUE :-: CHICAGO, ILL.
New York Office, 71 Fulton Street
Manufacturers of Automatic Valve Specialties

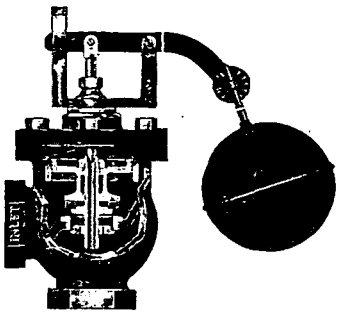


Fig. 318—Float Valve, Globe and Angle

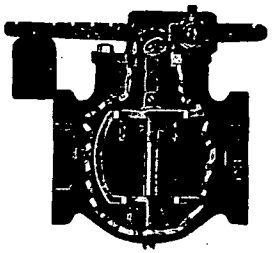


Fig. 321—Back Pressure Valve Horizontal and Vertical

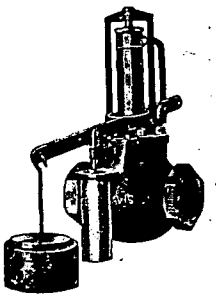


Fig. 305—Pressure Regulator Piston Type

EVERY problem in automatic pressure regulation finds a solution in Davis Valve Specialties.

Engineers and contractors specify and use them because of their well earned reputation for unusually good and long reliable service.

On the next job that you expect to get particularly good results from the pressure regulating devices, let the Davis have a chance to prove their worth.

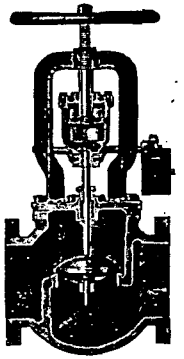


Fig. 338—Stop and Check Valve Globe and Angle

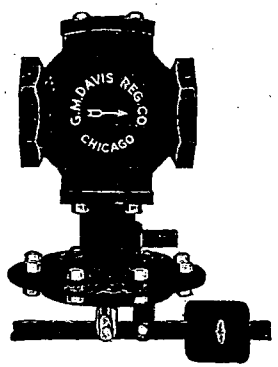


Fig. 311—Pressure Regulator Diaphragm Type

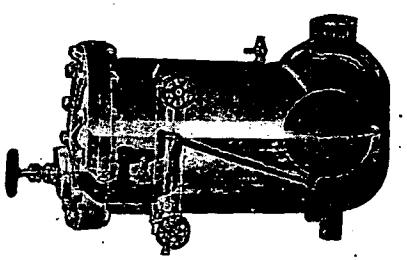


Fig. 328—Steam Trap, Continuous Flow

C. A. Dunham Co.

Administrative and General Offices: 450 East Ohio Street, Chicago
Factories at Marshalltown, Iowa, and Toronto, Ont., Canada

BRANCH SALES OFFICES:

Birmingham, Boston, Charlotte (N.C.), Chicago, Cincinnati, Cleveland, Columbus (Ohio), Dallas, Davenport, Denver, Des Moines, Detroit, El Paso, Indianapolis, Kansas City, Los Angeles, Louisville, Milwaukee, Minneapolis, New Orleans New York, Omaha, Philadelphia, Pittsburgh, Portland (Ore.), Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Troy, Washington (D.C.)

C. A. DUNHAM CO., LTD., General Offices and Factory, Toronto, Ont.
1523-41 Davenport Road

BRANCH SALES OFFICES: Calgary, Montreal, Ottawa, Toronto, Winnipeg, Vancouver, Halifax.

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Distributors: Munsing & Co., Paris, France, 47 Rue Fontaine-au-roi

Manufacturers of The Dunham Differential Vacuum Heating System and Specialties

The DUNHAM HEATING SERVICE

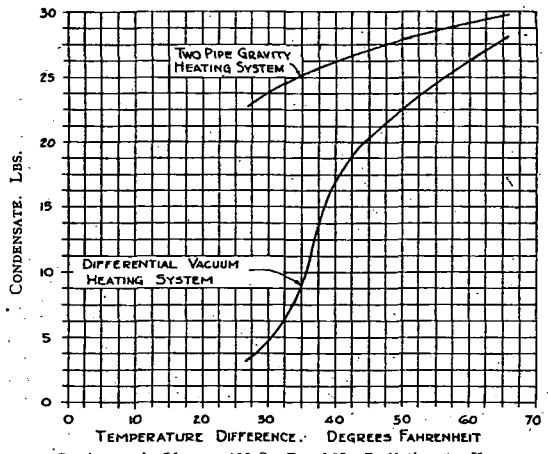
This Service is delivered through over 70 Branch and Local Sales Offices throughout the United States, Canada and the United Kingdom. These Branch and Local sales offices bring Dunham Heating Service as close to your office as your telephone. Consult your telephone directory for the address of our office in your city. An engineer will counsel with you on any project.

DUNHAM DIFFERENTIAL VACUUM HEATING SYSTEM

U. S. PATENT No. 1644114

(Additional patents in the United States, Canada and Foreign Countries applied for, and pending)

This system will heat properly any building without the usual fuel and heat waste caused by overheating and by *excessive* window ventilation. It furnishes steam to the radiators at the rate they are using it, by circulating it at a high degree of vacuum or sub-atmospheric pressure, with correspondingly low radiator temperature; or by operation of a control valve it can be operated as a mechanical vacuum return line system at the pressure above atmosphere, which the weather condition calls for.



Condensate in Lbs. per 100 Sq. Ft. of Net Radiation per Hour

A fixed differential with the return pressure always lower than the radiator pressure is maintained. This produces circulation with sub-atmospheric pressures (vacuums) on the steam side of the system. Economical operation is the natural result of such performance. The system is simple in design, durable and flexible to meet varying weather conditions. The outstanding feature of economy of operation is accomplished by supplying heat to the radiators at the rate the building is using it, by;

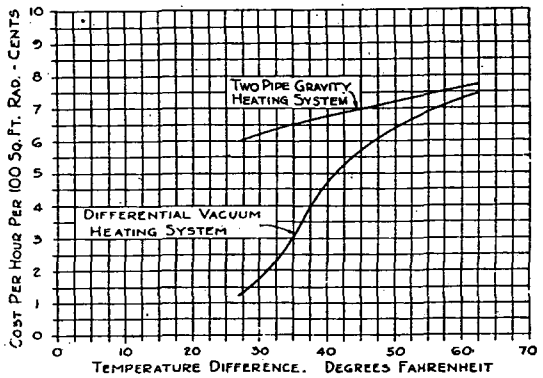
Regulating the sub-atmospheric pressure, or

the degree of vacuum, at which the steam circulates in the supply piping and radiators.

Controlling the vacuum in the return piping so that a substantially constant difference in pressure is maintained between the radiators and return piping at all pressures.

Briefly the operation of the system is as follows:

The generation of steam, when starting with a cold boiler under vacuum, begins at a much lower temperature due to sub-atmospheric pressure because of the vacuum produced by the pump. This results in an appreciable saving of fuel.



Cost of Heating 100 Sq. Ft. Net Radiation per Hour based on Gas at $1.00 per 1000 Cu. Ft.

The steam expands under this vacuum condition and fills the radiators (just as it does when generating on pressures above atmosphere) with the result that substantially the entire radiator surface works at temperature corresponding to the vacuum maintained in the system. The Differential Controller on the pump maintains the condition in the return at a pressure less, or a vacuum greater, than in the radiator. Circulation is thereby maintained irrespective of supply pressure or vacuum. The system fills with steam at the various sub-atmospheric pressures. The Dunham Radiator Traps on the radiators function under these wide ranges of pressure. All air and water is released from the radiator, but steam is not released. See Chart 1060A on page 581 for explanation.

In severe weather the pressure can be regulated to supply steam at such a rate that in the boiler, supply piping and radiators, pressures at or greater than atmosphere will be maintained while operating as a mechanical vacuum return line system.

During the Fall, mild Winter and Spring weather, the steam is circulated under the sub-atmospheric pressures and vacuum condition necessary to provide

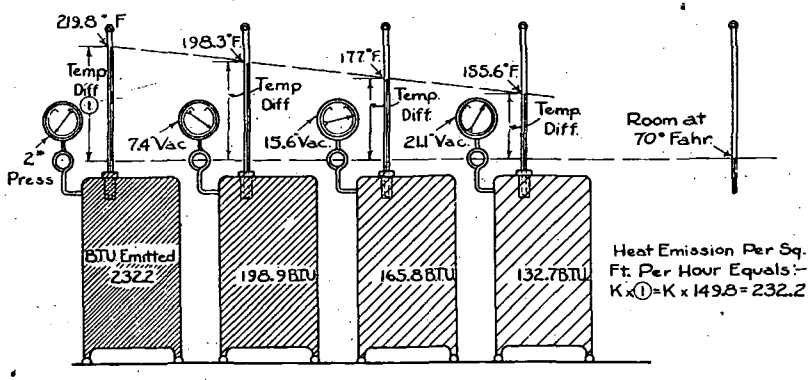


Fig. 1083
The Heat Emitted by a Radiator Depends on the Temperature Difference Between Radiator and the Air of the Room
Radiator Temperature Depends on Pressure of Steam in Radiator

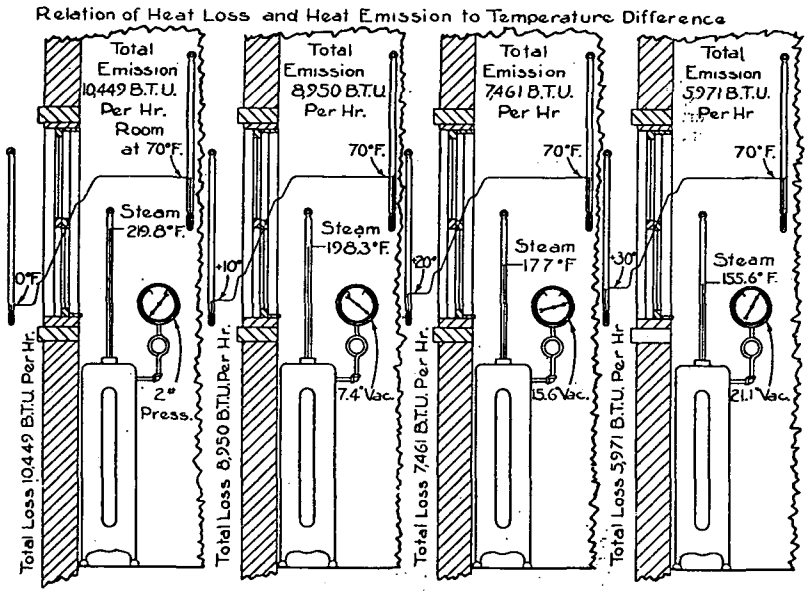


Fig. 1076

Showing how heat output of radiator must be decreased as the outside temperature increases, if the room temperature is to remain constant

the heat at the desired rate *without overheating*.

It is common knowledge that there is a definite steam temperature corresponding to every steam pressure. In the Dunham Differential Vacuum Heating System this principle is utilized. Steam is used at the sub-atmospheric pressures for mild weather thereby securing large fuel economies, comfort and convenience.

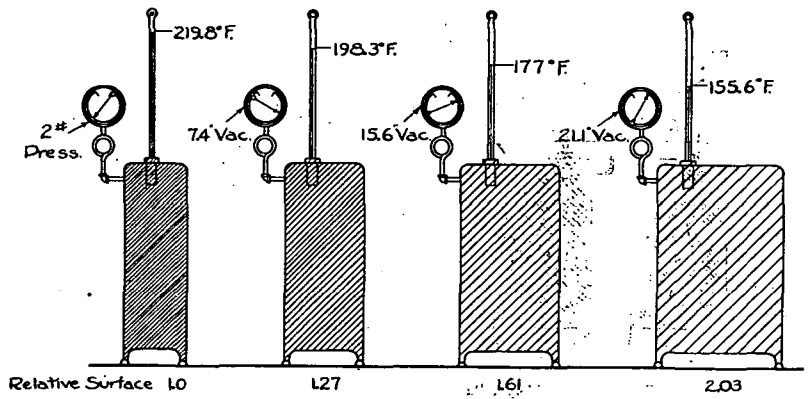


Fig. 1084

Relative Heating Surface filled by the Required Weight of Steam at Various Pressures

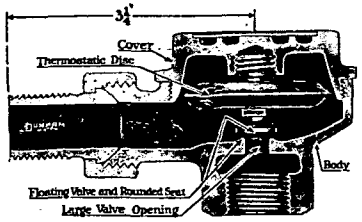


Fig. 819

Sectional View of Dunham Thermostatic Radiator Trap

The users of Dunham Traps have long been aware of its ability to operate uniformly over a wide range of pressures and vacuums. The accompanying graph, visualizes the performance of a Dunham No. 1 Radiator Trap operating from a vacuum of 25 in. by gauge to 25 lb. pressure gauge.

The outlet temperature in this test bore the same relation to the inlet temperature of the radiator over the entire pressure range of 25 in. vacuum to 25 lb. gauge, a pressure substantially 37½ lb. higher than the 25 in. vacuum. The temperature difference between inlet and outlet was between 4 and 5 deg. Graph shows the constant uniformity of temperature between radiator and return lines throughout the entire range of pressures.

The radiator efficiency was consistently high (almost 100 per cent) and there was no steam leakage or water accumulation.

The condensation rate in the 5.0 lb. gauge test increased due to air movement in the room and a low room temperature, the trap responded immediately by passing the increased condensate under this condition without leakage of steam.

The test was conducted on a 3 col. 38 in.—100 sq. ft. radiator.

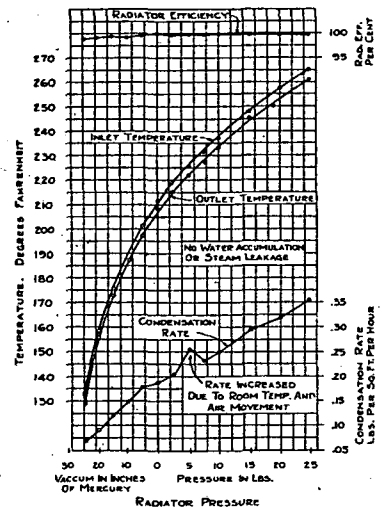


Fig. 1060A

The Dunham traps conform with the standard dimension of 3¼ in. from center of trap to end of union nipple, as adopted by *The Heating and Piping Contractors' National Association* for ½ in. radiator traps.

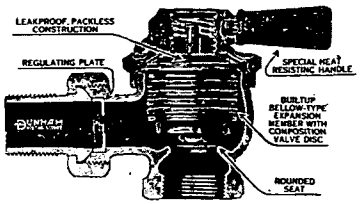
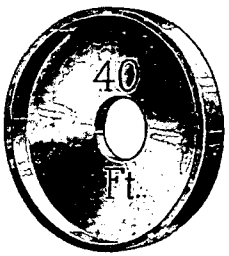


Fig. 837B

Sectional View, Type 105, Dunham Packless Radiator Valve

The valve is made packless by means of the bellows construction, consisting of a series of corrugated phosphor bronze diaphragms which permit the free up and down movement of the spindle and valve disc. This construction obviates the use of springs, packing or stuffing boxes of any kind and entirely prevents the leakage of steam, air or water. The prevention of the leakage of air into the radiators of vacuum systems is a most important factor, for such leakage will destroy the vacuum when operating the steam side of the system below atmospheric pressure. The holding of such vacuum is an important factor in economical operation and is especially to be desired in mild weather. It further has the advantage that no steam, water or dirt can come in contact with the thread of the valve spindle. The importance of this will be appreciated. It assures easy turning of handle at all times. This construction prevents leakage of steam and water into the room, marring the walls, furnishings or floors.



Type 190

By means of the Regulating Plate (Type 190) the correct proportion of vapor *necessary to properly* heat each radiator is provided.

The plate is inserted in a recess in the neck of the valve, the plate orifice being calibrated to the number of feet of radiation in each radiator.

The use of the Regulating Plate simplifies many things which have been serious barriers to progress in the art of heating, *for without this plate* the resistance which vapor encounters in flowing from the boiler to the radiator cannot be the same for each raditor.

The resistance opposing the flow of condensate and air from the radiator to the boiler is not uniform for each radiator, because the size and length of the pipe through which the vapor flows to each radiator cannot be exactly proportioned to the supply required by the radiator according to its size.

Under conditions either of pressure or of vacuum a 26 sq. ft. radiator should heat no more rapidly than a 100 sq. ft. radiator irrespective of the relative location of the two with reference to the boiler, but in usual actual practice and with no provision for interposing resistance to the steam vapor flow, there will be irregularity in heating of each respective radiator.

During the milder days of the heating season, there are times when a radiator should give off only a fraction of the heat required under cold weather conditions. To secure this result high vacuum low temperature steam is utilized.

Dunham Packless Valves are made in both lever and wheel handle type in the following sizes: Lever ½, ¾, 1, 1¼, 1½ in. Wheel ½, ¾, 1, 1¼, 1½, 2 in.

Lever handle made only in angle pattern.

Wheel handle made in angle, straightway and corner patterns and can be supplied with wheel or lever handle.

The valves can be supplied with lock and shield, and special extension stems for use on radiators behind grilles, seats, etc., or on ceiling of the room

TYPICAL HEATING SPECIFICATIONS
"D" Series System for Office Buildings, Hotels, Apartments, Etc.

1. General Conditions. The general conditions governing this work shall be those established as standard by the American Institute of Architects.

2. Construction and Material. The heating apparatus proposed includes the furnishing, delivery, and erection on the premises of all necessary material and labor, which shall be first-class in all particulars, and in accordance with specifications and plans.

3. Boiler. The steam boiler shall be a..... with guaranteed rating for .....sq. ft. of radiation installed upon suitable foundation, and equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30 in. vacuum and a 7 in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations.)

4. Smoke Pipe. Connect boiler to chimney with suitable iron smoke pipe same size as boiler smoke outlet. Provide Check Damper and hand stop damper between check damper and boiler.

5. Reducing Pressure Valve. On all systems not equipped with full automatic control, install two Sub-Atmospheric Dunham Reducing Pressure Valves, Type 302 (of proper size), with necessary gate valves and a Dunham 15 lb. x 30 in. compound gauge, all in accordance with manufacturer's details and instructions.

(Engineers and Architects will be furnished on application with suitable specification designed to meet conditions where Centralized Thermostatic Control is to be used or when it is desired to divide up the mains so as to carry more heat on one side of the building than on the other.)

6. Pipe and Fitting. Furnish and erect with tight connections all necessary piping of sizes shown on plans and run as indicated, supported and properly graded to insure free and noiseless circulation, using fittings of cast iron of standard quality. The ends of all pipes shall be reamed or filed. Proper provision must be made for expansion.

7. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. Install horizontal swing check valve with brass disc in bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg. On down-feed systems take the spring pieces from the bottom of steam main at 90 deg.

8. The end of each steam main shall be dripped as indicated on the plans through a Dunham Trap into the return main; a full sized scale pocket must be provided and the Trap shall be installed at least 4 ft. from the scale pocket, and located above the return piping, into which they discharge by gravity. All drip points must discharge into return piping without the use of lift connections. A gate valve shall be installed on the inlet side of each Dunham Trap used for dripping purposes. All in accord with details furnished by manufacturer.

9. Grade steam mains ½ in. in 10 ft. Grade return mains 1 in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runouts to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible. ½ in. per foot is preferable.

10. Return mains shall be connected to the Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer.

11. Risers are to be run concealed or in the open as directed by the architect. Each down feed steam riser must be dripped into the return through a Dunham Trap. Install traps as instructed by manufacturer. All concealed piping must be tested at 15 lb. water pressure before being concealed.

12. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work should be performed after system is completed and while it is working with a vacuum in both steam and return lines.

13. The System when finished shall be tested for tightness. When system is filled with steam, drop the fire when 20 in. of vacuum is secured and stop pump. After an hour there shall be at least 10 in. of vacuum remaining on the gauge.

14. Floor Plates, Sleeves. Furnish proper floor and ceiling plates, and protecting sleeves on all pipes passing through floors or finished partitions.

15. Differential Vacuum Pump. Furnish and install one (or duplex) Dunham Differential Vacuum Pump of "D" Series, size ....., having a rated capacity of .....sq. ft. of direct radiation. The pump (or pumps) shall be installed and connected in accordance with manufacturer's instructions and details.

16. Check Valves. Check valves shall be of the horizontal swing type with brass disc and of the best grade and make obtainable. They shall be installed as called for by the plans, and in accordance with details supplied with pump.

17. Radiation. Furnish and install radiation as shown on the plans. It shall consist of ..... sq. ft. of direct radiation of approved make. All radiators must be of hot water pattern provided with ¾ in. top inlet tapping and with ½ in. eccentric bushing in the return tapping. All air valve tappings shall be plugged.

18. Radiator Traps and Valves. Each radiator shall be provided with a Dunham Thermostatic Radiator Trap of suitable capacity installed at the return outlet and with a Dunham Packless Radiator Valve with Regulating Plate installed at inlet connection. The plates shall not be inserted in the valves until after the system has been cleaned, but before final test is made.

19. Painting. All exposed piping in finished rooms, and all radiators shall be painted a priming coat of flat paint and thereafter painted or enameled as directed by architect. All uncovered piping in basement, boiler front and other exposed parts shall be painted one coat of black asphaltum. The finishing coat of paint must be applied when the entire system is under vacuum, so that paint will fill up air leaks.

20. Covering. Cover all steam piping in basement (and in roof space on down feed systems) with four-ply, 1 in. thick asbestos sectional covering, fittings with asbestos cement. Cover all steam and return risers and also other piping run concealed in outside walls with two-ply, ½ in. thick asbestos sectional covering. Cover boiler as specified by boiler manufacturer.

21. Finishing Up. Thoroughly blow down and clean out system under a steam pressure of 5 lb., allowing condensate to be wasted to sewer.

Operate system a week, using Dunham Temporary Caps on traps, or Dunham Temporary Elbows on the return of radiators. Surface blow-off the boiler, as follows:

Remove the safety valve and connect a temporary blow-off pipe to the safety valve tapping, extending it outside or to some suitable drain. Shut-off all radiator valves or valves in main. Fill the boiler with water to top of gauge glass. Build a very hot fire and blow steam and water out through the safety valve tapping and pipe connected thereto. Raise and keep pressure up to 10 lb.; fire hard, supply cold water constantly in at bottom of the boiler, maintaining water line at top of gauge glass; keep up continuously for six hours; during the last two hours of the period fill boiler full of water, allowing the hot water to flow from it under the said pressure through and out of the top blow-off. At the end of the period, close the water feed valve, bring the pressure up to 10 lb., open blow-off at bottom of boiler, draw the fire quickly, and entirely drain the boiler. Allow the boiler to cool, replace the safety valve, and fill the boiler slowly.

22. Guarantee. The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, under a pressure differential of 1 in. mercury between steam and return mains, with a vacuum of 10 in. in steam main. If the apparatus shall fail to accomplish this guarantee by reason of any defect developing within the period of one full heating season and that defect is due to faulty material or poor workmanship, the Heating Contractor shall remedy such defect at his own cost within reasonable time after notice thereof.

23. Finally. Nothing herein contained can be construed to relieve Heating Contractor from making good and perfect work in all usual details of construction, and he will be held responsible to provide and furnish necessary material and to perform all necessary labor and to bear all expenses incidental to the satisfactory completion of the work.

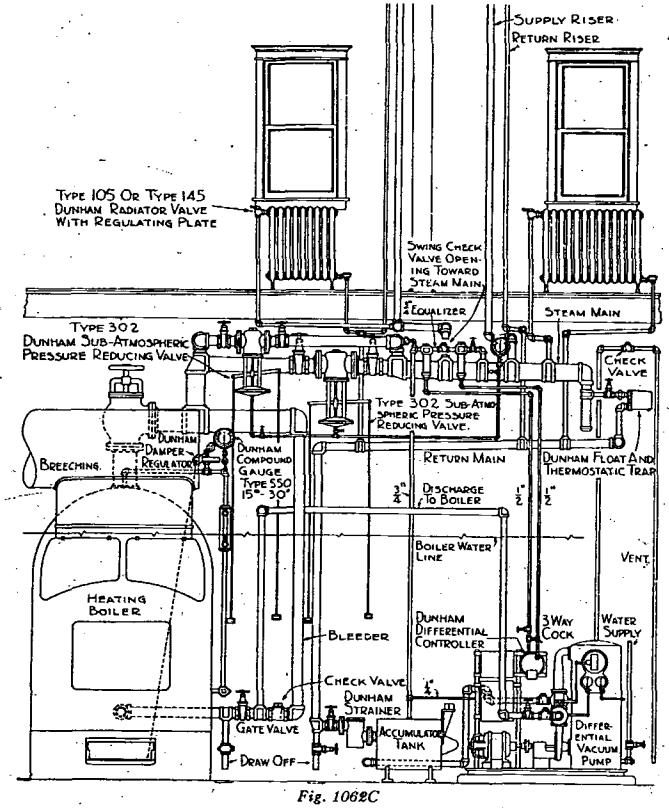


Fig. 1062C

Method of Installing Dunham Differential Vacuum Heating System—"D" Series—as applied to the heating of office buildings, hotels, apartment houses, etc.

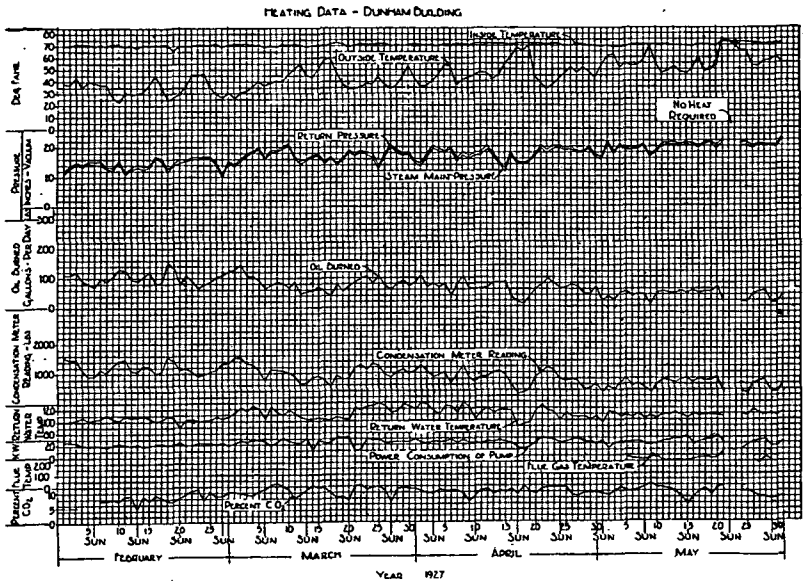


Fig. 1128

Heating Data from a Nine-Story Office Building in Chicago

Averages per Day of Heating Season, October, 1926 to May, 1927, inclusive

Room Temperature	71.2° Fahr.
Outside Temperature	40.3° Fahr.
Return Pressure	16.85 in. Vacuum
Boiler Pressure	15.17 in. Vacuum
Boiler Water Temperature (Steam Table) corresponding to Boiler Pressure	178.69° Fahr.
Return Water Temperature	104° Fahr.
Fuel Oil Consumption (18-20 Baume)	101.5 Gal.
Oil Burner in Operation	11.6 hours
Power Consumed by Differential Vacuum Pump	13.98 K. W

This system is a Dunham Differential Vacuum Heating System with semi-automatic control and "D" Series Differential Vacuum Pump.

There is approximately 7704 sq. ft. of radiation, supplied with heat from two fire box boilers, each having a catalog rating of 6000 sq. ft.

The boilers are equipped with an industrial type oil burner supplying heat from the front end of the boiler. Each boiler is valved in such a way that either one can be cut out from the heatingsy stem.

The steam main located on the basement ceiling, is divided into two branches. The radiation is divided approximately equally between them. The end of each branch is dripped through a Dunham Float and Thermostatic Trap into the vacuum return line (also located on the basement ceiling).

The steam and return risers extending up nine floors are concealed in the walls. The radiators are of the Corto type with Dunham No. 105 Inlet Valve at the top of each radiator. Each valve is equipped with a Regulating Plate.

The chart of performance shown at the top of this page, is not a special test, but is merely the record of each day's operation taken from the regular daily records kept by the operating engineer.

Two marked results (gained over the ordinary vacuum return line system formerly operated) have consistently obtained (1) Appreciable fuel economy (2) Comfort thru the absence of overheating in mild weather.

TYPICAL HEATING SPECIFICATIONS

"DH" Series System for Residences

1. **General Conditions.**
   Same as "D" Series. (page 582.)

2. **Construction and Material.**
   Same as "D" Series.

3. **Boiler.**
   The steam boiler shall be a ..... with guaranteed rating for ..... sq. ft. of radiation installed upon suitable foundation, and equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30 in. vacuum and a 10 in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations.)

4. **Smoke Pipe.**
   Connect boiler to chimney with suitable iron smoke pipe same size as boiler smoke outlet. Smoke pipe must be provided with approved Dunham Check Damper and hand stop damper between check damper and boiler. (On gas and automatic oil fired installations omit Dunham Check Damper).

5. **Boilerstat.**
   Furnish a Dunham Boilerstat, Type 360. Contractor shall drill and tap an opening in the boiler for this instrument, locating same with its bulb 2 in. below boiler water line. This Mercury Switch shall be installed and wired to pump in accordance with instructions furnished.

6. **Pipe and Fitting.**
   Same as "D" Series.

7. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg.

8. The end of each steam main shall be dripped as indicated on the plans by means of a wet drip line to boiler, properly vented through Dunham Trap No. 1 in accord with details furnished by manufacturer.

9. Grade steam mains ½ in. in 10 ft. Grade return mains and drip mains 1 in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runouts to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible. ½ in. per foot is preferable.

10. Return mains shall be connected to the Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer.

11. Risers are to be run concealed or in the open as directed by the architect. All concealed piping must be tested at 15 lb. water pressure before being concealed.

12. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work should be performed after system is completed and while it is working with a vacuum in both steam and return lines.

13. The System when finished shall be tested for tightness. When system is filled with steam, drop the fire when 20 in. of vacuum is secured and stop pump. After an hour there shall be at least 10 in. of vacuum remaining on the gauge.

14. **Floor Plates, Sleeves.**
   Furnish proper floor and ceiling plates, and protecting sleeves on all pipes passing through floors or finished partitions.

15. **Differential Vacuum Pump and Air Eliminator.**
   Furnish and install a "DH" Dunham Differential Vacuum Pump having a rated capacity of 2000 sq. ft. of direct radiation. The pump shall be installed and connected in accordance with manufacturer's instructions and details.

   Furnish and install in accordance with manufacturer's instructions a Dun-

ham Air Eliminator, Type 220-B. Install a Dunham Air Check, Type 222, on vent opening of Eliminator; also install Air Check on top of vent pipe of Differential Pump.

16. Check Valves.
Same as "D" Series.

17. Radiation.
Same as "D" Series.

18. Radiator Traps and Valves.
Same as "D" Series.

19. Painting.
Same as "D" Series.

20. Covering.
Same as "D" Series.

21. Finishing Up.
Same as "D" Series.

22. Guarantee.
Same as "D" Series.

23. Finally.
Same as "D" Series.

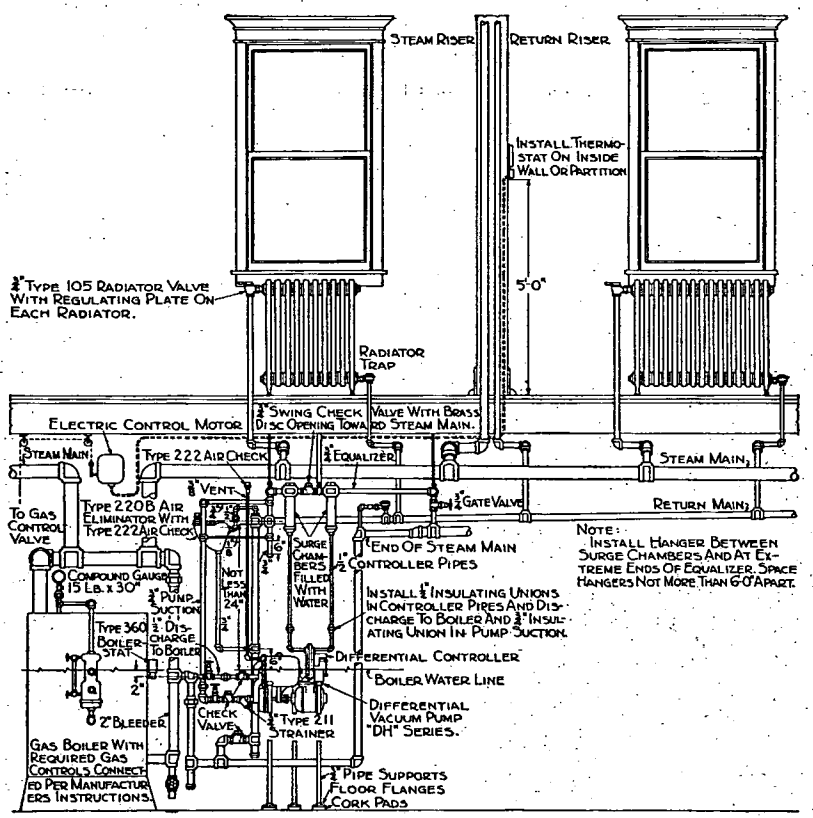
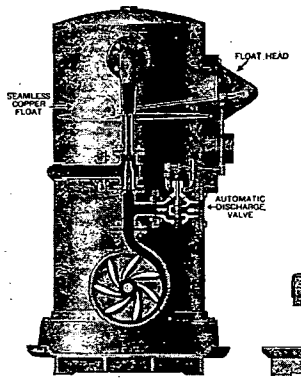
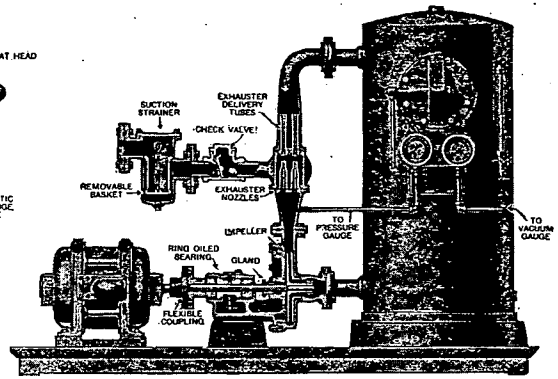


Fig. 1059B

Method of Installing Dunham Differential Heating System—"DH" Series—as applied to residences. Illustration shows Gas Boiler, however, System uses Coal, Gas or Oil fuel





DUNHAM DIFFERENTIAL VACUUM PUMP—"D" Series

(ILLUSTRATION SHOWS PRINCIPAL PARTS ONLY)

Manufactured under Young and Dunham Patents

(Ask for Bulletin 115)

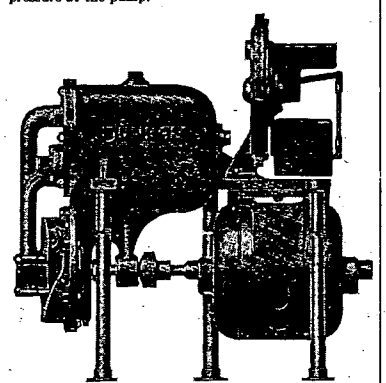
The Pump is a reliable vacuum system pump for handling both gases and liquids efficiently as well as returning the condensate to Boiler.

The unit is completely assembled (including electrical equipment) at the factory and thoroughly tested before shipment. They are ready to run when the feed wiring is connected.

The unit consists of a centrifugal pump, bronze fitted, of enclosed impeller high efficiency type, an approved make of motor and electrical equipment, mounted with a heavy welded tank on a substantial cast iron base. It includes a vacuum producing element of highest efficiency, which easily produces a high vacuum. The operation of the pump is controlled by the Differential Controller which is governed by the difference in pressure in the steam mains and radiators, and the return lines, a method not utilized in vacuum heating prior to the Dunham Differential Vacuum Steam Heating System.

The motor used is of 40 deg. rating, of more than ample power for the maximum load that will come on the unit. A safety factor insuring freedom from motor trouble.

Standard Units in several sizes are built to discharge against a pressure of not more than 20 lb. at the pump. Special pumps are furnished to discharge against 35 lb. pressure at the pump.



Dunham Differential Pump, "DH" Series
Manufactured under Dunham patents.
Ask for Bulletin 114

PRODUCTS

Specialties for use in connection with The Dunham System of Heating, known according to its several adaptable forms as "The Dunham Differential Vacuum Heating System." The Dunham Home Heating System; The Dunham Return System and The Dunham Vacuum Return Line System—all two-pipe systems, and The Dunham Air Line System for use in connection with one-pipe steam systems.

These specialties are Radiator Traps; Float and Thermostatic Traps; Air Line Valve; Return Traps; Medium Pressure Traps; Packless Radiator Valves; Pressure Reducing Valves; Vacuum Pumps; Condensation Pumps; Vacuum Pump Governors; Air Eliminators; Air Check; Oil Separators; Dirt Strainers; Air Vents; Damper Control; Gauges.

The Dunham Vacuum Return Line System

Simplicity of the key note of Dunham design. 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.

The Dunham Return Line System

This System makes use of the Dunham Return Trap or Condensation Pump, which provides a positive automatic return of water to the boiler when it is desired to raise the steam pressure.

This Dunham System is 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 Home Heating System

This is specially for the small home. It uses steam at very low pressure. The design is such that a partial vacuum can be obtained on receding fire, with water continuing boiling which will prolong the heating period.

Bulletins

Bulletins of standard architectural size with detailed information covering each Dunham Product and System, including roughing-in dimensions, will be furnished on request.

The Fulton Sylphon Company

NEW YORK
Hudson Terminal Bldg.
50 Church Street

PHILADELPHIA
Drexel Bldg.
4th and Chestnut Streets

Knoxville, Tennessee

SALES OFFICES:
DETROIT
General Motors Building
REPRESENTATIVES IN ALL PRINCIPAL CITIES

CHICAGO
Wrigley Bldg.
Michigan Boulevard

BOSTON
Federal Bldg.
136 Federal Street

Patentees and manufacturers of Sylphon products. Sylphon Automatic Air and Vent Valves; Packless Expansion Joint; Thermostats for regulating temperatures of homes by warm air furnaces, steam, vapor or hot water boilers; Temperature and Pressure Regulators, Temperature Regulating Radiator Covers; and other Heating Specialties.

Advantages

All Sylphon devices embody the seamless, one-piece bellows of drawn metal shown at right. There is not a bit of solder throughout its length—no chance for leaks or breaks. It is a feature found exclusively in Sylphon Products. Sylphon diaphragms or bellows are made in sizes ranging from 1⅛ to 12 in. O. D.

No. 410 Sylphon Air Line Valve

An automatic, non-adjustable air line valve that will silently expel air and condensation, but close against steam. Has as its basic principle the Sylphon thermostat, which will quickly and effectively distinguish between steam and air, freely allowing the air and condensation to pass, but preventing the passage of steam. This means that every inch of radiating surface becomes 100 per cent efficient. Ask for Bulletin RRAV-3.

Cut Open View

SPECIFICATION—All radiators to be equipped with Sylphon Air Line Valves known as (either No. 410 or No. 410-A), as manufactured by The Fulton Sylphon Company, Knoxville, Tenn.

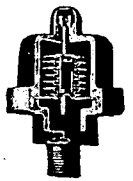
No. 510 Sylphon Vent Valves for Primary Heating Coils

For venting air from large heating coils used in stacks and in indirect heating with fan blowers, where low-pressure steam is used. Venting port 3/16 in. dia. Has a powerful Sylphon bellows as thermostat which closes valve immediately steam reaches it. Does not close against water. Can be installed in any position. Made entirely of cast brass; ruggedly constructed. Ask for Bulletin RRAV-3.

SPECIFICATION—Heating Coils, where shown on plans, shall be vented with No. 510 Sylphon Vent Valves as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., and installed in accordance with instructions furnished by the manufacturer.

No. 527 Quick Vent Valve

For venting mains, long runs of pipe, indirect stacks, drop risers, and all low-pressure steam jobs where a large amount of air must be expelled quickly. Contains Sylphon bellows as thermostat. Vents entire piping system and thereby heating radiators quicker under less pressure. No adjustment. Does not close against water. Venting port 1/16 in. diameter. Valve connection 3/8 in. pipe thread. Ask for Bulletin RRAV-3.

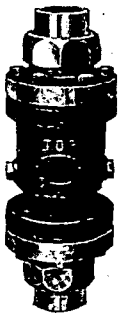


Cut Open View

SPECIFICATION—The ends of long runs of pipe, risers or loops shall be vented with a No. 527 Sylphon Quick Vent Valve, as manufactured by the Fulton Sylphon Company, Knoxville, Tenn.

No. 110 Sylphon Packless Expansion Joint for Low Pressure Steam Heating Risers

The Sylphon Packless Expansion Joint eliminates all packed type expansion joints, scissors, swing loops and similar devices generally used in installing low pressure steam heating risers. The pipe movement is taken up in the joint by the expansion of a Sylphon bellows so utilized as to provide a continuous sealed line.



No. 110

Sylphon Packless Expansion Joints are designed for use on steam pressures up to 15 lb. per sq. in., but may be temporarily subjected to steam pressures up to 25 lb. per sq. in. They should never be tested with steam pressures in excess of 25 lb. per sq. in., or water pressures in excess of 50 lb. per sq. in.

Sylphon Joints should be located near the floor or ceiling. If concealed in walls, access doors or removable panels should be provided. It is important to install them with the end marked "top" in the correct position. Piping should be installed in a true vertical position, but the guides on the outside casing insure correct alignment, and prevent torsional or eccentric strains on the Sylphon bellows. Ask for Bulletin RREJ-100.

Principal Dimensions, Pipe Sizes and List Prices No. 110

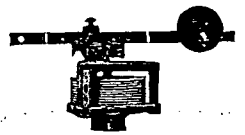
Pipe size, in.	¾*	1	1¼	1½	2	2½	3
Lengths:							
A—Extended	12	11 5/8	11 3/4	13 1/8	13 1/4	14 5/8	15 3/8
B—Compressed	10 1/2	10 3/8	10 1/4	11 5/8	12 1/4	13 1/8	13 3/8
D—Width	3 5/8	3 5/8	4 1/8	4 1/2	5 1/8	6	6 3/8
E—Installed	11 3/4	11 3/8	11 1/2	12 7/8	13 1/2	14 3/8	15 1/8
Shipping wt., lb.	15	15	18	25	35	50	60
List prices	$12	12	14	16	20	23	27

*Using 1 in. joint fitted with face bushings.

SPECIFICATION—Install where shown on riser plans No. 110 Sylphon Packless Expansion Joint, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., with end marked "top" in proper position; the joint to be of ____ *in. pipe size and for steam (water) pressure of not* over 15 lb. (50 lb.) per sq in.

No. 22 Steam Damper Regulator

Used to control the dampers on steam heating boilers. A simple, accurate regulator which will control the draught so as to maintain a constant steam pressure up to 5 lb. This regulator is sensitive, positive in action and will last a life time, due to the Sylphon one-piece, seamless, solderless, flexible metal bellows which it contains as diaphragm. Ask for Bulletin RRDR-8.



SPECIFICATION—The boiler shall be equipped with a No. 22 Sylphon Steam Damper Regulator, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., and installed in accordance with instruction of the manufacturer.

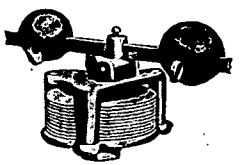
No. 22-J Steam Damper Regulator

This Regulator is identical in construction with No. 22 except that it contains a smaller Sylphon bellows as its diaphragm and is therefore suitable for small steam boilers or those having light dampers which do not require much power for their operation. Will maintain a constant steam pressure up to 8 lbs. gauge. Ask for Bulletin RRDR-8

SPECIFICATION—The boiler shall be equipped with a No. 22-J Sylphon Steam Damper Regulator, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

No. 924 Steam Damper Regulator

For low pressure steam boilers where extra sensitiveness and greater power are required to operate the damper. Is identical in construction with No. 22 except that it contains a larger Sylphon bellows as its diaphragm, and distance between rocker pivot and plunger pivot is greater. Will operate with pressures up to 3 lbs. gauge.

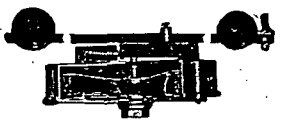


Ask for Bulletin RRDR-8

SPECIFICATION—Boiler shall be equipped with a No. 924 Sylphon Steam Damper Regulator as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

No. 925 Vapor Damper Regulator

Specially designed to control dampers on boilers used with vapor heating systems. Extremely powerful and sensitive. Has extra large flexible Sylphon bellows as diaphragm. One ounce change in vapor pressure produces a 6¼ lbs. force to open or close dampers. Operates from 2 ozs. to 1 lb. gauge, perfectly smoothly and will not "flutter" under any condition.

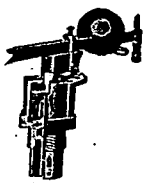


Ask for Bulletin RRDR-8

SPECIFICATION—The boiler shall be equipped with a No. 925 Sylphon Vapor Damper Regulator, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., and installed in accordance with instructions of the manufacturer.

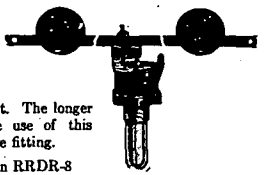
No. 45-A Hot-Water Damper Regulator

Used to control the dampers on hot-water heating boilers Contains Sylphon Bellows as diaphragm. A simple, accurate regulator which will control the draft so as to maintain a constant temperature of the water at any point between 120 deg. and 220 deg. fahr. Prevents the temperature of the water from rising higher than necessary. Installed on domestic hot-water heaters, insures faucet water of even temperature every hour of the day. Prevents the generating of steam in the system, thus eliminating disagreeable sputtering and blowing-off when faucet is open. Ask for Bulletin RRDR-8.



No. 45 Hot-Water Damper Regulator

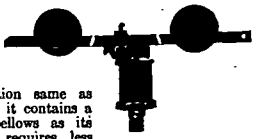
Same as No. 45-A except bulb is 4 in. instead of 2 in. long and rocker does not have adjustment. The longer bulb permits the use of this regulator in a pipe fitting.



Ask for Bulletin RRDR-8

No. 46 Hot-Water Damper Regulator

This regulator with bulb 1 in. long, is designed especially for small hot-water-heating boilers, or those having light dampers, also, domestic hot-water supply heaters. Construction same as No. 45 except that it contains a smaller Sylphon bellows as its diaphragm, as it requires less power to operate the light dampers of such heaters. Also suitable for laundry heaters, garbage burners, garage heaters, etc. Ask for Bulletin RRDR-8.



SPECIFICATION—(Boiler, heater, or tank heater shall be equipped with a No. (45, 45-A, 45-B or 46) Sylphon Hot-Water Damper Regulator, as manufactured by The *Fulton Sylphon Company*, Knoxville, Tenn., the regulator to have a temperature range of (specify temperature range. No. 45 and 45-A have temperature range of 120 deg. to 220 deg. fahr.; No. 45-B has temperature range of 100 deg. to 200 deg. fahr.; No. 46 has temperature range of 130 deg. to 200 deg. fahr.) and to be installed in accordance with instructions furnished by the manufacturer.

Nos. 42, 43, 44, Hot-Water Damper Regulators

These regulators are used where conditions require side instead of direct connections. The hot-water circulates around an inner bulb containing a volatile liquid, which in turn causes the Sylphon bellows to expand or contract as the temperature of the water rises or falls, thus closing or opening the draft dampers.

Ask for bulletin RRDR-8.

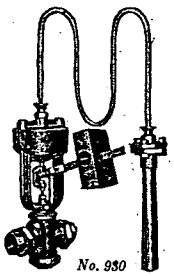
SPECIFICATION—(Boiler heater or tank heater) shall be equipped with a No. (42, 43, or 44) Sylphon Hot-Water Damper Regulator, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn., the regulator to have a temperature range of (specify—No. 42 controls from 120 deg. to 180 deg. fahr.; No. 43 from 160 deg. to 220 deg. fahr.; No. 44 from 190 deg. to 240 deg. fahr.) and to be installed in accordance with instructions furnished by manufacturer.

No. 930 and No. 931 Temperature Regulators for Control of Liquids

Used to automatically control temperatures of liquids heated by steam, and especially for hot-water supply tanks in apartments, hotels, clubs, etc., and regularly furnished with a temperature range of 140 deg. to 180 deg. fahr.

No. 930 has lever and weight method of adjustment and is made in valve sizes ½ to 8 in. inclusive. No. 931 has spring type adjustment and is made in valve sizes ½ to 2½ in. inclusive.

Upon application a chart will be furnished showing how to determine size of regulator needed for any given condition. Ask for chart and Bulletin RRTR-110.



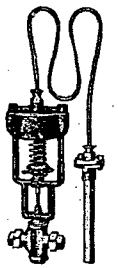
No. 930

No. 980 and No. 981 for Control of Air

Star Shaped Bulb

When used to automatically control temperature of air in dry rooms, etc., these regulators are equipped with our special "star-shaped" bulb, which gives greatest area of exposed surface to mass of any design known.

Furnished in either lever and weight type (No. 980) or spring adjusting type (No. 981). No. 980 is made in valve sizes ½ in. to 5 in. incl. and No. 981 in sizes ½ in. to 2½ in. inclusive.



No. 981

Temperature Ranges Nos. 930, 931, 934, 935, 980, 981

No.	Range	No.	Range
21	10 to 50° F.	28	180 to 220° F
22	20 to 60° F.	29	190 to 230° F
23	40 to 80° F.	30	210 to 250° F
24	60 to 100° F.	31	220 to 260° F
25	100 to 140° F.	32	230 to 270° F
*26	140 to 180° F.	33	245 to 285° F
27	160 to 200° F.	34	275 to 315° F

*For service water heating. Nos. *932* and *942* are *10* deg. higher.

On special order at $2.50 net additional cost, regulators Nos. 930, 931, 932, 935, 942, 980 and 981 will be furnished with reversed valve interior for controlling cooling mediums.

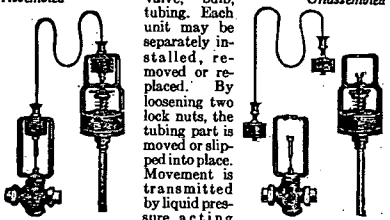
Valves—Double-seated, balanced type, bronze disc and seats. Bronze bodies fitted with bronze unions, in sizes ½ to 1¼ in. inclusive. Sizes 2 in. and above have iron bodies, bodies flanged and drilled standard. Companion flanges furnished at extra cost. *Flexible metal tubing* 8 ft. long. Supplied longer on order, at 30 cents per ft. net.

SPECIFICATION—Install where shown on plans, a Sylphon Temperature Regulator (Nos. 930, 931, 980 or 981) as manufactured by The Fulton Sylphon Company, Knoxville, Tenn.; regulator to have a temperature range of (specify) deg. fahr. and valve of (specify) inches in size, ground for steam pressure of (specify), lbs. with tubing (specify) ft. long.

No. 932 Sylphon Temperature Regulator

Detachable Tube Type: This is the latest development in self-contained regulators, and on account of its flexibility of installation is very popular with the heating trade. This regulator is composed of three distinct and separable units: valve, bulb, tubing. Each unit may be separately installed, removed or replaced. By loosening two lock nuts, the tubing part is moved or slipped into place. Movement is transmitted by liquid pressure acting between two small Sylphon bellows and is frictionless. Liquid is non-freezing.

Assembled *Unassembled*



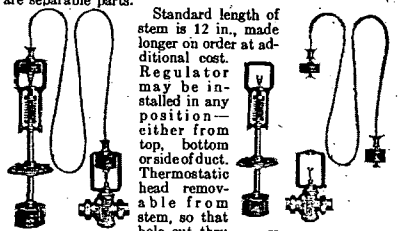
These features are patented and possessed by no other regulator. One transmission unit fits all regulators having valve sizes ½ in. to 1¼ in. inclusive; another unit for valves 1½ in. to 4 in. inclusive. Ask for Bulletin RRTR-110.

SPECIFICATION—Install where shown on plans No. 932 Sylphon Temperature Regulator as manufactured by The Fulton Sylphon Company, Knoxville, Tenn.; regulator to have a temperature range of (specify) deg. fahr.; and valve of (specify) inches in size, ground for steam pressure of (specify) lbs. with tubing (specify) ft. long.

No. 942 Sylphon Temperature Regulator

Separable Transmission Type: For control of air temperatures in ducts of fan and blower heating systems where valve must be at some distance from thermostatic head. Easily installed, as valve, transmission unit and thermostatic head are separable parts.

Standard length of stem is 12 in., made longer on order at additional cost. Regulator may be installed in any position—either from top, bottom or side of duct. Thermostatic head removable from stem, so that hole cut thru duct wall need be only large enough to pass a ¾ in. pipe. Made in valve sizes ½ to 4 in., inclusive. Ask for Bulletin RRTR-110.



Assembled *Unassembled*

Valves—Double seated balanced type, with bronze discs and seats. Bronze bodies fitted with bronze unions in sizes ½ to 1½ in., inclusive. Sizes 2 in. and above have iron bodies, bodies flanged. Fitted with companion flanges on order at additional cost.

SPECIFICATION—Install in duct where shown on plans No. 942 Separable Transmission type Sylphon Temperature Regulator as manufactured by The Fulton Sylphon Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) deg. fahr. with valve of (specify) inches in size ground for steam pressure of—lbs., a transmission tubing of (specify) ft. long and extension stem of (specify) inches long.

Principal Dimensions and List Prices Nos. 930, 931, 980 and 981 Sylphon Regulator

Valve Sizes, Inches	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
List prices 930	$60	$65	$70	$75	$80	$ 90	$ 95	$100	$110	$120	$175	$225	$275
List prices 931	$60	$65	$70	$75	$80	$ 90	$ 95					...	...
List prices 980	$70	$75	$80	$85	$90	$100	$110	$125	$140	$150	$225	...	...
List prices 981	$70	$75	$80	$85	$90	$100	$110					...	...
Bulb thread IPS 930	1"	1"	1"	1"	1"	1"	1¼"	1¼"	1¼"	1¼"	1¼"	2½"	2½"
Bulb thread IPS 931	1"	1"	1"	1"	1"	1¼"	1¼"						
Bulb length 930	16"	16"	16"	16"	16"	16"	16"	24"	24"	24"	24"	24"	24"
Bulb length 931 and 981	16"	16"	16"	16"	16"	16"	16"					...	...
Bulb length 980	16"	16"	16"	16"	16"	16"	16"	16"	16"	16"	16"		
Lever bar length 930	24"	24"	24"	24"	24"	24"	24"	36"	36"	36"	36"	36"	36"
Lever bar length 980	41"	41"	41"	41"	41"	41"	41"	43"	43"	43"	43"	...	...

No. 934 Sylphon Temperature Regulator

For control of liquids. Made in valve sizes of ¼ and ⅜ in. only, and for steam pressures under 100 lb. For controlling temperature of steam tables, pasteurizing and sterilising apparatus, size box on slashers, tempering tanks, percolators, glue kettles, and small tanks of all kinds where a minimum amount of steam, accuracy of control, and compactness of instrument are required. Valves are all-bronze, single seated, needle type with screw ends right-hand threads. Ask for Bulletin RRT-110.

No. 934

SPECIFICATION—Install where shown on plans for control of (specify) No. 934 Sylphon Temperature Regulator, as manufactured by The Fulton Sylphon Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) deg. fahr., with valve of (specify) inches in size, ground for steam pressure of (specify) lbs. and tubing (specify) ft. long.

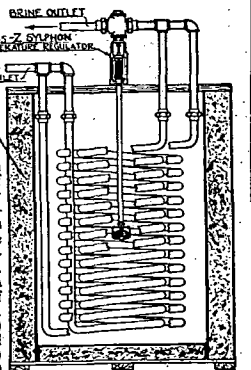
No. 935 Sylphon Temperature Regulator

For control of liquids or air. Made in valve sizes ¼ to 1½ in., inclusive. (Sizes ¼ and ⅜ in. are for steam pressures under 100 lb. only.) For controlling temperatures of open liquor vats, tanks, dryers, dry rooms, warming ovens, proofing rooms, etc. May be installed in any position. Extension stem is regularly furnished 12 in. long, but can be made any length on special order. Valves are double seated balanced type with bronze discs and seats and fitted with unions, except ¼ and ⅜ in. sizes, which are all-bronze single seated, needle type, with screw ends right-hand threads. Ask for Bulletin RRT-110.

No. 935

No. 935-Z for Control of Cold Storage Rooms and Boxes and Drinking Water

When used for control of calcium chloride brine, valves are ½ to 1½ in., incl., balanced piston type made entirely of bronze and fitted with bronze unions. Temperature ranges: 10° to 50°; 20° to 60°; 40° to 80° F. Ask for Bulletin RRT-106.

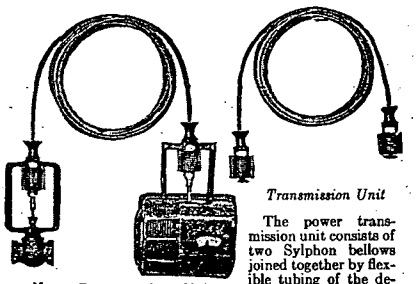


No. 935-Z—Sylphon Regulator on open type water cooler

SPECIFICATION—Install where shown on plans for control of (specify) No. 935 (or 935-Z) Sylphon Temperature Regulator as manufactured by The Fulton Sylphon Company, Knoxville, Tenn. Regulator to have a temperature range of (specify) degrees fahr. with valve of (specify) inches in size, ground for steam (or brine) pressure of (specify) lbs. and extension stem of (specify) inches long.

No. 11 Sylphon Transmission Regitherm

The latest development in automatic control of air temperatures for industrial uses. A simple, self-contained, sturdy instrument without complicated mechanism to continually get out of order. Valve is mounted in steam line, Regitherm placed on wall or column 5 ft. above floor, power transmission unit is joined by means of T-slot connections.



No. 11 Regitherm Assembled *Transmission Unit*

The power transmission unit consists of two Sylphon bellows joined together by flexible tubing of the desired length, completely filled with a non-freezing liquid. Tubing regularly furnished 25 ft. in length, but can be made any length required. Made in valve sizes ½ to 2½ in., incl. Regularly furnished to operate from 60° to 80° F. Other ranges on application.

Valves—Double seated balanced type, bronze discs and seats. Bronze bodies fitted with bronze unions in sizes ½ to 1½ in., inclusive. Sizes 2 and 2½ in. have iron bodies; bodies flanged, and drilled standard. Companion flanges furnished at extra cost. Ask for Bulletin RRR-102.

No. 11-Z for Control of Cold Storage Rooms

For control of calcium chloride brine furnished with following temperature ranges: 20° to 40°; 35° to 55°; 40° to 60°; 45° to 65°; 55° to 75° F. Ask for Bulletin RRT-106.

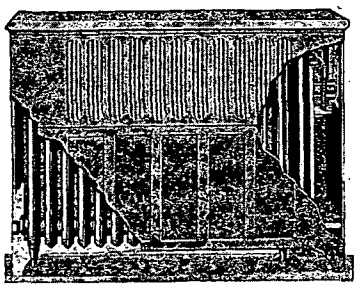
SPECIFICATION—Install where shown on plans for control of (specify) No. 11 (or No. 11-Z) Sylphon Liquid Transmission Regitherm as manufactured by The Fulton Sylphon Company, Knoxville, Tenn. Regitherm to have a temperature range of (specify) deg. fahr., a valve of (specify) inches in size, ground for steam (or brine) pressure of (specify) lbs. and transmission tubing of (specify) ft. long.

The Ja-Nar Radiator Cover

Made of fine furniture steel, lined with heat insulating material. Completely covers either high or low hot water and steam radiators. Can be installed in old homes as easily as in new. Furnished in light or dark oak, mahogany, walnut and various tinted enamels, or to match wood work.

Furnished in three types: 1st, Automatic Temperature Control; 2nd, Manually Operated Temperature Control; 3rd, Uncontrolled Type.

The controlled type is equipped with a thermostatic device which automatically opens or closes the shutters to regulate *the heat sent out into the room.* Can *be set to operate* at temperature desired. Ask for Pamphlet on the Ja-Nar.



The Ja-Nar cut away to show Radiator and thermostat

SPECIFICATION—Install where shown on plans, a Ja-Nar Radiator Cover as manufactured by The Fulton Sylphon Company, Knoxville, Tenn. The contractor will furnish to the manufacturer information as to size of radiator and other measurements necessary to build the Ja-Nars. (Specify finish for each room. State whether to be of automatic control type, hand control type or uncontrolled type.)

Hoffman Specialty Co., Inc.

Waterbury, Conn.

GENERAL SALES DEPARTMENT

25 West 45th Street :-: **New York, N. Y.**

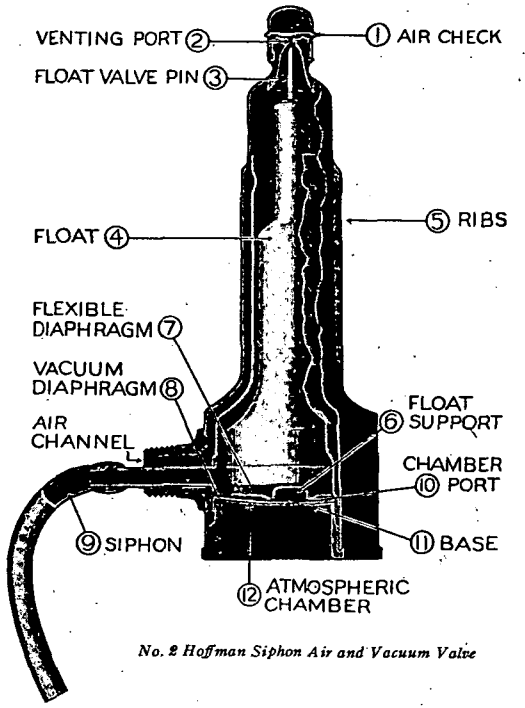
Hoffman Valves and Controlled Heat Equipment

HOFFMAN VENTING VALVES

In the Hoffman line there is a specially designed venting valve for every type of steam heating system. The basic principle used in the design of all Hoffman venting valves is that of an all-metal thermostatic member, with one or more flexible diaphragms, containing a volatile or heat sensitive fluid which causes valve action upon slight temperature changes.

Hoffman valves have a wide pressure range in which they operate with the same degree of accuracy, for the internal fluid pressure in the thermostatic member maintains a constant relationship with the external steam pressures throughout the whole range of pressure for which each valve is intended.

Hoffman valves are automatic, non-adjustable and guaranteed to properly function for a period of five years from date of installation when installed and operated under normal conditions for which designed.



No. 2 Hoffman Siphon Air and Vacuum Valve

HOW THE NEW HOFFMAN No. 2 VACUUM VALVE OPERATES

In ordinary one-pipe systems, when fire is banked, generation of steam ceases due to intake of air through vent port. With the No. 2 Valve the Air Check (1) prevents return of air to radiator while continued condensation of steam causes a slight vacuum to form in the radiator and valve. When a vacuum of 1 in. is reached inside the valve, atmospheric pressure acting through Chamber Port (10) in bottom of valve pushes the Vacuum Diaphragm (8) and Float (4) upward, thus positively closing the Venting Port (2).

The pressure exerted on Vacuum Diaphragm (8) is in direct relation to degree of vacuum obtained by condensation of steam in radiator. With absolute vacuum inside, there would be approximately 15 lb. dead weight holding Valve Pin (3) on its seat against intake of air at that point.

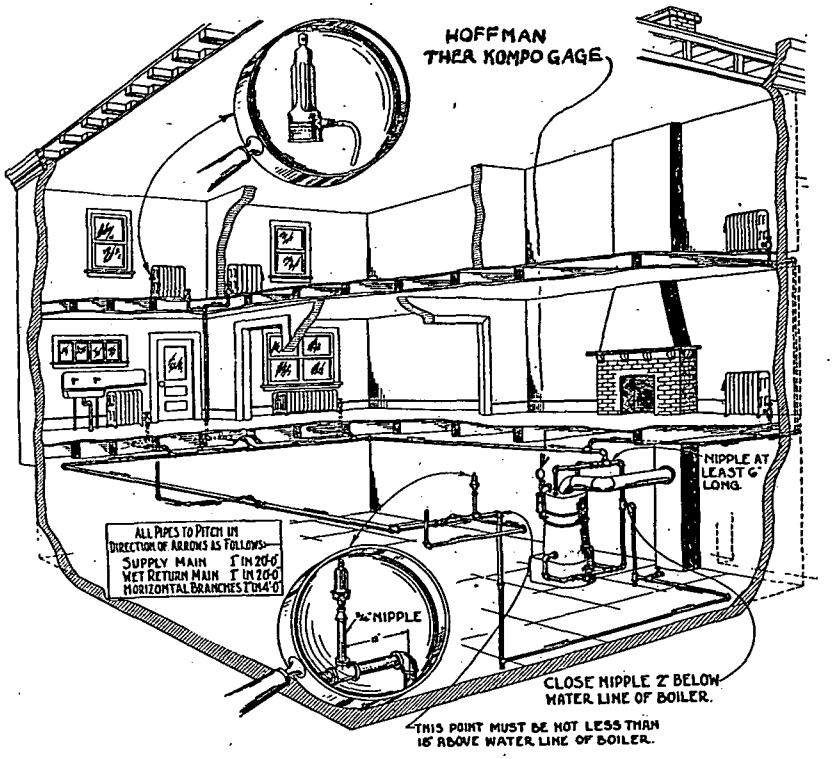
By closing the port when pressure goes below atmosphere, vaporization continues under vacuum and heat is given off by the radiator for long periods after fire is banked, also when drafts are applied vaporization starts at temperatures below 212 deg. fahr.; the vaporizing temperature being dependent on the vacuum present in the system. This action results in a very even radiator temperature.

HOW TO VACUUM-IZE A ONE-PIPE STEAM SYSTEM

To enjoy the comfort and economy of this new heating system all that is necessary is to equip the radiators all over the house with these new **No. 2 Hoffman Air and Vacuum Valves,** and if there are one or more air valves on the piping in the cellar, these must also be changed. **The No. 6 Hoffman Vacuum Valve** is best suited for this purpose as it allows those radiators furthest from the boiler to heat up just as quickly as the nearest one.

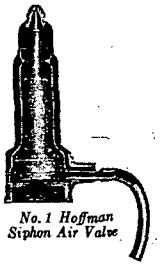
The use of even a single **No. 2 Hoffman Vacuum Valve** on the worst radiator will enable that particular radiator to stay warm after steam pressure has diminished, but with air leaking in at other points complete heating comfort and economy will not be secured unless every radiator air valve is a **No. 2 Hoffman.**

Heating contractors and engineers appreciate that while the big air leak in any steam heating system is through the air valves (this leak is stopped by the **No. 2 Hoffman**) there are liable to be other leaks which must be stopped if the system is to be fully efficient. Complete instructions as to what to do and how to do it are sent with the valves and should be carefully observed to get the best service.



Write for Descriptive Circular—Locking the Door Against the Heat Thief

ALL METAL—NON-ADJUSTABLE—THERMOSTATIC



No. 1 Hoffman Siphon Air Valve

The No. 1 Hoffman Siphon Air Valve is designed for systems of the one-pipe gravity type, to vent all air from radiators without loss of steam. After contact of water with the valve the siphon drains all water from the valve and venting occurs without the slightest "spit" even if the radiator is under pressure.

Radiator connection, ⅛ in. Maximum guaranteed operating pressure, 10 lb.

The No. 2 Siphon Air and Vacuum Valve is similar in construction to the No. 1, but in addition, when the radiator is once freed from air, return of air through the vent port is prevented. Through its use an ordinary one-pipe steam system may be changed into a vacuum type. See page 506.

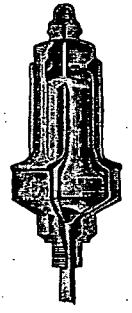
Radiator connection, ⅛ in. Maximum guaranteed operating pressure, 10 lb.

The No. 3 Hoffman Air Line Valve is specially designed for Air Line, or as they are frequently termed "Paul" Systems. It is sensitive in action and closes the instant steam fills the radiator.

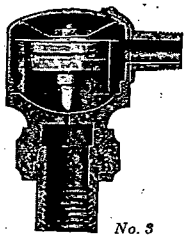
Radiator connection, ⅛ in.; Air Line connection, ¼ in. Maximum guaranteed operating pressure, 10 lb.

The No. 4 is used in venting mains, risers, vento stacks, coils, etc. All air is freely vented through a ⅛ in. vent port without steam loss.

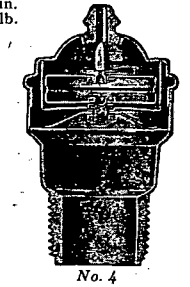
Standard connection, ¾ in., can also be supplied with ¼ in. connection. Maximum guaranteed operating pressure, 10 lb.



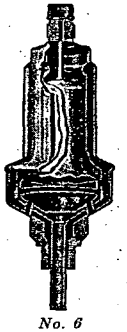
No. 5



No. 3



No. 4

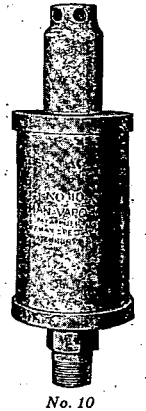


No. 6

The No. 5 is particularly adapted for use in venting: Ends of steam mains; Ends of dry return mains; Indirect radiators; Blast or "Vento" stacks; Hot-water generators; Dryers and drums, etc.

The basic principle is the same as the No. 1 Valve, having separate channels for air and water which are only found in Hoffman Valves.

Pipe connection, ⅜ in.; vent port for less than 3 lb. is ⅜ in.; for 3 lb. and over is ⅛ in. Unless otherwise ordered, will be shipped with ⅛ in. port. Maximum guaranteed operating pressure, 10 lb.



No. 10

The No. 6 is similar in design and application to the No. 5 with the additional feature of the Air Check or Vacuum starter above vent port and vacuum diaphragm in base. This Valve is similar in operation to the No. 2 valve and is used on return mains when No. 2 valves are used on the radiators.

Pipe connection, ⅜ in.; vent port for less than 3 lb. is ⅜ in.; for 3 lb. and over is ⅛ in. Unless otherwise ordered, will be shipped with ⅛ in. port. Maximum guaranteed operating pressure, 10 lb.

The No. 10 Hoffman Vapor Valve is used for venting the return mains in vapor systems or for other conditions where a large venting capacity is required. The vent port is ¾ in. in diameter.

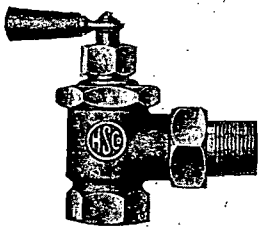
Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.

The No. 11 Hoffman Vapor Vacuum Valve is similar in appearance, construction and application to the No. 10 valve with the addition of a vacuum check on the vent port which prevents the return of air to the system through the vent port.

Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.

Write for Descriptive Circular—The Watchman of the Coal Pile

NO. 19 QUICK-OPENING HOFFMAN RADIATOR VALVE



The No. 19 Hoffman Radiator Valve

The No. 19 Hoffman Valve is of the quick-opening, semi-packless type intended for vacuum pump installation or for vapor systems where modulation is not required.

Valve is made in ¾ in. size only, having a capacity up to 200 sq. ft. direct cast iron radiation.

Valve stem is in one piece, the end engaging in disc holder having a quadruple thread which allows full port openingwith three quarters of a turn of handle.

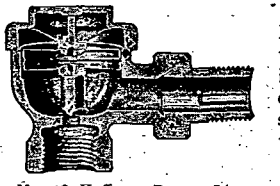
Valve body is a steam metal casting; bonnet nut and tail piece are hot brass forgings; coupling nut, stem and disc holder made of rod brass. Valve is heavily nickel-plated with polished trimmings.

Stem packing is lubricated, compressed asbestos fibre that will last indefinitely and require no attention other than an occasional take-up of the packing nut. Valve handle is hard black fibre that withstands severe service without breakage. Valve disc is genuine Jenkins Bros. composition.

The disc holder has a wide lug sliding between two vertical guides in valve body which prevent rotation of the disc as valve is opened or closed. This insures the same seating surface on the disc after each operation and also causes disc pressure to be exerted uniformly over entire seat, thus reducing possibility of leakage.

The No. 19 Valve is regularly furnished in Lever Handle pattern but, where required, Wood Handles, Lock Shields or Closed Tops are furnished without extra charge. Extension Stems with either Lever or Wood Handles can be supplied at an extra charge.

NO. 18 HOFFMAN RETURN LINE VALVE OR RADIATOR TRAP



No. 18 Hoffman Return Line Radiator Trap

This valve is similar in basic principle to the **No. 8 Hoffman Return Line Valve (or Trap).** It is used where radiators contain not over 100 sq. ft. of direct cast iron radiation and the pressure at the trap is not in excess of 15 lb. It effectively differentiates between steam, air and water. Holding steam—passing air and water.

The thermostat consists of one chamber made by two diaphragms separated by a space ring to which they are fastened. In the center of the bottom diaphragm, the valve pin is attached, the joint being expanded and made absolutely tight. The thermostat is held in its cage by a pin expanded and attached to the top diaphragm, this pin extending through the cage and engaging with the boss on the cap.

Thermostat contains a small quantity of thermostatic fluid, sealed under vacuum, insuring extremely sensitive Valve action. The fluid is such that its pressure maintains constant relationship with steam pressure and consistency of valve operation under varying pressure is thus obtained.

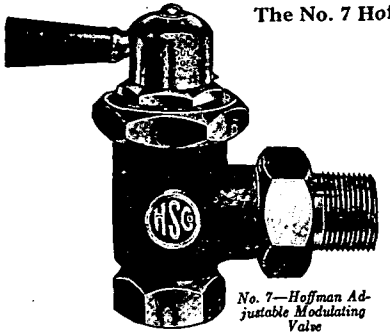
The thermostat is made of Special Hoffman Diaphragm Metal that will not soften under repeated action. It will not stretch causing permanent elongation of the thermostat and resultant premature closing of the valve port.

The thermostat is held in a three-legged cage, the feet of which rest on a shoulder in the valve body. The distance from shoulder to valve seat and the distance from feet of cage to seating surface in valve pin, is accurately controlled in machining the body, making all thermostats have uniform valve travel. The thermostats are thus made interchangeable without adjustment and all valves operate with the same degree of sensitiveness.

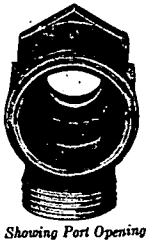
Write for Descriptive Circulars

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

The No. 7 Hoffman Adjustable Modulating Valve



No. 7—Hoffman Adjustable Modulating Valve



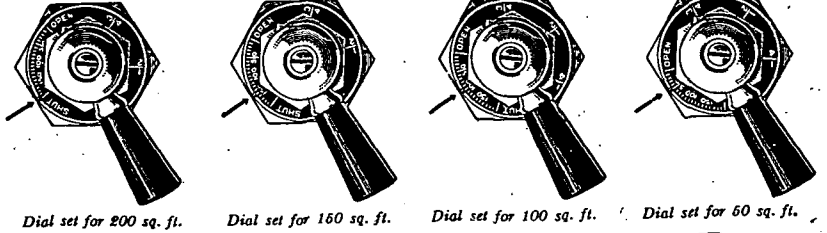
Showing Port Opening

For use in Vapor or Vapor Vacuum systems, is made in ¾ in. size, angle pattern only, having a range of adjustment up to 200 sq. ft. of direct cast-iron radiation.

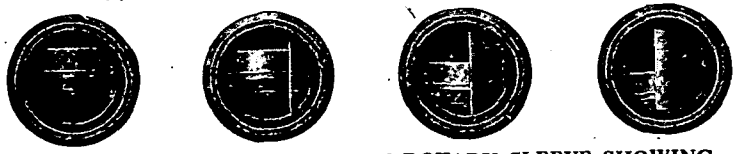
After installation, whether the system is in operation or cold, the port of each valve is adjusted for the size of the radiator to which it is attached. Adjustment is simple; loosen a locknut; turn valve handle until proper number of graduations are visible on the dial plate; then tighten locknut. The valve handle may then be moved to admit sufficient steam to heat a quarter, half, three-quarter, or entire radiator. The valve stem stuffing box has a frictionless metallic fibre packing that will last indefinitely and require no attention, giving at the same time, a valve action so free that the pressure of only one finger is required to open the valve.

The No. 7 Valve is regularly supplied with lever handle. On special orders, it can be furnished with wood wheel, lock shield, closed top, extension stem and handle, or chain pull.

POSITIONS OF TOP DIAL PLATE FOR VARIOUS SIZES OF RADIATORS



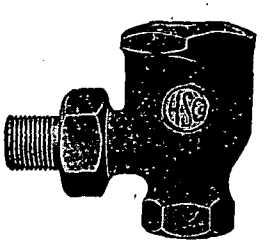
Dial set for 200 sq. ft. *Dial set for 150 sq. ft.* *Dial set for 100 sq. ft.* *Dial set for 50 sq. ft.*

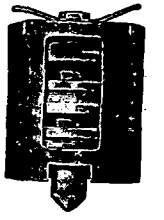


CORRESPONDING POSITIONS OF ROTARY SLEEVE SHOWING PORT AREAS FOR ABOVE GRADUATIONS

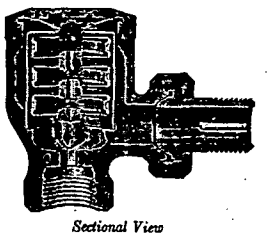
The visible adjustment enables the designing engineer and heating contractor to make a final accurate adjustment which compensates for slight irregularities in pipe sizes, failure to ream pipe, installation of extra fittings not forseen in original layout, etc. The advantages of an adjustable port in forced hot water systems to secure proper balance makes the No. 7 Valve especially adaptable for such use.

Write for Descriptive Circular—Hoffman Controlled Heat





Interchangeable Thermo Member



Sectional View

The Nos. 8 and 9 Hoffman Return Line Valves

These valves are automatic, non-adjustable, thermostatic and relieve all air and condensation without the loss of steam from radiators, pipe coils, indirect radiation, steam mains and risers, steam kettles, sterilizers and other devices where it is desired to get full efficiency and economy without waste of steam.

In service, they have established a reputation for efficiency and consistency of operation with the same degree of sensitiveness under either high or low pressure.

The body of the valve is made of cast steam metal; cap and tail piece are hot brass forgings; nut of rod brass; the thermostat of a special Hoffman alloy. In continued operation the thermostats will not break, stretch or lose their tension, giving long life and perfect operation.

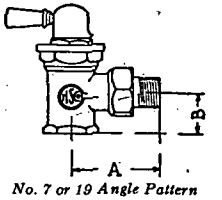
Chief Features

The valve consistently operates under a pressure range from 13 in. of vacuum to 50 lbs. steam pressure. Water at a temperature of approximately 12 deg. less than the temperature corresponding to the steam pressure causes full valve opening and free discharge of condensation.

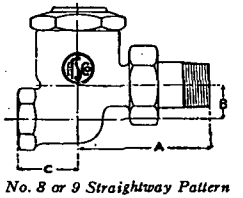
The thermostatic member is removable and may be changed from one valve to another of the same size without adjustment. This feature is appreciated by engineers who require the removal of the thermostat from the valves, until the system is thoroughly cleaned, and likewise by contractors complying with this practice.

The No. 8 Valve has ½ in. pipe connections, ¼ in. port and is furnished in Angle, Straightway, Right and Left-hand Offset Patterns. The normal capacity is 200 sq. ft. of cast iron radiation.

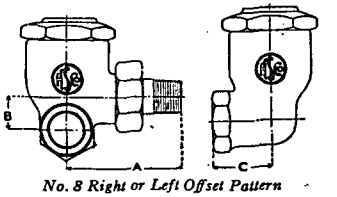
The No. 9 Valve with ¾ in. connection is made in Angle and Straightway Patterns only, and is suitable for 600 sq. ft. of cast iron radiation. For pressures up to 15 lbs. valve has ⅜ in. port, for higher pressures $\frac{3}{16}$ in. port.



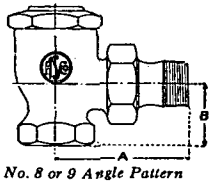
No. 7 or 19 Angle Pattern



No. 8 or 9 Straightway Pattern



No. 8 Right or Left Offset Pattern



No. 8 or 9 Angle Pattern

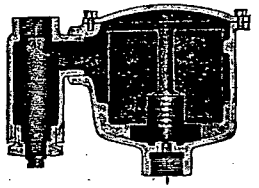
DATA AND DIMENSIONS

STYLE	Size Inches	Diameter Valve Port Inches	Maximum Capacity Square Feet	DIMENSIONS A	B	C
No. 7 Angle	¾	..	200	2 1/16	1 3/16	...
No. 19 Angle	¾	..	200	2 7/16	1 3/16	...
No. 8 Angle	½	¼	200	2 1/16	1 1/16	...
No. 8 Straightway	½	¼	200	2 1/16	1 1/16	1 1/16
No. 8 Offset	½	¼	200	2 1/16	1 1/16	1 5/16
No. 18 Angle	½	¼	100	2 1/4	1 1/4	...
No. 18 Straightway	½	¼	100	2 1/4	5/8	1 3/16
No. 18 Offset	½	¼	100	2 1/4	5/8	1 3/16
No. 9 Angle	¾	⅜*	600	3 1/16	1 1/16	...
No. 9 Straightway	¾	⅜*	600	3 1/16	5/8	1 1/2

*No. 9 Valve furnished with ⅜ in. port for pressures above 15 lb.

Write for Descriptive Circular—Hoffman Controlled Heat

The No. 12 Hoffman Blast Trap is especially adapted for draining condensation from the following types of steam appliances:



No. 12 Hoffman Blast Trap

Indirect Radiators	Dryers and Drums
Blast or "Vento" Stacks	Hot-Water Generators
Ends of Steam Mains and Risers	Unit Heaters, etc.

Where the operating pressure is not in excess of 30 lb.

In functioning this trap distinguishes between steam, heated air and water of condensation giving free discharge of air and condensation.

The Trap embodies the desirable feature of open bucket or float traps because it relieves condensation immediately upon its arrival at the trap regardless of the water temperature. Coupled with the float is a thermostatic member which positively overcomes the chief difficulty with float traps by automatically relieving air as well as condensation from the system.

Normally the vent port is open and remains open until steam reaches the thermostat when closure takes place. If small quantities of condensation flow to the trap, the thermostat opens and discharges the water but if large amounts of condensation, beyond the capacity of the thermostat accumulate, the float lifts the thermostat from its seat and maximum discharge capacity is obtained.

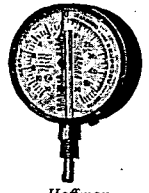
Table of Nominal Capacities No. 12 Hoffman Blast Trap

Pressure, lbs. per sq. in.	½	1	2	3	4	5
Capacity, lbs. per hr.	800	1,000	1,500	1,800	2,000	2,500
Capacity in sq. ft. of radiation on the basis of ¼ lb. of condensation per hr. per sq. ft.	3,200	4,000	6,000	7,200	8,000	10,000

Maximum Operating Pressure, 30 lb. Capacities for over 5 lb. pressure, furnished on application. With Strainer; inlet connection, 1 in.; outlet, 1 in. Without Strainer; inlet connection, 1¼ in.; outlet, 1 in.

HOFFMAN THER-KOMPO-GAGE

Measures pressure up to 30 lb., vacuum to 30 in., and temperature to 225 deg. Pressure is registered in ounces up to 5 lb. Vacuum is shown in half inches up to 10 in.



Hoffman Ther-Kompo-Gage

Temperature of steam or vapor being generated in the boiler is indicated on the thermometer.

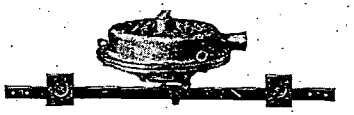
Used in Hoffman "Controlled Heat" installations or in one-pipe gravity vacuum systems equipped with No. 2 valves; indicates efficiency of the apparatus when a warm house is maintained with vapor at a temperature considerably below 212 deg.

THE HOFFMAN VALVE LOCK

Hoffman Valve Lock

Prevents theft of No. 1 and No. 2 valves in public buildings, etc. No extra tapping is required as lock is easily applied when valve is inserted in radiator. By using set screws, valve is locked in position and can only be removed by a special key.

Write for Descriptive Circular—Hoffman Controlled Heat



Hoffman Damper Regulator

One of the most important features of the Hoffman Damper Regulator is the accurate control of the dampers so that only sufficient pressure is maintained at the boiler to insure adequate circulation to all radiators.

It is extremely sensitive in its action and accomplishes control so efficiently that when radiator inlet valves are opened or closed, the fire is accelerated or retarded to meet the change in demand for vapor.

The compensating or balancing plate is like a pair of scales. It is practically frictionless, remarkably sensitive and operates on slight changes in pressure.

It has an additional feature for the convenience of the installing fitter, in that the fulcrum on which the lever is suspended may be turned at different angles, permitting a straight chain connection with the dampers instead of at an angle, which might cause the dampers to bind.

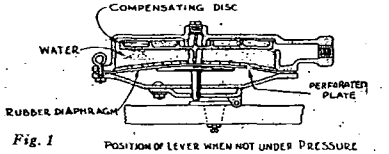


Fig. 1

Fig. 1 shows Damper Regulator under no pressure. Compensating plate is in its uppermost position, the bottom of the plate being in line with bottom of inlet. The space above diaphragm is filled with water up to the inlet. Weights on lever are to be so placed that they will hold the diaphragm against the perforated plate. Drafts are held open until the predetermined pressure is generated, when through diaphragm action which in turn is transmitted to the lever, drafts are closed.

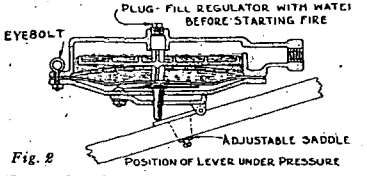
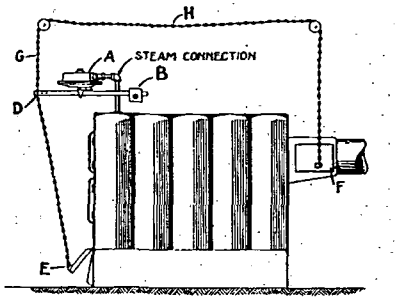


Fig. 2

Fig. 2 shows position of Damper Regulator when drafts are closed. Vapor pressure has overcome upward force exerted by the weights on lever arm and forced diaphragm downward. The water on the diaphragm lowers with it and likewise the compensating plate until top of the plate is level with the bottom of the inlet, thus preventing any addition to the water above the diaphragm. With a slight drop in vapor the weights force the diaphragm upward and drafts are opened.



IN MAKING steam connection to boiler, locate Damper Regulator so that chain to "E" and "F" operate freely. Regulator should be set level. Remove plug on top of Regulator and fill with water.

With no pressure on boiler and weight "B" in position on lever, connect chain between "D" and "E" so that draft "E" will be open as wide as required for sufficient draft. Connect "G" over pulleys to "F" leaving just enough slack to chain "G" so check draft "F" is closed.

Set weight "B" so lever "D" tilts when steam is raised to pressure to be maintained. If pressure increases, draft "E" will close and check fire. If fire is clean and pressure continues to increase, lever "D" moves downward, opening check draft "F," completely checking fire. As pressure decreases, "F" will *gradually* close and if pressure falls below the desired amount "E" will open.

Connections should be made so that draft "E" opens slightly and check draft "F" opens wide.

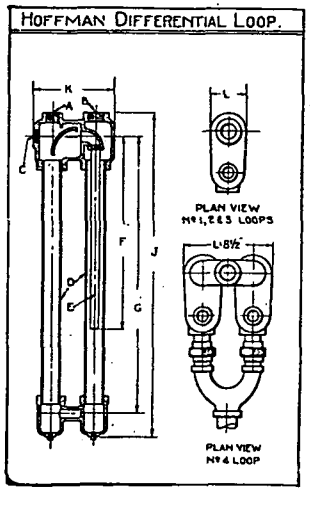
Write for Descriptive Circular—Hoffman Controlled Heat

Hoffman Differential Loop

Hoffman Differential Loop

The Differential Loop is the safety device for maintaining a steady water line in vapor and vapor vacuum systems. It is entirely automatic, non-adjustable and has no moving parts to stick at a critical moment.

In operation the water rises in the return main **only** to a certain predetermined height. The loop then functions, blowing over a small quantity of steam which closes the No. 10 or 11 Valve used for venting the system and then compresses the air which is "bottled up" in the return main and builds up a pressure which prevents further rise of water in the vertical part of the return beyond the predetermined amount. As soon as this is accomplished, and the action is almost instantaneous, the loop reseals and no more steam is blown over until the differential pressure is lost. It will be readily seen that, by the alternate blowing over and resealing of the loop, a constant differential pressure will be maintained between the steam main and return main. Also by the maintenance of this differential no matter how high the boiler pressure goes, circulation will start in a radiator as soon as the inlet valve is opened even though the return main vent is closed through loop action.



Standard Differential Loops are made in four sizes, to handle systems up to 15,000 sq. ft. of radiation. For larger systems the No. 4 Loops can be installed in a battery.

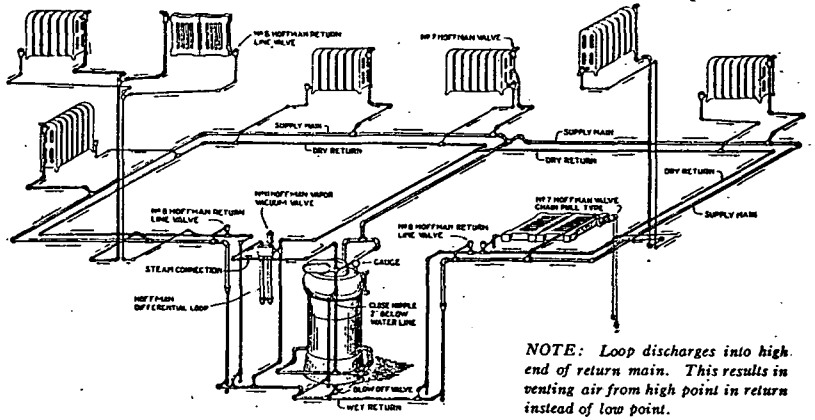
No. 1 and No. 2 Loops should not be used where the low point in the dry return is less than 24 in. above boiler water line; with the No. 3 and No. 4 Loops this distance must be at least 30 in.

DIMENSIONS AND CAPACITIES OF HOFFMAN DIFFERENTIAL LOOPS

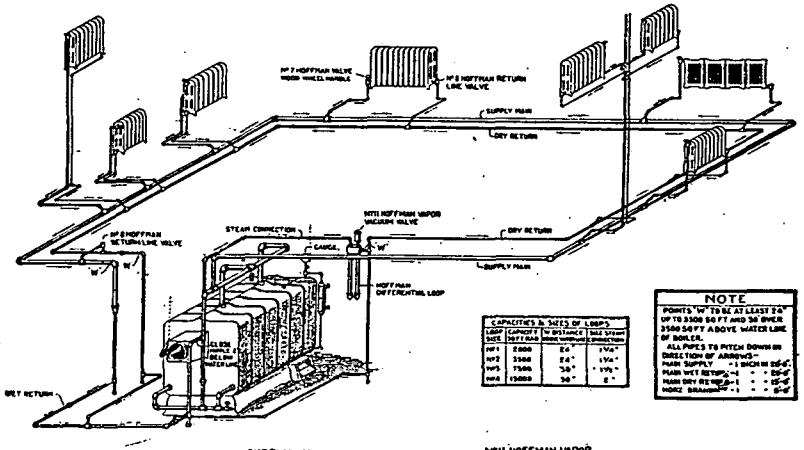
Loop No.	A	B	C	D	E	F	G	J	K	L	Capacity Sq. Ft. Rad.
1	¾"	1¼"	1¼"	1½"	½"	18¼"	26"	30⅝"	7⅝"	3"	2000
2	¾"	1¼"	1¼"	1½"	¾"	18¼"	26"	30⅝"	7⅝"	3"	3500
3	¾"	1½"	1½"	2"	1"	25"	32"	37¾"	10"	3¾"	7500
4	¾"	2"	2"	2"	1"	25"	32"	37¾"	10"	8½"	15,000

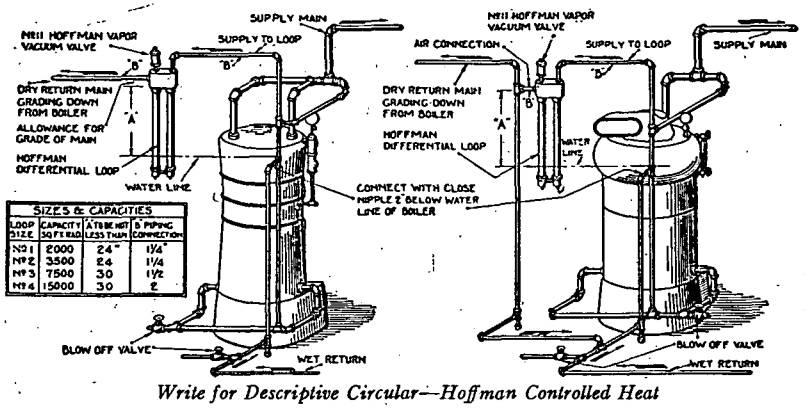
Write for Descriptive Circular—Hoffman Controlled Heat

TYPICAL INSTALLATIONS HOFFMAN "CONTROLLED HEAT" EQUIPMENT



NOTE: Loop discharges into high end of return main. This results in venting air from high point in return instead of low point.





Write for Descriptive Circular—Hoffman Controlled Heat

William S. Haines & Company

12th and Buttonwood Sts., **Philadelphia, Pa.**

Manufacturers of Equipment for Vapor and Vacuum Heating Systems

Haines Vento Thermostatic Trap.

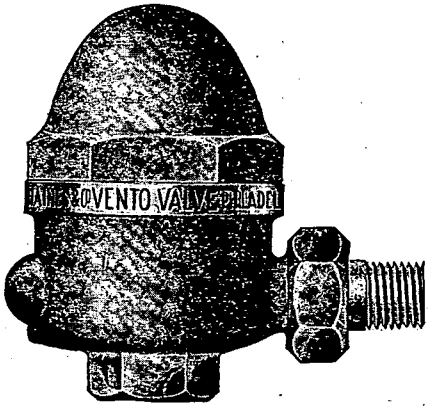
Haines Medium Pressure Thermostatic Trap.

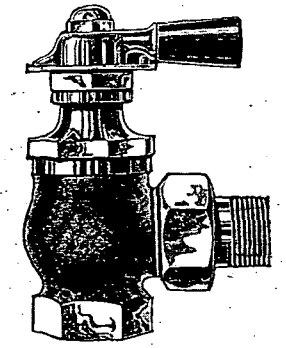
Haines High Pressure Thermostatic Trap.

Haines Float and Thermostatic Blast Trap.

Haines Vent Trap.

Haines Modulating Valve.





HAINES traps pass all of the air and the water of condensation without permitting the escape of steam.

The HAINES trap is operated by a spring tempered bourdon tube in which a volatile liquid is hermetically sealed. The thermostatic member is mounted outboard the valve seat closing the valve piece against the flow of steam. A variation of 1 deg. fahr. is sufficient to open or close the valve. Due to the horizontal seat and the placing of the thermostat in the return line HAINES traps do not become inoperative from scale, or other foreign matter and they cannot freeze.

HAINES thermostatic traps are made in sizes from ½ to 1½ in.

Every trap is factory tested and adjusted before shipment.

They are suitable for pressures from below atmosphere to 100 lb. per square inch.

HAINES modulating valves never need repacking. They seat tightly and open on less than a full turn of the lever or wheel handle.

Made in sizes from ½ to 2 in. in angle, globe, or corner pattern.

HAINES VENTO TRAPS

No. of Trap	Center to Inlet	Center to Outlet	Capacity Sq. Ft.
1	2⅞"	1¼"	125
2	3¼"	1⅝"	200
2E	3⅜"	1⅝"	250
3	3⅝"	1⅝"	400
3E	3⅞"	1⅝"	500

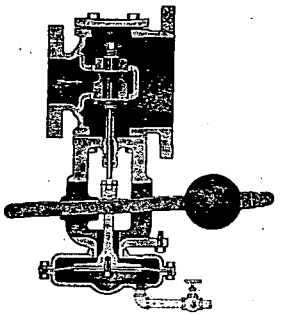
HAINES MODULATING VALVES

Size of Valve	Center to Inlet	Center to Outlet
½"	1⅜"	2½"
¾"	1½"	2⅝"
1"	1⅝"	3"
1¼"	1⅞"	3⅝"
1½"	2⅛"	4¼"
2"	2⅝"	4⅝"

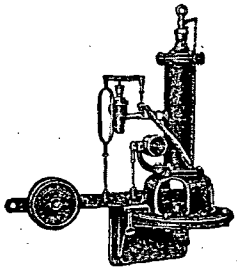
Kieley & Mueller, Inc.

Manufacturers of Specialties for Steam, Water, Air, Oil and Gas

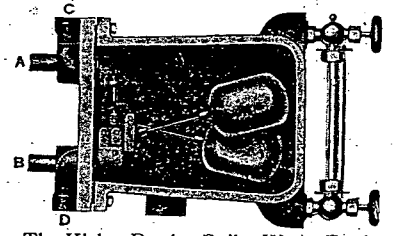
34 West 13th Street **Agents in all Principal Cities** **New York City**



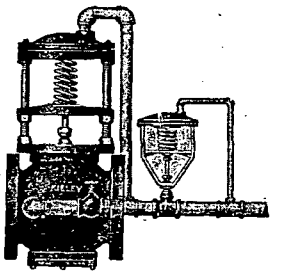
The Kieley Special 98 Reducing Valve is suitable for reducing steam for Vapor and Vacuum Heating. This valve will reduce 100 lb. pressure to a range of 0 to 15 lbs.



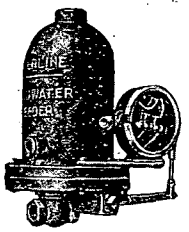
The Climax Junior Damper Regulator is hydraulically operated, and suitable for low pressure heating systems operating from 0 to 15 lbs. This regulator will function on pressure changes of less than ¼ of a lb.



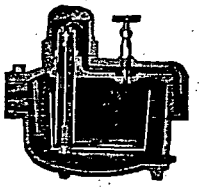
The Kieley Duplex Boiler Water Feeder is a safeguard against boiler damage and flooding, due to uncontrolled water feed. Made in sizes ¾ to 1 in.



Kieley Auxiliary Operated Regulating Valve is suitable for reducing high pressure steam to atmospheric pressure. The Pilot Control operates the main valve on pressure fluctuations of less than ¼ lb.



This Rapid Direct to Boiler Water Feeder is furnished when required with an electric cut-out switch, and is readily adaptable for oil burning boilers. Made in sizes ¾ to 2 in. Maximum water pressure 100 lb.



Steam Traps suitable for all purposes and pressures. Bucket type for high pressure service, and Ball Float type for low pressure suitable for drying kilns and blast coils.

Other Specialties Mfg.

Other Specialties—Return Traps, Air Traps, Temperature Controllers, Oil Separators, Steam Separators, Strainers, Pump Governors, Water Columns and Balanced Valves.

Illinois Engineering Company

General Offices and Factory: CHICAGO

Branches and Representatives

Atlanta					
Baltimore	Dallas	Kansas City	New York City	Providence	Seattle
Boston	Denver	Los Angeles	Oklahoma City	Richmond (Va.)	Shreveport
Buffalo	Detroit	Memphis	Omaha	Rochester	South Bend
Cedar Rapids	Grand Rapids	Milwaukee	Peoria	St. Louis	Spokane
Cincinnati	Harrisburg	Minneapolis	Philadelphia	St. Petersburg	Toledo
Cleveland	Houston	Montreal	Pittsburgh	San Francisco	Toronto
Columbus	Indianapolis	New Orleans	Portland	Scranton	Youngstown

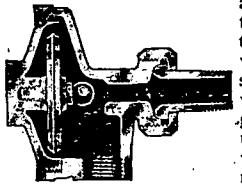
PRODUCTS—Illinois Heating Systems—Eclipse Steam Specialties

Illinois Heating Systems

Successfully installed in thousands of buildings—the result of over 25 years of special work in this line, and the ultimate in efficiency and economy.

Illinois Thermo Trap

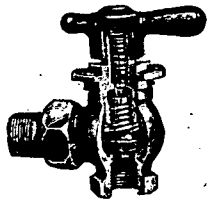
The original vertical seat trap. Dirt does not lie on seat—self cleaning, non-adjustable, positive in operation; durable, will stand 50 lb. steam pressure which shows the great strength of the diaphragm, which is the reason for the long life and durability of these Traps. Thousands in operation for over 15 years without diaphragm replacements.



Thermo Trap

Illinois Modulating Supply Valve

Quick Opening—only a half turn of handle from open to closed position. Packless, Bakelite handle, steam tight on 50 lbs. pressure. Large diameter of thread spool and machine cut threads make valve easy of operation.



Modulating Valve

The improved Bakelite handle insulates the hand from heat.

The graduated dial shows the open or closed or any position of the valve.

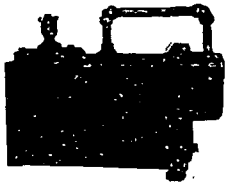
Furnished with Lock Shield and Key, or with Bakelite Wheel handle, upon order.

Illinois Vapor Systems

Illinois Vapor Systems are capable of operating automatically on any pressures possible in a low pressure heating system—from 10 lb. to 20 in. of vacuum. Our improved equipment actually insures operation under vapor—less than atmospheric pressure—with only two or three firing periods per 24 hrs. The advantages are healthful, modulated heat, and a *fuel saving of 25-30 per cent* over other systems of heating. This result is secured by the ILLINOIS HEAT RETAINOR—Browne Patent, a device which marks an epoch in the heating art.

Illinois Heat Retainor

This improved device not only vents air from the System on ⅛ oz. pressure, but it absolutely prevents air pulling back into the System, thus allowing the System to remain under vacuum for hours at a time.



Illinois Heat Retainor

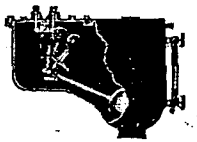
No dirt or scale can reach the valve of the Retainor, and even the air passing through same is washed, so this device will remain in operative condition over long periods.

Our Bulletin No. 22, describes the operation in detail—Copy sent upon request.

Illinois Return Trap or Alternating Receiver

This device automatically puts the water back in the boiler against any boiler pressure possible in a low pressure heating system.

The float trips the weights which in turn positively operate the valves. The operation is forceful and positive and this mechanism cannot be caught on dead centre by water half filling the tank. No external parts to be adjusted or tampered with. No stuffing boxes—all working parts enclosed in the tank.



Illinois Return Trap

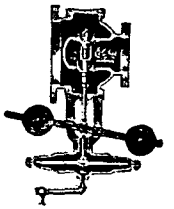
Our Sales-Engineering Organization will be glad to give detailed technical information regarding our products and to advise as to their proper installation.

ILLINOIS PRODUCTS—Eclipse Steam Specialties

Eclipse Steam Specialties

The old John Davis Co. Eclipse Steam Specialties have been on the market for over 40 years, and embody the improvements and refinements suggested by this long period of service. These Specialties are quality products, having bronze and monel metal pistons, seat rings and valve parts, the bodies are extra heavy, and every piece of apparatus is carefully steam tested—under working pressure where same is given—before shipment.

Pressure Reducing Valves, for all pressures and services.
Back Pressure, and *Atmospheric Relief Valves.*
Separators, Oil and *Steam, Cast Iron* and *Steel.*
Steam Traps, all pressures.
Non-Return or *Stop* and *Check Valves.*
Pump Governors, Balanced Valves.
Float Valves, Expansion Joints, Pipe Strainers.



Reducing Valve

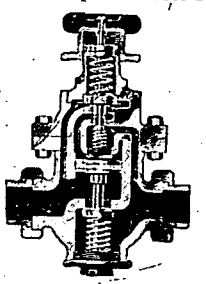
Reducing Valves. In general use on Vacuum or low pressure Heating Systems. Will reduce to 4 oz. pressure from even 150 lb. initial pressure.

The large diaphragm insures sensitive operation.

Made in both straight-way and expanded outlet bodies.

Sizes ¾ in. to 12 in.

Eclipse Master Reducing Valve

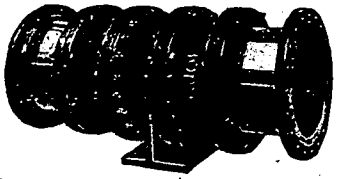


A pilot type valve will reduce from any pressure up to 250 lb. down to 10 lb. and hold reduced pressure constant at all times—even against a "dead end" pipe.

Made of Bronze with monel valves and trimmings.

Sizes ½ in. to 6 in.

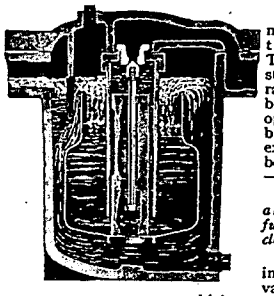
Illinois Expansion Joints - Single and Double Traverse



Heavy duty joints, the liners are cast bronze—not brass tubing. The bolts are through bolts, no stud bolts used.

Tapped for service connections in anchor section if desired.

Eclipse Steam Trap



Something new in Steam trap design. The valve and stem are separate from the bucket and only operated by the bucket at its extreme top and bottom travel

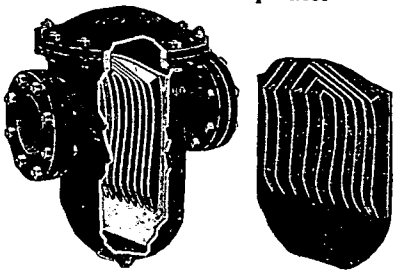
—Result—

Valve is always either full open or tight closed.

No wire drawing or cutting of valve and seat, which are of Monel metal. Steam tight and long lasting.

Bulletin No. 33 describes in detail.

Horizontal Oil Separator

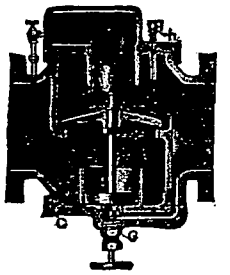


These Separators have a baffle removable without disturbing the piping. Occasional cleaning is necessary for proper elimination of oil.

The port areas are over 3 times the diameter of the pipe area, hence these separators are effective.

Eclipse Back Pressure and Combination Relief Valves

Made in Vertical and Horizontal types, straight-way or angle pattern, for condensing and non-condensing engines.



It is noiseless and works equally well on pressure or vacuum, air cushioned by back pressure in dashpot. Constructed entirely of metal with no springs; wearing parts of special bronze.

Size 4 in. to 36 in.

Catalog and Bulletins—Illinois Heating Systems—144 pages

BULLETINS

No. 14—Heating Specialties.
No. 22—Vapor System Details.
No. 45—Non-Return Valves
No. 103—Pressure Reducing Valves.
No. 203—Back Pressure, and Relief Valves, Exhaust Heads.
No. 33—Steam Traps.
No. 53—Separators—Oil and Steam.
No. 203—Float and Balanced Valves.

TRADE MARK KELLY

Complete Satisfaction

Kelly Brass Works

226 West Ontario Street

Chicago, Ill.

TRADE MARK KELLY

Scientific Construction

"Kelly" Valves are made especially for steam-heating service and have many features which recommend their use by the engineer, architect and heating contractor.

The interior construction of "Kelly" Air Valves are identical. The float shown in the sectional views is sealed with a phosphor bronze diaphragm at the bottom. A definite amount of volatile liquid is placed in the float before sealing which vaporizes from the heat of the steam causing the diaphragm to expand and raise the float thereby closing the escape port in the top of the valve.

No adjustment is required. They will operate under all pressures venting the radiator of the accumulated air and closing against steam and water. Any water of condensation in the valve will be drained back to the radiator through the syphon tube.

The outer shell of the valve is threaded into a cast brass base and the valves are substantially constructed and are all GUARANTEED FOR FIVE YEARS.

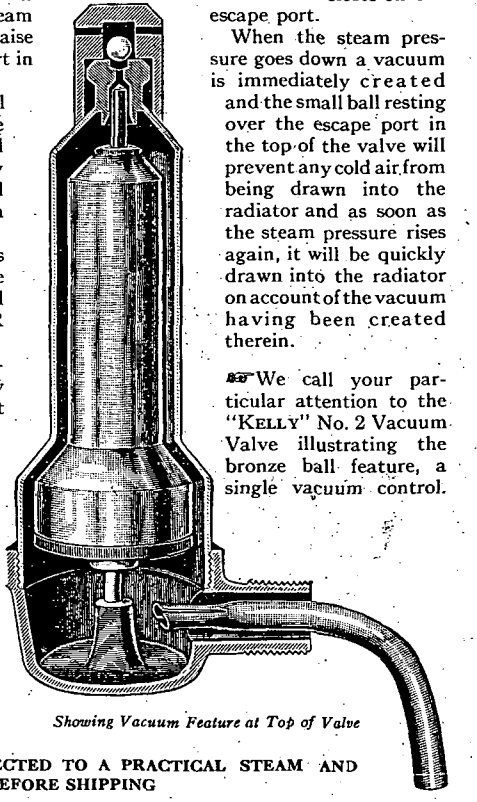
All "Kelly" Air Valves are so constructed that no one can possibly tamper with them and prevent perfect operation under all conditions.

"Kelly" Air Valves are made in four styles. The No. 1 is made with a ⅛ in. side connection and the No. 3 is made with a ¼ in. bottom connection. The No. 2 and No. 4 are identical in construction as the No. 1 and No. 3, the only difference that they are made with a vacuum top.

The sectional view shows the vacuum feature at the top of the valve. The small bronze ball is loosely encased at the top, resting over the escape port in the top of the valve. When the steam is turned on in the radiator the slightest pressure will raise the ball permitting the escape of all the air until the steam begins to enter the valve causing the volatile liquid in the float to expand the diaphragm which raises the float and forces the float pin against the seat and closes off the escape port.

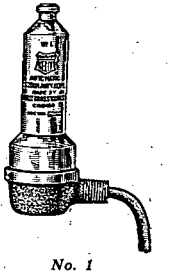
When the steam pressure goes down a vacuum is immediately created and the small ball resting over the escape port in the top of the valve will prevent any cold air from being drawn into the radiator and as soon as the steam pressure rises again, it will be quickly drawn into the radiator on account of the vacuum having been created therein.

☞We call your particular attention to the "KELLY" No. 2 Vacuum Valve illustrating the bronze ball feature, a single vacuum control.



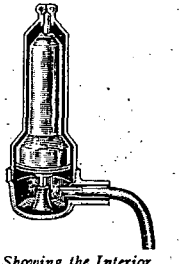
Showing Vacuum Feature at Top of Valve

☞EVERY "KELLY" VALVE IS SUBJECTED TO A PRACTICAL STEAM AND VACUUM TEST BEFORE SHIPPING



No. 1
Made with ⅛ in. Pipe Thread Connection
List Price $1.50

No. 3
Made with ¼ in. Pipe Thread Connection
List Price $1.75



Showing the Interior of the Valve

"KELLY"

Syphon Non-Adjustable Steam, Air and Vacuum

VALVES

For years we have said that when better Automatic Air Valves are made they will bear the name of the Kelly Brass Works. This is entirely true. The models of the "Kelly" Syphon Non-adjustable Automatic Steam Air and Vacuum Valves shown are the most effective valves we have ever designed and manufactured.

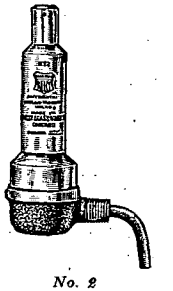
Always striving for simplification, we have been able to make a remarkable valve, reducing the number of parts to a minimum and making them of the best material obtainable. Then we entirely eliminated the adjustments that have proven superfluous.

"Kelly" Air Valves are manufactured —not merely assembled. They cannot be tampered with. There are no adjustments to be made. Each valve is scientifically constructed, carefully tested, tried and sealed. The result is, that there is nothing to get out of order. This means long life and satisfactory service to the user.

Complete Satisfaction

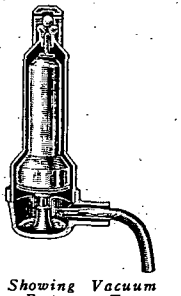
TRADE MARK KELLY

Scientific Construction



No. 2
Made with ⅛ in. Pipe Thread Connection
List Price $2.50

No. 4
Made with ¼ in. Pipe Thread Connection
List Price $2.75



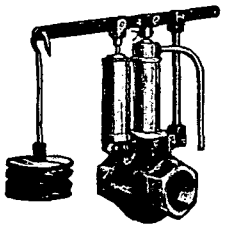
Showing Vacuum Feature at Top of Valve

Klipfel Manufacturing Co.

2641-2659 West Harrison Street

Chicago, Ill.

Manufacturers of Automatic Valve Specialties



No. 1 Pressure Regulator, Piston Type

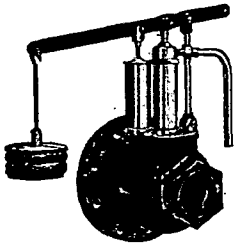
Sizes: ⅜ to 14 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends but screwed ends will be furnished unless otherwise specified; sizes 7 in. and above, flanged ends, only.

Nos. 1 and 2 Pressure Regulators

Piston Type

Automatically reduce any initial steam, air or water pressure to any desired reduced pressure down to 2 lb. and maintain reduced pressure constantly regardless of fluctuations in initial pressure, or changes in the demand for steam. Working parts removable while valve remains in pipe line.

No. 2 Pressure Regulator, Piston Type, Expanded Outlet—Similar to No. 1 Regulator except have expanded outlet, allowing use of low pressure pipe of larger size than high pressure supply pipe.



No. 2 Pressure Regulator, Piston Type, Expanded Outlet

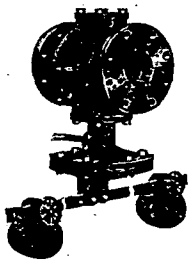
Sizes: 1 x 2 to 12 x 24 in., inclusive. Bronze bodies, screwed ends only in sizes 1¼ x 2½ in. and under. Iron bodies with bronze inner valves and trimmings in sizes above. Unless otherwise specified, Nos. 2 and 4 will be shipped with inlet screwed and outlet flanged in sizes 1½ x 3 to 4 x 6 in., inclusive, although they can be furnished with other style ends; sizes 4 x 8 in. and above, both ends flanged, only.

Nos. 3 and 4 Pressure Regulators

Diaphragm Type

Automatically reduce any initial steam pressure to any desired reduced pressure, either below atmosphere or up to 10 lb. above atmosphere, and constantly maintain reduced pressure regardless of initial pressure fluctuations or changes in the demand for steam.

No. 4 Pressure Regulators, Diaphragm Type, Expanded Outlet—Similar to No. 3, except have expanded outlet. Sizes, same as No. 2 Pressure Regulator.



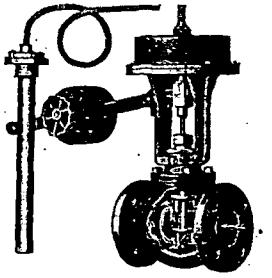
No. 3 Pressure Regulator, Diaphragm Type

Sizes, same as No. 1 Pressure Regulator, Piston Type.

No. 48 Vapor Thermostats

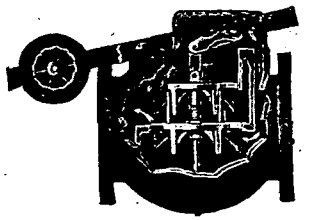
Automatically maintain hot water in steam heated tanks at any desired temperature between 140 and 180 deg., but can be made special for other temperatures at an extra price. The sensitive all-metal bellows will move the inner valve farther on a given temperature-pressure change than any competing bellows of the same diameter and length.

No. 49 (Spring Type) is made in sizes ½ to 2½ in., inclusive, for use where space does not permit the use of the frictionless roller bearing lever with weight.



No. 48 Vapor Thermostat

Sizes: ½ to 8 in., inclusive. Bronze bodies in sizes 1½ in. and under, union connections only. Iron bodies in sizes 2 in. and above, flanged ends only.

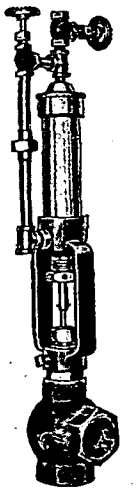


No. 28 Noiseless Back Pressure Valve

Sizes: 2 to 24 in., inclusive. All sizes made flanged ends; sizes 2 to 8 in., inclusive, also made screwed ends. Unless otherwise specified, sizes 6 in. and under will be shipped screwed ends; sizes 8 in. and above, flanged ends.

No. 28 Noiseless Back Pressure Valves

Automatically and noiselessly maintain any desired back pressure on exhausts of non-condensing engines. Because of the patented construction, inner valve is effectively stabilized and cannot pulsate in unison with the stroke of the engine. Operative in either horizontal or vertical positions. Iron bodies, bronze inner valves and trimmings. Preferable installation is in horizontal pipe line.

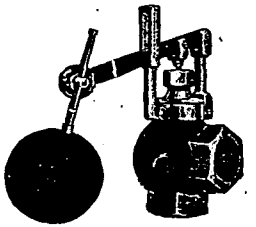


No. 25 Improved Pump Governor

No. 25 Improved Pump Governors

Automatically control any type of steam pump and maintain discharge at constant pressure. Simple; direct acting; bronze semi-balanced taper seated inner valves and seats; Monel metal stems.

Sizes: ⅜ to 12 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless ordered flanged; sizes 7 in. and above, flanged ends, only. Made angle and globe patterns in all sizes, and for any steam or water pressure. Angle pattern will be shipped unless globe is specified.



No. 6 Balanced Float Valve

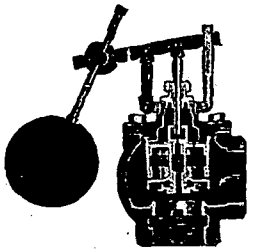
Sizes: ⅜ to 20 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; sizes 7 in. and above, flanged ends, only. All sizes 14 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 16 in. and above made globe patterns, only.

No. 6 Balanced Float Valves

Automatically control the supply of hot or cold water to open tanks and maintain practically constant water level. Angle and globe patterns, with seamless copper float, for working pressures up to 200 lb. Swivel guide yoke can be turned to any position.

No. 7 Single Seated Float Valves

Automatically maintain a constant level of hot or cold water in open tanks. Single seated, auxiliary operated. Seat area equal to pipe size. Will not leak. Swivel guide yoke allows float to be turned to any position. Angle and globe patterns for working pressures up to 200 lb. All working parts of bronze.



No. 7 Single Seated Float Valve

Sizes: ¾ to 12 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; size 8 in., flanged ends only. Sizes 8 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 10 and 12 in. made to order, flanged ends, globe pattern only.

Our 80 page Catalog No. 26 with new sectional illustrations, roughing-in dimensions and valuable engineering data is ready for distribution.

Write for your Copy—TODAY!

Jas. P. Marsh & Company

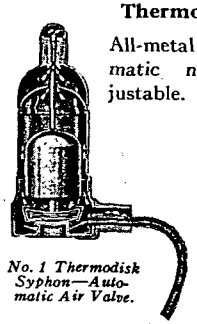
Established 1865

114-124 S. Clinton St. - CHICAGO, ILL.

SALES AGENCIES IN MOST PRINCIPAL CITIES

Thermodisk

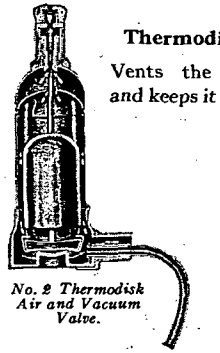
All-metal Automatic non-adjustable.



No. 1 Thermodisk Syphon—Automatic Air Valve.

Thermodisk

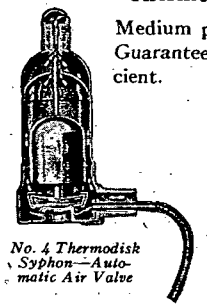
Vents the air and keeps it out.



No. 2 Thermodisk Air and Vacuum Valve.

Thermodisk

Medium priced. Guaranteed efficient.

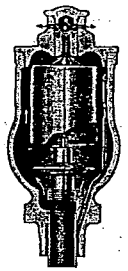


No. 4 Thermodisk Syphon—Automatic Air Valve

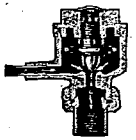
No. 7 Thermodisk Air Eliminator

Free and unlimited vent of all air, hot or cold, cannot water-log, do not spit or leak water, and close instantly for steam or vapor.

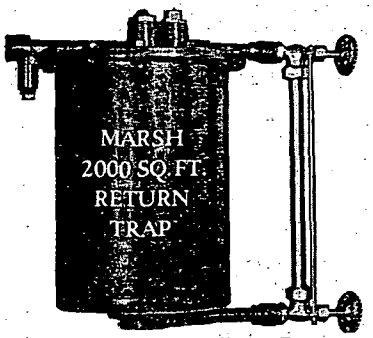
Sizes and capacities for every requirement.



No. 5 Thermodisk Rapid Vent

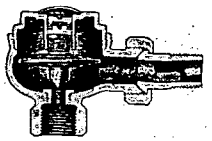


No. 3 Thermodisk Air Line Valve

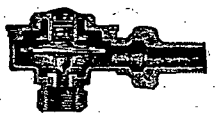


Marsh 2000 Sq. Ft. Boiler Return Trap for returning water of condensation to Boiler. Also furnished in larger sizes

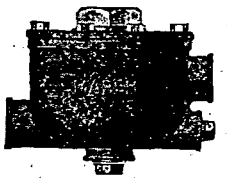
Marsh Reflux Traps for installation on return of radiators of any two-pipe return steam heating system. Also for pipe coils in Refining, Cooking and Drying apparatus.



No. 1 Reflux Trap

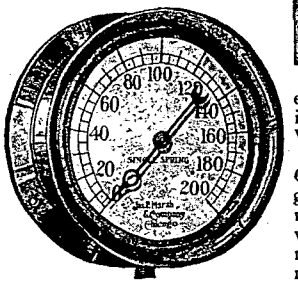


No. 2 Reflux Trap

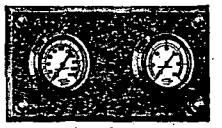


No. 4 Reflux Cast Iron Body Thermostatic Drip Trap

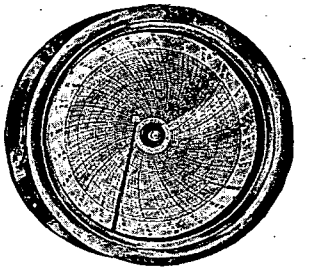
Marsh Indicating Gauge



Marsh Gauge Board



Marsh Recording Gauge

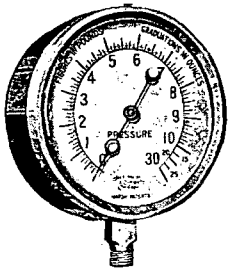


Marsh Gauges for every requirement of indicating Pressure, Vacuum, Altitude, etc.

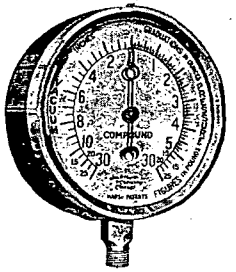
Marsh Recording Gauges where a high grade, accurate instrument is required and where it is desired to match other instruments on Gauge Boards, etc.

We specialize in Gauge Board outfits complete with all instruments.

Low Pressure Ounce Gauge



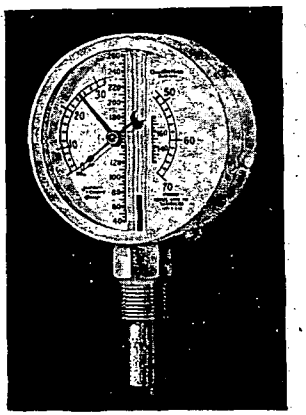
Compound Ounce Gauge



Show exact pressure in ounces and pounds.

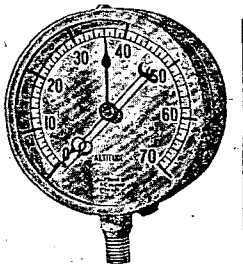
A necessity for the intelligent, economical and proper operation of "Vapor," "Vacuum," "Semi-Vacuum," and "Atmospheric" Heating Systems and for any low pressure boiler.

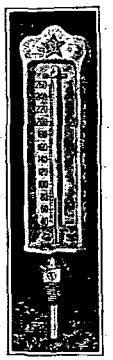
Marsh Ther-Alti-Meter



Combined Altitude Gauge and Hot Water Thermometer. The two indications, altitude and temperature, at a glance. The ideal and logical instrument to specify for any hot water heating boiler.

Marsh Altitude Gauge and Hot Water Thermometer





For any hot water heating boiler where the separate Altitude Gauge and Hot Water Thermometer are preferred.

Architects and Heating Engineers will find illustrated and described a Marsh Gauge, Radiator or Steam Trap, Automatic Air Valve, Vent and Heating Specialty for each service requirement—in literature which we will be pleased to send upon request.

Marine-Galligan Co., Inc.

1830 Ludlow Street

Philadelphia :-: Penna.

Number	M-G PRODUCT
1	⅛ Inch Siphon Air Valve.
2	⅛ Inch Siphon Air and Vacuum Valve.
3	¼ Inch Quick Vent Float Air Valve.
4	⅛ x ¼ Inch Air Line Valve.
5	¾ Inch Vapor Vent Valve.
6	¾ Inch Vapor Vacuum Vent Valve.
7	½ Inch Lever Handle Modulating Radiator Valve.
27	¾ Inch Lever Handle Modulating Radiator Valve.
37	1 Inch Lever Handle Modulating Radiator Valve.
47	1¼ Inch Lever Handle Modulating Radiator Valve.
8	½ Inch Round Handle Packless Radiator Valve.
28	¾ Inch Round Handle Packless Radiator Valve.
38	1 Inch Round Handle Packless Radiator Valve.
48	1¼ Inch Round Handle Packless Radiator Valve.
58	1½ Inch Round Handle Packless Radiator Valve.
68	2 Inch Round Handle Packless Radiator Valve.
9	½ Inch Packless Radiator Gate Valve.
29	¾ Inch Packless Radiator Gate Valve.
39	1 Inch Packless Radiator Gate Valve.
49	1¼ Inch Packless Radiator Gate Valve.
59	1½ Inch Packless Radiator Gate Valve.
10	½ Inch Lock and Shield Packless Valve.
210	¾ Inch Lock and Shield Packless Valve.
310	1 Inch Lock and Shield Packless Valve.
410	1¼ Inch Lock and Shield Packless Valve.
510	1½ Inch Lock and Shield Packless Valve.
610	2 Inch Lock and Shield Packless Valve.
11	½ Inch Thermo Radiator Trap.
12	½ Inch Thermo Radiator Trap.
212	¾ Inch Thermo Radiator Trap.
14	¾ Inch Thermo Drip Trap.
15	¾ Inch Float and Thermo Drip Trap.
215	1 Inch Float and Thermo Drip Trap.
315	1¼ Inch Float and Thermo Drip Trap.
415	1½ Inch Float and Thermo Drip Trap.
515	2 Inch Float and Thermo Drip Trap.
16	5 Inch Diameter Retard Compound Gauge.
216	8 Inch Diameter Retard Compound Gauge.
17	10 Inch Vapor Damper Regulator.
18	1000 Square Feet Capacity Alternator.
218	3000 Square Feet Capacity Alternator.
318	6000 Square Feet Capacity Alternator.
19	1800 Square Feet Capacity Direct Return Trap.
219	3600 Square Feet Capacity Direct Return Trap.
319	6000 Square Feet Capacity Direct Return Trap.
419	9000 Square Feet Capacity Direct Return Trap.
20	Duplex Water Feeders.
101	M-G Boiler Cleaning Compound per pound
102	M-G Boiler Mending Liquid per quart

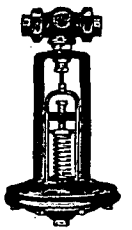
Mason Regulator Company

Boston, Mass.

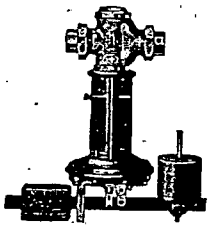
San Francisco, Calif. Montreal, Canada

Manufacturers of

Pressure Regulators and Steam Specialites

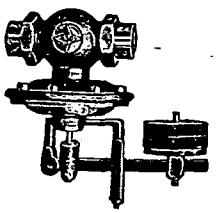


No. 229, Spring Type
Sizes ½"–1¼"



No. 21, Lever Type
Sizes 8"–16"

PRESSURE REDUCING VALVES FOR HEATING SYSTEMS

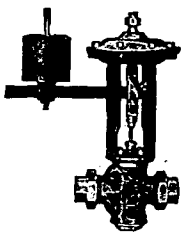


Vacuum Regulating Valve
Sizes ½"–4"

For regulating the amount of vacuum on separate branches of a main vacuum system.

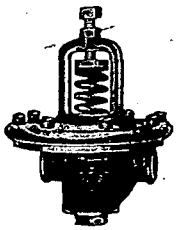
The new **Mason** Reducing Valves for heating systems are rapidly attaining the same popularity as the well known **Mason** high pressure reducing valves so widely used industrially.

These valves are up to the **Mason** standard of quality but are exceedingly moderate in price. For economy as well as lasting satisfaction it is very much to your advantage to specify **Mason.**



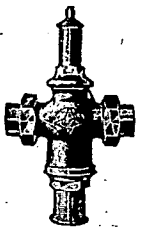
Vacuum Pump Regulators
Sizes ½"–4"

For regulating the supply of steam to the requirements of a steam driven vacuum pump and thereby automatically maintaining a uniform vacuum on the system.



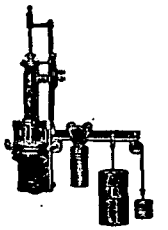
Household Water Pressure Regulator
Sizes ½"–1"

Designed for domestic service where the city water pressure is too great for economical house use. Eliminates noise in bathroom fixtures, leaking faucets and splashing in bowls and tubs.



Standard Reducing Valve
Sizes ½"–8"

For High Pressure Service.



Damper Regulator

Made in various sizes for handling damper equipment on both high and low pressure boilers, operating on forced, induced, or natural draft.

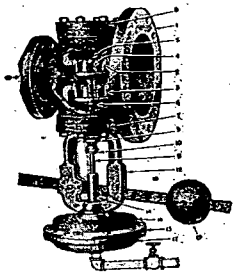
CATALOG—Write for Pocket Catalog and Handbook No. 62. It contains complete information about these and other **Mason** Regulators.

The McAlear Mfg. Co.

1901-1907 So. Western Avenue **CHICAGO**

Power and Heating Specialties for Controlling Pressures and Flow of Steam, Water, Air or Gas

PRESSURE REDUCING VALVES—used in Low Pressure, Vacuum or Vapor heating systems or any other service where close regulation and control are required.



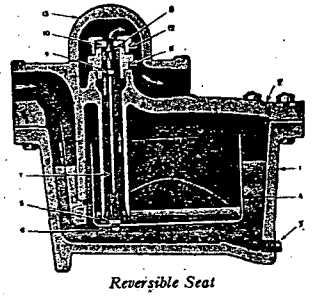
USE

Fig. 155 for initial pressures up to 150 lb. and reducing to service pressures 0-10 lb.

Fig. 185 Single Seated Valves on dead end service where reduced pressure is below 10 lb.

Fig. 235 Spring Weighted type for initial pressures up to 200 lb. and reducing to service pressures above 10 lb. Fig. 255 Single Seated Valves for dead end service such as cooking tables, kitchen utensils, laundry mangles, etc.

STEAM TRAPS—For draining water of condensation from any steam apparatus or steam mains.

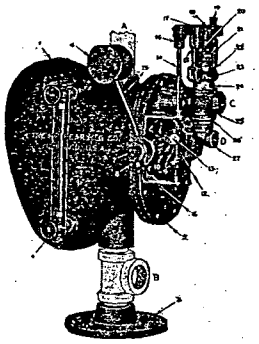


Reversible Seat

SPECIFY

Fig. 685 for pressures up to 250 lb.

Fig. 715 for special low pressures.



No. 781—Low Pressure, up to 15 lbs.

AIR ELIMINATOR AND RETURN TRAPS—Designed for automatically returning water of condensation from low pressure steam or vapor systems direct to boiler and to exhaust the air to atmosphere.

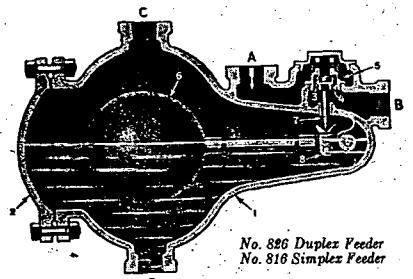
CAPACITIES

Size No.	Inlet In.	Outlet In.	Steam In.	Vent In.	Capacity Sq. Ft.
0	1¼	1¼	1	¼	1000
1	1½	1½	1	¼	2000
2	2	2	1	¼	4000
3	2½	2½	1	¼	6000
4	2½	2½	1	⅜	12,000
5	3	3	1¼	⅜	18,000
6	3	3½	1¼	⅜	24,000

McAlear Direct-to-Boiler Water Feeders

For maintaining constant water line in steam boilers.

McAlear Automatic Water Feeders prevent boiler fractures from low water, decrease fuel consumption and reduce maintenance expense.



No. 886 Duplex Feeder
No. 816 Simplex Feeder

For oil burner installations—Feeders are equipped if desired, with LOW WATER ELECTRIC CUT-OUTS.

The McAlear line of Power, Heating, Gas and Oil Specialties include: Thermostatic Radiator Traps, Packless Radiator Valves, Air Vents, Grease Extractors, Dirt Strainers, Vacuum Pump Governors, Damper Regulators, Back Pressure Valves, Water Regulating Valves, Tank Controllers, Gas Regulating Valves, Liquid Level Controllers and many other devices. General Catalogue No. 28 illustrating our complete line, will be gladly furnished upon request.

Milwaukee Valve Company

"MILVACO" Heating Specialties

Burrell and Chase Streets **Milwaukee, Wis.**

Representatives in all Principal Cities

NEW YORK, N.Y.	NEWARK, N.J.	LOUISVILLE, KY.	HELENA, ARK.	SAN FRANCISCO, CALIF.
WASHINGTON, D.C.	SEATTLE, WASH.	CINCINNATI, OHIO	DULUTH, MINN.	CONNELLSVILLE, PA.
SPOKANE, WASH.	PORTLAND, ORE.	DAYTON, OHIO	KANSAS CITY, MO.	RICHMOND, VA.
READING, PA.	MINNEAPOLIS, MINN.	COLUMBUS, OHIO	BALTIMORE, MD.	BOSTON, MASS.
LOS ANGELES, CALIF.	DETROIT, MICH.	DENVER, COLO.	FORT WORTH, TEXAS	DALLAS, TEXAS
PITTSBURGH, PA.	CLEVELAND, OHIO	ST. LOUIS, MO.	OMAHA, NEBR.	PHILADELPHIA, PA.
CHICAGO, ILL.	WINNIPEG, CANADA	INDIANAPOLIS, IND.	TOLEDO, OHIO	

Packless Valves

NOTE.—In addition to types illustrated, Dole-Milwaukee Packless Valves can be furnished in the following patterns:

Lock and Shield Angle.
Lock and Shield Graduate.
Union Gate.
Union Globe and Right and Left Hand Corner.
Always specify steam or water.
Send for Bulletin No. 24

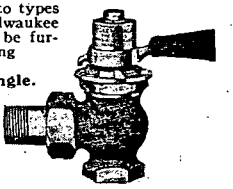


Fig. 209-M
Lever Handle Graduate

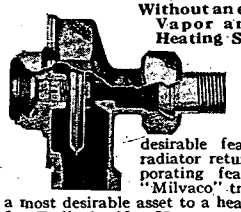
Fig. 215-M
Quick Opening Angle

Fig. 210-M
Knob Handle Graduate

All patterns made in sizes ⅛ to 2 in. inclusive.

Thermostatic Trap

Without an equal for Vacuum, Vapor and Modulating Heating Systems.



Illustrated below is a sectional view showing construction of "Milvaco" Thermostatic Traps. Embodying every desirable feature of successful radiator return traps and incorporating features exclusive in "Milvaco" traps, this product is a most desirable asset to a heating system. **Send for Bulletin No. 23.**

Roughing-in Dimensions and Capacities

Fig. No.	Capacity Sq. Ft. Rad.	Pipe Conn.	A Center Line Outlet to End of Spud	B Face of Outlet to Center of Spud
0	75	½″	2¼″	1⅝″
1	200	½″	3¼″	2″
2	500	¾″	3¼″	2⅛″

NOTE.—The standard roughing-in dimension, "A" for ½ in. traps as adopted by the Heating and Piping Contractors' National Association, is 3¼ in. which standard we adhere to. We can, however, upon special request, supply traps with this dimension any length from 2⅝ to 4 in.

Send for Bulletins showing complete line of specialties.

"Milvaco" Air Eliminator

A heavy substantial float vent for use on heating systems or apparatus where rapid elimination of air is necessary, and where passage of both steam and water must be prevented.

Made in ½ and ¾ in. sizes.

Send for Bulletin No. 26

"Milvaco" Quick Vent

For use at high points on any installation where a large volume of air must be rapidly vented.

A large substantial vent for heavy duty service.

Vents completely at high or low pressures, and the check valve prevents the return of air into the system.

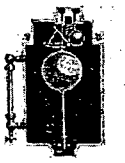
Construction the same as Air Eliminator, eliminating the float.

Made in ½ and ¾ in. sizes.

Send for Bulletin No. 26

"Milvaco" Boiler Return Trap

An ideal trap for use on vapor systems for returning water of condensation to the boiler. Positive in action; noiseless in operation; and mechanism not dependent upon action of springs.



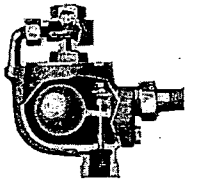
Capacity 4000 sq. ft. direct radiation.

Pipe connection 2 in.

Steam and Vent connections ½ in.

Send for Bulletin No. 25

"Milvaco" Drip Trap



"Milvaco" Drip Traps are a combination float and thermostatic trap which drip any main or riser on any heating system or apparatus where it is necessary to positively eliminate both air and water and close against steam. Not dependent upon temperature for action. Guaranteed to eliminate drip troubles.

Made in ½, ¾ and 1 in. sizes.

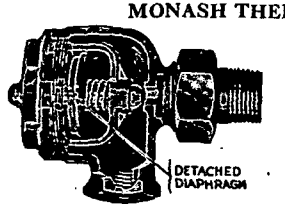
Send for Bulletin No. 27.

Monash-Younker Co., Inc.

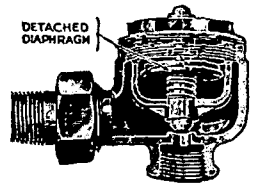
ESTABLISHED 38 YEARS

CHICAGO NEW YORK

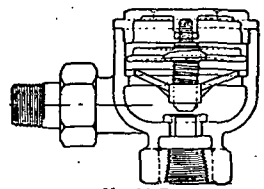
MONASH THERMOSTATIC RETURN LINE TRAPS



No. 35-A-½ in.
Made in Angle only.



No. 35-B-½ in.
Made in Angle, Right, Left and Straightway.



No. 36-B
Made in Angle only.

The working parts or "ELEMENT" of MONASH Thermostatic line of Traps are described on following page.

Designed to overcome the various faults of ordinary return line traps, the MONASH have proven their efficiency in rigid tests in actual operation over a period of *Thirteen Years* in many large buildings.

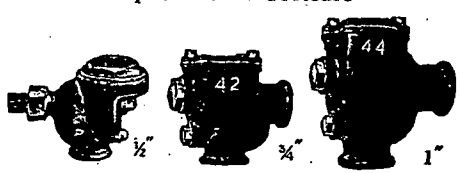
When MONASH Traps are specified the responsibility of the heating engineer ceases because they are *Guaranteed in Writing for Ten Years*—for pressure not to exceed Ten (10) lbs.

The No. 35 Trap can be furnished with either a vertical or horizontal seat as illustrated above.

No. 35 A	or B ½ in.	200 sq. ft. 65 lbs. water per hour
No. 36 B	½ in.	350 sq. ft. 108 lbs. water per hour
No. 36 B	¾ in.	590 sq. ft. 160 lbs. water per hour
No. 36 BX	¾ in.	800 sq. ft. 280 lbs. water per hour

Monash Thermostatic Heavy Duty or Drip Traps for 25 lbs. Pressure

MONASH thermostatic special heavy duty or drip traps are made with **dirt-pocket, clean-out** and **by-pass.** Vertical seat and diaphragm outside the steam chamber. Especially suitable for **blast coils, dry kiln coils, main drips, dryers, laundry machinery** and all points where large quantities of condensation is to be handled.



No.	40	42	44
Size.....inches	½	¾	1.
Sq. Ft. of Radiation.....	350	1500	4000
Water per Hour.....pounds	108	475	1250
Net Weight.....pounds	3.25	5.00	7.50

Monash Guaranteed Automatic Air Valves

No. 1

MONASH No. 1, all metal, non-adjustable automatic air valve in which the base and nipple are in one casting—no soldered or sweated joints to come apart.

MONASH No. 6, four-way-drain, lock-shield, automatic air valve with all working parts above opening to radiator. Self-cleaning; no flooding of floors and other damage.

No. 6

Specify MONASH Valve holder with valve.

Monash Quick Venting Valves

No. 27

For mains and risers the MONASH No. 27 thermostatic quick venting valve is desirable. Has heavy brass body and cover, phosphor bronze thermostatic diaphragm.

Operates automatically at all pressures up to 10 lb.

Insures rapid steam circulation. Closes against steam, but does not close against water.

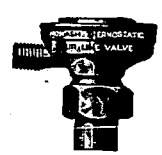
Connections are ⅜ in., 1 lb. net weight.

Monash Thermostatic Air Line Valves

for drip or air line systems; also for venting vento stacks and blast coils.

Is rapid in action and positive in results, passing all air but closing tightly against steam.

Made of brass, white plated; the No. 2 is ⅛x¼ in., the No. 3 is ¼x⅜ in. 1 lb. net weight.



No. 2

A WORD TO HEATING AND VENTILATING ENGINEERS

Obsolete and defective Return Line Radiator Traps can be reconstructed and made BETTER THAN NEW by inserting the MONASH THERMOSTATIC TYPE "C" ELEMENT into the old Trap Bodies.

Have your client send us an old (half-inch) Radiator Trap complete with nut and tail piece attached and if it has a screwed-in seat, we will replace it with *our own* seat and insert our MONASH Thermostatic Type "C" Element into the Trap Body and return it to *your* client for test on consignment, postpaid.

This MONASH Element consists of a Diaphragm, which is the heart of the Trap, and the construction of same is illustrated and described herewith below.

If the Trap, sent us by your client, is one that we cannot reconstruct, then we will gladly furnish a *MONASH Ten Year Guaranteed Trap Complete* with the proper length tail piece so that it will fit into the roughing-in dimensions of the old Trap and no pipe fitting need be done. **This will give you an opportunity to learn first hand all about the virtues of the MONASH Element in the old Trap Body or the MONASH Trap complete.**

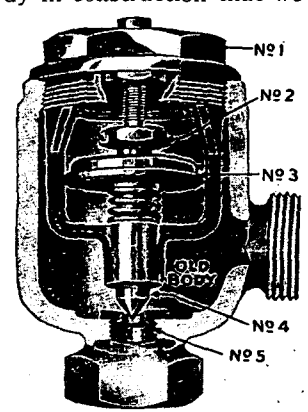
We feel confident that once you know more about the MONASH Product you may want to specify it in your work.

MONASH THERMOSTATIC DIAPHRAGM

This Diaphragm is as sensitive to the various changes of temperature as the most delicate instrument, yet, so sturdy in construction that we do not hesitate to *Guarantee it in Writing for Ten Years.*

Cover (No. 1) is cast in one piece with the guide, which permits the plunger (No. 4) to be in perfect alignment with the seat (No. 5) when closing.

Diaphragm (No. 3), the heart of the Trap, is held securely in place between the adjusting screw (No. 2) and the plunger (No. 4). It is therefore a separate and independent unit not attached to any part of the Trap Body, permitting the Diaphragm to be removed without disturbing the adjustment, as this can be done from the exterior of the Trap.



MONASH Type "C" Element

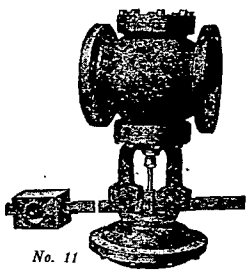
These exclusive features in the MONASH Trap are covered by *United States and Foreign patents.*

Mueller Steam Specialty Co., Inc.

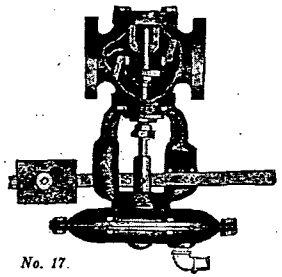
502 West 126th Street "MUESSCO" New York City

Steam, Water, Air, Oil and Gas Specialties for Heating and Power Plants

Pressure Reducing Valves—Straight Pattern and With Increased Outlet



No. 11



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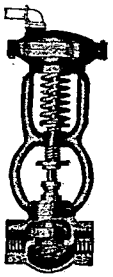
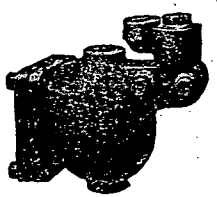


No. 21

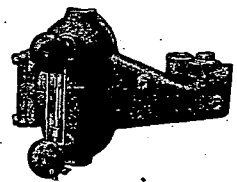
No. 11—For Vacuum, Vapor and Low Pressure Heating Systems. Initial Pressures, up to 200 lb.; Reduced Pressures, 0 to 10 lb.

No. 17 and 21—For automatic control of reduced pressures on dead-end service, requiring a tight closing valve, such as tank heaters, kitchen utensils, sterilizing apparatus, laundry equipment, kettles, cookers, driers, etc. Initial Pressures up to 200 lb. Reduced Pressures 0 to 150 lb.

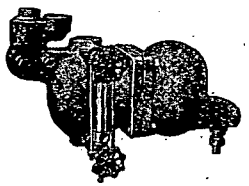
Constructed with full globe bodies. Center guide eliminates the wings on discs, and increases efficiency, assures minimum noise and prolongs the life of the seats and discs. Lever and weight operates on a steel roller bolt, assuring a most sensitive valve. Spring type furnished with special long springs for sensitive operation and wide ranges of reduced pressures.



No. 501 Junior up to 5000 Sq. Ft.

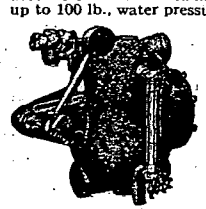


No. 507 Up to 22,500 Sq. Ft.
No. 511 for Industrial Service



No. 517 Duplex up to 22,500 Sq. Ft.

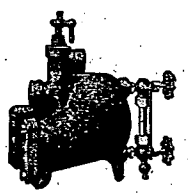
Automatic Water Feeders with a powerful leverage to control the water line in steam boilers, etc. They supply make up water to compensate for evaporation, leaks, steam utilized in process work and condensation wasted. Where condensation held up in the system eventually returns in large quantities, our Duplex type protects the boiler against flooding. All working parts of non-corrosive metal, are accessible without breaking pipe connections. Provided with an integral strainer. For steam pressures up to 100 lb., water pressures up to 120 lb.



No. 315 up to 25 lb. Pressure
No. 317 up to 150 lb. Pressure

Simple, Positive and Compact Air Eliminators and Return Steam Traps for returning the condensation from any type of low or high pressure heating system or apparatus, direct to boiler at high temperatures and discharging the air to the atmosphere.

No.	Inlet	Outlet	Steam	Vent	Sq. Ft. Rad.
1	1	1¼	¾	½	3000
2	1¼	1½	¾	½	6000
3	1½	2	1	¾	8000
4	2	2½	1¼	¾	13,000
5	2½	3	1¼	¾	25,000



No. 219 up to 30 lb. Pressure
No. 221 up to 150 lb. Pressure

Simple, Sturdy and Compact Steam Traps for draining water of condensation from steam apparatus and steam mains.

Powerful compound leverage enables them to take care of large quantities of condensation.

Equipped with strainer, water gages, air cock, blow-off and integral by-pass valve, when desired.

All working parts accessible without disturbing any pipes.

Valves sealed with several inches of water, making the escape of steam impossible.

Made in sizes from ¼ to 3 in.

CATALOGUE and BULLETINS covering our COMPLETE LINE gladly furnished on application.

O-E Specialty Mfg. Co.

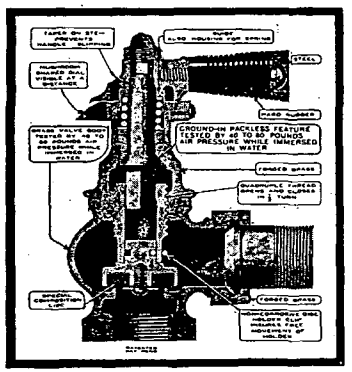
5-7-9 Keefe Ave., MILWAUKEE, WIS.

Packless Graduated Valves, Ball-Check Return Elbows, Thermo-Nickel Return Traps, Air Exhausters, Vacuum Valves, Vacuum Pressure Gages, Differential Return Traps and Balanced Swing Check Valves.

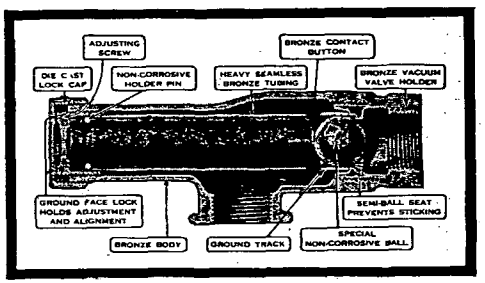
Attention Engineers!

Let us post you on the "O-E" Venturi H.W. Circulation Fitting, and "O-E" H.W. Flow-Control Return Fitting.

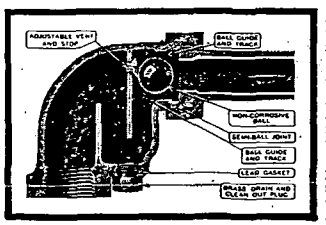
The operation of the **"O-E" Perfect Vapor Vacuum-Pressure System** is very simple: vapor generated at boiler passes up through main supply pipe and is admitted to radiator at top through the "O-E" Packless Graduated Valve. Water of condensation is returned to boiler through a ½-in. "O-E" Elbow. In passing through the Elbow the water is first trapped by means of a wall or diaphragm cast in the Elbow, *outside of the radiator*, making a water seal which holds the vapor in radiator and prevents it from short circuiting into the return main. Should the Supply Valve of radiator be closed and condensation form a vacuum any water that might be in the return pipes is prevented from returning to radiator by the "O-E" Patent Elbow, which is equipped with a small brass ball operating on a smooth guide or track, and so arranged that when a vacuum takes place in radiator ball will immediately roll against port and close it. Elbow is noiseless in operation, as water seal is below ball, which is an important feature. As soon as Supply Valve is again opened ball rolls off of seat allowing condensation and air to pass easily and freely into return main.



The "O-E" Improved Perfect Packless Graduated Valve is *absolutely packless* and never requires packing. It is tested by air and water test before shipment. It is quick opening, little more than one-half turn fully opens or closes it. Sand blasted and nickel plated. The handle being made of hard rubber, will not crack and is always cool and easy to operate. The graduated dial and pointer admit of partial opening so that just the amount of heat desired can be obtained. All valves are fitted with composition disc on a swivel seat without extra charge. Graduated Supply Disc will be attached when specified, at slight additional cost.



An air vent is tapped in the slot of the screw stop in the return elbow which not only allows air to escape freely into return system when Supply Valve is open, but also equalizes the pressure on both sides of Water Seal, thus preventing it from syphoning out, which it might otherwise do. All air and condensation pass through main return pipe in basement to a point above boiler where air is separated from water by means of "O-E" Patent *Air Exhauster* and *Vacuum Valve*.



The "O-E" Perfect Ball-Check Water Seal Union Elbow with Adjustable Air Vent is made in two sizes, ½-in. Capacity 250 sq. ft. ¾-in. Capacity 500 sq. ft.

The "O-E" Improved Air Exhauster and Vacuum Valve is *simple and very sensitive*, operating as follows:

Being connected at a high point above where the return main enters boiler, all air in the system seeks outlet at the Air Exhauster, which is open when there is any air in the system, and as soon as all air is exhausted and heat comes in contact with the Expansion Member in Exhauster, same expands and forces the Special Bronze Ball against the seat, closing the port. When closed system will cool slightly causing a vacuum which will hold ball on seat. As soon as vacuum is lost ball will roll away from seat and permit air to escape freely and quickly. The Improved cap locks the expansion post after it is properly adjusted and also holds post in a rigid horizontal position. All Exhausters are set for ordinary use, but can be adjusted to suit any particular system to which they are attached. All Exhausters are threaded for 1-in. I. P. both inlet and outlet.

Made in one size only, 1 in. x 1 in. Capacity 2,000 sq. ft.

We also announce the O-E Thermo-Nickel Return Trap, a combination thermostatic trap with a ball-check and many new features. Ask for descriptive bulletin and general catalog.

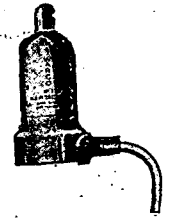
W. A. Russell & Company

Grand Central Terminal Building, **New York City**

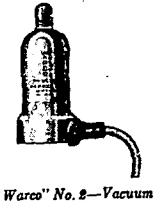
CHICAGO BOSTON PITTSBURGH LOS ANGELES

ESTABLISHED 1890

(All Valve Cuts one-quarter actual size)

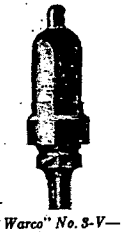


"Warco" No. 1
⅛ in. Side-Outlet Air Valve for Radiators



"Warco" No. 2—Vacuum
⅛ in. Side-Outlet Vacuum Air Valve for Radiators

"Warco" No. 3
¼ in. Bottom-Outlet Air Valve for Mains, Coils and Risers



"Warco" No. 3-V—Vacuum
¼ in. Bottom-Outlet Vacuum Air Valve for Mains, Coils and Risers

"Warco" No. 5
⅜ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

"Warco" No. 4
¾ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

"Warco" No. 6—Vacuum
⅜ in. Bottom-Outlet Quick Vent Vacuum Air Valve for Mains and HV Stacks

The Complete Line of Seven Improved "Warco" Air and Vacuum Valves was developed throughout by Mr. W. A. Russell, who, 37 years ago, invented the volatile liquid Air Valve principle and whose inventive genius is the basis of all successful Air Valves in use today.

Every one of the seven "Warco" Valves is manufactured under Mr. Russell's personal supervision; every one is tested, before shipping, under actual steam conditions; and, when properly installed and operated, they are all guaranteed to give five full years of satisfactory service.

"Warco"

Automatic Air and Vacuum

Valves

Stickle Steam Specialties Co.

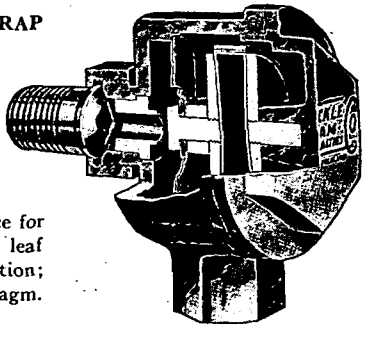
Main Office and Works, INDIANAPOLIS, IND.

NEW YORK OFFICE
48 E. 41st St.

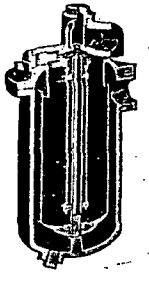
BOSTON OFFICE
52 Sudbury St.

Manufacturer of the STICKLE Open Coil Feed Water Heaters and Purifiers, STICKLE Steam Traps high and low pressure and vacuum, Pressure Regulators, Damper Controls, Back Pressure Valves, Standard Balance Valves, Vacuum Heating Specialties, Blast Coil Heaters, Heating and Ventilating Equipment, Triplex Oil and Steam Separators.

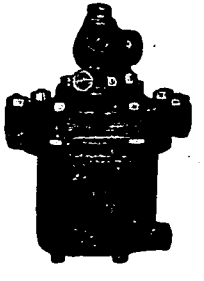
STICKLE THERMOSTATIC RADIATOR TRAP



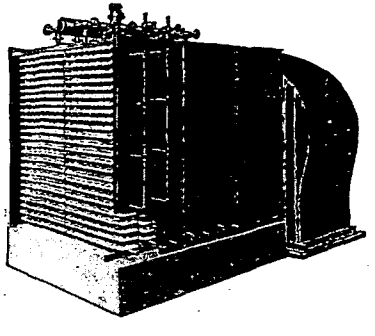
The special feature of the STICKLE Thermostatic Radiator Trap is the diaphragm; with box shape inverted heads, side walls reinforced with seamless drawn brass tubing, a solid disc protecting each head and so constructed that the diaphragm cannot get out of place. The diaphragm is so reinforced that there is no possible chance for it to become distorted or ruptured. The flat leaf bronze spring makes a positive opening action; supplementing the spring action of the diaphragm.



STICKLE THERMIC VACUUM TRAPS



Designed for draining steam headers and risers on low pressure heating systems. A Thermostatic trap will close on hot water and for this reason they will not drain a steam header. This trap is mechanically operated with positive air release. No matter what the temperature of the water this trap will handle it. This is the ideal trap for Blast Coil Service, made in sizes up to 2 inch. Send for the descriptive matter.



STICKLE VAPOR VACUUM HOT BLAST HEATER

Primarily designed to operate with the condensation from the dryers of a paper machine, for heating air to ventilate the machine room. When connected to the return line of a vacuum heating system it will maintain from 10 to 15" of vacuum on the pump without the use of cooling water.

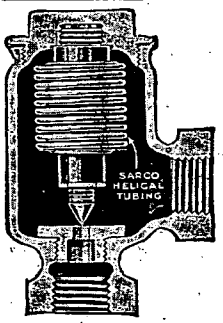
Write us regarding this heater. It has no equal. Cold air is heated and used, instead of using cooling water which goes to the sewer, the heat being lost.

Sarco Co., Inc.

183 Madison Ave., New York

BOSTON BUFFALO CHICAGO CLEVELAND DETROIT PHILADELPHIA LOS ANGELES

RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE CONTROL AND STRAINERS



SARCO STEAM TRAP No. 9

For pressures 0 to 100 lbs.

For industrial purposes, hospitals, laundry and kitchen equipment. Sarco Steam Trap No. 9 consists of a heavy bronze body with a powerful motor element of helical seamless bronze tubing containing an expansion fluid.

Is of the balanced pressure type, suitable for any steam pressure from 0 to 100 lbs. *without readjustment.*

Has unusually great capacity, large valve area and quick, high lift when discharging. Closes instantaneously. No live steam can escape. Cannot air bind.

Small in size and low in price.

Write for Booklet No. 261.

List Prices F. O. B. Bethlehem, Pa.		Dimensions	Capacity
½″	$ 8.50	1¾″ inlet to outlet	500 lbs. of water per hour
¾″	11.50	1¾″ inlet to outlet	600 lbs. of water per hour
1″	14.50	2″ inlet to outlet	800 lbs. of water per hour

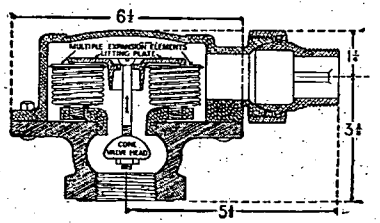
For Steam Pressure from 0 to 30 lbs. Type 9–1 can be used. It has the same capacities as Type 9–2 but is furnished with brass composition valve heads and seats at ½″–$7.50; ¾″–$10.50; 1″–$13.50 list.

SARCO HIGH AND LOW PRESSURE BLAST TRAPS

This Heavy-Service or Blast Trap is for draining steam coils of hot-water tanks, vento stacks and main drip lines; also where a large capacity trap is required such as for draining coils in dryers, vacuum pans, heating coils, cooking vessels, etc.

Will handle great flows of condensation without loss of steam. Is entirely thermostatic, so removes the air as well as water.

Operates on the same principle as the Sarco Steam Trap No. 9–2.



Section of 1¼″ and 1½″ No. 9-3

No. 9–3, PRESSURES 0–30 LBS.
Brass Composition Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lbs. per Hour
1″ $25.00	1,000
1¼″ 27.50	1,000
1½″ 30.00	1,500
2″ 37.50	2,000

Can be furnished in offset patterns at same prices.

No. 9–4, PRESSURES 0–100 LBS.
Monel Valve Head and Seat

List Prices F. O. B. Bethlehem, Pa.	Capacities Lbs. per Hour
1″ $30.00	1,250
1¼″ 32.50	1,250
1½″ 35.00	3,250
2″ 42.50	5,000

Write for Blast Trap and Heavy Service Booklet.

SARCO TEMPERATURE REGULATOR

For hot-water service tanks, and cold storage plants; also for manufacturing purposes and dry room or kiln control. Write for Booklet No. 91.

SARCO SELF-CLEANING STRAINER

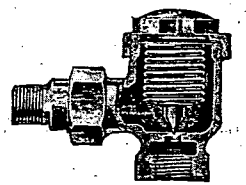
For Steam, water and oil lines. Write for Booklet No. 204

Sarco Co., Inc.

183 Madison Ave., New York

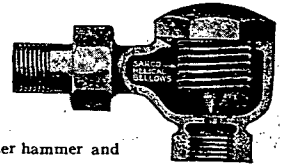
BOSTON BUFFALO CHICAGO CLEVELAND DETROIT PHILADELPHIA LOS ANGELES

RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE CONTROL AND STRAINERS



Type E

Sarco Radiator Traps



Type H

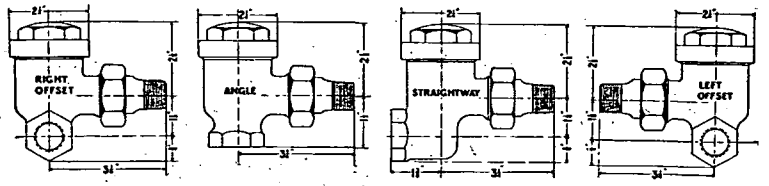
For vacuum, vapor and low-pressure heating systems. The Sarco is of the thermostatic type, using Seamless Helical Bellows and a volatile liquid filling. Its positive action keeps radiators thoroughly drained, preventing water hammer and air binding.

Helical Bellows is phosphor bronze. It has a high lift, insuring free discharge, a maximum closing pressure and an unusually long life. Body is heavy brass, nickel plated. Is factory adjusted and can be used on all pressures up to 25 lbs. without adjusting.

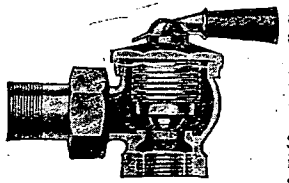
Write for Booklets Nos. 116 and 303.

List Prices F. O. B. Bethlehem, Pa.			Dimensions		CAPACITY—DIRECT RADIATION Vapor System	Vacuum System
Type E	½″	$ 6.00	A 3¼″	B 1½″	200 Sq. Ft.	250 Sq. Ft.
Type E	¾″	8.00	A 3¼″	B 1½″	600 Sq. Ft.	800 Sq. Ft.
Type E	1″	15.00	A 3⅝″	B 2″	1500 Sq. Ft.	1800 Sq. Ft.
Type H	½″ Angle type only	5.00	3¼″	1½″	125 Sq. Ft.	150 Sq. Ft.

Angle, straightway and offset types are furnished in Type E at same prices.



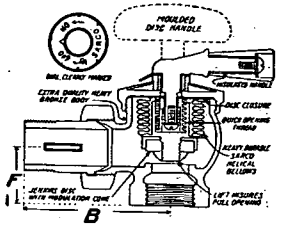
SARCO PACKLESS INLET VALVE



For use on vapor and vacuum heating systems.

This valve cannot leak as it is of the true Packless type.

By the use of the Sarco Helical Tubing it eliminates the necessity for packing of any kind.



Section of ½″ and ¾″ Valve

Valve opens or closes with a three-quarter turn and the pressure is always even, smooth and regular. Easy to turn. Dial is distinctly marked.

Has heavy brass, well-nickeled body. Furnished with lever or round moulded handles.

Write for Booklet No. 151.

List Prices F. O. B. Bethlehem, Pa.		Center Inlet to Outlet	CAPACITIES Feet Direct Radiation
½″	$5.50	3″	up to 40 sq. ft.
¾″	6.00	3″	41 to 75 sq. ft.
1″	7.50	3½″	76 to 125 sq. ft.
1¼″	9.50	3½″	126 to 200 sq. ft.

TRANE HEATING SPECIALTIES

(See Trane Heat Cabinets on page 485; Unit Heaters on page 503; and Trane Pumps on pages 564 and 565.)

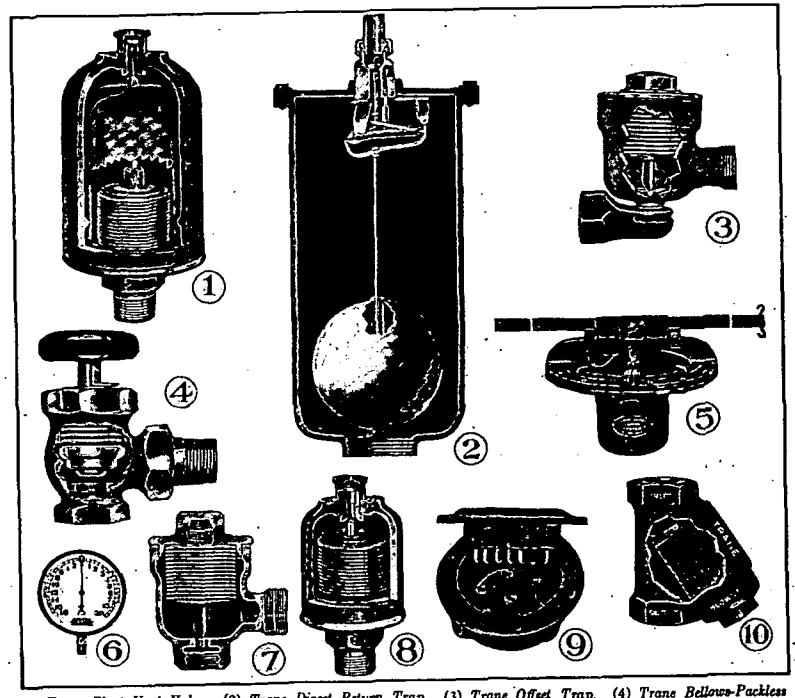
The Trane Company

La Crosse, Wis.

Branch Offices

New York, Chicago, Boston, Cincinnati, Newark, Philadelphia, Buffalo, Cleveland, Detroit, Seattle, Los Angeles, Albany, New Orleans, San Francisco, Houston, Louisville, Minneapolis, Salt Lake City, Greensboro, N.C., Zanesville, Ohio, Tampa, Fla., Baltimore, Md., Des Moines, Iowa, New Haven, Conn., Sheboygan, Wis., Kansas City, Mo., Atlanta, Ga., Portland, Ore., St. Louis, Mo.; ENGLAND: 22-23 Clerkenwell Close, London, E. C. 1; CANADA: The Trane Co., 21-23 River St., Toronto, 2; 108 Union Trust Building, Winnipeg; 604 McIntyre Bldg., 751 Victoria Sq., Montreal: 942 Pender St., West, Vancouver, B.C.; JAPAN: Mitsubishi Shoji Kaisha, Ltd., Tokyo; CHINA: C. J. Doughty & Co., 30 Brenan Road, Shanghai.

The Trane Systems of Vapor and Vacuum Heating, Patented Heating Specialties, Trane Heat Cabinets, Unit Heaters, Blast Heaters and Trane Automatic Electric Pumps, For All Purposes



(1) *Trane Float Vent Valve.* (2) *Trane Direct Return Trap.* (3) *Trane Offset Trap.* (4) *Trane Bellows-Packless Radiator Valve.* (5) *Trane Regulator.* (6) *Trane Vapor-Vacuum Gauge.* (7) *Trane Bellows Radiator Trap.* (8) *Trane Quick Vent Valve.* (9) *Trane Blast Trap.* (10) *Trane Strainer.*

TRANE HEATING SPECIALTIES

No. 1 Trane Float Vent Valve vents air but closes tightly against steam and water. Capacity unlimited for practical purposes. Full ¼ in. venting ports. ¾ in. pipe connection only. Weight 4 lb. Contains genuine Trane bellows.

No. 2 Trane Direct Return Traps and broken boilers are never found on the same vapor heating or straight steam job. Two sizes: 2,000 and 4,000 sq. ft. Multiples used for larger requirements.

No. 3 Trane Offset Pattern Traps are standard Trane 14 corrugation bellows trap with a special offset fitting on the outlet that can be swung to any position desired.

No. 4 Trane Bellows-Packless Valves are packless in every respect. Contain genuine Trane bellows. Brass body. Nickeled, highly polished trimmings. Practically indestructible handle. Especially designed as companion product for use with Trane Bellows Traps (No. 7) in connection with Trane Vacuum Pumps. (See Trane Pumps in Pump section of this Guide). Valves furnished in ½ in., ¾ in., 1 in. and 1¼ in. sizes.

No. 5 Trane Vapor Regulators are sensitive to ounces pressure instead of pounds.

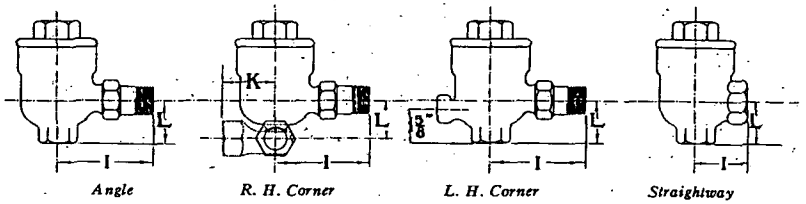
No. 6 Trane Pressure-Vacuum Gauges register to 30 lb. pressure and 18 in. vacuum. Also furnished to register to 30 in. vacuum only over entire scale. 4½ in. face. ¼ in. pipe connection.

No. 7 Trane Bellows-Type Radiator Traps have 14 corrugation bellows. These bellows are made without seams or joints of any kind. Trap bodies are made of steam brass. Sizes and styles are as listed below. Guaranteed range is from 15 in. vacuum to 25 lb. pressure without adjustment of any kind. These same traps are also available for high pressure service up to and including 125 lb.

No. 8 Trane Quick Vent Valves do the work of Float Vent Valves (see No. 1), except that they are designed to close against steam only. ¾ in. pipe connection. Contain Genuine Trane 14 corrugation bellows.

No. 9 Trane Heavy Duty Blast Traps take the place of the bulky steam trap. They are used on blast coils and on large steam mains where a large amount of condensation is encountered.

No. 10 Trane Strainers are made with a perforated metal strainer which is removable for cleaning. Made in ½, ¾, 1 and 1¼ in. sizes.



Angle *R. H. Corner* *L. H. Corner* *Straightway*

SIZES, CAPACITIES, ETC., OF TRANE RADIATOR TRAPS

Style	Size Inches	Capacity in Sq. Ft. at Various Pressure Differences				DIMENSIONS, INCHES				
		4 oz.	8 oz.	1 lb.	2 lb.		Size	L	I	K
No. B2	½	200	375	395	560	Angle	½ and ¾	1⅜	3¼	——
							1	2	3⅝	——
No. B3	¾	400	585	770	1080	Offset	½ and ¾	1⅜	3¼	1½
						High Pressure	½ and ¾	1⅜	1⅝	——
No. B4*	1	800	1125	1700	2250	High Pressure	1	1¾	2	——

*Made in angle pattern only. **Write for information on Trane large capacity traps.**
Sizes conform to recommendations of *Heating and Piping Contractors' National Association.*

ESTABLISHED 1888

WARREN WEBSTER & COMPANY

Pioneers of the Vacuum System of Steam Heating

Camden, N. J. Branches in 52 Cities

Manufacturers of Webster Systems of Steam Heating and Webster System Equipment—More Than 41,000 Installations—Webster Series 78 Traps for "Process" Steam Pressures—Also Webster Feed Water Heaters of Genuine Puddled Wrought Iron, Steam and Oil Separators and Expansion Joints

Webster Products

WEBSTER VACUUM AND MODULATION SYSTEMS OF STEAM HEATING.

WEBSTER SYSTEM APPARATUS: Including Sylphon Traps; Diaphragm (No. 7) Traps; Modulation Supply Valves; Sylphon Quick-Opening Packless Valves; Dirt Strainers; Dirt Pockets; Drip Traps; Heavy-Duty Traps; Double Service Valves; Water Accumulators; Expansion Joints; Lift Fittings; Suction Strainers; Vacuum Governors; Hy-lo Traps and Controllers; Damper Regulators; Vent Traps and Vent Valves; Boiler Return Traps; Air Separating Tanks.

WEBSTER FEED WATER HEATERS, Webster Lea-Heater-Meters, Steam and Oil Separators.

WEBSTER SERIES 78 Traps for "Process" steam pressures (10 to 100 lb. per sq. in.).

Webster Service

Is an integral part of every Webster System delivered through 52 branch offices. Webster Service places the accurate, comprehensive information resulting from the extensive experience of this organization at the disposal of engineers, architects and heating contractors.

Webster Service in printed form includes: SERVICE DETAILS, a loose-leaf service showing correct connections and saving a substantial amount of the designer's time; CATALOGUE BULLETINS describing Webster apparatus from the standpoint of the engineer.

Webster Vacuum Systems

Operate on exhaust or live steam at very low pressure. Used with direct radiation or in combination with blast coils or unit heaters. Particularly suited for large buildings or where process steam is used. The Webster organization was the pioneer in the field of vacuum steam heating systems. The present type of Webster Vacuum Systems incorporates the experience gained in thousands of installations and the results of years of specialization and perfection of quality apparatus. Full details on request.

Webster Type "R" Modulation Systems

A low pressure steam heating system suitable for buildings having little or no demand for "process" steam and a basement or other means for placing low pressure boiler *below* the lowest radiator. For installations from 500 to 32,000 sq. ft. of equivalent direct cast iron radiation. Can be operated safely and satisfactorily by unskilled labor.

OPERATION: Steam pressure is controlled by the sensitive Webster Damper Regulator. Steam is admitted to radiators through Webster Modulation Valves or Webster Sylphon Valves. Condensation and air are freely discharged past Webster Return Traps which close on contact with steam, thus avoiding waste. Air and condensation are carried to the basement apparatus consisting of the Webster Boiler Return Trap and Vent Trap in combination. All air escapes through the Webster Vent Valve. The Webster Boiler Return Trap provides positive equalization of pressure assuring return of water to boiler.

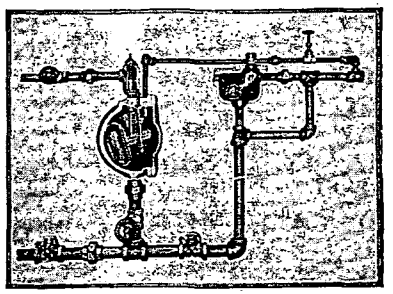


Fig. 1. Webster Type "R" System Basement Equipment 0025 Size Units for 1500 sq. ft. or less

Webster Boiler Return Traps

Made in five sizes for use in Webster Type "R" Systems. The superior design of this perfected device may be seen in Fig. 2. Entire mechanism is suspended from and operates around a single monel metal shaft. Stainless steel leaf springs together with large surface fin assure complete silence of operation. No tight joints in mechanism to be affected by dirt or foreign matter. Steam is deflected on entering, preventing boring and reducing condensation. Positive acting, self-seating valves. Shipped completely assembled, ready to install.

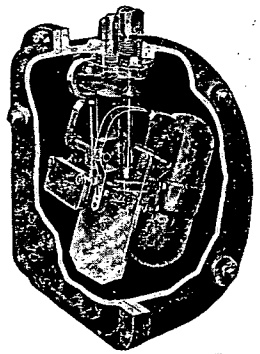


Fig. 2. Webster Boiler Return Trap 023 Size, for 1501-2500 sq. ft.

Webster Sylphon Packless Quick-Opening Supply Valves

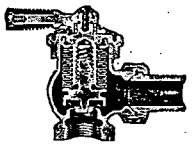


Fig. 3. Webster Sylphon Packless Quick-Opening Valve

Open with less than a turn of lever or wheel handle. Positively packless, having flexible laminated Sylphon bellows completely enclosing stem. Body of steam brass, composition disc, hard rubber handle. Made in ½ to 2 in. sizes. Ask for Bulletin 705-51.

Webster Modulation Supply Valves

Provide by means of scientifically curved modulating plug, close heat control of each radiator. Particularly well-suited for residence, apartment and hotel, as it permits heating any desired portion of radiator. Sizes ½ to 1¼ in. Ask for Bulletin 705-3.

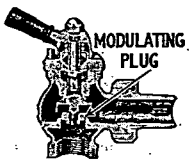


Fig. 4. Webster Modulation Supply Valve

Webster Sylphon Traps

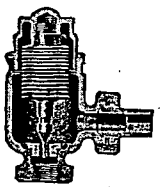


Fig. 5. Webster Sylphon Trap

Effectively discharge all condensation and entrained air from radiators or coils without permitting passage of steam. Operation is by means of a sensitive volatile liquid contained in a rugged Sylphon bellows. Factory adjusted, and made in sizes from ½ to 1¼ in. Rating from 14 to 750 lbs. of condensation per hour depending on size of trap and pressure difference. *Ask for Bulletin 701.*

Webster No. 7 Traps

A multi-diaphragm trap—wholly automatic—Webster quality throughout—provided to meet requirements of those having personal preference for diaphragm type of thermostatic element. Same ratings as Webster Sylphon Trap.

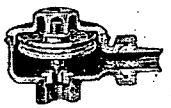


Fig. 6 Webster No. 7 Trap

Webster Drip Trap, Size 026

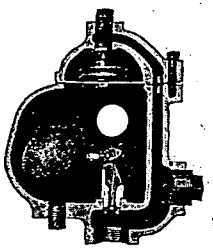


Fig. 7. Webster Drip Trap

A heavy duty trap, capable of handling large volumes of condensation and air. Compact and light in weight for mounting in pipe line without other support. For drip points, blast stacks, unit heaters, etc. Ratings from 500 to 1800 lbs. of condensation per hour depending on pressure difference.

Webster Heavy Duty Traps

A heavy-duty trap for handling unusually large volumes of condensation and air at pressures up to 15 lbs. per sq. in. Rating from 700 to 31,000 lbs. of condensation per hour depending on size of trap and pressure difference.

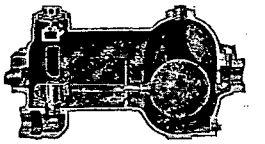


Fig. 8. Webster Heavy Duty Trap

Webster Series "78" Traps

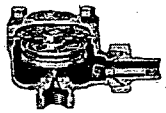


Fig. 9. Webster Series 78 Trap

Webster Series 78 Traps have been developed to meet the needs of users of "process" steam at 10 to 100 lb. per sq. in. When installed in accordance with the recommendations of Webster Service, they provide the answer to a multitude of problems of efficient discharge of air and water of condensation from process-steam using equipment. Increased production through quicker heating up and higher maintained temperature of heating surfaces result.

DESIGN AND CONSTRUCTION: Unusual construction features include automobile-type copper-asbestos gasket, heavy-gauge monel metal diaphragm, renewable stainless steel valve piece and seat, expanded opening for quiet operation, cast steam brass body and hot forged brass cap bolted on with monel metal tap bolts.

SIZES AND TYPES: Webster Series 78 Traps are made in ½, ¾ and 1 in. sizes and in two pressure classes. Class 2 Traps are designed for pressures from 10 to 50 lb.; Class 3 for 50 to 100 lb.

RATINGS: The range of application of Series 78 Traps is limited only by the following three factors:

1. Pressure—10 lb. (or less) to 100 lb. per sq. in.
2. Volume of Condensation—60 to 1210 lb. water per hour (at 100 lb. per sq. in.).
3. Temperature—No superheat.

APPLICATIONS: Webster Series 78 Traps may be used to advantage in hundreds of different applications. Most of these fall into three groups.

1. To discharge both air and water of condensation from single pieces of apparatus within its capacity.
2. For installation on each unit of a battery—as for example a battery of kettles instead of the old fashioned method of trying to handle the entire battery through one "master" trap.
3. For venting air *only* from apparatus formerly provided with a handcock or similar inadequate means, and where the volume of condensation is handled by a "bucket type" trap.

WHERE USED: Webster Series 78 Traps are used in heating systems; Sterilizers; Cooking and Laundry Apparatus and in the process industries. Ask for 4-page data form to use in analyzing your "process steam" problem.

Webster Series 78 Dirt Strainers

The Webster Series 78 Dirt Strainer has been provided to be placed ahead of every Webster Series 78 Trap located at a drip point in the supply piping or attached to apparatus which is likely to contain core, sand, pipe scale or sediment.

Vapor Engineering Company

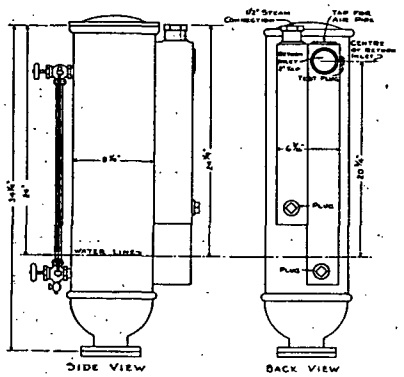
489 Fifth Avenue
New York City
Chas. E. Scott—R. C. Willis

10 South 18th Street
Philadelphia, Pa.
J. W. Glassey—M. S. Buck

VECO VAPOR SPECIALTIES

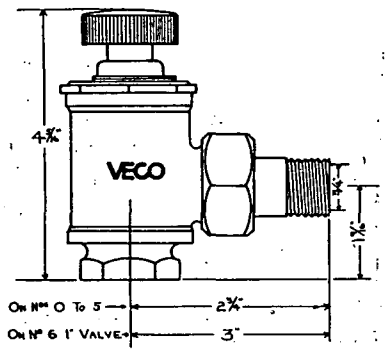
Non Mechanical and Positive in Operation

Engineers for the design of "open-to-atmosphere" vapor heating systems for factory, public and residential buildings, regardless of size, construction or location. Veco Vapor specialties are the result of 21 years of specialization in vapor heating work



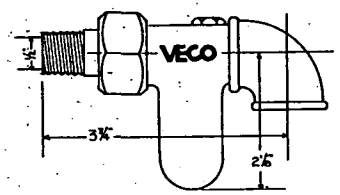
VECO GOVERNOR

Combining, Safety Valve, Air Eliminator and positive control of Boiler draft, Gas supply valve, or Oil Burner



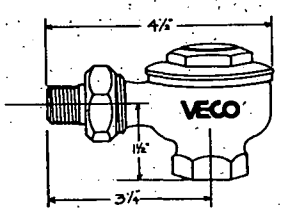
VECO SUPPLY VALVE

Packless, Leakless, Graduated.
¾ in. Nos. 0 to 6 up to 139 sq. ft. inclusive.
1 in. No. 6 up to 140 to 150 sq. ft. inclusive.



VECO RETURN SEAL

No moving parts. For all standard vapor work



VECO THERMOSTATIC TRAP

For Central Plant work, Ventilating Units, etc.

Full cooperation is offered to Architects, Engineers and Contractors in the planning of Veco Systems which are fully Guaranteed as to material—and satisfactory operation.

CoKal Stoker Corporation

1010 Wrigley Bldg., **Chicago, Ill.**

PRODUCTS.—CoKal Hand Operated Stoker Grate; CoKal Hopper Feed Stoker (Hand Operated); CombustiKator, Hand Operated; CombustiKator Mechanical Drive; CombustiKator, Automatic Mechanical Drive; CoKal Hopper Feed Mechanical Drive; CoKal Pulverzone Semi-Mechanical Stoker; CoKal Automatic Pulverzone Semi-Mechanical Stoker; CoKal Hangover Back Boiler Arches; CoKal Hangover Ignition Arches; Automatic Fireman

For the Hopper Feed Mechanical Drive—PULVERZONE Semi-Mechanical and Full-Mechanical Stokers, automatic control is furnished for electric, steam engine, or hydraulic head operation.

For ten years this company has been designing and installing coal burning equipment. It has perfected apparatus suitable for all classes of coal, and lignite. Its equipment is suitable for all types of boilers, all types of loads. It has specialized, in particular, in equipment suitable for that vast class of plants having one boiler or more from 50 hp. and up.

CoKal Pulverzone Semi-Mechanical and Mechanical Stokers

These two types of coal burning equipment undoubtedly represent the latest word in design. The PULVERZONE combines the three approved methods of burning coal in one: **Pulverized coal burning, spread method, coking method.** *Outstanding features of the* PULVERZONE are that it enables the fines to be burned in suspension, the larger lumps upon the stoker bars, while turbulence before, at and after ignition is maintained in the furnace. Consequently furnace volume is fully utilized, resulting in smokelessness at all loads, extremely high efficiencies and enormous overload capacities with marked freedom from fuel bed, ash and clinker troubles.

Maximum combustion rate is very much increased for a given draft because there is no clogging of the fuel bed due to the fines. Less ash removal results, due to complete combustion and less fuel bed troubles, with smaller ash pit loss.

By maintaining two combustion zones it is possible to burn the cheapest sizes of coal—screenings—with an efficiency approached only in the very largest plants.

The CoKal PULVERZONE FULL-MECHANICAL stoker can be operated with full automatic control to vary the rate of coal feed, supply of air and rate of stoker bar travel. It also automatically cleans the fire, removes the ashes and resets ash dump plate. Drive can be by electricity, steam or water.

Front View of Full-Mechanical PULVERZONE, *showing Electric Drive with Automatic Coal Feed, Ash Removal and Stoking Mechanisms with Co-ordinated, Synchronized Air and Fuel Supply According to the Load.*

CoKal CombustiKator

Designed especially to develop high combustion efficiency and smokelessness without skilled supervision for low-pressure heating plants. The CombustiKator (hand operated or automatic) consists of the CoKal inside hopper and standard mechanical stoker. All coal is coked before reaching the furnace proper. The volatile is distilled and pre-heated before being burned in the furnace.

No cleaning of fires is required. No care or skill is needed for firing. All the fireman does is to throw coal through the firing door against the refractory hopper wall. The coal is automatically spread evenly over the stoker bars as it is advanced over them. The fireman cannot interfere with the fuel bed nor cause smoke. No rush of cold air occurs when firing doors are opened. This apparatus is ideal for all types of firebox, fire and water tube boilers for low-pressure work where the firing is done by unskilled labor yet freedom from smoke is important. It is as easy to operate as the old-fashioned domestic magazine stove.

The automatic CombustiKator automatically feeds the coal and removes the ash according to the demands for steam.

RILEY STOKER CORPORATION

"RILEY" Underfeed Stokers — "JONES" Underfeed Stokers — "HARRINGTON" Traveling Grate Stokers

"MURPHY" Automatic Furnaces — Pulverized Coal Installations

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BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT
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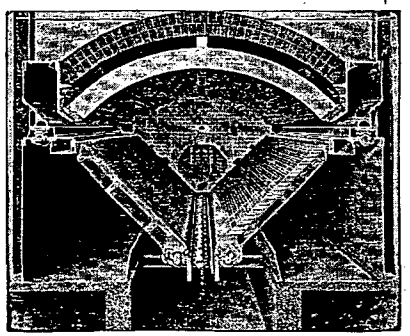
Riley Engineering and Supply Co., Ltd., Toronto

COMBUSTION EQUIPMENT FOR EVERY NEED

Riley Stoker Corporation manufactures Riley Multiple-Retort Stokers, Jones Side Dump, Lateral Retort and Standard Stokers, Harrington Traveling Grate Stokers, Murphy Automatic Furnaces, and the Atrita Unit Pulverizer. These stokers are suitable for different types of boilers and can take care of large or small boilers burning anthracite coal, coke breeze, Eastern bituminous, Pittsburgh, Illinois, Indiana, Iowa coals and lignites.

Write for catalogues covering each of these types for your reference files.



Murphy Automatic Furnace

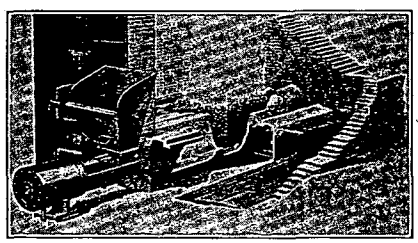
MURPHY AUTOMATIC FURNACE

The Murphy Automatic Furnace is of the overfeed, natural draft type and is particularly adapted for use in office buildings, hotels and schools. It saves 15 to 25 per cent over hand-fired methods, it saves labor, it is smokeless in operation, it does not emit gases to circulate up through the building. All ash and refuse are removed automatically. This means a clean fire and high efficiency at all times. The Murphy Furnace does away with the necessity of opening fire doors and thereby eliminates the admission of cold air. The coal supply for the furnace is under absolute control and automatic regulation. It is a natural draft furnace and requires no fan or blower equipment.

JONES SIDE DUMP UNDERFEED STOKER

The Jones Side Dump Stoker is of the forced draft, underfeed type and is very widely used for both heating and power loads in all types of buildings thruout the country. It is of the side cleaning type, ashes being dropped into a shallow ashpit, permitting easy removal. Only slight excavation is required for the two shallow ashpits, therefore the installation cost is low. The stoker gives high efficiency and responds very quickly to load demands. It has a fuel burning capacity of 1200 to 1800 lbs. of coal per hour. This stoker is made in steam driven type and also mechanically driven type.

Where bigger boilers are used Riley Stokers, Harrington Traveling Grate Stokers, Atrita Unit Pulverizers and Lateral Retort Stokers can be used.



Jones "Side Dump" Underfeed Stoker

THE DEPENDABILITY AND ECONOMICAL OPERATION OF RILEY STOKER CORPORATION EQUIPMENT PARTICULARLY ADAPTS IT TO HEATING REQUIREMENTS

A few well-known Installations

NEIL HOUSE, Columbus, Ohio
BLACKSTONE HOTEL, Chicago, Ill.
SEVENTY-SIX SCHOOLS IN Detroit, Mich.
MAXWELL HOUSE, Nashville, Tenn.
UNIVERSITY OF Chicago, Ill.
SIXTEEN SCHOOLS IN Buffalo, N. Y.
DETROIT MASONIC TEMPLE, Detroit, Mich.
UNION CENTRAL LIFE BLDG., Cincinnati, Ohio
STATLER HOTEL, Detroit, Mich.
NEW WILLARD HOTEL, Washington, D. C.
GIBSON HOTEL, Cincinnati, Ohio
PHOENIX HOTEL, Lexington, Ky.
THIRTY-THREE SCHOOLS IN Cleveland, Ohio
INTERSOUTHERN LIFE BLDG., Louisville, Ky.
SYRACUSE HOTEL, Syracuse, N. Y.
OHIO MASONIC HOME, Springfield, Ohio
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CHICAGO & NORTHWESTERN BLDG., Chicago., Ill.

Honeywell Heating Specialties Company

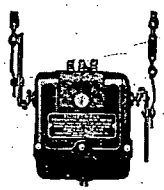
Wabash, Indiana

Manufacturers of Honeywell Temperature Regulators for Residential or other Heating Plants—Hot Water, Vapor, Steam, or Warm Air.

Fifteen-Day Jeweled Balance Clock Thermostat

Plain Pattern Thermostat

Wall Plate Used on All Honeywell Thermostats



New Type Electric Regulator Motor

The HONEYWELL Temperature Regulator is an automatic device which opens and closes the dampers of the heater (any type) whenever the room temperature varies one degree from that for which the Regulator is set.

The HONEYWELL Temperature Regulator has but two parts, the thermostat and the motor. The thermostat is placed on an inside wall at some central location and electrically controls the operation of the motor, which is located near and connected to the heater.

The automatic regulation so effected insures a constant temperature, day and night, minimum fuel consumption and maximum comfort and health. The cost of operation, even with the electric motor models, is negligible.

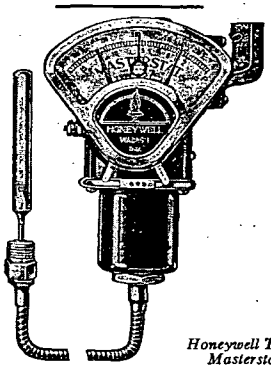
The exclusive HONEYWELL Wall Plate is standard with all HONEYWELL Thermostats. Its use simplifies installation to such a point that the novice mechanic finds it easy.

The Regulator is made in three types, Gravity Motor, Spring Motor, and Electric Motor; and nine models, three of each type. The first model of each type is equipped with plain thermostat, requiring manual adjustment for day and night temperatures. The second model of each type is equipped with one-day clock pattern thermostat which automatically brings the room temperature to the degree for which the Regulator is set, at any predetermined hour. The third model of each type is equipped with 15-day automatic clock thermostat which automatically regulates both the day and night temperatures, at any predetermined degree and hour, without manual adjustment of any kind.

LIST PRICES—(Subject to Discount)

TYPE DR, Electric Motor—15-Day Jeweled Clock Thermostat	$80.00
TYPE DS, Electric Motor—One-Day Clock Thermostat	68.00
TYPE DQ, Electric Motor—Plain Thermostat	60.00
TYPE SR, Spring Motor—15-Day Jeweled Clock Thermostat	64.00
TYPE SS, Spring Motor—One-Day Clock Thermostat	52.00
TYPE SQ, Spring Motor—Plain Thermostat	44.00
TYPE GR, Gravity Motor—15-Day Jeweled Clock Thermostat	57.00
TYPE GS, Gravity Motor—One-Day Clock Thermostat	45.00
TYPE GQ, Gravity Motor—Plain Thermostat	37.00

(Above prices include necessary installation materials).



Honeywell Type A Masterstat

Oil Burner Manufacturers and Dealers have long felt the need of and will appreciate such a device as the HONEYWELL Type A Masterstat.

Designed for use with the intermittent type oil burner, it is a safe means against firing a dry boiler and in addition limits the pressure or temperature of the heating plant to the desired point.

The Masterstat is applicable to steam, vapor, vacuum, hot water or warm air systems.

Details will be supplied upon request.

Minneapolis Heat Regulator Co.

Established 1885

Offices and Factory **Minneapolis, Minn.**

Branch Offices In All Principal Cities

The "MINNEAPOLIS" HEAT REGULATOR

Refer to Telephone Directory for Local Agency Address

For Coke — Coal — Gas — Oil — Steam

The "Minneapolis" Heat Regulator provides fully automatic control for all types of heating plants burning any kind of fuel. **Economy** of operation, improved **Health,** added **Safety,** more **Comfort,** greater **Convenience** are insured when the "Minneapolis" is installed.

House Heating Plants are successfully regulated by the "Minneapolis" whether the system is Steam, Hot Water, Vapor, Vacuum, or Warm Air. **Large heating plants** such as used in Factories, Apartments, Hotels, can be kept at predetermined temperatures or pressures with the "Minneapolis." **Hot Water Supply Systems** can be controlled by the "Minneapolis" Limit Control. **Applications** where the requirement is a dependable accurate means of controlling temperature—heat or cold— can be handled with complete satisfaction by the "Minneapolis." **The "Minneapolis" Unit Heater Control** is an outstanding advancement in Unit Heating. Three methods of control are provided, meeting every condition or demand, namely:

Fully Automatic Control is provided by a combination of "Minneapolis" Units consisting of:

One Room Thermostat—Standard Series	**Clock Type recommended**
One Limit Control—Standard Series	**Reverse hook-up**
One 3 P. S/S Electric Motor—Standard Series	**Circuit selector and switch built in**
One Balanced quick-opening lever type valve	

Low Voltage Wiring simplifies installation.

The room thermostat controls the Unit Heater operation in accordance with the temperature conditions in the area being heated. The Limit Control prevents blowing unheated air from the Unit Heater. It insures the proper temperature of the heating coil before the fan is started. The 3 P. S/S Electric Motor opens the valve in the steam line when the thermostat calls for heat. It closes off the steam line when the proper temperature has been established in the area being heated.

Automatic Control without Steam Shut-off is provided in two ways. The three unit system of control consists of:

One Room Thermostat—"Series 10"	**Clock type recommended**
One R. A. Limit Control—"Series 10"	**Reverse action**
One Relay Switch—"Series 10"	**Controlling 110 volt line**

Low voltage wiring between operating units reduces installation costs. "Series 10" principle of operation requires the making or breaking of only one circuit, a safe and positive method of control.

The two unit system of Control consists of:

One Room Thermostat—"Series 10"	**Clock type recommended**
One Relay Switch—"Series 10"	**Controlling 110 volt line**

The fully automatic and the three unit systems are recommended where outside air intakes are used. When air is recirculated and no outside air intake is used, the two unit system is entirely satisfactory.

Complete description of the operation of each system together with installation diagrams are available in pamphlet form. Catalogs describing in detail the Standard Series and Series 10 Units in addition to the Unit Heater Control pamphlet will be sent upon request.

Johnson Service Company

Milwaukee, Wis.

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NEW YORK, N. Y., 28 East Twenty-ninth Street
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CANADIAN REPRESENTATIVE

Johnson Temperature Regulating Company of Canada, Limited

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Products and Services

ENGINEERS and CONTRACTORS for the CONTROL of TEMPERATURE or HUMIDITY for any purpose and over every range used in manufacturing purposes or buildings, furnishing and installing:

Temperature Controlling Apparatus for any and all kinds of heating and ventilating systems.

Temperature Controlling Apparatus for any industrial process requiring the medium of heat.

Control of Humidity in industrial processes requiring artificial humidity.

Temperature Control of hot water tanks and all liquids.

Control of Temperatures of refrigerating and cold storage plants.

Thermostat Control of electric motors on automatic refrigerating machines.

Manufacturers of THERMOSTATS and Other APPARATUS for the CONTROL of TEMPERATURES and HUMIDITY, including:

Pneumatic Room and Insertion Thermostats and Humidostats.

Electric Room and Insertion Thermostats and Humidostats.

"Sylphon" Metal Diaphragm Valves.

High Grade Dampers of all Shapes and sizes.

Low Pressure, Limited Capacity, Electric Air Compressors.

Low Pressure, Limited Capacity, Hydraulic Air Compressors.

Air and Water Reducing Valves.

Pneumatic Switches or Push Buttons.

Specific Applications of Temperature Control

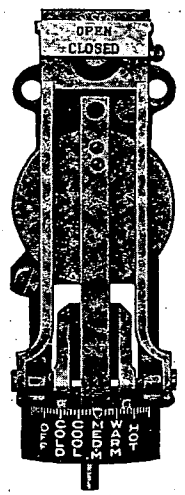
Bake ovens for enamels, japans, etc.
Core drying ovens.
Drying room for paint, varnish, patent leather, etc.
Storage room for tobacco, rubber or similar goods.
Cold storage rooms, fur vaults, etc.
Canning machinery, cookers, exhausters, processors.
Corn and oats drying apparatus.
Fruit drying apparatus.

Johnson All-Metal Thermostats

Every Johnson Thermostat is ALL-METAL throughout, having no soft or hard rubber parts to deteriorate and become inoperative. Every thermostat exquisitly made and thoroughly tested for accuracy, efficiency and durability.

Johnson Positive Thermostat

Has a snap action for closing and opening valves quickly, positively and fully, thereby assuring their durable and satisfactory operation. Has an indicator showing at a glance whether the heat is "ON" or "OFF." Has a convenient means for shutting off the heat when desired.



Model Positive Metal Diaphragm Thermostat

Johnson Intermediate Thermostat

Has all-metal movement, giving true graduated motion to mixing dampers for "Blast Heating Systems" and, where desirable, can be used to operate steam valves on a "Vacuum Heating System."

Johnson Compound Thermostat

The Johnson All-Metal Compound Thermostat combines the feature of both the Positive and Intermediate and is applicable for control of valves or dampers where certain units are to be operated positively and others intermediately at an interval of a few degrees in temperature.

Johnson Dual or Two-Temperature Thermostat

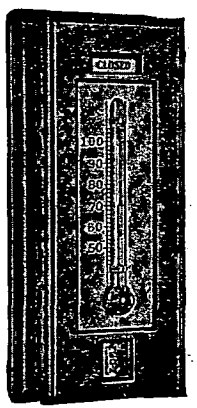
The Dual, or two-temperature Thermostat provides for a daytime temperature (usually 70°) and a night-time temperature (35° to 50°), as desired, for all or some of the rooms in a building, simply by the manipulation of a single push button by the engineer or other person in authority. It is a factor for the greatest economy in school buildings, a number of rooms of which are occupied at night as well as day, and for any buildings in which some of the rooms are occupied only at certain times, such as churches, auditoriums, masonic temples and lodges.

Thermostat Covers

The covers which conceal the thermostat proper are small, inconspicuous and very neat in design and workmanship.

There are two distinct styles: one called the **R** type and one called the **P** type.

The **R** type is a die-casting, very beautifully designed and used generally in residences and other handsomely decorated buildings.


Model R. I. Cover 4¾"x2"x1⅛" deep

The **P** type is a pressed metal cover, very finely finished but not as 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.

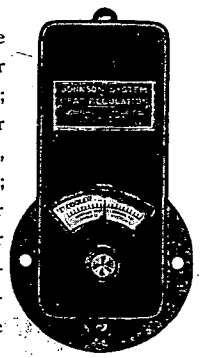
Johnson Pneumatic Insertion Thermostat

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.

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.

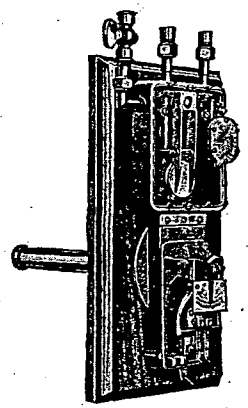

Pneumatic Insertion Thermostat

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 lb. per sq. in., and used to control temperatures of liquids and air by automatically opening and closing a diaphragm valve or damper. Graduations made to meet requirements, limited to a total range of 60 deg.

Multiple Insertion Thermostat

Similar to the insertion duct thermostat, excepting that one multiple thermostat takes the place of a number of separate duct thermostats set for different temperatures. The 4-point multiple thermostat shown will operate four separate diaphragm valves at as many different temperatures. It has become very popular with heating engineers for the control of heating and tempering coils where it is desired to have these coils turn on at different temperatures. It is made to work with positive action when controlling valves; with graduated action when controlling dampers; or with both positive and graduated action when controlling valves and dampers.


Multiple Insertion Thermostat

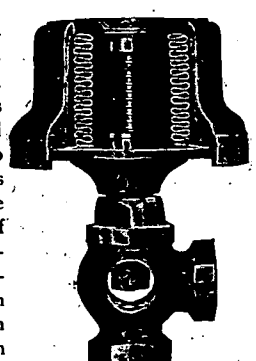
Tank Thermostat

Designed for insertion through 1-in. tapped hole in tank and controlling, in the case of hot water tanks, a diaphragm valve on the supply pipe to the steam coils in the tank. It can be used to control the temperature of any liquid, either hot or cold. It is especially adaptable for controlling the temperature of water in hot water heating plants by its control of the boiler draft doors.

Humidostats and Humidifiers

The humidostat automatically controls the supply of moisture delivered to the air by a humidifier and maintains a constant percentage of relative humidity. It operates a diaphragm valve on the steam coils in the pan humidifier. The pan is provided with float box to maintain constant water level and is located in the ventilating air duct leading throughout the building. Steam jet and water spray types of humidifiers are also furnished.

"Sylphon" Metal Diaphragm Valves



"Sylphon" Metal Diaphragm Valve

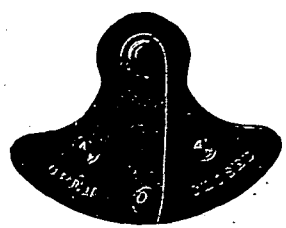
This valve having an indestructible 1-piece metal diaphragm, is permanent and requires no repairs. Its value for the control of steam is obvious and particularly so in connection with steam coils, radiators in wall boxes where excessive heat would destroy rubber diaphragms.

Humidity Control

The supplying of moisture to the heated air in buildings and the automatic control of the percentage of moisture in this air are recognized by authorities to be as important as maintaining proper temperatures.

Pneumatic Switch Control

Remote valve and damper control plays, by means of our pneumatic switches, a very important part in the economical operation of the modern heating plant especially in schools. It saves the janitor's time for other duties, and makes it possible to accomplish results in the operation of the heating plant which can not be obtained in any other way. It makes it easy to operate the fresh air, return air and vent dampers, with the corresponding assurance that these dampers will be economically operated as intended by the heating engineer.



Pneumatic Switch

The following types of pneumatic switches for different purposes and different conditions are made:

Lever Handle Switch,

Push Button Switch,

Indicating Switch, to open and close dampers partially as desired.

Electro Pneumatic Switch, to open and close dampers automatically—with the starting and stopping of fan motors.

How to Specify

Furnish and install a complete system of automatic temperature regulation and humidity control, furnishing all necessary thermostats, valves, dampers, humidifiers, special devices, air compressors, piping and fittings, and labor of installing system, except setting valves and dampers in position—all in accordance with the following schedule and detailed specification:

SCHEDULE—State the rooms to be controlled and number of thermostats in each; the manner in which the tempered air, if there is any, is to be controlled; the manner in which the drafts of the boiler are to be controlled; and specify the manner of the control of any fresh air, vent or return air dampers, stating the location and number of switches.

THERMOSTATS—Where the greatest economy of fuel and the most flexible handling of the heating system is desired specify the Johnson Dual or Two-Temperature thermostat and that it shall operate at all times at one set pressure not less than 15 lbs. per square inch. If dual thermostats are not desired specify Johnson Metal Diaphragm Model Thermostat, size, 4½ x 2 x 1 in.; and state whether it is to have residence or school cover, indicating device, positive shut-off, and whether it is to be positive or intermediate motion. Specify the number and kind of inserted thermostats.

VALVES—Specify Johnson Metal Diaphragm Valve having the "Sylphon" Metal Bellows for its diaphragm. State whether valves are to be plain or nickel-plated with or without unions; add: Valves to be placed in position by heating contractor.

AIR COMPRESSORS—Specify kind of air compressor (steam, hydraulic, electric or power driven), requiring that the air compressor shall be of sufficient size to operate the system, with a factor of safety not less than 3, and requiring that it be provided with all necessary governing devices, fittings, gage, etc.

HUMIDOSTATS—Specify Johnson Humidostat and Humidifier, stating the kind of humidifier, whether perforated steam or copper evaporating pan.

DAMPERS—Specify that dampers shall be made by the heat regulating contractor, but installed by the galvanized iron contractor, and that dampers shall consist of wrought iron frames, sheet steel blades, strongly cleated, with brass bearings.

GUARANTEE—Require that system be complete in every respect, and that all necessary material and special fittings shall be furnished whether specifically mentioned or not. Require that entire system be guaranteed free from all original defects in material and workmanship, and that any parts proving defective or wearing out within 2 years from date of completion shall be replaced free of charge. Require that thermostats shall operate the valves or dampers to which they are attached, at a variation of not to exceed 1 deg. above or below any given point.

Contracting

This company contracts to furnish and install in complete working order the Johnson System of Temperature Control, including thermostats, valves, piping, etc., and gives annual inspection and prompt service to all plants constantly.

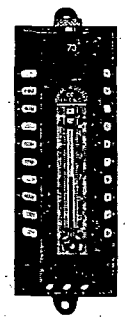
National Regulator Co.

TRADE METAPHRAM MARK

Factory and General Offices
2301 Knox Avenue
Chicago
OFFICES IN ALL PRINCIPAL CITIES

Manufacturers of Temperature and Humidity Control Apparatus of all descriptions and for all purposes; contractors for the installation of Temperature Control Systems in connection with heating and ventilating plants and industrial processes; patentors and sole manufacturers of Metaphram Diaphragms. National Regulator Company's products are all characterized by a marked simplicity and strength as well as by sensitiveness, and by the absence of complications and over-elaboration that necessitate expert and frequent operating attention.

The National Policy

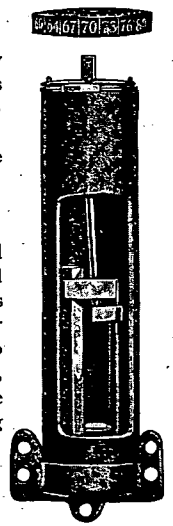


National Room Type Thermostat

The policy of the National Regulator Company is to accomplish the best obtainable results in the simplest possible way, avoiding complicated piping and intricate valve arrangements. Expert service is available in every part of the country.

The National Thermostat

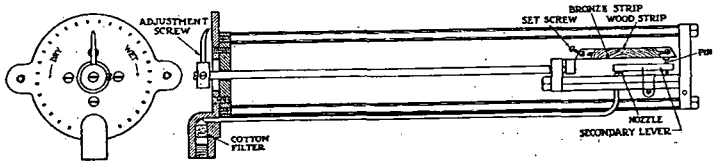
The thermostatic element is the most durable and the most sensitive material obtainable—a special vulcanized rubber in the form of a tube. This material is not subject to corrosion or any other adverse chemical or physical change, and there is no known limit to its effective life. Inside the tube, entirely protected from dust or tampering, is the simple system of levers which constitute the working parts. The National Thermostat does not require minute air ports, special seats of mica or patent leather, or *any* easily affected material. It is adjusted quickly, stays in adjustment, while its principles are easily grasped by the ordinary caretaker.



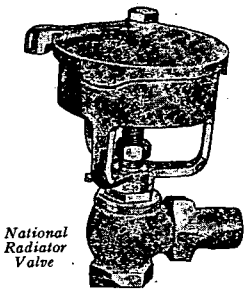
Cutaway View of National Thermostat

Gradual Operation

In practically every process of control of modern heating apparatus, whether it be



National Humidity Controller



National Radiator Valve

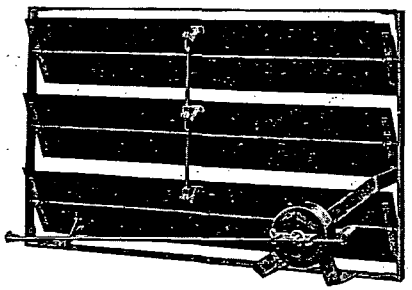
of steam and water by valves, or of air by dampers, better thermostatic results are obtained by gradual than by positive action. Steady intermediate regulation gives far better results than a succession of open and shut movements. National Thermostats meet this condition with a "floating" action that is unique in its effectiveness. This is true of the room thermostat and also of the insertion type for control of air in ducts.

National Humidity Controllers are positive and not affected by temperature changes. They are made in both room and insertion type.

Metaphram Diaphragms

Metaphram Diaphragms

The Metaphram Separable Diaphragm is an important product of the National Regulator Company, by whom it was developed and patented. The sections are constructed of a high grade of spring brass which is not spun or heated in the manufacturing process and so retains all its original resiliency and strength. The sections are built up into units by means of finely threaded integral studs. Metaphrams are self-collapsing. The actuating force (compressed air, steam, etc.) is applied on the *inside* of the diaphragm. So large a surface is presented to its action that the maximum of power is obtained with a minimum of travel. The result is a diaphragm unit that has not been equaled either in effective power or in durability. Metaphram diaphragms are widely used in damper regulators by leading boiler manufacturers as well as in the various functions of thermostatic control, and have met with an extraordinary success.

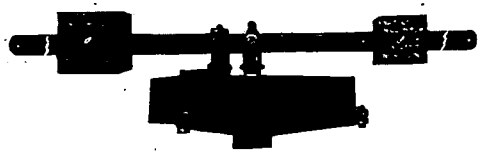


Metaphrams assembled into motor operating National Louvre Damper

Metaphram Damper Regulators

A complete line of Low Pressure Steam Boiler Damper Regulators, employing the Metaphram Diaphragms, is manufactured. The varying requirements of steam boilers cannot be met by one style of Regulator. The National line supplies the right Regulator for every condition. They are the most powerful Regulators made and will last indefinitely.

Type	Size	List Price F.o.b., Chicago
A-Junior	4-in.	$12.00
A	4-in.	15.00
B	5½-in.	18.00
C	7-in.	20.00
D	10-in.	27.00



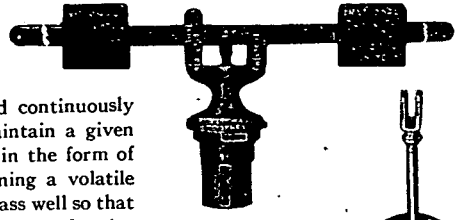
Type D-10 in. for Vapor or Vacuum

Damper Regulator Construction

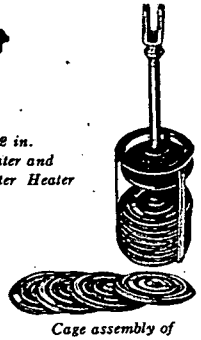
Note that the diaphragms are entirely enclosed and the moving parts protected from accidental injury. The self-collapsing feature of the Metaphram Sections helps to operate the lever and close the damper. The diaphragms are not injured by the highest vacuum.

Type F Damper Regulator

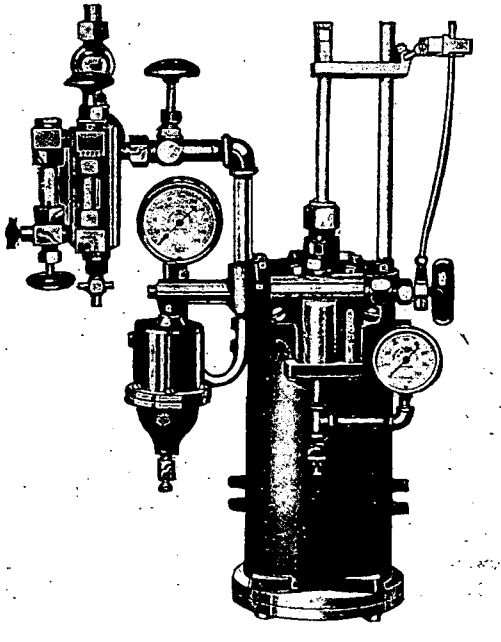
Metaphram Type F Damper Regulator for hot water boilers and domestic water heaters. Price $18.00 f.o.b. Chicago. A sensitive and powerful device that accurately and continuously apportions the draft required to maintain a given temperature. The Metaphrams are in the form of twelve separate wafers, each containing a volatile fluid. The wafers operate in a dry, brass well so that they may be inspected or renewed *without drawing the water*. This Regulator has advantages that have been quickly and widely recognized.



Type F-2 in. for Hot Water and Domestic Water Heater



Cage assembly of separable Metaphrams



A-Jacks High Pressure Steam Damper Regulator

Price $145.00, f.o. b. Chicago

Maintains the best conditions for combustion automatically. The A-Jacks operates from the steam pressure and requires no hydraulic supply or waste lines. It is simple, all metal, gives graduated action, and has positive adjustment. It is adapted for use with stoker or blower engines or electrically operated devices. Is being widely used under all conditions. Correspondence is invited.

THE POWERS REGULATOR CO.

36 years of specialization in temperature control

GENERAL OFFICES AND FACTORY
CHICAGO, ILL.
2719 GREENVIEW AVENUE

GENERAL EASTERN OFFICES
NEW YORK, N. Y.
126 EAST 44th STREET

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CHARLOTTE, N. C.	INDIANAPOLIS, IND.	ROCHESTER, N. Y.
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CINCINNATI, OHIO	LOS ANGELES, CALIF.	SAN FRANCISCO, CALIF.
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DENVER, COLO.	MILWAUKEE, WIS.	SEATTLE, WASH.
	MINNEAPOLIS, MINN.	

THE CANADIAN POWERS REGULATOR CO., LTD., TORONTO, ONT.
BRANCHES
CALGARY, HALIFAX, MONTREAL, VANCOUVER, WINNIPEG (3306A)

Products

Automatic Temperature Controlling Systems, applying them, under the supervision of Powers engineers, to the heating plants, new or old, in residences, offices, factories, schools, institutions, and to any other conditions of artificial heating where uniform temperature is desired.

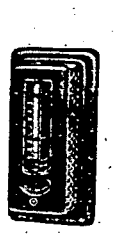
Automatic Regulators for ACCURATELY controlling temperature of Liquids, Gases and Air, Pressure Reducing Valves, High Pressure Steam Traps, Humidity Control Devices, Shower Mixing Valves, Etc.

Temperature Controlling Appliances

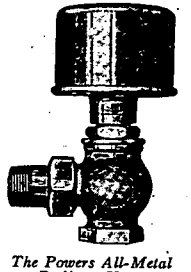
Powers thermostats are accurate in their working and will maintain their adjustment. They are of the vapor disc type, exclusive with Powers regulators, and are *not thrown out of adjustment by extremes* of temperature or long disuse. For over 35 years the accurate control obtained by this method has been the standard of thermostatic control by which all other methods are measured. In design, Powers thermostats are second to none in beauty and perfection of finish; in size, as small as is consistent with the reliability so necessary in such instruments; in operation, sure, with gradual or positive action, as conditions require.

Diaphragm radiator valves, diaphragm motors, mixing dampers and other equipment are especially rugged in construction, dependable and durable; built regardless of expense, for efficiency and long service.

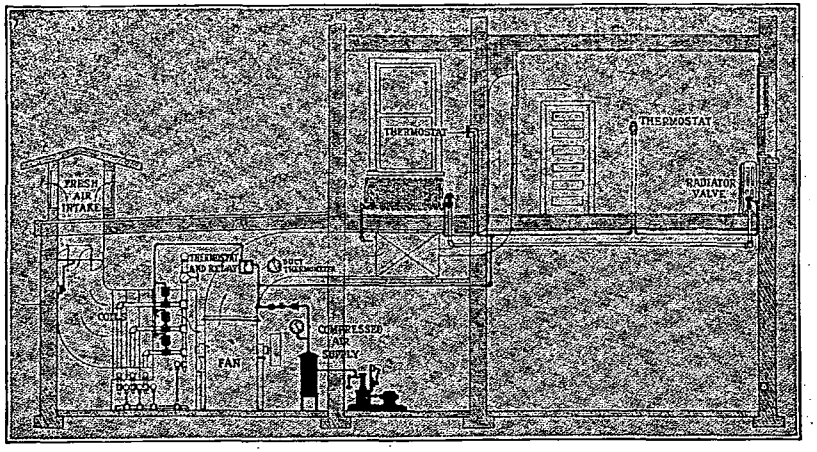
Motive power used in these systems is compressed air. The company builds its own air compressors, operated by steam, or electricity, and characterized by their reliability, noiseless operation, perfect control and long life.



Type D Thermostat



The Powers All-Metal Radiator Valve



Application of Powers Control to Combination (Split) System of Heating—Direct radiation supplies the heat; fan supplies warm air for ventilation. Thermostats control valves on radiators to maintain proper room temperature. Ventilating coils are controlled by a thermostat placed in the fan discharge duct.

Installations

Installations of Powers systems are invariably made by the company. At each branch office is maintained a competent engineering and erecting force, sparing no expense to maintain the highest efficiency. Powers special devices, however, are easily installed by any engineer or contractor.

Prices

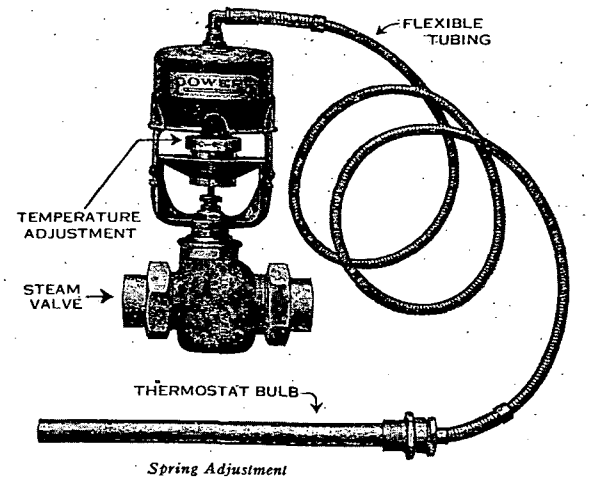
Price for Powers regulation covers the system installed complete, and is only named after a careful study of the requirements. Our price is not lowest, but no other system will be found so efficient and economical. Customers are served with the sole aim of getting results for them; and experience shows that **satisfactory service from a temperature controlling system is of much more importance than its first cost.**

Specifications

Heating systems, and the requirements for temperature control, vary widely in detail. Much of the dissatisfaction experienced with some systems of temperature regulation is due to the attempt to force a ready-made inflexible system or device to meet special requirements, taking no account of the conditions peculiar to the situation to be treated.

For these reasons we believe special study should be given each case. We shall be glad to submit to any Architect or Engineer a detailed Specification, accompanied by a guaranteed price, to cover complete system of temperature control installed, the price to hold if specification is used. This guarantees full protection to the client against advantage being taken of a close specification. This company will gladly collaborate with Architect or Engineer in preliminary plans. As specialists in temperature control, The Powers Regulator Company has unusual facilities for solving problems in this particular field.

Engineers, Architects, and others who wish further information regarding the Powers System, will find it in the following books: *Elimination of Heat Waste* shows applications in schools, churches, and other public buildings, residences, etc.; *Shop and Office Temperatures* shows applications in shops, offices and workrooms, also presents proof of fuel savings and increased production due to its use.



Spring Adjustment

The Powers No. 11 Tank Regulator

Used on steam heated hot water service tanks in hotels, apartment buildings, offices, schools, shops, hospitals, factories, laundries, etc. Because this regulator prevents overheated water, it saves fuel and prolongs the life of valves and packings. Self-operating; easily installed. Of great durability, guaranteed accurate and positive in action.

In ordering, always give size of tank, steam pipe size, steam pressure, and temperature wanted.

The spring type regulator is commonly used for this work, except in sizes larger than 4-inch, when the lever type is used. Smaller sizes will be furnished in lever type if preferred.

The regulator will be furnished to operate at 160 deg. fahr., with adjustability 20 deg. above and below that point, unless otherwise specified.

Flexible connection tube is 6 ft. long for sizes 1½-inch and smaller; 8 ft. for 2-inch to 4-inch, inclusive; and 10 ft. for larger sizes. Additional lengths of tubing will be furnished at 30 cents net per ft. A net charge of $2.00 is made for flexible tubing shorter than standard.

Flanged valves will be drilled standard unless otherwise ordered.

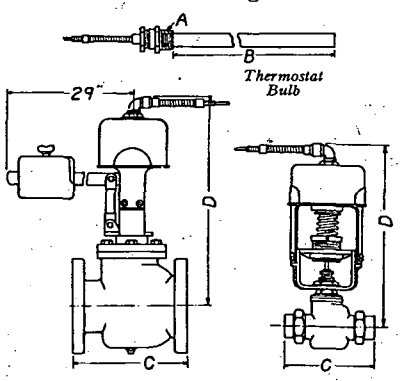
Specification

In connection with the (steam heated) hot water storage tank, furnish and install Powers No. 11 *Tank Regulator with (..... inch) standard valve* with standard length of flexible tubing. Regulator shall maintain the temperature of the water at (..... deg.) with steam pressure at (..... lbs.).

NOTE—Where installation is to control steam coil and auxiliary coal burning heater, specify No. 12 Regulator with chains, pulleys, etc., for the control of dampers on auxiliary heater (see Bulletin No. 129).

For coal burning heaters without steam coils, use Powers No. 13 Regulator (see Bulletin No. 136).

For Dimensions, Prices, etc., See Next Page



Iron Body Lever and Weight Adjustment

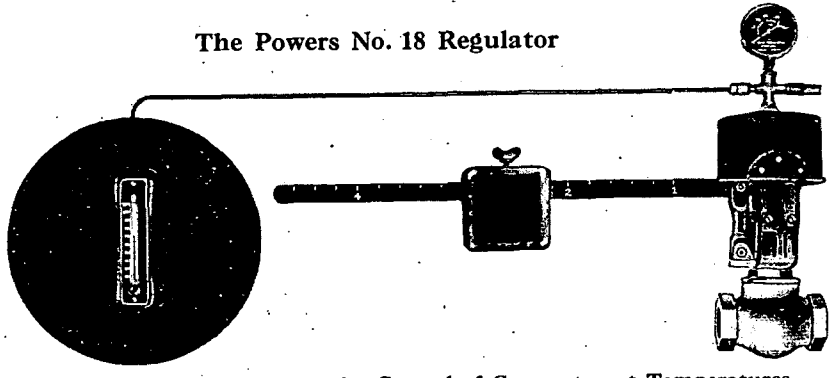
Brass Body Spring Adjustment

THE POWERS No. 11 TANK REGULATOR—Prices and Principal Dimensions

Valve Size.....Inches	½	¾	1	1¼	1½	2	2½
List Price (Standard Valve)	$60	$65	$70	$75	$80	$90	$95
List Price (Monel Valve)	$67	$72	$78	$83	$92	$104	$110
Style of Body	Union	Union	Union	Union	Union	Screwed	Screwed
Material of Body	Brass	Brass	Brass	Brass	Brass	Iron	Iron
Dimension A.....Inches	1	1	1	1	1	1	1
B.....“	10	10	12	14	14	16	16
C.....“	5⅝	6	6⅜	6⅛	7⅛	8	9
D.....“	11	11⅛	11⅛	11⅝	12⅝	14⅜	15¼

Valve Size.....Inches	3	3½	4	5	6	8
List Price (Standard Valve)	$100	$110	$120	$175	$225	$275
List Price (Monel Valve)	$118	$135	$150	$215		
Style of Body	Screwed	Flanged	Flanged	Flanged	Flanged	Flanged
Material of Body	Iron	Iron	Iron	Iron	Iron	Iron
Dimension A.....Inches	1	1	1	1¼	1¼	1¼
B.....“	18	20	20	20	20	24
C.....“	9½	10¾	10¾	12	13½	16⅛
D.....“	15¼	15⅝	15⅝	21⅛	23	24

The Powers No. 18 Regulator



A Self-Operating Regulator for Control of Compartment Temperatures Between 60 Deg. and 100 Deg. Fahr.

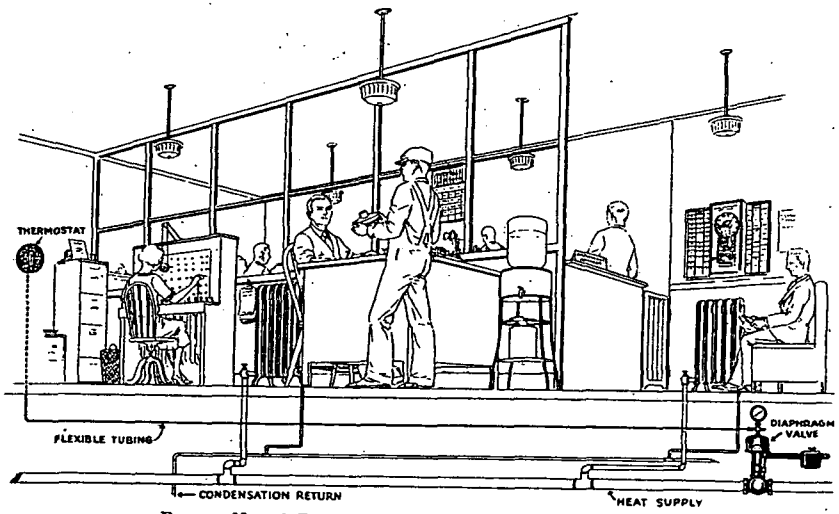
The Powers No. 18 Regulator shown above is a self-contained unit, not as sensitive in operation as the air pressure types but inexpensive and capable of good general control between the limits of 60 deg. and 100 deg. fahr., where such control can be obtained by the operation of a single valve regulating the heat supply. The control of this valve is gradual and an efficient return line vacuum system is essential.

This regulator is used in shops, offices, warehouses, storage rooms, low temperature drying rooms, small ventilating units, greenhouses, etc.

It is easy to install and is very DURABLE. Gives true gradual control. By changing the position of the adjusting weight, different temperatures over a 20 deg. fahr. range at the thermostat may be secured.

The flexible connecting tube may be of any length up to 75 feet or with the smaller valves 100 feet, and is usually of lead closely armored with galvanized steel wire. Armored copper tube can be furnished where conditions of vibration require its use, as in the control of fan ventilating units.

Standard flexible lead connecting tube of 50 feet will be sent unless otherwise specified; excess if any, can be coiled up near



Powers No. 18 Regulator applied to Direct Heating System

valve or damper motor. Additional tube length will be furnished at 20 cents net per foot.

For control of ventilating units or under other conditions of vibration, copper tube, armored, must be used instead of lead—such armored copper tube will be furnished at an extra net charge of 20 cents per foot for first 50 feet, and 30 cents per foot for excess.

Always specify desired operating temperature and steam pressure, and state whether latter is constant or fluctuating.

Bulletin 145 gives complete information.

PRICE LIST AND SHIPPING WEIGHTS OF No. 18 REGULATOR AND VALVE COMPLETE

Size	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"	4"
Price—Low Pressure	$50	$55	$60	$65	$70					
Price—High Pressure	60	65	70	75	80	$90	$125	$145	$175	$185
Shipping Weight (Lbs.)	45	48	50	55	60	65	110	120	160	170

No. 15 Regulator, self-contained, for the control of drying rooms, dry kilns, ovens, etc. Bulletin No. 138.

Dial Thermometers for air ducts and hot water tanks. Accurate, easy to read, reasonably priced. Bulletins No. 140 and No. 155.

High Pressure Steam Trap, ⅜ inch and ½ inch sizes only, for pressures from 5 lbs. to 125 lbs. Used on restaurant fixtures, hospital sterilizers, heating coils, cooking kettles, etc. Bigger capacity than any other trap its size. Acts quickly, closes tight. Gives years of dependable service without replacement of thermostatic element. Bulletin No. 115.

Hospital Sterilizer Control Valve—Makes sterilizer noiseless and saves steam. Bulletin No. 122.

Thermostatic Steam and Water Mixer—Automatically heats cold water with high pressure steam and delivers warm water at any temperature up to 120 deg. fahr. Bulletins No. 137 and No. 137-A.

Style D Steam and Water Mixer—Small, non-thermostatic mixer; supplies warm water for wash sinks, shower baths, and processes requiring a low cost warm water supply. Safe against scalding, easy to install, noiseless. Heats only the amount of water desired at the time. Capacity 10 gals. per min. with 40 lbs. pressure on supply lines. Bulletin No. 137-A.

Pressure Reducing Valve for steam, air and water. Simple, durable, accurate. Bulletin No. 118.

Complete set of bulletins describing the entire Powers line will be sent upon request.

Simplex Heat Regulator Company, Inc.

2938 Pillsbury Avenue, **Minneapolis, Minnesota**

PRODUCTS—Thermostats complete with Motors, for all types of Warm Air, Hot Water, or Steam Heating Systems, and also for Hot Water Supply Systems, whether equipped with Oil, Coal, or Gas Furnaces.

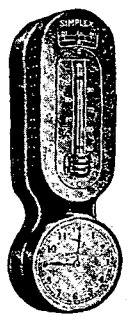
Separate Items Include

Thermostats, with or without clocks; Hydrostats; Electric Motors; Spring Motors; Gravity Motors.

THERMOSTATS

No. 30 Simplex Room Thermostat

Every SIMPLEX thermostat is equipped with a large and very sensitive coil of thermostatic metal, the expansion or contraction of which acts on an extremely simple and direct mechanism, with platinum contact points, making circuit with the motor. Regulation is accurate to within 1 deg. fahr. variation.

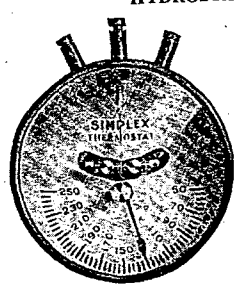


No. 31 Simplex Room Thermostat

All thermostats are equipped with the finest grade thermometers, which are given a quadruple test to insure absolute correlation between the thermostatic coil and thermometer. The standard finish is sand blast bronze, which is durable and attractive, blending well with any interior decoration.

Equipped with high-grade clock which automatically raises the temperature to the desired degree at any predetermined hour.

HYDROSTATS



SIMPLEX hydrostats are equipped with sensitive thermostatic coils, working through a balanced mechanism with dial indicators. Regulation is accurate to 1 deg. fahr. Made in tube and flush types for regulation of temperature on boilers, furnaces, and closed or open hot water supply tanks. Also used in *Dual Control* with any SIMPLEX thermostat.

SPECIFICATIONS—Temperature Control

Furnish and install in a neat and workmanlike manner complete SIMPLEX Temperature Control for the heating plant and domestic hot water supply system herein specified. Locate thermostat for heating plant at point designated by architect and owner, and leave the entire mechanism in perfect performing order. Furnish owner with letter of guarantee.

Units together with all necessary appurtenances, connections, controls, etc., to be furnished with this installation, are:

One { No. 30 Thermostat / No. 31 Thermostat with Clock } Select *one* Model

If desired with Dual-Control or for Hot Water Supply.

One SIMPLEX Hydrostat

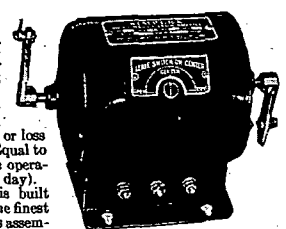
One { New SIMPLEX Electric Motor / SIMPLEX Spring Motor / SIMPLEX Gravity Motor } Select *one* Model

All installed according to Manufacturer's instructions, installation charts and drawings.

NOTE:—On Dual-Control, both thermostat and hydrostat, operate on a single motor. On domestic hot water supply systems, a single motor will operate both draft on heater and valve on steam supply.

ELECTRIC MOTOR

The SIMPLEX Electric Motor has been designed primarily for heat regulator use. Great care has been taken to insure strength, convenience, and reliability. Exhaustive tests of six weeks continuous running, night and day, without lubrication, have shown no overheating or loss of efficiency. (Equal to 50 years service operating 10 times a day).



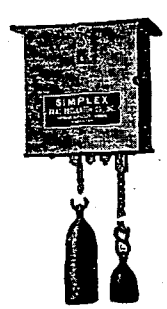
This motor is built throughout of the finest materials, and is assembled in a dust and damp-proof aluminum housing. Arranged for mounting horizontally on shelf or vertically on wall, with basement switch conveniently placed in either case.

SPRING MOTOR

The SIMPLEX Spring Motor derives its power from a heavy duty steel spring, which operates the lever arms through bronze reduction gears. It is provided with basement switch, winding indicator, and safety switch to insure furnace drafts being closed on the last operation. Assembled in a galvanized steel case, *black enameled* and absolutely rust-proof.

GRAVITY MOTOR

SIMPLEX Gravity Motor operates by an iron weight on chain. Fan governor provides smooth and silent operation, and a safety stop prevents furnace drafts being left open on last operation. Assembled same as Spring Motor Unit.



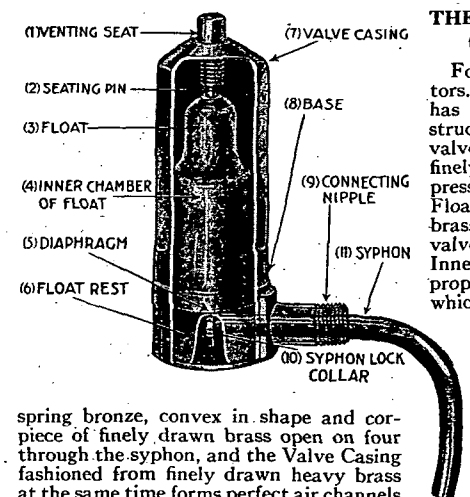
CATALOG—Notice to the Profession and Trade

Please write for copy of our general catalog, describing equipment and typical installations.

The Dole Valve Company

1913-1933 Carroll Avenue, CHICAGO, ILL.

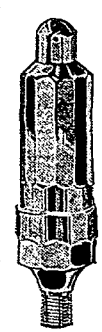
Manufacturers of High Grade Radiator Valves and Brass Specialties



THE DOLE SYPHON AIR VALVE (non adjustable, automatic)

For venting low pressure steam radiators. Fully guaranteed for five years. It has the Venting Seat (1) of heavy construction, threaded and brazed into the valve casing. The Seating Pin (2) of finely machined hard metal is hydraulically pressed to a perfect radius, while the Float (3) is of light but strong annealed brass, which rises when water enters the valve, positively preventing leakage. The Inner Chamber of Float (4) contains the proper amount of thermostatic liquid which forms a powerful gas when steam comes in contact with the float, thus the diaphragm is expanded and the valve closed against the escape of either steam or water. The Diaphragm (5) is made from special spring bronze, convex in shape and corrugated. The Float Rest (6) is one piece of finely drawn brass open on four sides to permit water to drain through the syphon, and the Valve Casing (7) of beautiful dodecagon design, fashioned from finely drawn heavy brass presents an attractive exterior and at the same time forms perfect air channels inside the valve. The Base (8) of heavy drawn brass *threaded on the interior* to meet exterior threading on the casing is firmly brazed to insure great strength and durability. The Connecting Nipple (9)—one piece of extra heavy drawn brass has ⅛ in. standard iron pipe thread, which conforms to the requirements of all radiators. A Syphon Lock Collar (10) made from extra heavy brass firmly brazed to the syphon prevents either accidental or intentional removal of the syphon from the valve. (Note, the valve can be removed from the radiator without the syphon becoming detached). The Syphon (11)—one piece of annealed brass tubing, *is perfectly formed to fit inside the radiator column.* Assembled into the valve free from obstruction, thus preventing interference when the valve is attached to the radiator. Regarding the finish, the entire valve is finely nickel plated, of an artistic design and highly polished. A real "beauty" and it works.

List Price.....$1.50



THE DOLE STRAIGHT SHANK QUICK VENT AIR VALVE

For quick venting the ends of steam mains, specially useful for venting hot water generators and low pressure feed water heaters where a straight shank valve is required. Made from similar material, constructed in like manner and operates on the same principle as the Dole Syphon Air Valve. Made in three sizes—¼ and ⅛ in. List Price **$2.00** and the ¾ in. List Price **$3.00.**

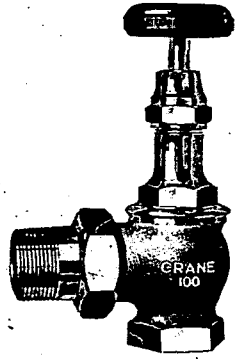
CRANE CO.

Manufacturers of Valves, Fittings, Fabricated Piping, Steam Specialties, Plumbing and Heating Materials

836 S. Michigan Avenue **Chicago, Ill.**

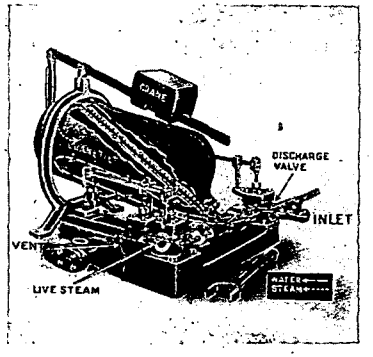
Branches in All Principal Cities

Write for catalogues and full information about any materials in which you are interested



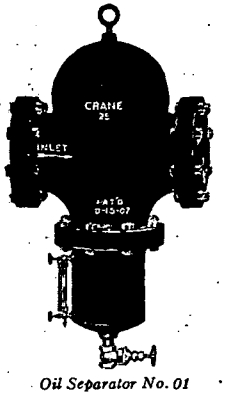
Radiator Valve No. 220

Brass. For steam or vacuum systems. Self-adjusting packed stuffing box. Crane renewable disc.



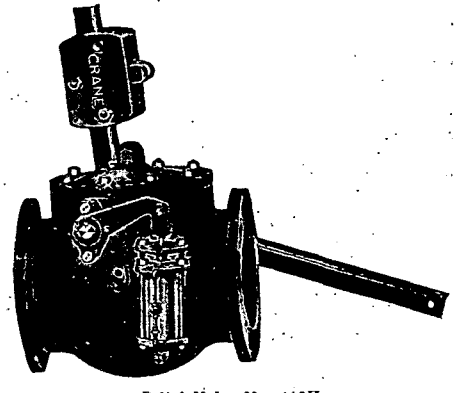
Cranetilt 3-Valve Trap No. 100

For lifting condensation to a higher point, for vacuum or pressure lines, for lines of varying pressure, for draining oil separator, for metering.



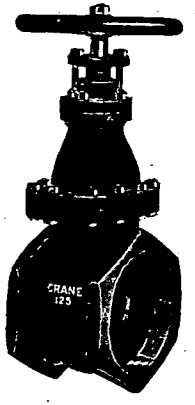
Oil Separator No. 01

Cast iron. For elimination of oil and water from exhaust or vacuum lines.



Relief Valve No. 416H

Back pressure and exhaust. Iron body, brass mounted. For condensing or non-condensing engines. Dashpot cushions the disc and prevents pound or hammer.



Wedge Gate Valve No. 460

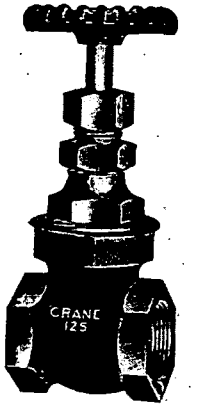
Standard, non-rising stem. Iron body, brass trimmings. Screwed or flanged.

Cast Iron Elbow

Standard, screwed. For steam working pressures to 125 lbs. and water working pressures to 175 lbs.

Cast Iron Tee

Standard, screwed. For steam working pressures to 125 lbs. and water working pressures to 175 lbs.

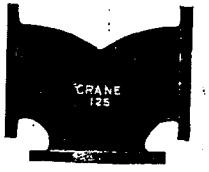


Wedge Gate Valve No. 438

Standard, brass. Non-rising stem. With gland in stuffing box.

Elbow No. 526

Standard, cast iron. Flanged. For steam working pressures to 125 lbs.

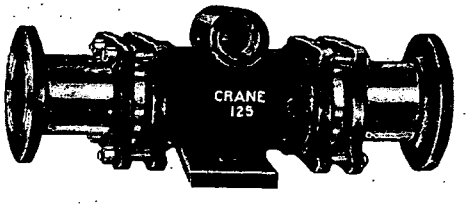


Elbow No. 538

Standard, cast iron. Double branch. Flanged. For steam working pressures to 125 lbs.

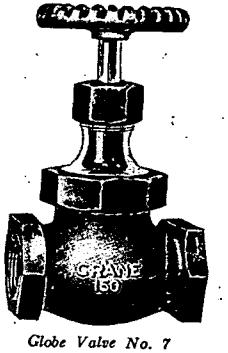
Check Valve No. 27

Brass. Horizontal or angle patterns. Crane renewable disc. Union bonnet.



Double Expansion Joint No. 409

Iron body, brass sleeves. Flanged. Furnished with screwed ends when so specified. For steam working pressures up to 125 lbs.



Globe Valve No. 7

Brass. Many purpose valve. Crane renewable disc. Union bonnet.

The Fairbanks Company

NEW YORK, N. Y. BOSTON, MASS.
PITTSBURGH, PA. LONDON, ENGLAND

Factory: **Binghamton, N. Y.**

Fairbanks Bronze Globe Valves

Fig. 01

Simple in construction; parts quickly and easily renewed; stuffing box packed with specially moulded vulcabeston ring which is durable and cannot be blown or washed out; valves can be packed under pressure when wide open. Made in sizes ⅛ to 3 in.

Fairbanks Bronze Radiator Valves

Globe and Angle Types

Embody all good points of the Fairbanks Fig. 01 Valve. Furnished with Wood Wheels or lock shield and T handles. Made in sizes ⅛ to 2 in.

Fig. 012

Fairbanks Standard Bronze Gate Valves

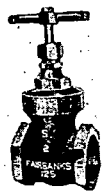


Fig. 0205

For general service. Stuffing boxes can be repacked under pressure when wide open. Guides in wedge and ribs in body so fitted as to insure true and easy movement; prevent wedge from touching seats except at point of closing. Made in sizes from ¼ to 3 in.

Fairbanks Bronze Swing Check Valve

As perfect a check valve as ever constructed. Has full area equal to pipe connection and straightway passage. The rotating disc works freely, never sticking on the seat. Made in sizes ¼ to 3 in.

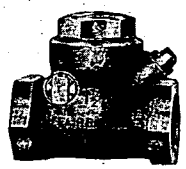


Fig. 0601

Fairbanks Iron Body Valves

Globe and Angle Types with Renewable Vulcabeston Ring Disc

Fig. 0101

Embody the most modern renewable features. Have a raised round seat upon which scale, grip or other sediment will not lodge. Disc Rings will not crack or flake; easily and quickly renewed. Valve so constructed as to eliminate all rattling or tilting when open.

Fairbanks Standard Iron Body Gate Valves

Designed for a maximum steam working pressure of 125 lb. Guides in wedge and ribs in body so finished and fitted as to insure true and easy movement; prevent wedge from touching seats in body, except at point of closing. Made in sizes from 2 to 12 in. Flanged type up to 20 in.

Fig. 0402

Fairbanks Iron Body Swing Check Valves

Fig. 0701

Designed with a 45 deg. Angle seat making it possible to use the valve in either a horizontal or a vertical position. Regularly equipped with Bronze Disc; can be furnished with Rubber Disc for water service. Made in sizes 2 to 12 in.

Fairbanks Sphero Ball Valves

An entirely different principle,—designed and built to meet the need of an easily operated, quickly repaired valve. Construction is simple and substantial. Has straight through passageway, renewable seats, interchangeable parts, and is easily opened or closed. Made in sizes from ½ to 8 in.

Fig. 0828

Jenkins Bros.

Manufacturers of Valves and Mechanical Rubber Goods

PRINCIPAL STORES AND OFFICES

80 White Street, NEW YORK, N. Y. — 524 Atlantic Avenue, BOSTON, MASS. — 133 North 7th Street, PHILADELPHIA, PA. — 646 Washington Boulevard, CHICAGO, ILL.

FACTORIES IN ELIZABETH, N. J. AND BRIDGEPORT, CONN.

JENKINS BROS., LIMITED

CANADIAN WORKS AND HEAD OFFICE: MONTREAL, QUE., 103 St. Remi Street
LONDON OFFICE: 6 Great Queen Street, Kingsway, W. C. 2

The New Modulating Valve—*with a vertical seat*

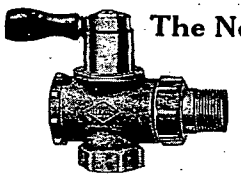


Fig. 700, Jenkins Modulating Valve

A notable improvement over present day modulating valves lies in Fig. 700 Jenkins Modulating Valve which has a vertical instead of a horizontal seat, affording these particular advantages:

Foreign matter cannot lodge on seat and prevent tight closing of valve.

Vacuum is under disc holder, which is fitted with Jenkins Rubber Composition Disc, with a tendency to draw disc to the seat. Spring holds disc against seat. Seating and tightness do not depend on threaded spindle that needs to be turned down tight to prevent leakage.

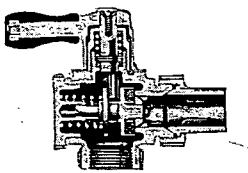


Fig. 700, Sectional View

This valve cannot leak around spindle. Handle of red Bakelite does not get hot, will not crack or chip.

Made of bronze, nickel plated, ¾ inch size, suitable for 100 square feet of radiation. The center to end dimensions conform to the recommendations of Heating and Piping Contractors National Association and Manufacturers Standardization Society. Write for Bulletin 105 for complete details.

PRODUCTS

Jenkins Globe, Angle, Cross, Check, Hose, Blow-Off, Safety and Gate Valves; Radiator Supply Valves; Automatic Radiator Air Valves.

Also, Rapid Action Valves; Steam Traps; Gage Cocks; Marine Valves, Needle Valves—Valve Discs; Jenkins '96 and Jenarco Sheet Packing, Gaskets, Pump Valves; Compressed Asbestos Joisting; and Moncrieff Scotch Gauge Glasses.

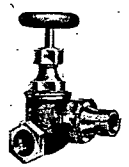


Fig. 180, Bronze Offset Corner, Radiator with Union

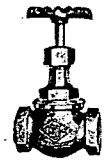


Fig. 106, Bronze Globe, Screwed

RADIATOR VALVES

Regularly furnished with black composition wheels, or, if desired, with bronze, wire or iron wheels.

Lock shield valves, to be operated with key, designed to prevent tampering, can be supplied in all the different patterns.

Corner valves are made in two patterns—regular and offset.

Regular styles of finish follow:

Rough body, finished trimmings, No. 1 screwed, No. 6 with union.

Finished and polished all over, No. 2 screwed, No. 7 with union.

Rough body, nickel-plated trimmings, No. 3 screwed, No. 8 with union.

Rough body, nickel-plated all over, No. 4 screwed, No. 9 with union.

Finished and nickel-plated all over, No. 5 screwed, No. 10 with union.

Fig. 351, Bronze Radiator Gate, Screwed

Fig. 352, Bronze Swing Check Valve

CATALOG

A catalog of all the Jenkins valves, giving sizes, styles and list prices, mailed on request.

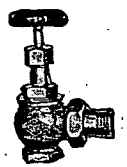


Fig. 168, Radiator Angle, with Union

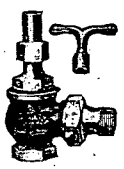


Fig. 170, Bronze Lock Shield Radiator Angle, with Union

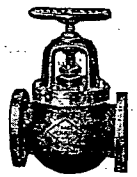


Fig. 142, Iron Body Globe, Flanged

Fig. 325, Iron Body Gate, Screwed

Fig. 370, Bronze Gate, Screwed

Marsh Valve Company

Plant and General Offices: DUNKIRK, NEW YORK

Exclusive Sales Distributors:

APPLETON & LIPTROTT, INC., 1480 Broadway, New York City

Edward T. Hetherington,
1718 Sansom Street, Philadelphia, Pa.

United States Radiator Corporation,
General Offices, Detroit, Mich.
All territory east of West lines of Michigan and Ohio and north of Virginia, except New York and Philadelphia

John W. Mabbs,
431 S. Dearborn Street, Chicago, Ill.

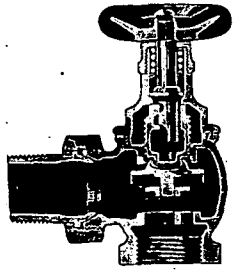
Jas. P. Marsh & Company,
118 S. Clinton Street, Chicago, Ill.
All territory south of Ohio River and west of Michigan and Ohio, except Cook County, Chicago, Ill.

We specialize on high-grade Radiator Valves and make the largest line of any company in the world.

The re-enforced packless feature of our Packless and Modulated lines both steam and water and the upper seat features of our Union Bonnet, Special and Gate lines are distinctive, scientific, mechanical principles, used with these lines exclusively.

MARSH RE-ENFORCED PACKLESS RADIATOR VALVES

Oval Wheel or Lock Shield



Flat-Disc

All sizes and patterns Globes, Angles Corner and Back Offsets

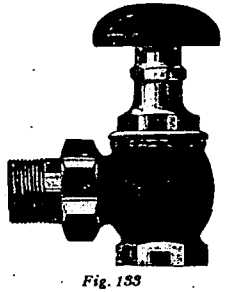


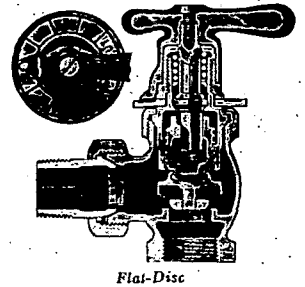
Fig. 133

We call particular attention to the scientific mechanical construction of the Re-enforced Cone Metal Packless Feature of our Modulated and Packless Valves. These are the only Packless Valves in which the Packless feature is re-enforced or in any way protected against leakage due to wear or cracks of so-called Packless parts and are GUARANTEED against wear or defects of Packless construction and leakage through bonnets.

QUICK OPENING

A three-fourths turn will fully open a three-quarter inch valve, and from this up to one and one-quarter turns for balance of line through two inches. These valves, account of low pitch of thread due to large diameter of cylinder, will seal and lock against any pressure.

MARSH RE-ENFORCED MODULATED LEVER HANDLE RADIATOR VALVES



Flat-Disc

These Valves may be had with Oval Wheel in place of Lever Handle same as *Fig. 147*

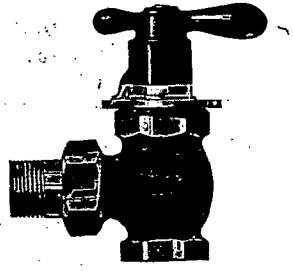
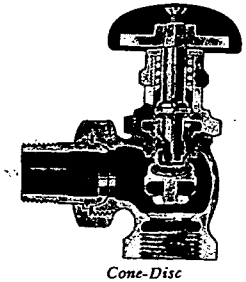


Fig. 132

The Modulation or Graduation is accomplished by a cone disc nut, regulating volume of steam, according to pressure, until indicator registers valve about two-thirds open, when the further turning of lever handle until indicator registers open, will give full valve capacity; a feature of material value in a valve in which volume or capacity for modulating purposes is choked down, and to meet extreme weather conditions, full pipe capacity is required.

MARSH RE-ENFORCED PACKLESS CONE DISC RADIATOR VALVES

Oval Wheel or Lock Shield



Cone-Disc

These Discs will not crack or leak through valve seat.

No clogging or water hammer from return condensation

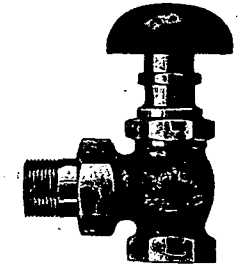
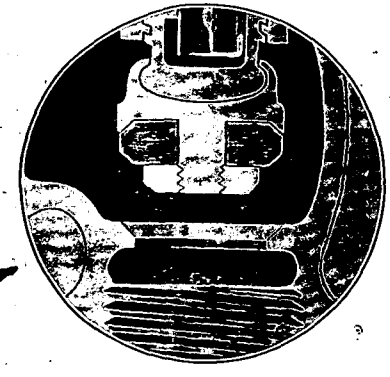


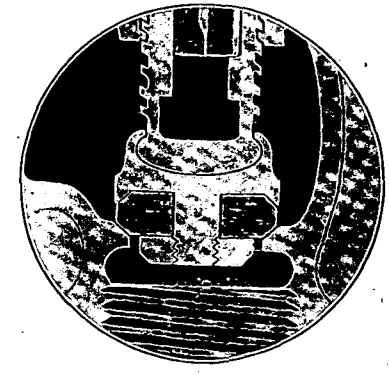
Fig. 141

Marsh Cone Discs are without question the greatest improvement in radiator valve construction in the past fifty years or since the composition disc replacing the old style metal-to-metal disc and seat.

This Cone Disc construction combined with the Marsh Re-enforced Packless Feature is the last word in completing radiator valve maximum efficiency at popular price, all of which will check 100 per cent true upon investigation.



¾ in. Full Size



Positive Seal

The above views showing cone disc and beveled seat are to actual size of a ¾ in. valve and are made to full size to show the following advantages of this construction over the old style flat disc and seat:

First: Through design of disc and protection afforded from disc nut covering under surface they will not warp and crack as will a flat disc which overhangs valve seat.

Second: The compression is at right angles to face of seat, forcing disc compound inward to center, making disc more compact and harder instead of scoring and extruding over seat, opening cracks or seams if any, as with a flat disc.

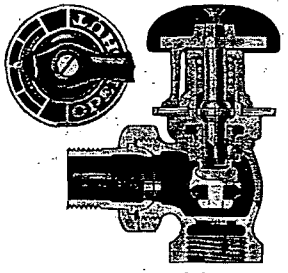
Third: While the life of these cone discs because of construction, as proven by tests, is three to five times the life of a flat disc, and a CRACKED DISC IS IMPOSSIBLE, the matter of exchange if desired is very simple, as to remove disc nut the disc will drop from disc-holder, while with a flat disc it must be dug out, often destroying disc-holder. Further, these cone discs are reversible and can be turned over or replaced with new at the same cost as for a flat disc.

Fourth: The beveled seat is low in valve body, giving perfect drainage and will wash free from sand or scale in system, positively providing against leakage through scale or grit imbedding in disc AS IS COMMON with a raised flat seat and flat disc construction.

Fifth: Through this low beveled seat, to return condensation through valve for a one-pipe system, the flow will hold to the outer wall leaving center of valve throat and pipe free rather than shoot out over a raised seat to the center of pipe as is common with a heavy flow over a flat seat, clogging flow of steam, causing hammer or pounding of system.

The foregoing are all, each and every one, practical points which will prove out in test and practice. Positively a better valve at a less cost than can be had from any other source.

MARSH RE-ENFORCED MODULATED CONE DISC RADIATOR VALVES



Cone-Disc Mod.

Oval Wheel, Lever Handle or Lock Shield

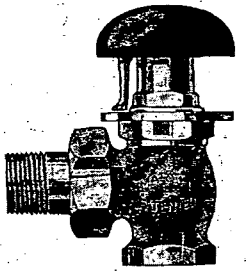


Fig. 147

The Modulation feature of our Cone Disc Line is the same as with our union bonnet flat disc Figure 132.

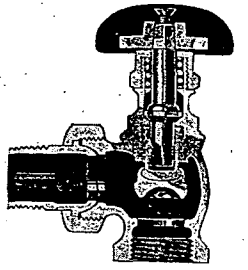
Our Cone Disc Modulated valves unless otherwise ordered are fitted with Oval Wheel. When Lever Handle is preferred, Fig. No. is 148.

With our Oval Wheel Handle you have the same dial and indicator control as with Lever handle and a much stronger and more serviceable CONSTRUCTION than is possible with a Wood wheel as this composition won't break or split as will wood.

Further, this wheel is removable and interchangeable with our Lever handle, effecting a material advantage to customer in matter of convenience of changing from one to the other on job if for any reason change is desired.

MARSH RE-ENFORCED PACKLESS WATER RADIATOR VALVES

Oval Wheel or Lock Shield



Packless

A Genuine Packless Water Valve Guaranteed to hold any pressure required for forced circulation

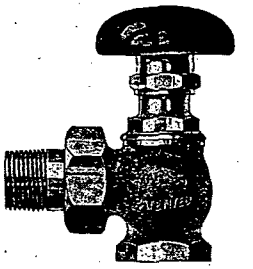


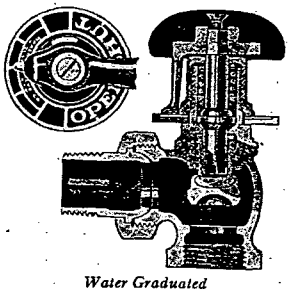
Fig. 137

Marsh re-enforced packless Hot Water Radiator Valves are not only a boon but the answer to hot water heating problems, permitting the same ease of operation and complete temperature control as with steam.

These hot water valves are quick opening, can be operated—opened and closed—with perfect ease by a child and positively will not stick or leak.

They will hold high pressure suitable for forced circulation up to any pressure radiation will stand, and cost no more than the cheap competition valves.

MARSH RE-ENFORCED GRADUATED WATER RADIATOR VALVES



Water Graduated

Oval Wheel, Lever Handle or Lock Shield

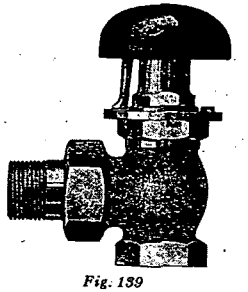


Fig. 139

SOMETHING ENTIRELY NEW IN WATER HEAT REGULATION

We have made a special study of hot water heat regulation and control and are pioneers in the matter of individual radiator control, through a graduated valve, employing the same principle as with steam. If you can modulate, graduate, or regulate individual radiator vapor or vacuum steam heat through a valve (and you can), then why not by the same principle regulate water heat, and, for that matter more consistently than steam, as with water you have something to regulate, while with steam, to allow fire to drop below a given point, you have nothing.

For sleeping rooms, heat regulation with the Marsh Graduated water valves may be controlled with the same ease of operation and certainty of results as is possible with a Modulated valve on a steam system, and at a much less cost than for a vapor or vacuum system installation.

Further, water circulation for each radiator, graduating for same or balancing of system, can be increased from nothing to full pipe capacity and held or locked at any intermediate point, if desired, by simply turning dial so that stop on same will register against indicator or pointer and locking dial in this position, preventing further opening of valve or turning of wheel or lever handle to the left.

These valves cost but little more than our regular water valves and much less than steam modulated valves.

Pierce, Butler & Pierce Mfg. Corp.

41 East 42nd Street, New York City

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Radiator Valves, High Pressure Valves, Hot Water Valves, Hot Water Thermometers, Pressure and Altitude Gages

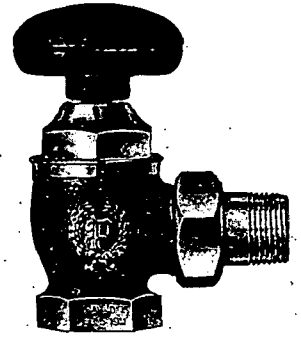


Fig. 156. Angle Valve with Union
(With Genuine Jenkins Bros. Disc)

PIERCE PACKLESS VALVE—Improved Pattern

THE Pierce Packless Valve is now offered in a much more compact and attractive pattern than ever before.

The handle is of highly polished Bakelite, a most effective heat insulator; it is always cool and comfortable to the hand.

The closing pressure is transmitted through a coiled spring. No extra powerful wrist is required for closing the valve, and the elastic pressure follows up and keeps it tight.

The nickel plating is, as it always has been, decidedly superior both in thickness and finish. The parts are plated separately and washed thoroughly before assembly. Consequently the insides of Pierce Packless Valves are never fouled with corrosive salts of nickel, as is the case when valves are plated *after* being assembled.

The Pierce Packless is not a cheap "competition" valve. Nevertheless the price is so modest that the amount it adds to the cost of a radiator installation is insignificant as compared with the satisfaction it gives.

The John Call Company

VENTILATING SPECIALISTS

128 North Franklin Street **Philadelphia, Pa.**

BRANCHES IN ALL PRINCIPAL CITIES

ROOF VENTILATORS AND WINDOW VENTILATORS

Products

The Liberty Ventilator. A roof ventilator for any type building or enclosure, such as Schools, Hospitals, Foundries, Barns, Churches, Armories, Residences and similar structures.

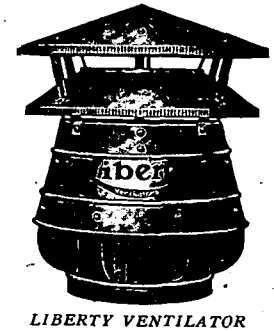
Also highly efficient for increasing draft in chimneys, flues, stacks, etc. Back drafts impossible, regardless of wind conditions. Rain or snow cannot penetrate. No moving parts to rattle or require attention. Substantially and staunchly built of any metal desired. Large stocks for prompt shipment.

The Pul-Air Impingement Ventilator

The Pul-Air Ventilator

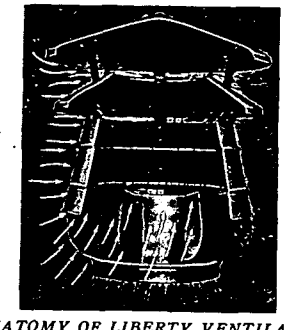
A good practical roof ventilator of the mushroom type, consisting of a double-cone top. Scientific storm band and impingement band. Made in every size and of any metal. Strongly built. Large stocks carried. Will not back draft; maximum of free areas.

THE LIBERTY VENTILATOR



LIBERTY VENTILATOR

Good architectural lines and symmetry



ANATOMY OF LIBERTY VENTILATOR—showing positive venturi action. White arrows indicate outside winds. Black arrows foul air being pulled out

Embraces all four principles of scientific ventilation:—1st, Impingement; 2nd, Positive and Negative sides of Ventilators; 3rd, Siphonage; 4th, Stack Action. A positive and complete venturi action.

The Liberty Ventilator combines the principles of siphonage and air impingement. This in conjunction with the positive and negative sides of the ventilator creates a vacuum to which the air is naturally sucked regardless of the direction of the wind. Stack action, also, is so accommodated as to accelerate this movement. The free areas of the Liberty ventilator create no resistant constant. **Send for copy of tests conducted by Carnegie Institute of Technology, and Massachusetts Institute of Technology.**

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AIR PUMPS (*See Pumps, Air*)

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Wing, L. J., Mfg. Co.
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Wing, L. J., Mfg. Co.
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Cleanser

Vinco Co., Inc., The

Controllers (*See Controllers*)

Coverings (*See Asbestos and Insulating Products*)

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McAlear Mfg. Co.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.

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Weil-McLain Co.

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Burnham Boiler Corp.
Continental Heater Corp. (*Now* National Radiator Corp.)
Efficient Heating Boiler Co.
Fitzgibbons Boiler Co., Inc.
Frost Mfg. Co., The
General Air Filters Corp.
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Newport Boiler Co.
Oil City Boiler Works
Orr & Sembower, Inc.
Pacific Steel Boiler Corp.
Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
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Spencer Heater Co.
Titusville Iron Works
U. S. Radiator Corp.
Universal Smokeless Boiler Co.
Weil-McLain Co.

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Coatesville Boiler Works
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Efficient Heating Boiler Co.
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COAL SAVER
American Blower Co.
Combustion Specialties Corp.
Economy Grate & Equipment Co., Inc.
Minneapolis Heat Regulator Co.

COCKS—Air
Bishop & Babcock Sales Co., The
Crane Co.
Mueller Co.

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Boiler Drain
Crane Co.
Mueller Co.

Boiler Supply
Crane Co.
Mueller Co.

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Crane Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
O-E Specialty Mfg. Co.

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Grinnell Co., Inc.
Whitlock Coil Pipe Co.

Blast
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American Blower Co.
American Radiator Co.
Modine Mfg. Co.
New York Blower Co.
Pecco, Inc.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co., The
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
York Heating & Ventilating Corp.

Pipe
American Blower Co.
Badger, E. B., & Sons
Crane Co.
Grinnell Co., Inc.
Pecco, Inc.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

Tank
Badger, E. B., & Sons
Crane Co.
Kewanee Boiler Co.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.

COLLECTORS, DUST (*See Dust Collectors*)

COLUMNS—Water
American Gas Products Corp.
American Radiator Co.
American-Schaeffer & Budenberg Corp.
Crane Co.
Kieley & Mueller Co.
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Titusville Iron Works

COMPOUNDS—Boiler
Richardson & Boynton Co.
Vinco Co., Inc., The

COMPRESSORS
American Steam Pump Co.
Bishop & Babcock Sales Co., The
General Electric Co.
Nash Engineering Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sturtevant, B. F., Co.
Trane Co., The

CONDENSERS
Alberger Heater Co.
American Steam Pump Co.
Buffalo Steam Pump Co.
Carrier Engineering Corp.
Davis Engineering Corp.
Frank, O. E., Heater & Engineering Co., Inc.
General Air Filters Corp.
Rome Brass Radiator Corp.
Westinghouse Electric & Mfg. Co.
Whitlock Coil Pipe Co.

CONDUIT—Underground
American District Steam Co.
Johns-Manville Corp.
Ric-wiL Co., The
Westinghouse Electric & Mfg. Co.

CONTROL EQUIPMENT
Absolute Con-tac-tor Corp.
American Radiator Co.
General Electric Co.
Honeywell Heating Specialties Co.
Johnson Service Co.
Klipfel Mfg. Co.
McDonnell & Miller
Minneapolis Heat Regulator Co.
Mueller Co.
National Regulator Co.
Powers Regulator Co.
Trane Co., The
Westinghouse Electric & Mfg. Co.

CONTROL SWITCHES (*See Switches, Control*)

CONTROLLERS—Automatic Air
Minneapolis Heat Regulator Co.

Boiler
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Davis, G. M., Regulator Co.
Fitzgibbons Boiler Co., Inc.
Honeywell Heating Specialties Co
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co., The
McDonnell & Miller
Marine-Galligan Co., Inc.
Mueller Steam Specialty Co., Inc.
Powers Regulator Co.
Sarco Co., Inc.
Simplex Heat Regulator Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The

Electric Heat
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Johnson Service Co.
Klipfel Mfg. Co.
Minneapolis Heat Regulator Co.
Powers Regulator Co.
Rome Brass Radiator Corp.
Simplex Heat Regulator Co., Inc.
Westinghouse Electric & Mfg. Co.

Fan Engine
American Blower Co.
Clarage Fan Co.
Frost Mfg. Co., The
Kieley & Muller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sturtevant, B. F., Co.

Feed Water
American Radiator Co.
American Schaeffer & Budenberg Corp.
Burnham Boiler Corp.
Davis, G. M., Regulator Co.
Economy Pumping Machinery Co.
Fulton Sylphon Co., The
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.

Gas Burner
Minneapolis Heat Regulator Co.

Motor
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Economy Pumping Machinery Co.
General Electric Co.
Honeywell Heating Specialties Co.
Mason Regulator Co.
Trane Co., The
Westinghouse Electric & Mfg. Co.

Pump
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Buffalo Steam Pump Co.
Chicago Pump Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Economy Pumping Machinery Co.
General Electric Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The
Westinghouse Electric & Mfg. Co.

Shower Bath
American Schaeffer & Budenberg Corp.
Crane Co.
Mueller Co.
Powers Regulator Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

Tank
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Davis, G. M., Regulator Co.
- Fulton Sylphon Co., The
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Powers Regulator Co.
- Sarco Co., Inc.
- Simplex Heat Regulator Co., Inc.
- Stickle Steam Specialties Co.

Unit Heaters
- Minneapolis Heat Regulator Co.

Temperature (*See Regulators, Temperature*)

CONVEYING SYSTEMS (*See Systems, Dust Collecting and Exhaust*)

COOLING EQUIPMENT—Building
- American Blower Co.
- Atmospheric Conditioning Corp.
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Air Conditioning Corp. of America
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- Rome Brass Radiator Corp.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

COOLING TOWERS
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Spray Engineering Co.

Cooling Ponds
- Spray Engineering Co.

COUPLINGS
- Mogul Machine Co.

COVERING—Boiler (*See Asbestos and Insulating Products*)

Magnesia
- Johns-Manville Corp.

Pipe and Tank
- Johns-Manville Corp.
- Ric-wiL Co., The

DAMPER—Quadrants
- York Heating & Ventilating Corp.

DAMPER REGULATORS (*See Regulators, Damper*)

DEHUMIDIFYING APPARATUS
- American Blower Co.
- Atmospheric Conditioning Corp.
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Shipp, C. C., & Co.
- Skinner Bros. Mfg. Co., Inc.
- Spray Engineering Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

DIFFUSERS—Air
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Knowles Mushroom Ventilator Co.
- National Air Filter Co.
- Shipp, C. C., & Co.
- Spray Engineering Co.
- Sturtevant, B. F., Co.

DRAFT GAGES (*See Gages, Draft*)

DRYING APPARATUS
- American Blower Co.
- Atmospheric Conditioning Corp.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Lebanon Boiler Works
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Petty, J. K., & Co., Inc.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

DUST COLLECTING SYSTEMS (*See Systems, Dust Collecting*)

DUST COLLECTORS
- American Blower Co.
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- General Air Filters Corp.
- Midwest Air Filters, Inc.
- New York Blower Co.
- Pecco, Inc.
- Reed Air Filter Co.
- Skinner Bros. Mfg. Co., Inc.
- Spray Engineering Co.
- Sturtevant, B. F., Co.

DUST COUNTERS
- Hill, E. Vernon, Co.

DUST FILTERS
- Drying Systems, Inc.
- General Air Filters Corp.
- Midwest Air Filters, Inc.
- National Air Filter Co.
- Reed Air Filters Co., Inc.
- Spray Engineering Co.

DUST SEPARATORS (*See Separators, Dust*)

ELBOWS—Radiator
- American District Steam Co.
- American Radiator Co.
- Burnham Boiler Corp.
- Crane Co.
- Fulton Sylphon Co., The
- U. S. Radiator Corp.

ELECTRIC HEATING APPARATUS
- Westinghouse Electric & Mfg. Co.

ELECTRIC MOTORS (*See Motors, Electric*)

ELIMINATORS—Air
- American District Steam Co.
- Badger, E. B., & Sons Co.
- Bishop & Babcock Sales Co., The
- Call, John, Co., The
- Dunham, C. A., Co.
- General Air Filters Corp.
- Hoffman Specialty Co., Inc.
- Kieley & Mueller, Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- Milwaukee Valve Co.
- Monash-Younker Co., Inc.
- Mueller Steam Specialty Co., Inc.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Sarco Co., Inc.
- Skinner Bros., Mfg. Co.
- Sturtevant, B. F., Co.
- Trane Co., The

ENGINES—Fan
- American Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Frost Mfg. Co., The
- New York Blower Co.
- Sturtevant, B. F., Co.

Steam (*Automatic, High Speed, Throttling, Una-Flow, and Vertical*)
- American Blower Co.
- Ames Iron Works
- Clarage Fan Co.
- Frost Mfg. Co., The
- Herbert Boiler Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Sturtevant, B. F., Co.
- Titusville Iron Works

EXHAUST FANS (*See Fans, Exhaust*)

EXHAUST HEADS
- Buffalo Forge Co.
- Call, John, Co., The
- Crane Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co.
- Patterson-Kelley Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

EXHAUST SYSTEMS
- American Blower Co.
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Davis Engineering Corp.
- Ilg Electric Ventilating Co.
- New York Blower Co.
- Pecco, Inc.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Wing, L. J., Mfg. Co.

EXPANSION JOINTS (*See Joints, Expansion*)

FANS—Blower (*See Blowers, Fan*)

Booster
- American Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Honeywell Heating Specialties Co.
- Reed Air Filter Co.
- Sturtevant, B. F., Co.

Cooling Tower
- American Blower Co.

Exhaust
- American Blower Co.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Clarage Fan Co.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Skinner Bros. Mfg. Co., Inc
- Sturtevant, B. F., Co.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Ventilating
- American Blower Co.
- Bayley Blower Co.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Call, John, Co., The
- Clarage Fan Co.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Skinner Bros. Mfg. Co., Inc.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

FEEDERS (*See Boiler Feeders*)

Boiler
- Crane Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co., The
- McDonnell & Miller
- Mueller Steam Specialty Co., Inc.

Water
- American Gas Products Corp.
- Kieley & Mueller, Inc.
- McDonnell & Miller
- Mueller Steam Specialty Co., Inc.

FILTERS—Air
- American Blower Co.
- Call, John, Co., The
- General Air Filters Corp.
- Midwest Air Filters, Inc.
- National Air Filter Co.
- Reed Air Filter Co., Inc.
- Spray Engineering Co.
- Sturtevant, B. F., Co.

FIRE BRICK CEMENT (*See Cement, Fire Brick*)

FITTINGS—Flanged
- American District Steam Co.
- Crane Co.
- Grinnell Co., Inc.

Furnace
- International Heater Co.
- Langenberg Mfg. Co.

Pipe
- Crane Co.
- Grinnell Co., Inc.
- International Heater Co.
- Westinghouse Electric & Mfg. Co.

FOG ELIMINATORS
- American Blower Co.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Ilg Electric Ventilating Co.
- Modine Mfg. Co.
- Pecco, Inc.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

FORCED DRAFT
- Economy Grate & Equipment Co., Inc.

FURNACE CEMENT
- Insulating Products Corp.
- Johns-Manville Corp.

FURNACES—Automatic
- New York Blower Co.
- Riley Stoker Corp.

Boiler
- CoKal Stoker Corp.

Electric
- Westinghouse Electric & Mfg. Co.

Filters
- Reed Air Filter Co.

Gas
- American Gas Products Corp.

Insulation
- Insulating Products Corp.

Pipeless
- Hart & Crouse Co.
- International Heater Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Thatcher Co., The
- Utica Heater Co. (*Now* National Radiator Corp.)

Smokeless
- CoKal Stoker Corp.

Warm Air
- American Gas Products Corp.
- Hart & Crouse Co.
- International Heater Co.
- Langenberg Mfg. Co.
- New York Blower Co.
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Utica Heater Co. (*Now* National Radiator Corp.)

GAGE—Boards
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Dunham, C. A., Co.
- Marsh, Jas. P., & Co.
- Warren Webster & Co.

Cocks (*See Cocks, Gage*)

Glasses (*See Glasses, Gage*)

Valves (*See Valves, Gage*)

GAGES—Draft
- American Schaeffer & Budenberg Corp.
- Combustion Specialties Corp.
- Ellison, Lewis M.
- Higgin Mfg. Co.
- Hill, E. Vernon, Co.
- Hoffman Specialty Co., Inc.
- Warren Webster & Co.

Compound
- American Schaeffer & Budenberg Corp.
- Hoffman Specialty Co., Inc.
- Trane Co., The

Pressure
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Dunham, C. A., Co.
- Marsh, Jas. P., & Co.
- O-E Specialty Mfg. Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Thrush, H. A., & Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.

Steam
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Burnham Boiler Corp.
- Dunham, C. A., Co.
- Hoffman Specialty Co.
- Marsh, Jas. P., & Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.

Vacuum
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Dunham, C. A., Co.
- Haines, William S., & Co.
- Hoffman Specialty Co.
- Illinois Engineering Co.
- Marsh, Jas. P., & Co.
- O-E Specialty Mfg. Co.
- Pierce, Butler & Pierce Mfg. Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

Water
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Crane Co.
- Marsh, Jas. P., & Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Pierce, Butler & Pierce Mfg. Co.
- U. S. Radiator Corp.

Furnaces (*See Furnaces, Gas*)

Heaters—Room (*See Heaters, Gas*)

Heating Systems (*See Heating Systems, Gas*)

Water Heaters
- American District Steam Co.
- American Radiator Co.
- Alberger Heater Co.
- Burnham Boiler Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- General Air Filters Corp.
- Page, Wm. H., Boiler Co.
- Smith, H. B., Co., The
- Stickle Steam Specialties Co.
- Thatcher Co., The
- Universal Smokeless Boiler Co.

GASKETS—Asbestos
- Crane Co.
- Jenkins Bros.
- Johns-Manville Corp.

Boiler
- Johns-Manville Corp.

Metallic
- Johns-Manville Corp.

Rubber
- Jenkins Bros.
- Johns-Manville Corp.

GATES—Blast
- American Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- New York Blower Co.
- Sturtevant, B. F., Co.

GENERATOR COOLING SYSTEMS
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- Reed Air Filter Co.
- Spray Engineering Co.
- Sturtevant, B. F., Co.

Generating Equipment
- General Electric Co.
- Westinghouse Electric & Mfg. Co.

GENERATORS—Electric
- General Electric Co.
- Honeywell Heating Specialties Co.
- Sturtevant, B. F., Co.
- Westinghouse Electric & Mfg. Co.

Heat (*See Boilers, Furnaces and Heaters*)

Hot-Water
- Alberger Heater Co.
- American Gas Products Corp.
- American Radiator Co.
- Burnham Boiler Corp.
- D. & T. Mfg. Co.
- Excelso Products Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- General Air Filters Corp.
- Honeywell Heating Specialties Co.
- Mueller Co.
- Page, Wm. H., Boiler Co.
- Patterson-Kelley Co.
- Whitlock Coil Pipe Co.

Turbines
- General Electric Co.
- Westinghouse Electric & Mfg. Co.

Vacuum
- Dunham, C. A., Co.
- Haines, Wm. S., & Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co.
- O-E Specialty Mfg. Co.
- Trane Co., The

GLASSES—Gage
- Crane Co.
- Jenkins Bros.
- O-E Specialty Mfg. Co.

GOVERNORS—Condensation
- Davis, G. M., Regulator Co
- Dunham, C. A., Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Trane Co., The
- Warren Webster & Co.

Pump (*See Regulators, Pump*)

Vacuum (*See Regulators, Vacuum*)

GRATES—Dumping
- Economy Grate & Equipment Co., Inc.
- Fitzgibbons Boiler Co., Inc.
- Frost Mfg. Co., The
- Kewanee Boiler Co.
- Oil City Boiler Works
- Universal Smokeless Boiler Co.

Rocking
- Economy Grate & Equipment Co., Inc.
- Frost Mfg. Co., The
- Kewanee Boiler Co.
- Oil City Boiler Works
- Universal Smokeless Boiler Co.

Shaking
- CoKal Stoker Corp.
- Economy Grate & Equipment Co., Inc.
- Frost Mfg. Co., The
- Kewanee Boiler Co.
- Oil City Boiler Works
- Titusville Iron Works
- Universal Smokeless Boiler Co.

Stationary
- CoKal Stoker Corp.

Water Cooled
- Economy Grate & Equipment Co., Inc.

GRILLES AND REGISTERS (*See Registers and Grilles*)

HANGERS—Adjustable Pipe
- Crane Co.
- Fitzgibbons Boiler Co., Inc.
- Grinnell Co., Inc.
- Smith, H. B., Co., The

Pipe
- Crane Co.
- Grinnell Co., Inc.
- Kewanee Boiler Co.
- Midwest Air Filters, Inc.
- National Radiator Co. (*Now* National Radiator Corp.)
- Pierce, Butler & Pierce Mfg. Co.
- York Heating & Ventilating Corp.

Radiator
- American Radiator Co.
- Burnham Boiler Corp.
- Grinnell Co., Inc.
- Healy-Ruff Co.
- Kewanee Boiler Co.
- McAlear Mfg. Co., The
- Modine Mfg. Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Pierce, Butler & Pierce Mfg. Co.
- Smith, H. B., Co., The
- Thatcher Co., The
- U. S. Radiator Corp.
- York Heating & Ventilating Corp.

HEADERS
- Alberger Heater Co.
- Crane Co.
- General Air Filters Corp.
- Grinnell Co., Inc.

HEAT EXCHANGERS
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Crane Co.
- Davis Engineering Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- Patterson-Kelley Co.
- Rome Brass Radiator Corp.
- Sturtevant, B. F., Co.
- Whitlock Coil Pipe Co.

Heat Insulating (*See Insulating*)

Regulators, Automatic
- Honeywell Heating Specialties Co.
- Minneapolis Heat Regulator Co.

HEATERS—Air
- American Blower Co.
- Bayley Blower Co.
- Buffalo Forge Co.
- Circulair Heat, Inc.
- Clarage Fan Co.
- Frank, O. E., Heater & Engineering Co., Inc.
- General Air Filters Corp.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- Nesbitt, John J., Inc.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Spencer Heater Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- Warren Webster & Co.
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Automatic Hot Water
- American Radiator Co.
- Crane Co.
- Excelso Products Corp.
- Davis Engineering Corp.
- Ilg Electric Ventilating Co.
- Kewanee Boiler Co.
- Mueller Co.
- Neptune Meter Co.

Blast
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Sturtevant, B. F., Co.
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Cabinet
- Circulair Heat, Inc.
- Modine Mfg. Co.
- Rome Brass Radiator Corp.
- Trane Co., The

Combination, Water and Steam with Warm Air
- International Heater Co.

Fan System
- Aerofin Corp.
- American Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Sturtevant, B. F., Co.
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Feed Water
- Alberger Heater Co.
- Davis Engineering Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- Frost Mfg. Co., The
- Patterson-Kelley Co.
- Rome Brass Radiator Corp.
- Stickle Steam Specialties Co.
- Warren Webster & Co.
- Whitlock Coil Pipe Co.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Spencer Heater Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- Warren Webster & Co.
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Gas
- American Gas Products Corp.
- American Radiator Co.
- Crane Co.
- Universal Smokeless Boiler Co.

Hot Water Service
- Alberger Heater Co.
- American Gas Products Corp.
- American Radiator Co.
- Crane Co.
- Davis Engineering Corp.
- Excelso Products Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- Frost Mfg. Co., The
- Heggie-Simplex Boiler Co.
- International Heater Co.
- Kewanee Boiler Co.
- Molby Boiler Co., Inc.
- Neptune Meter Co.
- Oil City Boiler Works
- Orr & Sembower, Inc.
- Page, Wm. H., Boiler Co.
- Patterson-Kelley Co.
- Richardson & Boynton Co.
- Rome Brass Radiator Corp.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Thatcher Co., The
- U. S. Radiator Corp.
- Weil-McLain Co.
- Whitlock Coil Pipe Co.

Indirect
- Aerofin Corp.
- American Blower Co.
- American Gas Products Corp.
- Buffalo Forge Co.
- Clarage Fan Co.
- Davis Engineering Corp.
- Excelso Products Corp.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- Modine Mfg. Co.
- Newport Boiler Co.
- Patterson-Kelley Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co., Inc.
- Smith, H. B., Co., The
- Sturtevant, B. F., Co.
- Trane Co., The
- Whitlock Coil Pipe Co.
- York Heating & Ventilating Corp.

Industrial
- American Blower Co.
- Buffalo Forge Co.
- Clarage Fan Co.
- Davis Engineering Corp.
- General Air Filters Corp.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Lebanon Boiler Works
- Modine Mfg. Co.
- Patterson-Kelley Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Petty, J. K., & Co., Inc.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Instantaneous Hot Water
- Alberger Heater Co.
- Davis Engineering Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- General Air Filters Corp.
- Patterson-Kelley Co.
- Powers Regulator Co.
- Whitlock Coil Pipe Co.

Room
- American Blower Co.
- American Radiator Co.
- Buffalo Forge Co.
- Circulair Heat, Inc.
- Clarage Fan Co.
- General Air Filters Corp.
- International Heater Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- Pecco, Inc.
- Rome Brass Radiator Corp.
- Thatcher Co., The
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

School (*See Room*)

Space
- Westinghouse Electric & Mfg. Co.

Tank
- Alberger Heater Co.
- American Radiator Co.
- Burnham Boiler Corp.
- Davis Engineering Corp.
- Frank, O. E., Heater & Engineering Co., Inc.
- International Heater Co.
- Kewanee Boiler Co.
- Molby Boiler Co., Inc.
- National Radiator Co. (*Now* National Radiator Corp.)
- Neptune Meter Co.
- Page, Wm. H., Boiler Co.
- Patterson-Kelley Co.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Thatcher Co., The
- Thrush, H. A., & Co.
- United States Radiator Corp.
- Universal Smokeless Boiler Co.
- Weil-McLain Co.
- Whitlock Coil Pipe Co.

Unit
- Aerofin Corp.
- American Blower Co.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Circulair Heat, Inc.
- Clarage Fan Co.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- Nesbitt, John J., Inc.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Wall Type
- Circulair Heat, Inc.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

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Water (*Incinerator*)
- Alberger Heater Co.
- General Air Filters Corp.
- Heggie-Simplex Boiler Co.
- Kewanee Boiler Co.
- Lebanon Boiler Works
- Oil City Boiler Works
- Petty, J. K., & Co., Inc.
- Westinghouse Electric & Mfg. Co.

HEATING AND VENTILATING APPARATUS
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Burnham Boiler Corp.
- Call, John, Co., The
- Carrier Air Conditioning Corp. of America
- Carrier Engineering Corp.
- Clarage Fan Co.
- Coatesville Boiler Works
- Cooling and Air Conditioning Corp.
- Crane Co.
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Fitzgibbons Boiler Co., Inc.
- General Air Filters Corp.
- General Electric Co.
- Hart & Crouse Co.
- Heggie-Simplex Boiler Co.
- Hoffman Specialty Co.
- Honeywell Heating Specialties Co.
- Ilg Electric Ventilating Co.
- International Heater Co.
- Kelly Brass Works
- Kewanee Boiler Co.
- Kieley & Mueller, Inc.
- Langenberg Mfg. Co.
- Marsh, Jas. P., & Co.
- Midwest Air Filters, Inc.
- Minneapolis Heat Regulator Co.
- Modine Mfg. Co.
- Nash Engineering Co.
- Neptune Meter Co.
- Newport Boiler Co.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Page, W. H., Boiler Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Reed Air Filter Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Sarco Co., Inc.
- Simplex Heat Regulator Co., Inc.
- Skinner Bros. Mfg. Co.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Spray Engineering Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Trane Co., The
- U. S. Radiator Corp.
- Utica Heater Co. (*Now* National Radiator Corp.)
- Warren Webster & Co.
- Weil-McLain Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

HEATING SPECIALTIES
- American Blower Co.
- American District Steam Co.
- American Gas Products Corp.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Burnham Boiler Corp.
- Clarage Fan Co.
- Combustion Specialties Corp.
- Crane Co.
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- General Air Filters Corp.
- Grinnell Co., Inc.
- Haines, William S., & Co.
- Hoffman Specialty Co., Inc.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Minneapolis Heat Regulator Co.
- Monash-Younker Co., Inc.
- Mueller Steam Specialty Co., Inc.
- Nash Engineering Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Newport Boiler Co.
- O-E Specialty Mfg. Co.
- Page, Wm. H., Boiler Co.
- Peerless Unit Ventilation Co., Inc.
- Powers Regulator Co.
- Russell, W. A., Co.
- Sarco Co., Inc.
- Simplex Heat Regulator Co., Inc.
- Stickle Steam Specialties Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.

HEATING SYSTEMS—Gas
- American Blower Co.
- American Gas Products Corp.
- Barnes & Jones
- Carrier Engineering Corp.
- Circulair Heat, Inc.
- Clarage Fan Co.
- Coatesville Boiler Works
- Dunham, C. A., Co.
- Hoffman Specialty Co.
- Marsh, James P., & Co.
- McAlear Mfg. Co.
- Mueller Co.
- Neptune Meter Co.
- Newport Boiler Co.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Spencer Heater Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- Vapor Engineering Co., Inc.
- Warren Webster & Co.

Hot Blast
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Grinnell Co., Inc.
- Ilg Electric Ventilating Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co., Inc.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Hot Water
- American Blower Co.
- American Gas Products Corp.
- Barnes & Jones
- Buffalo Forge Co.
- Burnham Boiler Corp.
- D. & T. Mfg. Co.
- Davis Engineering Corp.
- Fitzgibbons Boiler Co.
- Grinnell Co., Inc.
- Hart & Crouse Co.
- Honeywell Heating Specialties Co.
- International Heater Co.
- Kewanee Boiler Co.
- Mueller Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Neptune Meter Co.
- Newport Boiler Co.
- Page, Wm. H., Boiler Co.
- Patterson-Kelley Co.
- Pecco, Inc.
- Richardson & Boynton Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Sarco, Inc.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Thatcher Co., The
- Thrush, H. A., & Co.
- U. S. Radiator Corp.
- York Heating & Ventilating Corp.

Steam
- American Blower Co.
- American District Steam Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Burnham Boiler Corp.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Davis Engineering Corp.
- Dunham, C. A., Co.
- Fitzgibbons Boiler Co.
- Grinnell Co., Inc.
- Hart & Crouse Co.
- Hoffman Specialty Co., Inc.
- Illinois Engineering Co.
- International Heater Co.
- Kelly Brass Works
- Kewanee Boiler Co.
- Kieley & Mueller, Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Newport Boiler Co.
- Page, Wm. H., Boiler Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Richardson & Boynton Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Sarco Co., Inc.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Trane Co., The
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

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- Spencer Heater Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Steam (*Exhaust*)
- American Blower Co.
- American District Steam Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Davis Engineering Corp.
- Dunham, C. A., Co.
- Grinnell Co., Inc.
- Haines, William S., & Co.
- Hoffman Specialty Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- Page, Wm. H., Boiler Co.
- Patterson-Kelley Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Sarco Co., Inc.
- Smith, H. B., Co., The
- Stickle Steam Specialties Co.
- Trane Co., The
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Steam (*Vacuum*)
- American Blower Co.
- American District Steam Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Dunham, C. A., Co.
- Grinnell Co., Inc.
- Haines, William S., & Co.
- Hoffman Specialty Co.
- Illinois Engineering Co.
- Kelly Brass Works
- Kewanee Boiler Co.
- Kieley & Mueller, Inc.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- Monash-Younker Co.
- Mueller Co.
- Nash Engineering Co.
- Newport Boiler Co.
- O-E Specialty Mfg. Co.
- Page, Wm. H., Boiler Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Sarco Co., Inc.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Steam (*Vapor*)
- American District Steam Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Dunham, C. A., Co.
- Grinnell Co., Inc.
- Haines, William S., & Co.
- Hart & Crouse Co.
- Hoffman Specialty Co.
- Illinois Engineering Co.
- International Heater Co.
- Kewanee Boiler Co.
- Kieley & Mueller, Inc.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- Monash-Younker Co.
- Newport Boiler Co.
- O-E Specialty Mfg. Co.
- Page, Wm. H., Boiler Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Rome Brass Radiator Corp.
- Sarco Co., Inc.
- Smith, H. B., Co., The
- Spencer Heater Co.
- Stickle Steam Specialties Co.
- Trane Co., The
- U. S. Radiator Corp.
- Vapor Engineering Co., Inc.
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

Tank in Basement
- D. & T. Mfg. Co.
- Neptune Meter Co.
- Mueller Co.
- Thrush, H. A., & Co.

Warm-Air
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- Hart & Crouse Co.
- Ilg Electric Ventilating Co.
- International Heater Co.
- Langenberg Mfg. Co.
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Rome Brass Radiator Corp.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Thatcher Co., The

HOT BLAST HEATING SYSTEMS (*See Heating Systems, Hot Blast*)

HOT PLATES
- Westinghouse Electric & Mfg. Co.

HOT WATER CIRCULATING PUMPS (*See Pumps, Circulating*)

HOT WATER HEATERS, AUTOMATIC (*See Heaters, Automatic Hot Water*)

HOT WATER HEATERS, INSTANTANEOUS (*See Heaters, Instantaneous Hot Water*)

HOT WATER HEATERS, SERVICE (*See Heaters, Hot Water Service*)

HOT WATER HEATING SYSTEMS (*See Heating Systems, Hot Water*)

HYGROMETERS
- Grinnell Co., Inc.

HUMIDIFIERS
- American Blower Co.
- Atmospheric Conditioning Corp.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- Grinnell Co., Inc.
- Ilg Electric Ventilating Co.
- Johnson Service Co.
- Langenberg Mfg. Co.
- Midwest Air Filters, Inc.
- New York Blower Co.
- Pecco, Inc.
- Powers Regulator Co.
- Reed Air Filter Co.
- Shipp, C. C., & Co.
- Skinner Bros. Mfg. Co., Inc.
- Spray Engineering Co.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

HUMIDITY CONTROL
- American Blower Co.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Atmospheric Conditioning Corp.
- Bishop & Babcock Sales Co., The
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Grinnell Co., Inc.
- Johnson Service Co.
- Klipfel Mfg. Co.
- Midwest Air Filters, Inc.
- Modine Mfg. Co.
- New York Blower Co.
- Pecco, Inc.
- Powers Regulator Co.
- Sarco Co., Inc.
- Shipp, C. C., & Co.
- Spray Engineering Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

INCINERATORS, Hot Water (*See Heaters, Water, Incinerator*)

INSTRUMENTS—Air Testing (*See Air Testing Instruments*)

Indicating
- American Schaeffer & Budenberg Corp.
- Combustion Specialties Corp.
- Ellison, Lewis M.
- Hill, E. Vernon, Co.
- Marsh, Jas. P., & Co.

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Recording
- American Schaeffer & Budenberg Corp.
- Marsh, Jas. P., & Co.

INSULATING MATERIALS (*See Asbestos and Insulating Products*)

Boiler
- Samuel Cabot, Inc.
- Johns-Manville Corp.

Cold
- Armstrong Cork & Insulation Co.
- Samuel Cabot, Inc.
- Celotex Co.
- Flax-li-num Co.
- Johns-Manville Corp.
- MacAndrews & Forbes Co.
- Universal Gypsum & Lime Co.
- Wood Conversion Co.

Heat
- Armstrong Cork & Insulation Co.
- Samuel Cabot, Inc.
- Celotex Co.
- Flax-li-num Co.
- Johns-Manville Corp.
- MacAndrews & Forbes Co.
- Ric-wiL Co., The
- United States Gypsum Co.
- Universal Gypsum & Lime Co.
- Wood Conversion Co.

Sound Deadening
- Armstrong Cork & Insulation Co.
- Sameul Cabot, Inc.
- MacAndrews & Forbes Co.
- Wood Conversion Co.

JOINTS—Expansion
- Alberger Heater Co.
- Badger, E. B., & Sons Co.
- Crane Co.
- Fulton Sylphon Co., The
- Illinois Engineering Co.
- Mogul Machine Co.
- Warren Webster & Co.

Pipe
- Crane Co.
- Grinnell Co., Inc.

KILNS, DRY
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- New York Blower Co.
- Sturtevant, B. F., Co.
- Trane Co., The

LIQUID, BOILER (*See Boiler Liquid*)

MACHINES, REFRIGERATING (*See Refrigerating Machinery*)

MAGNESIA PRODUCTS (*See Asbestos and Insulating Products*)

MECHANICAL DRAFT APPARATUS
- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Combustion Specialties Corp.
- Ilg Electric Ventilating Co.
- Kieley & Mueller, Inc.
- Mason Regulator Co.
- New York Blower Co.
- Sturtevant, B. F., Co.
- Wing, L. J., Mfg. Co.

METAL WEATHER STRIPS (*See Weather Strips, Metal*)

METERS—Feed Water
- Johns-Manville Corp.

Flow
- American District Steam Co.
- Spray Engineering Co.

Water
- Johns-Manville Corp.
- Neptune Meter Co.

MICA
- Westinghouse Electric & Mfg. Co.

MIXERS, STEAM AND WATER (*Thermostatic*)
- Fulton Sylphon Co., The

MIXERS, WATER (*Thermostatic*)
- Fulton Sylphon Co., The

MOISTENERS, AIR (*See Humidifiers*)

MOTOR CONTROLLERS (*See Controllers, Motor*)

MOTORS—Electric
- General Electric Co.
- Honeywell Heating Specialties
- Ilg Electric Ventilating Co.
- Johnson Service Co.
- Sturtevant, B. F., Co.
- Westinghouse Electric & Mfg. Co.

NOZZLES—Brine Spray
- Atmospheric Conditioning Corp.
- Badger, E. B., & Sons Co.
- Buffalo Forge Co.
- General Air Filters Corp.
- Spray Engineering Co.

Spray
- American Blower Co.
- Atmospheric Conditioning Corp.
- Badger, E. B., & Sons Co.
- Bayley Mfg. Co.
- Buffalo Forge Co.
- Carrier Engineering Co.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- Jenkins Bros.
- New York Blower Co.
- Spray Engineering Co.
- Sturtevant, B. F., Co.
- Warren Webster Co.

OIL BURNERS
- Aladdin Utilities Corp.
- American NoKol Co.
- Automatic Burner Corp.
- Ballard Oil Equipment Co.
- Hardinge Bros., Inc.
- Johnson, S. T., Co.
- May Oil Burner Corp.
- Williams Oil-O-Matic Heating Corp.
- Winslow Boiler & Engineering Co.

Controls, Temperature
- Honeywell Heating Specialties Co.
- Minneapolis Heat Regulator Co.

PACKING—Asbestos
- Jenkins Bros.
- Johns-Manville Corp.
- New York Blower Co.

Metallic
- Johns-Manville Corp.

Rubber
- Jenkins Bros.
- Johns-Manville Corp.

PIPE—Bending
- Badger, E. B., & Sons Co.
- Crane Co.
- Grinnell Co., Inc.

Cast Iron
- Crane Co.
- Grinnell Co., Inc.

Coils (*See Coils, Pipe*)

Covering (*See Covering, Pipe and Tank; also, Conduits*)

Fittings
- Crane Co.
- Grinnell Co., Inc.
- Westinghouse Electric & Mfg. Co.

Hangers (*See Hangers, Pipe*)

Joint Cement (*See Cement, Pipe Joint*)

Plugs (*See Plugs, Pipe*)

Wrought Iron and Steel
- Crane Co.
- Grinnell Co., Inc.

PIPELESS FURNACES (*See Furnaces, Pipeless*)

PITOT TUBES AND GAGES
- American Blower Co.
- Clarage Fan Co.
- Higgin Mfg. Co.
- Hill, E. Vernon, Co.

PLATES—Floor
- American Radiator Co.
- Crane Co.
- Grinnell Co., Inc.
- National Radiator Co. (*Now* National Radiator Corp.)

PLUGS—Fusible
- Crane Co.
- Grinnell Co., Inc.

Pipe
- Crane Co.
- Grinnell Co., Inc.

POWER PLANT SUPPLIES
- American Blower Co.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Buffalo Forge Co.
- Clarage Fan Co.
- Crane Co.
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

- Economy Pumping Machinery Co.
- General Air Filters Corp.
- General Electric Co.
- Grinnell Co., Inc.
- Illinois Engineering Co.
- Johns-Manville Corp.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Sarco Co., Inc.
- Sturtevant, B. F., Co.
- Trane Co., The
- Westinghouse Electric & Mfg. Co

PRESSURE GAGES (*See Gages Pressure*)

PROTECTORS—Radiator
- American Radiator Co.
- Fulton Sylphon Co., The
- Modine Mfg. Co.
- Reed Air Filter Co.
- U. S. Radiator Corp.

PSYCHROMETERS
- Grinnell Co., Inc.
- Higgin Mfg. Co.
- Hill, E. Vernon, Co.

PUBLICATIONS
- American Society of Heating and Ventilating Engineers
- Heating & Ventilating Magazine
- Hill, E. Vernon, Co.
- Warren Webster & Co.

PUMPS—Air
- American Steam Pump Co.
- Bishop & Babcock Sales Co., The
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- McAlear Mfg. Co.
- Nash Engineering Co.
- O-E Specialty Mfg. Co.
- Powers Regulator Co.
- Trane Co., The

Automatic Electric
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- General Electric Co.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

Boiler Feed
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The

Centrifugal
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The

Circulating
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Nash Engineering Co.
- Trane Co., The

Condensation
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The

Differential Vacuum
- Dunham, C. A., Co.

Electric
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

Fuel Oil
- Johnson, S. T., Co.

High Pressure Steam Fuel Oil
- Johnson, S. T., Co.

Rotary
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- Nash Engineering Co.
- Trane Co., The

Steam
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Nash Engineering Co.

Sump
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Economy Pumping Machinery Co.
- Nash Engineering Co.
- Trane Co., The

Triplex
- Buffalo Steam Pump Co.

Turbine
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- General Electric Co.
- Nash Engineering Co.
- Skidmore Corp.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

Vacuum
- American Steam Pump Co.
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Dunham, C. A., Co.
- Economy Pumping Machinery Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co.
- Nash Engineering Co.
- O-E Specialty Mfg. Co.
- Skidmore Corp.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.

RADIATOR—Air Valves (*See Valves, Air*)

Brackets
- American Radiator Co.
- Continental Heater Corp. (*Now* National Radiator Corp.)
- Grinnell Co., Inc.
- Healy-Ruff Co.
- Hoffman Specialty Co.
- Kewanee Boiler Co.
- McAlear Mfg. Co., The
- National Radiator Co. (*Now* National Radiator Corp.)
- Pierce, Butler & Pierce Mfg. Co.
- Smith, H. B., Co., The
- Thatcher Co., The
- U. S. Radiator Corp.
- York Heating & Ventilating Corp.

Covers
- American Radiator Co.
- Fulton Sylphon Co., The
- Reed Air Filter Co.
- U. S. Radiator Corp.

Elbows (*See Elbows, Radiator*)

Electric—Steam
- Rome Brass Radiator Corp.
- Trane Co., The

Enclosures
- Fulton Sylphon Co., The
- Reed Air Filter Co.

Hangers (*See Hangers, Radiator*)

Humidifiers (*See Humidifiers*)

Return Line Valves (*See Valves, Return Line*)

Shields (*See Protectors, Radiator*)

Traps (*See Traps, Radiator*)

Valves (*See Valves, Radiator*)

RADIATORS—Fan System
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Buffalo Forge Co.
- Burnham Boiler Corp.
- Circulair Heat, Inc.
- Clarage Fan Co.
- Modine Mfg. Co.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Shaw-Perkins Mfg. Co.
- Smith, H. B., Co., The
- Sturtevant, B. F., Co.
- Trane Co., The

Electric
- Westinghouse Electric & Mfg. Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

Gas
- American Gas Products Corp.
- Grinnell Co., Inc.

Hot Water
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Burnham Boiler Corp.
- Clarage Fan Co.
- Continental Heater Corp. (*Now* National Radiator Corp.)
- Hardinge Bros., Inc.
- Ilg Electric Ventilating Co.
- International Heater Co.
- Kewanee Boiler Co.
- Modine Mfg. Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Page, Wm. H., Boiler Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Reed Air Filter Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Shaw-Perkins Mfg. Co.
- Smith, H. B., Co., The
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Union Radiator Co., (*Now* National Radiator Corp.)
- U. S. Radiator Corp.
- Utica Heater Co. (*Now* National Radiator Corp.)
- Weil-McLain Co.
- York Heating & Ventilating Corp.

Steam
- Aerofin Corp.
- American Blower Co.
- American Gas Products Corp.
- American Radiator Co.
- Buffalo Forge Co.
- Burnham Boiler Corp.
- Clarage Fan Co.
- Continental Heater Corp. (*Now* National Radiator Corp.)
- International Heater Co.
- Kewanee Boiler Co.
- Modine Mfg. Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Page, Wm. H., Boiler Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Reed Air Filter Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Rome-Turney Radiator Co., The
- Shaw-Perkins Mfg. Co.
- Smith, H. B., Co., The
- Sturtevant, B. F., Co.
- Thatcher Co., The
- Union Radiator Co. (*Now* National Radiator Corp.)
- U. S. Radiator Corp.
- Utica Heater Co. (*Now* National Radiator Corp.)
- Weil-McLain Co.
- York Heating & Ventilating Corp.

Wall
- American Radiator Co.
- Burnham Boiler Corp.
- Circulair Heat, Inc.
- Clarage Fan Co.
- Continental Heater Corp. (*Now* National Radiator Corp.)
- International Heater Co.
- Kewanee Boiler Co.
- Modine Mfg. Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- Page, Wm. H., Boiler Co.
- Pierce, Butler & Pierce Mfg. Corp.
- Reed Air Filter Co.
- Richmond Radiator Co.
- Rome Brass Radiator Corp.
- Smith, H. B., Co., The
- Thatcher Co., The
- Trane Co., The
- Union Radiator Co. (*Now* National Radiator Corp.)
- U. S. Radiator Corp.
- Utica Heater Co. (*Now* National Radiator Corp.)
- Weil-McLain Co.

RECEIVERS—Air
- Economy Pumping Machinery Co.
- Frost Mfg. Co., The
- General Air Filters Corp.
- Illinois Engineering Co.
- Kewanee Boiler Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- McAlear Mfg. Co., The
- Titusville Iron Works
- Trane Co., The
- Whitlock Coil Pipe Co.

Ammonia
- Crane Co.
- General Air Filters Corp.
- Titusville Iron Works
- Whitlock Coil Pipe Co.

Condensation
- American District Steam Co.
- American Gas Products Corp.
- Bishop & Babcock Sales Co., The
- Buffalo Steam Pump Co.
- Chicago Pump Co.
- Crane Co.
- Davis, G. M., Regulator Co.
- Economy Pumping Machinery Co.
- General Air Filters Corp.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Steam Specialty Co., Inc.
- Nash Engineering Co.
- Titusville Iron Works
- Trane Co., The

REFRIGERATING MACHINERY
- Carrier Engineering Corp.

REFRIGERATING SECTIONS
- American Radiator Co.
- Rome Brass Radiator Corp.

REGISTERS AND GRILLES
- Knowles Mushroom Ventilator Co.
- Modine Mfg. Co.
- Sturtevant, B. F., Co.
- Tuttle & Bailey Mfg. Co.

REGULATORS—Damper
- American District Steam Co.
- American Radiator Co.
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Carrier Engineering Corp.
- D. & T. Mfg. Co.
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- General Electric Co.
- Hoffman Specialty Co., Inc.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Minneapolis Heat Regulator Co.
- Mueller Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- National Regulator Co.
- Powers Regulator Co.
- Sarco Co., Inc.
- Shipp, C. C., & Co.
- Simplex Heat Regulator Co., Inc.
- Stickle Steam Specialties Co.
- Thrush, H. A., & Co.
- Trane Co., The
- U. S. Radiator Corp.
- Vapor Engineering Co., Inc.
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.

Feed Water
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Davis, G. M., Regulator Co.
- Fulton Sylphon Co., The
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Mueller Steam Specialty Co., Inc.
- Sarco Co., Inc.
- Stickle Steam Specialties Co.
- Warren Webster & Co.

Humidity
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- Grinnell Co., Inc.
- Johnson Service Co.
- Klipfel Mfg. Co.
- National Regulator Co.
- Powers Regulator Co.

Pressure
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Crane Co.
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- Hoffman Specialty Co.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Johnson Service Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- O-E Specialty Mfg. Co.
- Powers Regulator Co.
- Stickle Steam Specialties Co.
- Thrush, H. A., & Co.
- Trane Co., The
- Vapor Engineering Co., Inc.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

Pump
- American Radiator Co.
- Bishop & Babcock Sales Co., The
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Economy Pumping Machinery Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- Stickle Steam Specialties Co.
- Trane Co., The

Steam
- Absolute Con-tac-tor Corp.
- American District Steam Co.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Jenkins Bros.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- Powers Regulator Co.
- Sarco Co., Inc.
- Simplex Heat Regulator Co., Inc.
- Stickle Steam Specialties Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.
- Wing, L. J., Mfg. Co.

Temperature
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Carrier Engineering Corp.
- Cooling and Air Conditioning Corp.
- D. & T. Mfg. Co.
- Fulton Sylphon Co., The
- General Electric Co.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Johnson Service Co.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Minneapolis Heat Regulator Co.
- National Radiator Co. (*Now* National Radiator Corp.)
- National Regulator Co.
- O-E Specialty Mfg. Co.
- Powers Regulator Co.
- Sarco Co., Inc.
- Simplex Heat Regulator Co., Inc.
- Stickle Steam Specialties Co.
- Thrush, H. A., & Co.
- U. S. Radiator Corp.
- Westinghouse Electric & Mfg. Co.

Vacuum
- Absolute Con-tac-tor Corp.
- American Radiator Co.
- Bishop & Babcock Sales Co., The
- Chicago Pump Co.
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Economy Pumping Machinery Co.
- Fulton Sylphon Co., The
- Haines, William S., & Co.
- Hoffman Specialty Co.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Jenkins Bros.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Marine-Galligan Co., Inc.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- National Radiator Co. (*Now* National Radiator Corp.)
- O-E Specialty Mfg. Co.
- Stickle Steam Specialties Co.
- Trane Co., The
- U. S. Radiator Corp.
- Warren Webster & Co.

Vapor
- Absolute Con-tac-tor Corp.
- American District Steam Co.
- American Radiator Co.
- Bishop & Babcock Sales Co., The
- Davis, G. M., Regulator Co.
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- Haines, William S., & Co.
- Hoffman Specialty Co., Inc.
- Honeywell Heating Specialties Co.
- Illinois Engineering Co.
- Jenkins Bros.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Marine-Galligan Co., Inc.
- Mason Regulator Co.
- McAlear Mfg. Co.
- McDonnell & Miller
- Minneapolis Heat Regulator Co.
- Mueller Steam Specialty Co., Inc.
- O-E Specialty Mfg. Co.
- Powers Regulator Co.
- Simplex Heat Regulator Co., Inc.
- Trane Co., The
- U. S. Radiator Corp.
- Vapor Engineering Co., Inc.

Water
- American Radiator Co.
- American Schaeffer & Budenberg Corp.
- Bishop & Babcock Sales Co., The
- Davis, G. M., Regulator Co.
- Fulton Sylphon Co., The
- Honeywell Heating Specialties Co.
- Jenkins Bros.
- Kieley & Mueller, Inc.
- Klipfel Mfg. Co.
- Mason Regulator Co.
- McAlear Mfg. Co.
- Minneapolis Heat Regulator Co.
- Mueller Co.
- Mueller Steam Specialty Co., Inc.
- Powers Regulator Co.
- Simplex Heat Regulator Co., Inc.
- U. S. Radiator Corp.

Water Level (*See Controllers*)

REHEATERS—Air
- Aerofin Corp.
- American Blower Co.
- American Radiator Co.
- Buffalo Forge Co.
- General Air Filters Corp.
- Ilg Electric Ventilating Co.
- New York Blower Co.
- Pecco, Inc.
- Rome Brass Radiator Corp.
- Stickle Steam Specialties Co.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

RELAY SWITCHES (*See Switches, Control and Relay*)

ROOF INSULATION
- MacAndrews & Forbes Co.

ROOF VENTILATORS (*See Ventilators, Roof*)

ROTARY DRYERS (*See Drying Apparatus*)

ROTARY HACK SAW TOOLS
- Excelso Products Corp.
- Mueller Steam Specialty Co., Inc.

SCALE REMOVER—Boiler
- O-E Specialty Mfg. Co.
- Vinco Co., Inc., The

SCRUBBERS, AIR
- American Blower Co.
- Buffalo Forge Co.
- Sturtevant, B. F., Co.

SEPARATORS—Dust
- American Blower Co.
- Buffalo Forge Co.
- Call, John, Co., The
- Carrier Engineering Corp.
- New York Blower Co.
- Pecco, Inc.
- Sturtevant, B. F., Co.

Steam and Oil
- American District Steam Co.
- Bishop & Babcock Sales Co., The
- Crane Co.
- Davis Engineering Corp.
- Dunham, C. A., Co.
- Illinois Engineering Co.
- Kieley & Mueller, Inc.
- McAlear Mfg. Co.
- Patterson-Kelley Co.
- Stickle Steam Specialties Co.
- Warren Webster & Co.

SHEETS—Asbestos
- Johns-Manville Corp.
- New York Blower Co.

SHIELDS (*See Protectors, Radiator*)

SHOWER BATH CONTROLLERS (*See Controllers, Shower Bath*)

Sound Deadening (*See Insulation*)

SMOKE CONSUMER
- Combustion Specialties Corp.
- Universal Smokeless Boiler Co.

SOFTENERS, WATER (*See Water Softeners*)

SPECIALTIES, HEATING (*See Heating Specialties*)

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

SPECIALTIES—Sheet Metal
Call, John, Co., The
Sturtevant, B. F., Co.
York Heating & Ventilating Corp.

SPECIALTIES, STEAM (*See Steam Specialties*)

SPRAY COOLING SYSTEMS
American Blower Co.
Atmospheric Conditioning Corp.
Badger, E. B., & Sons Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Cooling and Air Conditioning Corp.
General Air Filters Corp.
New York Blower Co.
Spray Engineering Co.

SPRAY NOZZLES (*See Nozzles, Spray*)

STEAM CALORIMETERS (*See Calorimeters, Steam*)

STEAM ENGINES (*See Engines, Steam*)

STEAM HEATING SYSTEMS (*See Heating Systems, Steam*)

STEAM AND WATER MIXERS (*Thermostatic*) (*See Mixers*)

STEAM SPECIALTIES
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Fulton Sylphon Co., The
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Russell, W. A., Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
U. S. Radiator Corp.
Trane Co., The
Warren Webster & Co.

STEEL RADIATORS
Shaw-Perkins Mfg. Co.

STOKERS—Automatic
CoKal Stoker Corp.
Riley Stoker Corp.
Westinghouse Electric & Mfg. Co.

Hand Operated
CoKal Stoker Corp.

Mechanical
CoKal Stoker Corp.
Riley Stoker Corp.
Westinghouse Electric & Mfg. Co.

Pulverized
CoKal Stoker Corp.
Riley Stoker Corp.

STRAINERS—Oil
American Schaeffer & Budenberg Corp.
Crane Co.
CoKal Stoker Corp.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Trane Co., The

Steam
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.

Water
Crane Co.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Spray Engineering Co.

STRUCTURAL INSULATION
Armstrong Cork & Insulation Co.
Samuel Cabot, Inc.
Celotex Co.
Johns-Manville Corp.
Flax-li-num Co.
MacAndrews & Forbes Co.
United States Gypsum Co.
Universal Gypsum & Lime Co.
Wood Conversion Co.

SUPPLIES—Power Plant (*See Power Plant Supplies*)

SUPPORTS (*See Hangers, Pipe and Radiator*)

SWITCHES—Control-Relay
Absolute Con-tac-tor Corp.
General Electric Co.
Honeywell Heating Specialties Co.
McAlear Mfg. Co., The
McDonnell & Miller
Minneapolis Heat Regulator Co.
Powers Regulator Co.
Trane Co., The
Westinghouse Electric & Mfg. Co.

Thermostatic-Relay
Minneapolis Heat Regulator Co.

Safety
Westinghouse Electric & Mfg. Co.

SYSTEMS—Domestic Hot Water
Absolute Con-tac-tor Corp.
Davis Engineering Corp.
Excelso Products Corp.
Honeywell Heating Specialties Co.
International Heater Co.
Rome Brass Radiator Corp.
Smith, H. B., Co., The
Spray Engineering Co.
Spencer Heater Co.
Thrush, H. A., & Co.
U. S. Radiator Corp.

Dust Collecting
American Blower Co.
Buffalo Forge Co.
Call, John, Co., The
Carrier Engineering Corp.
Clarage Fan Co.
Midwest Air Filters, Inc.
National Air Filter Co.
New York Blower Co.
Pecco, Inc.
Reed Air Filter Co.
Skinner Bros. Mfg. Co., Inc.
Spray Engineering Co.
Sturtevant, B. F., Co.

Exhaust (*See Exhaust Systems*)

Hot Blast
Absolute Con-tac-tor Corp.
Aerofin Corp.
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Modine Mfg. Co.
New York Blower Co.
O-E Specialty Mfg. Co.
Pecco, Inc.
Rome Brass Radiator Corp.
Sturtevant, B. F., Co.
Trane Co., The
Wing, L. J., Mfg. Co.
York Heating & Ventilating Corp.

Spray Cooling (*See Spray Cooling Systems*)

Temperature Control
Absolute Con-tac-tor Corp.
American Blower Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Buffalo Forge Co.
Carrier Engineering Corp.
Clarage Fan Co.
Fulton Sylphon Co., The
Honeywell Heating Specialties Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mueller Co.
National Regulator Co.
Powers Regulator Co.
Sarco Co., Inc.
Simplex Heat Regulator Co., Inc.
Sturtevant, B. F., Co.

Catalogue Data of Manufacturers listed can be located by referring to pages 677 to 680

Ventilating (*See Ventilating Systems*)

TANK—Coils (*See Coils, Tank*)

Covering (*See Covering, Pipe and Tank*)

Heaters (*See Heaters, Tank*)

Regulators
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Fulton Sylphon Co., The
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Minneapolis Heat Regulator Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Regulator Co.
Page, Wm. H., Boiler Co.
Powers Regulator Co.
Sarco Co., Inc.
Simplex Heat Regulator Co., Inc.
Stickle Steam Specialties Co.

TANK—Heating Systems

TANKS—Blow-Off
Coatesville Boiler Works
Economy Pumping Machinery Co.
General Air Filters Corp.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Titusville Iron Works

Cast Iron
Bishop & Babcock Sales Co., The
Davis Engineering Corp.
D. & T. Mfg. Co.
Economy Pumping Machinery Co.
Excelso Products Corp.
Frank, O. E., Heater & Engineering Co., Inc.
Mueller Co.
Neptune Meter Co.
Patterson-Kelley Co.
Thrush, H. A., & Co.
Whitlock Coil Pipe Co.

Hot Water
Coatesville Boiler Works

Pressure
Ames Iron Works
American Schaeffer & Budenberg Corp.
Coatesville Boiler Works
General Air Filters Corp.
Harrisburg Star Boiler Corp.
Kewanee Boiler Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Lebanon Boiler Works
Oil City Boiler Works
Petty, J. K., & Co., Inc.
Thrush, H. A., & Co.
Titusville Iron Works

Steam
Coatesville Boiler Works

Storage
Ames Iron Works
Coatesville Boiler Works
Davis Engineering Co.
Frank, O. E., Heater & Engineering Co.
General Air Filters Corp.
Harrisburg Star Boiler Corp.
Kewanee Boiler Co.
Lebanon Boiler Works
National Radiator Co. (*Now* National Radiator Corp.)
Oil City Boiler Works
Page, Wm. H., Boiler Co.
Patterson-Kelley Co.
Petty, J. K., & Co., Inc.
Titusville Iron Works

TEMPERATURE REGULATORS (*See Regulators, Temperature*)

THERMOMETERS
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Hill, E. Vernon, Co.
Marsh, Jas. P., & Co.
National Radiator Co. (*Now* National Radiator Corp.)
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Simplex Heat Regulator Co., Inc.
Thrush, H. A., & Co.
U. S. Radiator Corp.

THERMOSTATS
Absolute Con-tac-tor Corp.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Fulton Sylphon Co., The
General Electric Co.
Honeywell Heating Specialties Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Minneapolis Heat Regulator Co.
Powers Regulator Co.
Sarco Co., Inc.
Westinghouse Electric & Mfg. Co.

TRAPS—Air Blast
Barnes & Jones
Davis, G. M., Regulator Co.
Grinnell Co., Inc.

Float
American District Steam Co.
Barnes & Jones
Crane Co.
Davis Engineering Corp.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Marine-Galligan Co., Inc.
McAlear Mfg. Co., The
Mueller Steam Specialty Co., Inc.
Sarco Co., Inc.
Trane Co., The

Radiator
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mueller Co.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Return
American Blower Co.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Dunham, C. A., Co.
General Air Filters Corp.
Haines, William S., & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P. & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Return (*Siphon*)
Bishop & Babcock Sales Co., The
Marsh, Jas. P., & Co.

Steam
American Blower Co.
American District Steam Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Davis Engineering Corp.
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
General Air Filters Corp.
Grinnell Co., Inc.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Johns-Manville Corp.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.

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Powers Regulator Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Sturtevant, B. F., Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Thermostatic
American District Steam Co.
Barnes & Jones
Dunham, C. A., Co.
Hoffman Specialty Co.
Jenkins Bros.
McAlear Mfg. Co., The
Milwaukee Valve Co.
Sarco Co., Inc.
Trane Co., The

Vacuum
American Blower Co.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Crane Co.
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
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Sarco Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

TURBINES—Steam
General Electric Co.
Sturtevant, B. F., Co.
Westinghouse Electric & Mfg. Co.
Wing, L. J., Mfg. Co.

TURBO-BLOWERS
American Blower Co.
Buffalo Forge Co.
New York Blower Co.
Sturtevant, B. F., Co.
Wing, L. J., Mfg. Co.

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American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Sylphon Co., The
Healy-Ruff Co.
Hoffman Specialty Co., Inc.
Jenkins Bros.
Kelly Brass Works
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Page, Wm. H., Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Rome Brass Radiator Corp.
Russell, W. A., Co.
Smith, H. B., Co., The
Trane Co., The
U. S. Radiator Corp.

Angle, Check and Globe
American Radiator Co.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Grinnell Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Marine-Galligan Co., Inc.
Marsh Valve Co.
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O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
U. S. Radiator Corp.

Automatic Gas Shut-off
Universal Smokeless Boiler Co.

Back-Pressure
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.

Blow-Off
American Schaeffer & Budenberg Corp.
Crane Co.
Davis, G. M., Regulator Co.
Fairbanks Co., The
Jenkins Bros.
Mueller Co.
Mueller Steam Specialty Co., Inc.
U. S. Radiator Corp.

Float
American Radiator Co.
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
Trane Co., The

Gage
Bishop & Babcock Sales Co., The
Crane Co.
Grinnell Co., Inc.
O-E Specialty Mfg. Co.
Stickle Steam Specialties Co.
U. S. Radiator Corp.

Gate
American District Steam Co.
American Radiator Co.
Crane Co.
Dole Valve Co., The
Fairbanks Co., The
Jenkins Bros.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
Milwaukee Valve Co.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.

Graduating
American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Milwaukee Valve Co.
Monash-Younker Co., Inc.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Hot Water
American Radiator Co.
American Schaeffer & Budenberg Corp.
Barnes & Jones
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Fairbanks Co., The
Jenkins Bros.
Marsh, Jas. P., & Co.

Marsh Valve Co.
National Radiator Co. (*Now* National Radiator Corp.)
Pierce, Butler & Pierce Mfg. Corp.
U. S. Radiator Corp.

Magnetic
Absolute Con-tac-tor Corp.
Minneapolis Heat Regulator Co.

Modulating
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American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
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Crane Co.
Dole Valve Co., The
Dunham, C. A., Co.
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Sarco Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Packless
American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
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Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Radiator
American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Fairbanks Co., The
Fulton Sylphon Co., The
Haines, William S., & Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
International Heater Co.
Jenkins Bros.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Powers Regulator Co.
Russell, W. A., Co.
Sarco Co., Inc.
Trane Co., The
U. S. Radiator Corp.
Vapor Engineering Co., Inc.
Warren Webster & Co.

Reducing
American District Steam Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Bishop & Babcock Sales Co., The
Davis, G. M., Regulator Co.
Dunham, C. A., Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Mason Regulator Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Stickle Steam Specialties Co.

Regrinding
Crane Co.
Fairbanks Co., The
Jenkins Bros.

Relief
American Radiator Co.
American Schaeffer & Budenberg Corp.
Crane Co.
Davis, G. M., Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
Neptune Meter Co.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Stickle Steam Specialties Co.
Thrush, H. A., & Co.
Titusville Iron Works

Return Line
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Dunham, C. A., Co.
Fairbanks Co., The
Haines, William S., Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
McAlear Mfg. Co.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.
Sarco, Inc.
Stickle Steam Specialties Co.
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Safety
American District Steam Co.
American Radiator Co.
American Schaeffer & Budenberg Corp.
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Jenkins Bros.
Marsh, Jas. P., & Co.
Mueller Co.
Mueller Steam Specialty Co., Inc.
National Radiator Co. (*Now* National Radiator Corp.)
O-E Specialty Mfg. Co.
Titusville Iron Works Co.
U. S. Radiator Corp.

Steam Feed
Crane Co.
Fairbanks Co., The
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.

Thermostatic
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Dole Valve Co., The
Dunham, C. A., Co.
Fulton Sylphon Co., The
Haines, William S., & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marsh, Jas. P., & Co.
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Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Simplex Heat Regulator Co., Inc.
Stickle Steam Specialties Co.
Trane Co., The

Vacuum
American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co., The
Burnham Boiler Corp.
Crane Co.
Davis, G. M., Regulator Co.
Dole Valve Co., The
Dunham, C. A., Co.
Haines, William S., & Co.
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Jenkins Bros.
Klipfel Mfg. Co.
Marine-Galligan Co., Inc.
Marsh, Jas. P., & Co.
Marsh Valve Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Mueller Steam Specialty Co., Inc.
O-E Specialty Mfg. Co.
Russell, W. A., Co.
Sarco Co., Inc.
Stickle Steam Specialties Co.
Titusville Iron Works
Trane Co., The
U. S. Radiator Corp.
Warren Webster & Co.

Vapor
- American District Steam Co.
- American Radiator Co.
- Barnes & Jones
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Crane Co.
- Davis, G. M., Regulator Co.
- Dole Valve Co., The
- Dunham, C. A., Co.
- Haines, William S., & Co.
- Hoffman Specialty Co.
- Illinois Engineering Co.
- Jenkins Bros.
- Kieley & Mueller, Inc.
- Marine-Galligan Co., Inc.
- Marsh, Jas. P., & Co.
- Marsh Valve Co.
- McAlear Mfg. Co.
- Monash-Younker, Co.
- O-E Specialty Mfg. Co.
- Sarco Co., Inc.
- Stickle Steam Specialties Co.
- Trane Co., The
- U. S. Radiator Corp.
- Vapor Engineering Co., Inc.
- Warren Webster & Co.

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Fans (*See Fans, Ventilating*)

Systems
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- American Blower Co.
- Buffalo Forge Co.
- Carrier Engineering Corp.
- Clarage Fan Co.
- Cooling and Air Conditioning Corp.
- General Air Filters Corp.
- General Electric Co.
- Ilg Electric Ventilating Co.
- Knowles Mushroom Ventilator Co.
- Midwest Air Filters, Inc.
- Nesbitt, John J., Co.
- New York Blower Co.
- Pecco, Inc.
- Peerless Unit Ventilation Co., Inc.
- Reed Air Filter
- Rome Brass Radiator Corp.
- Shipp, C. C., & Co.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- Trane Co., The
- Westinghouse Electric & Mfg. Co.
- Wing, L. J., Mfg. Co.
- York Heating & Ventilating Corp.

VENTILATORS—Mushroom
- American Blower Co.
- Call, John, Co., The
- Clarage Fan Co.
- Knowles Mushroom Ventilator Co.
- New York Blower Co.
- Sturtevant, B. F., Co.

Roof
- Buffalo Forge Co.
- Call, John, Co., The
- Ilg Electric Ventilating Co.
- Johns-Manville Corp.
- New York Blower Co.
- O-E Specialty Mfg. Co.
- Pecco, Inc.
- Skinner Bros. Mfg. Co., Inc.
- Sturtevant, B. F., Co.
- York Heating & Ventilating Corp.

Window
- Call, John, Co., The
- Reed Air Filter Co.
- Sturtevant, B. F., Co.

VENTS—Air
- American Radiator Co.
- Bishop & Babcock Sales Co., The
- Burnham Boiler Corp.
- Call, John, Co., The
- Crane Co.
- Dole Valve Co., The
- Dunham, C. A., Co.
- Fulton Sylphon Co., The
- Higgin Mfg. Co.
- Hoffman Specialty Co., Inc.
- Marsh, Jas. P., & Co.
- McAlear Mfg. Co.
- O-E Specialty Mfg. Co.
- Russell, W. A., Co.
- Trane Co., The

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Pecco, Inc., 2957 N. Market St., St. Louis, Mo.	499
Peerless Unit Ventilation Co., Inc., 718-34 Crescent Ave., Bridgeport, Conn.	500–502
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Whitlock Coil Pipe Co., The, 20 South St., Hartford, Conn.	510–511
Williams Oil-O-Matic Heating Corp., Bloomington, Ill.	462–463
L. J. Wing Mfg. Co., 663 Hudson St., New York, N. Y.	477–479
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Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1928

Contains Lists of Members Arranged Alphabetically and Geographically also Lists of Officers and Committees, Past Officers and Local Chapter Officers

Corrected to July 1927

Published at the Headquarters of the Society

29 West 39th Street, New York, N. Y.

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AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1927

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1927-28

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Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1927-28

HONORARY MEMBERS

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BILLINGS, DR. J. S. (1896), New York, N. Y. (Deceased March 10, 1913.)
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Arranged Alphabetically—All Grades

(Asterisk indicates authorship of papers)

(Junior 1916; Associate 1918; 1923) indicates, Elected Junior Member 1916; Elected Associate Member 1918; Elected Member 1923.

(Pres. 1923) indicates, Elected President in 1923 and is now a Presidential Member.

A

ABBOUD, Alfred, (Junior 1924), Pres. and Treas., (for mail), Alfred Abboud & Co., Inc., 45 Bromfield St., Boston, and Greendale Ave., Needham, Mass.

ABRAHAMSON, Paul, (1927), Secy., (for mail), Advance Heating Co., 117–19 N. Desplaines St., and 1440 Rosemont Ave., Chicago, Ill.

ABRAMS, Abraham, (Junior 1924), Secy. and Treas., (for mail), Berman Rathe Corp., 155 East 128th St., and 640 West 153rd St., New York, N. Y.

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ADAMS, Charles W., (1920), Vice-Pres., (for mail), The Daly Co., 1425 16th St., and Denver Athletic Club, Denver, Colo.

ADAMS, Henry, (Charter Member; Presidential Member), (Pres. 1899; Board of Managers 1894; Council 1895; 1898; 2nd Vice-Pres. 1897), Consulting Engr., (for mail), 1263-1269 Calvert Bldg., and 609 West 40th St., Baltimore, Md.

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ALLEN, Harry D., (1917), Htg. and Vtg. Contracting., (for mail), Harry D. Allen 2940 W. Lake St., and 1640 N. Tuna Ave., Chicago, Ill.

ALLEN, LeRoy E., (1921), Contracting Engr., (for mail), Grinnell Co., Inc., and 15 N. Elm St., Warren, O.

ALLEN, W. Harwell, (Junior 1910; 1911), Pres., State Htg. & Power Co., 272 Walnut St., and (for mail), 1346 Goodbar Place, P. O. Box 331, Memphis, Tenn.

ALLINSON, Orrie H., (1915), Jobstown, N. J.

ALMIRALL, Juan A., (1897), Pres., Almirall & Co., Inc., 53 Park Place, New York, N. Y.

ALT, Harold L.,* (1913), Htg. Engr., (for mail), Larkin Co., 1457 Broadway, New York, and 1571 East 16th St., Brooklyn, N. Y.

ALVORD, Arthur M., (1926), Pres., (for mail), Alvord & Swift, Grand Central Terminal, New York, and 240 Hamilton Ave., New Rochelle, N. Y.

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AMSTEIN, Albert W., (1924), Western Dist. Mgr., (for mail), Buckeye Blower Co., 608 S. Dearborn St., and 8314 S. Paulina St., Chicago, Ill.

ANDEL, Frank J., (1922), Pres. and Mgr., (for mail), Andel & Co., 4630 N. Lamon Ave., and 7512 Eastlake Ter., Chicago, Ill.

ANDEREGG, R. H., (1920), Chief Engr. and Mgr. Pump Dept., Trane Co., and (for mail), 625 S. Eighth St., La Crosse, Wis.

ANDERSON, Claude A., (1916), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 325 Commercial Tr. Bldg., Philadelphia, and 5025 Pulaski Ave., Germantown, Pa.

ANDERSON, F. Paul,* (1921), (Presidential Member), (2nd Vice-Pres. 1925; 1st Vice-Pres. 1926; Pres. 1927; Council 1924-26), Dean, College of Engrg., and Prof. Mech. Engrg., (for mail), Univ. of Kentucky, and 409 E. Main St., Lexington, Ky.

ANDERSON, H. J., (1919), Whitlock Coil Pipe Co., 149 Broadway, New York, N. Y.

ANDERSON, Phil Emanuel, (Associate 1926), Buyer, Htg. Dept., Wholesale Hardware & Heating, (for mail), Farwell, Ozmun, Kirk & Co., Second and Jackson Sts., and 1160 Orange St., St. Paul, Minn.

ANDERSON, S. A., Jr., (1909), (for mail), 1307 Adams Ave., and P. O. Box 486, 908 North Ave., LaGrande, Ore.

ANDRESEN, A. W., (1926), Crane Co., 400 Third Ave., N., and (for mail), 5311 Penn Ave., S., Minneapolis, Minn.

ANGUS, Harry H., (1918), Consulting Engr., 2 Bloor St., W., and (for mail), 34 Farnham Ave., Toronto, Ont., Can.

ARCHER, Frank Sibley, (Junior 1926), Sales Engr., (for mail), U. S. Radiator Corp., 303 Crosby Rd., and 12 Amherst St., Rochester, N. Y.

ARENBERG, Milton K., (Associate 1920), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., and 1380 Hyde Park Blvd., Chicago, Ill.

ARKLEY, L. M.,* (1922), Prof. Mech. Engrg., (for mail), Queen's University, and 22 Kensington Ave., Kingston, Ont., Can.

ARMAGNAC, Arthur S., (Associate 1907; 1914), Editor, Htg. and Vtg. Magazine, 1123 Broadway, New York, N. Y., and 375 Upper Mountain Ave., Upper Montclair, N. J.

ARMSPACH, Otto W.,* (1919), Mech. Engr., (for mail), E. Vernon Hill Co., 121 N. Clark St., and Villa Park, Chicago, Ill.

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ARTHUR, Harry W., (Associate 1920), Htg. Engr., (for mail), Arthur Service Co., 842 N. Olive Ave., Alhambra, Calif., and 1411 Federal St., N.W., Pittsburgh, Pa.

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ASTON, James, (1919), Metallurgical Engr., (for mail), A. M. Byers Co., 235 Water St., Pittsburgh, and 50 Forest Ave., Ben Avon, Pa.

ATKINSON, R. E., (Junior 1923), Engr., (for mail), C. A. Dunham Co., 230 E. Ohio St., and 4508 N. Kilpatrick Ave., Chicago, Ill.

ATKINSON, Robert E., (1897), (Board of Governors 1907), 6 Trafalgar Rd., Birkdale, Southport, Eng.

ATWATER, Lyman W., (1923), Htg. Engr., Wm. H. Curtin Mfg. Co., 331 Adams St., and (for mail), 552 Rugby Rd., Brooklyn, N. Y.

AUSTIN, Frank L., (1914), Archt., 240 College St., Burlington, Vt.

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AXEMAN, James E., (Junior 1925), Sales Engr., Spencer Heater Co., Williamsport, Pa., and (for mail), 346 Brooks Ave., Rochester, N. Y.

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B

BABBITT, Edward C., (1923), Engr., (for mail), Snyder, Babbitt & Mathews, 16 E. Broad St., and 1157 E. Mound St., Columbus, O.

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BAETZ, Henry, (1919), (for mail), Skinner Bros. Mfg. Co., Inc., 1424 S. Vandeventer St., and 5854 Etzel Ave., St. Louis, Mo.

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BAIER, Walter P., (Associate 1924), Pres., (for mail), Baier Bros., Inc., 4452 Cass Ave., and 1968 Gladstone Ave., Detroit, Mich.

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BAILEY, Jos. H., (Junior 1923), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, N. J.

BAIRD, F. X., (Associate 1925), 26 Boyden Ave., S. Orange, N. J.

BAKER, Edward V., (1923), Silent Partner, J. H. Olson, 4012 State St., and (for mail), 3654 Wentworth Ave., Chicago, Ill.

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BAKER, H. W. H., (1918), Sanitary and Htg. Engr., J. Twyford & Co., 20 British Bund, Tientsin, China.

BAKER, Howard C., (1921), Pres., (for mail), The Howard C. Baker Co., 213 Michigan St., and 15 Columbia St., Toledo, O.

BAKER, Irving C., (1921), Dist. Engr., American Blower Co., 614 Bona Allen Bldg., Atlanta, Ga.

BAKER, Roland H., (Associate 1924), Pres. and Treas., (for mail), R. H. Baker Co., Inc., Kendall Sq. Bldg., Cambridge, and 50 Washington St., Newton, Mass.

BALDWIN, William H., (1921), Sales Engr., (for mail), C. A. Dunham Co., Ltd., 229 College St., and 600 Windermere Ave., Toronto, Ont., Can.

BAMPTON, C. Morton, (1919), Vice-Pres. and Secy., (for mail), Ideal Htg. Co., 915 Gates Ave., Brooklyn, N. Y.

BARKER, Arthur H.,* (1906), Consulting Engr., (for mail), 100 Victoria St., Westminster, London, S. W. 1, and Oakhill House, Beckenham, Kent, Eng.

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BARNES, Arthur R., (1924), W. E. Hulse & Co., P. O. Box 183, Hiawatha, Kan.

BARNES, Ralph B., (1927), Barnes Heating Co., 210 W. Harrison St., Oak Park, Ill.

BARNSTEINER, Alphons, (Associate 1926), Elec. Engr., (for mail), Appliance Engrg. Dept., Westinghouse Elec. & Mfg. Co., and 212 Rowland Ave., Mansfield, O.

BARR, George W., (1905), Associate Mgr. of Sales, Fitzgibbons Boiler Co., 570 Seventh Ave., New York, and (for mail), 24 Chatfield Rd., Bronxville, N. Y.

BARRE, Louis S., (1925), Rue Denfert Rochereau, Decize—Nievre, France.

BARROWS, Charles E., (Associate 1921), Mgr., (for mail), City Sales Dept., Crane Co., 156 N. Jefferson St., Chicago, and Orrington Hotel, Evanston, Ill.

BARRY, Patrick I., (1920), Managing Director, (for mail), M. Barry & Co., 4 Marlboro St., and 2 Clarence Ter., St. Luke's, Cork, Ireland.

BARTH, Herbert E., (1920), Dist. Mgr., (for mail), American Blower Co., 2539 Woodward Ave., and 554 Webster Hall, Detroit, Mich.

BARTLETT, Amos C., (1919), N. E. Dist. Mgr., (for mail), B. F. Sturtevant Co., 555 Massachusetts Trust Bldg., Boston, and 10 Dunbarton Rd., Wollaston, Mass.

BARTLETT, Clarence D., (1923), Purchasing Agent, Raisler Htg. Co., 129 Amsterdam Ave., New York, N. Y., and (for mail), 852 Broad St., Bloomfield, N. J.

BARTLETT, C. Edwin, (1922), Pres., Bartlett & Co., Inc., 1938 Market St., Philadelphia, and 209 Creswell St., Ridley Park, Pa.

BARTLEY, John S., Jr., (1924) Archt., (for mail), 903 L. and J. Natl. Bk. Bldg., and 908 Elm St., Waterloo, Ia.

BARTON, Royal Elton, (1922), Engr., (for mail), McLean & Cousens Co., 65 Chandler St., Boston, and Fernald Ter., Dorchester, Mass.

BARWICK, Thomas, (1920), Consulting Engr., (for mail), Buchman & Kahn, Archts., 49 West 45th St., New York, N. Y., and 408 Rutland Ave., W. Englewood, N. J.

BASSLER, Edwin M., (1923), Gen. Mgr., (for mail), D. J. Murray Mfg. Co., 1002 Third St., and 905 First St., Wausau, Wis.

BASTEDO, Albert E., (1919), Vice-Pres. and Treas., (for mail), Burnham Boiler Corp., Irvington, and 12 Wilson Place, Hastings-on-Hudson, N. Y.

BATEMAN, William H., Jr., (1921), Htg. Engr., (for mail), C. J. Doyle, 2056 Pine St., and 2519 South 19th St., Philadelphia, Pa.

BAUM, Albert L., (1916), Member of Firm, Jaros & Baum, 116 West 39th St., and (for mail), 562 West 113th St., New York, N. Y.

BAYSE, Harry V., (1923), Pres., American Furnace Co., 2725 Morgan St., and 6959 Hancock Ave., St., Louis, Mo.

BEAHM, Robert B., 2nd, (1919), Treas., Eagan & Beahm, Inc., 304-6 Stephen Girard Bldg., Philadelphia, and Haverford, Pa.

BEASOM, George Reynold, (1927), Htg. Dept., Crane & Co., 200 South Ave., and (for mail), 51 Brookdale Ave., Rochester, N.Y.

BEATTY. David J., (1918), Engr., (for mail), Chas. Schneider Co., 492 East 163rd St., New York, and 1274 New York Ave., Brooklyn, N. Y.

BEAURRIENNE, Auguste,* (1912), Contracting and Consulting Engr., 25 Rue des Marguettes, Paris, 12th Arr., France.

BEEBE, Frederick E. W., (Associate 1915), Sales Engr., (for mail), Johnson Service Co., 118 East 28th St., New York, N. Y., and 543 Chilton St., Elizabeth, N. J.

BEERY, Clinton E., (1913), Sales Engr., Kewanee Boiler Co., 822 Washington Blvd., Chicago, Ill.

BEGGS, William E., (1927), Supt. and Engr., University Plbg. & Htg. Co., 3939 University Way, and 3639 Palatine Ave., Seattle, Wash.

BELING, Earl H., (Junior 1925), Htg. Engr., Warren Webster & Co., 549 W. Washington St., and (for mail), 5604 S. Carpenter St., Chicago, Ill.

BEMAN, Myron C., (1926), Consulting Engr., (for mail), Beman & Candee, 607 White Bldg., 55 Granger Place., Buffalo, N. Y.

BENDER, Charles P., (1923), Partner, (for mail), C. and J. Bender, 1734 Flatbush Ave., and 2045 East 19th St., Brooklyn, N. Y.

BENEDICT, Everett R., (1926), Construction Engr., (for mail), American District Steam Co., N. Tonawanda, and 245 Elmwood Ave., Buffalo, N. Y.

BENNETT, Irving T., (Junior 1927), Htg., (for mail), Metropolitan Engrg. Co., 1250 Atlantic Ave., and 234 East 42nd St., Brooklyn, N. Y.

BENNETT, Prescott D., (1926), Div. Sales Engr., (for mail), The Trane Co., 844 Rush St., and 7600 Bosworth Ave., Chicago, Ill.

BENNITT, George E., (1918), Utilization Dept., Consolidated Gas Co., 130 East 15th St., New York, N. Y.

BENTZ, Harry, (1915), Pres., (for mail), Bentz Engrg. Corp., 661 Frelinghuysen Ave., Newark, and 18 Holland Ter., Montclair, N.J.

BERCHTOLD, Edward Wm., (Associate 1925), Industrial Engr., Boston Consolidated Gas Co., 149 Tremont St., Boston, and (for mail), 266 Columbian St., S. Weymouth, Mass.

BERG, A. Herman, (1919), Pres., (for mail), Berg Htg. & Vtg. Co., 742 Laura Ave., and 140 N. Stafford, Huntington Park, Calif.

BERGER, Clyde D., (1922), Gen. Supt. and Mech. Engr., H. E. Crook Co., Inc., Contractors and Engrs., 28 Light St., and 2604 Overland Ave., Baltimore, Md.

BERGHOEFER, Victor A., (Junior 1926), Secy., Sterling Engrg. Co., 1640 Holton St., and (for mail), 1104 Island Ave., Milwaukee, Wis.

BERGNER, William G., (Associate 1923), Mgr. and Secy., Natl. Trade Extension Bureau, Mercantile Bk. Bldg., and (for mail), 720 Washington Ave., Evansville, Ind.

BERMAN, Louis K., (1908), Secy., (for mail), Raisler Htg. Co., 129 Amsterdam Ave., and 221 West 82nd St., New York, N. Y.

BERRINGER, Sidney H., (1926), Sales Engr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 1217–50th St., Milwaukee, Wis.

BEVERLEY, R. Carter, (1905), Pres. and Treas., R. C. Beverley Htg. Co., Inc., 308 E. Main St., and (for mail), 3812 Chamberlayne Ave., Richmond, Va.

BEVIL, Alexander Thomas, (Junior 1927), Asst. Htg. Engr., Crane Co., 254 Court, and (for mail), 353 Walker Ave., Memphis, Tenn.

BEYER, Jack E., (Junior 1924), Htg. and Vtg. Engr., The Weiss Htg. & Plbg. Co., 5604 Cedar Ave., and (for mail), 1317 East 112th St., Cleveland, O.

BIDWELL, Raymond E., (Associate 1924), Vice-Pres. and Local Mgr., (for mail), The Kellogg-Mackay Co., 2030 Walnut St., and 7310 Madison, Kansas City, Mo.

BILYEU, William F., (1927), Eastern Div. Mgr., The Trane Co., 600 S. Delaware Ave., Philadelphia, Pa., and (for mail), 110 Midway St., Riverton, N. J.

BINDER, Charles G., (1920), Mgr. Htg. Dept., Warren Webster & Co., 17th and Federal Sts., Camden, and (for mail), 115 Oak Ter., Merchantville, N. J.

BINDER, Irving, (Junior 1920; 1922), Estimator, Keasbey & Mattison, 131 Cedar St., and (for mail), 106 West 47th St., New York, N. Y.

BIRCH, Herbert R., (1922), Sales Engr., U. S. Radiator Corp., 101 Park Ave., and 875 West 181st St., New York, N. Y.

BIRKHOLZ, Harold A., (Junior 1926), Htg. Engr., L. H. Prentice Co., 1048-50 W. Van Buren St., and (for mail), 3731 N. Irving Ave., Chicago, Ill.

BIRKHOLZ, H. E., (Associate 1925), 512 Ravenswood Ave., Ravenswood Sta., Chicago, Ill.

BIRRELL, Allan Lloyd, (Associate 1925), Equip. Engr., (for mail), Chapman & Oxley, 1608 Northern Ontario Bldg., and 201 Pacific Ave., Toronto, Ont., Can.

BISHOP, Charles R., (1901), (Council 1916), Vice-Pres., (for mail), Caloroil Burner Corp., 250 Park Ave., New York, and 412 Locust St., Lockport, N. Y.

BISHOP, Frederick R., (1921), Salesman and Engr., Furnace Dept., Michigan Stove Co., 3306 E. Jefferson Ave., and (for mail), 4018 Pingree Ave., Detroit, Mich.

BJERKEN, Maurice H.; (Associate 1927), Dist. Mgr., (for mail), Hoffman Specialty Co., 200 Builders Exchange Bldg., and 4952–17th Ave., S., Minneapolis, Minn.

BLACK, Edgar Newbold, 3rd, (1922), Br. Mgr., Kewanee Boiler Co., Inc., Rm. 442, Land Title Bldg., Philadelphia, and (for mail), 108 Woodside Rd., Haverford, Pa.

BLACK, Fred C., (1919), Pres., (for mail), F. C. Black Co., 28 N. Desplaines St., and 4535 N. Ashland Ave., Chicago, Ill.

BLACK, George E., (1915), Factory Mgr., H. H. Robertson Co., Ambridge, and (for mail), 709 Broad St., Sewickley, Pa.

BLACK, Harry G., (1917), Htg. Contractor, (for mail), P. Gormly Co., 155 N. Tenth St., and 927 North 65th St., Philadelphia, Pa.

BLACK, John J. A., (Junior 1922; Associate 1925), Pres., (for mail), John Black & Son, Inc., 134 Prospect St., and 21 Prospect St., Trenton, N. J.

BLACKHALL, Wilmot R., (1922), Sales Engr., Gurney Foundry Co., Ltd., 500 King St., W., and (for mail), 332 Waverly Rd., Toronto, Ont., Can.

BLACKMAN, Alfred O., (1911), Consulting Engr., (for mail), 527 Fifth Ave., New York, N. Y., and 48 Hillcrest Ave., Stamford, Conn.

BLACKMORE, Frederick H., (1923), Plant Mgr., U. S. Radiator Corp., and (for mail), 526 E. Vandalia St., Edwardsville, Ill.

BLACKMORE, George C., (Charter Member), 435 Maple Ave., Edgewood Park, Allegheny Co., Pa.

BLACKMORE, J. J.,* (Charter Member), Council 1896; Bd. of Gov. 1904; Secy. 1914-15), 32 West 40th St., New York, N. Y.

BLADON, James B., (1909), Chief Engr., Darling Bros., Ltd., 120 Prince St., Montreal, and (for mail), 33 Holton Ave., Westmount, Que., Can.

BLAKE, Albert Henry, (1926), Dist. Mgr., (for mail), Sheldons, Ltd., 119 Pender St., W., and 3261 Second Ave., W., Vancouver, B. C.

BLANDING, Geo. H., (1919), Sales Engr., Johnson Service Co., 1355 W. Washington Blvd., Chicago, and (for mail), 729 Hayes Ave., Oak Park, Ill.

BLANEY, Charles A., (1914), Wheeler-Blaney Co., 223 N. Burdick St., Kalamazoo, Mich.

BLANKIN, Merrill F., (Junior 1919; Associate 1926), Vice-Pres., Haynes Selling Co., Inc., 2013 Sansom St., and (for mail), 3328 W. Penn St., Philadelphia, Pa.

BLESSED, William Arthur, (Junior 1927), Draftsman, Smith, Hinchman & Grylls, 800 Marquette Bldg., and (for mail), 250 W. Margaret Ave., Detroit, Mich.

BLEST, Frank S., (1923), Treas., (for mail, Blest & Emery Co., Inc., 784 Coney Island Ave., and 226 Argyle Rd., Brooklyn, N. Y.

BLISS, Sherwood C., (Associate 1926), 30 Argonne Drive, Kenmore, N. Y.

BLOMFELDT, Allen A., (1914), Sales Mgr., (for mail), Ilg Elec. Vtg. Co., 405 Union Central Bldg., Cincinnati, O., and 100 Mayo Ave., Newport, Ky.

BLOOM, Samuel C., (1915), Sole Owner, (for mail), S. C. Bloom & Co., 53 W. Jackson St., and 1953 East 72nd St., Chicago, Ill.

BOALES, William G., (Associate 1923), Salesman, Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), Webster Hall, Detroit, Mich.

BODDINGTON, William P., (1927), Mgr., (for mail), Canadian Powers Regulator Co., 106 Lombard St., and 214 Indian Rd., Toronto, Ont., Can.

BOEKER, Carl Herman, (1926), Vice-Pres. and Htg. Engr., Central Supply Co., Inc., 838-856 Main Ave., and (for mail), 39 High St., Passaic, N. J.

BOGARDUS, George W., (1925), Br. Mgr., (for mail), Kewanee Boiler Co., 707 Hubbell Bldg., and 215 Foster Drive, Des Moines, Iowa.

BOGATY, Hermann S., (1921), Chief Engr. (for mail), Proctor & Schwartz, Inc., Seventh and Tabor Rd., and 5243 N. Tenth St., Philadelphia, Pa.

BOISCLAIR, Hugh Cappes, (1926), Dist. Repr., (for mail), Warren Webster & Co., 342-3 Brown Marx Bldg., and 127 Pine St., Birmingham, Ala.

BOLLING, J. E.,* (Junior 1918; 1921), Publicity Engr., 100 Chestnut St., East Orange, N. J.

BOLSINGER, Raymon C., (1916), Secy., (for mail), Fowler & Wolf Mfg. Co., 521 Bulletin Bldg., Philadelphia, Pa., and 238 E. Madison Ave., Collingswood, N. J.

BOLTON, Reginald Pelham,* (1897), (Presidential Member), (Pres. 1911), (Board of Governors 1901; 2nd Vice-Pres. 1903; 1st Vice-Pres. 1905-1910; Board of Governors 1912-1913), Pres., (for mail), R. P. Bolton Co., 116 East 19th St., and 638 West 158th St., New York, N. Y.

BONDY, Winfield S., (Junior 1926), D. D. Kimball, 15 West 38th St., New York, and (for mail), 1154–52nd St., Brooklyn, N. Y.

BOON, George, (1915), Pres., (for mail), Boon & Sample, Inc., 3008 Ludlow St., and 6428 Morris Park Rd., Philadelphia, Pa.

BOOTH, Charles A., (1917), Vice-Pres., (for mail), Buffalo Forge Co., 490 Broadway, and 142 Summit Ave., Buffalo, N. Y.

BOOTH, Harry N., (Associate 1917; 1924), Mgr., (for mail), New York Br., U. S. Radiator Corp., 101 Park Ave., New York, and 40 Manursing Ave., Rye, N. Y.

BORNEMANN, Walter A., (Junior 1923; 1924), Sales Engr., (for mail), Carrier Engr. Corp., 2021 Land Title Bldg., Philadelphia, and 123 W. Wharton Ave., Glenside, Pa.

BOSTAIN, James C., (1923), Sales and Service Engr., (for mail), Williamson Heater Co., 337 W. Fifth St., Cincinnati, O., and Kenton Hills, Covington, Ky.

BOSTWICK, Clinton G., (1924), Supt., (for mail), Braman Dow & Co., 239 Causeway St., Boston, and 20 Wedgemen Ave., Winchester, Mass.

BOSWIN, George A., (1917), Secy., (for mail), R. B. Haywood Co., 1714 Sheffield Ave., and 902 Diversey Parkway, Chicago, Ill.

BOWDEN, Frank, (Associate 1924), Chief Engr. and Instructor., (for mail), Windsor & Walkerville Tech. School. Giles Blvd., and 1609 Dougall Ave., Windsor, Ont., Can.

BOWERS, A. F., (Associate 1919), Pres. and Treas., (for mail), Industrial Htg. & Engrg. Co., 490 Broadway, and 697 Hachett Ave., Milwaukee, Wis.

BOWERS, J. Sylvan, (1921), J. Sylvan Bowers Htg. Specialty Co., 2525a W. St. Louis Ave., St. Louis, Mo.

BOWMAN, Howard A., (Associate 1926), Sales Engr., (for mail), American Radiator Co., 339 Second Ave., and 5599 Baum Blvd., Pittsburgh, Pa.

BOYD, D. Knickerbacker,* (1921), (for mail), Otis Bldg., 112 South 16th St., and Coronado Apts., 22nd and Chestnut Sts., Philadelphia, Pa.

BOYD, William R., (Junior 1924; Associate 1926), Htg. Sales Engr., Turner Supply Co., 8 W. Sixth St., and 320 East 19th St., Chester, Pa.

BOYDEN, Davis S.,• (1909), (Council 1917), Supt. Steam Htg. Service Dept., (for mail), Edison Elec. Illuminating Co., 39 Boylston St., Boston, and 72 Gardner St., Allston, Mass.

BOYNTON, Daniel Wilcox, (Associate 1927), Boston Repr., (for mail), International Heater Co., 27 State St., Boston, and 46 Powder House Rd., Medford, Mass.

BRABBEE, Chas. W.,* (1925), (for mail), American Radiator Co., 675 Bronx River Rd., Yonkers, and DeWitt and Marguard Aves., Bronxville, N. Y.

BRADBURY, George L., (1921), Co-partner and Mgr., (for mail), Bradbury Bros. Htg. Co., 1219 Stout St., and 1254 Race St., Denver, Colo.

BRADFIELD, William W., (1926), Engr., 909 Michigan Trust Bldg., Grand Rapids, Mich.

BRADFORD, H. H., (Associate 1927), Salesman, Minneapolis Heat Regulator Co., 2753 Fourth Ave., and (for mail), 3504–14th Ave., S., Minneapolis, Minn.

BRADLEY, Eugene P.,• (1906), Pres., (for mail), Hester, Bradley Co., 4200 Forest Park Blvd., St. Louis, and 6935 Pershing Ave., University City, Mo.

BRADLEY, John T., (1908), (Bd. of Gov. 1911), Pres., (for mail), Bradley Htg. Co., 3834 Olive St., St. Louis, and 4 Yale Ave., University City, Mo.

BRADLEY, Royal H., (1915), Pres., (for mail), Kelsey Htg. Co., 277 James St., and 400 Oak St., Syracuse, N. Y.

BRADY, James L., (Associate 1925), (for mail), J. L. Brady Co., 551 15th Ave., and 1912 Third St., E. Moline, Ill.

BRAEMER, William G. R., (1915), Vice-Pres., (for mail), Universal Humidifying Co., 2013 Sansom St., Philadelphia, Pa., and 213 Warwick Rd., Haddonfield, N. J.

BRANDELES, H. J., (1921), Pres. and Mgr., (for mail), H. J. Brandeles Corp., 1602 Lincoln Ave., and 66 Prospect St., Utica, N. Y.

BRANIGIN, Harry L., (1926), Sales Mgr., (for mail), The Air Conditioning & Engineering Co., 2914 S. Jefferson Ave., and 4526 Shenandoah, St. Louis, Mo.

BRASCH, Harry Kenneth, (Associate 1926), Dist. Mgr., The Trane Co., La Crosse, Wis., and (for mail), 330 Central Bldg., Seattle, Wash.

BRASSINGTON, Arthur F., (Associate 1918), Htg. Engr., 520-24 West 41st St., New York, and (for mail), 337 Richmond Ave., Port Richmond, N. Y.

BRAUER, Roy, (1926), Htg. and Vtg. Engr., (for mail), The Schley & Nash Co., 712 Columbia Bank Bldg., Pittsburgh, and 2880 Glenmore Ave., Darmount, Pittsburgh, Pa.

BRAUN, Louis T., (1921), Secy., Chicago Master Steam Fitters Assn., 1213 Chamber of Commerce, and (for mail), 1418 Jonquil Ter., Chicago, Ill.

BRAY, Daniel S., (Associate 1920), Local Mgr., (for mail), Peerless Heater Co., 1235-45 St. Clair Ave., and 9925 Olivet Ave., Cleveland, O.

BRAYTON, William M., (1926), Sales Engr., (for mail), Robert Gordon, Inc., 22 W. Austin Ave., Chicago, and 1320 Chicago Ave., Evanston, Ill.

BRECKENRIDGE, L. P., (1920), Prof. Mech. Engrg. (Emeritus), Sheffield Scientific School, Yale Univ., New Haven, Conn., and (for mail), "The Brackens," N. Ferrisburg, Vt.

BREEN, Jos. W., (1916), Htg. Engr., Wyalusing Ave. and Fallon St., and (for mail), 957 Fallon St., W. Philadelphia, Pa.

BRENDER, Peter E., (1920), Chief Engr., Univ. of Mich. Hospital, and (for mail), 13272 Geddes Ave., Ann Arbor, Mich.

BRESNAHAN, James J., (1919), Pres and Treas., James J. Bresnahan, Inc., 37-41 Pearl St., and 92 Linwood Ave., Buffalo, N. Y.

BREWSTER, Donald R., (1926), Consulting Dry Kiln Engr., (for mail), 327 Whitewater Ave., Ft. Atkinson, Wis., and 349 Hawthorne St., Memphis, Tenn.

BRICKEY, Joel P., (Associate 1924), 665 S. Pearl St., Denver, Colo.

BRIDE, W. T., (Junior 1925), Supervising Engr., (for mail), Bride, Grimes & Co., 526 Essex St., and 116 E. Haverhill St., Lawrence, Mass.

BRIDGES, Frank G., (1919), 433 Dundee Drive, Cleveland, O.

BRINTON, Joseph W., (1920), Mgr. Boston Office, (for mail), American Blower Co., 10 High St., Boston, and 9 Summit Ave., Brookline, Mass.

BRODERICK, Joseph F., (Junior 1914; 1918), Engr., Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, N. Y., and (for mail), P. O. Box 388, Springdale, Conn.

BROGAN, James J., (Associate 1917), Brogan & Co., (for mail), 810 Race St., Philadelphia, and 6142 Lebanon Ave., Overbrook, Pa.

BRONSON, Carlos E., (1919), Mech. Engr., (for mail), Kewanee Boiler Co., and 311 McKinley Ave., Kewanee, Ill.

BROOKS, Thomas C., (1923), Pres. and Treas., T. C. Brooks Co., 101 W. Dedham St., Boston, Mass.

BROWN, Aubrey I., (1923), Asst. Prof. Htg. and Vtg., Ohio State University, and 45 E. Lakeview Ave., Columbus, O.

BROWN, Alfred Porter, (1927), Pres., B. F. Reynolds & Co., 118 W. Ohio St., Chicago, Ill.

BROWN, Foskett,* (1926), Pres., (for mail), Foskett Brown Mfg. Co., 1608 Harrison St., P. O. Box 722, and Vanderbilt Campus, Nashville, Tenn.

BROWN, John H., (1920), Mgr., (for mail), Keasbey & Mattison Co., 429 N. Washington Ave., and 3704 Blaisdell St., Minneapolis, Minn.

BROWN, Robert H., (1926), Research Engr., (for mail), Parks-Cramer Co., 1102 Old South Bldg., Boston, and 75 Glen Rd., Jamaica Plain, Mass.

BROWN, William H., (Associate 1923), Mgr. Plbg. and Htg. Dept., Brown Bros., 3412 North Ave., and (for mail), 1367–38th St., Milwaukee, Wis.

BROWNE, Alfred L., (1923), Repr., (for mail), Illinois Engrg. Co., 3514 Grand Central Terminal, New York, N. Y., and 253 Highland Rd., S. Orange, N. J.

BROWNELL, Chester D., (1923), Mgr. and Engr., (for mail), Reliable Plbg. & Htg. Co., 109 W. University Ave., and 307 W. White St., Champaign, Ill.

BROWNING, Hilbert K., (Junior 1926), Dist. Sales Rep., (for mail), A. M. Byers Co., 412 Shell Bldg., and 5841 Cabanne Ave., St. Louis, Mo.

BRUEGGEMAN, Arthur R., (1920), Pres., (for mail), The A. R. Brueggeman Co., Keith Bldg., Cleveland, and 17220 Aldersyde Drive, Shaker Heights, Cleveland, O.

BRUNETT, Adrian L., (1923), Mech. Engr., P. O. Box 16, Rockville, Md.

BRUNNER, Herbert, (1924), Consulting Engr. and Pres., (for mail), Brunner Engr. Co., Inc., 320 West 48th St., and 41 West 69th St., New York, N. Y.

BRUNT, T. Bayard, (1917), Chief Engr. and Mgr., Mechanical Equipt. Co., 214 South 12th St., Philadelphia, Pa., and (for mail), 405 Eighth St., Riverton, N. J.

BRUSMAN, Harry M., (1923), Htg. and Sanitary Engr., Natl. Cash Register Co., Dayton, O.

BRYANT, Alice G.,* (1921), 502 Beacon St., Boston, Mass.

BRYANT, Percy J., (1915), Chief Engr., (for mail), U. S. Military Academy, West Point, and 231 Carpenter Ave., Newburgh, N. Y.

BRYCE, Stephen D., (1921), Partner, (for mail), Bryce Htg. & Vtg. Co., 415 Spitzer Bldg., and 2907 Rockwood Place, Toledo, O.

BUDER, Chas. G.,* (1919), Western Sales Mgr., (for mail), Donk Bros. Coal Co., 314 N. Fourth St., St. Louis, and North Drive and Pine Ave., Forest Hills Park, Webster Grove, Mo.

BUEL, H. G., (Associate 1921), Vice-Pres., Tilghman Moyer Co., 141 N. Ninth St., and (for mail), 2135 Chew St., Allentown, Pa.

BUENGER, Albert,• (Junior 1917; 1920), Mech. Engr., C. H. Johnston, Archt., 360 Rober St., and (for mail), 1666 Stanford Ave., St. Paul, Minn.

BUENSOD, Alfred C., (1918), Mech. Sales Engr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., and 125 West 12th St., New York, N. Y.

BULKELEY, Claude A.,* (1923), Supt. and Mech. Research Engr., (for mail), Niagara Blower Co., 673 Ontario St., Buffalo, N. Y.

BUMSTEAD, Francis Edwin, (1925), Owner, (for mail), Bumstead Htg. & Plbg. Co., 414 E. Dale St., and 803 N. Wohsatch Ave., Colorado Springs, Colo.

BUNNELL, Ercell W., (Junior 1923; 1924), Consulting Engr., (for mail), American Trust Bldg., and 2214 13th Ave., N., Birmingham, Ala.

BURGER, John C., (1919), Estimator and Supt., (for mail), Geo. A. Henrich Co., 702 N. Wells St., and 7201 Chaplain Ave., Chicago, Ill.

BURKE, Fletcher H., (1925), Consulting Engr., (for mail), Fletcher H. Burke—John C. Wright, Associate, 681 Ellicott Sq., and 276 Sterling Ave., Buffalo, N. Y.

BURKE, George B., (1926), Vice-Pres., (for mail), Sarco Co., Inc., 53 W. Jackson Blvd., Chicago, and 611 Ninth St., Wilmette, Ill.

BURNAP, Charles W., (1922), Herman Nelson Corp., 724 Commercial St., Emporia, Kans.

BURNETT, Earle S., (1920), Mech. Engr., (for mail), Bureau of Mines, U. S. Helium Prod. Plant, P. O. Box 602, and 4005 Oakland St., Ft. Worth, Tex.

BURNS, Edward J., (1923), Htg. Engr., (for mail), H. Kelly & Co., 925 Plymouth Bldg., and 4716 Aldrich Ave., S., Minneapolis, Minn.

BURNS, Willard A., (1924), Collins & Burns Co., 1728 Farwell Ave., Chicago, Ill.

BURR, Ralph J., (Associate 1919), Htg. Contracting, Standish, Mich.

BURRITT, Charles G., (Associate 1916), Mgr., (for mail), Johnson Service Co., 922 Second Ave., and 1425 LaSalle Ave., Minneapolis, Minn.

BURT, Henry Jackson, (Associate 1926), Consulting Engr., (for mail), 645 N. Michigan Ave., Chicago, and 416 Ellis Ave., Wheaton, Ill.

BURT, John E., (1924), J. E. Burt & Son, 2442 South 16th St., Philadelphia, Pa.

BURTON, Clarence A., (1919), Mgr., (for mail), Kewanee Boiler Co., 2020 Wyandotte St., and 3534 Virginia Ave., Kansas City, Mo.

BUSHNELL, Carl D., (Associate 1921), Pres., (for mail), Bushnell Mchy. Co., Century Bldg., Pittsburgh, and 94 Pilgrim Rd., Rosslyn Farms, Carnegie, Pa.

BUTLER, Charles, (1920), 108½ W. Second St., Oklahoma City, Okla., and Hotel Sherman, Fourth and Hill Sts., Los Angeles, Calif.

BUTLER, Charles Willis, (Junior 1927), Salesman, The American Blower Co., 1221 Boatmens Bk. Bldg., St. Louis, Mo.

BUTLER, Peter D., (1922), Salesman, U. S. Radiator Corp., 101 Park Ave., New York, N.Y. and (for mail), 127 Edgewater Ave., Grantwood, N. J.

BUTLER, Thomas F., (Associate 1919), Htg. Vtg. and Plbg., (for mail), 545 Broadway, and W. Erie and Madison Aves., Lorain, O.

BYRNES, Thomas F., (Junior 1924; Associate 1925), Htg. and Vtg. Engr., The Frederick Raff Co., 164 State St., and (for mail), 31 Clifford St., Hartford, Conn.

C

CADWELL, William H., (1916), Pres., (for mail), The Beaton & Cadwell Mfg. Co., P. O. Box 1012, and 130 W. Main St., New Britain, Conn.

CALAHAN, John J., (1915), Supervising Engr., (for mail), Board of Education, Administration Bldg., 2 Harrison Ave., and 78 Bartholdi Ave., Jersey City, N. J.

CALEB, David,* (1923), Engr., Kansas City Power & Light Co., (for mail), 1330 Grand Ave., and 141 Spruce St., Kansas City, Mo.

CALLAHAN, Michael J., (1914), Pres. and Treas., Peerless Unit Ventilation Co., Skillman Ave., and Hulst St., Long Island City, N. Y.

CALLAHAN, Thomas H., (Junior 1924), Pres., (for mail), Callahan Engrg., Co., Inc., 20 Grove St., and 248 S. Lexington Ave., White Plains, N. Y.

CALVERT, Norman W.,* (1921), Engr. of Steam Distribution, (for mail), The Detroit Edison Co., 2000 Second Ave., and 3297 Clements, Detroit, Mich.

CAMPBELL, Everett K.,* (1920), Pres. and Treas., (for mail), E. K. Campbell Htg. Co., 2445 Charlotte St., and 3717 Harrison Blvd., Kansas City, Mo.

CAMPBELL, John Packard, (Junior 1927), Htg. Engr., The James Robertson Co., Ltd., P. O. Box 1000, St. John, and 18 Lancaster Ave., Fairville, N.B., Can.

CANTWELL, William T., (1920), Plbg. and Htg. Contracting, (for mail), 306 Bleecker St., and 1302 Brinckerhoff Ave., Utica, N. Y.

CARDER, William W., (Associate 1923), Br. Mgr., (for mail), Johnson Service Co., 210 Bona Allen Bldg., and 249 Peoples St., Atlanta, Ga.

CARLE, William E., (1926), Pres., (for mail), Carle-Boehling Co., 1641 W. Broad St., and 2220 Floyd Ave., Richmond, Va.

CARNAHAN, Glen C., (1924), Mgr., (for mail), Htg. Section, Peoples Gas, Light & Coke Co., 122 S. Michigan Ave., and 5428 Woodlawn Ave., Chicago, Ill.

CARPENTER, Randolph H., (1921), Mgr., New York Office, (for mail), Nash Engr. Co., Graybar Bldg., 43rd and Lexington Ave., New York, and 10 Jefferson Ave., White Plains, N. Y.

CARR, Clifford H., (Associate 1924), Pres. and Mgr., (for mail), C. H. Carr Mchy. Co., 411 Mutual Bldg., and 5108 Main St., Kansas City, Mo.

CARRIER, Willis H.,* (1913), (Council 1923-26), Pres., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), Rensselaer Rd., Essex Fells, N. J.

CARROLL, W. J., (Associate 1925), Br. Mgr., Kewanee Boiler Co., 402½ Mich. Trust Bldg., and (for mail), 339 Burton St., S.E., Grand Rapids, Mich.

CARSTEN, W. H., (1923), Pres. and Mgr., (for mail), Majestic Furnace & Mfg. Co., Inc., 1723 Westlake Ave., N., and 102 W. Canal St., Seattle, Wash.

CARSTENS, Emil, (Junior 1922; Associate 1925), Htg. Engr., H. B. Smith Co., 49th and Grays Ave., and 4615 N. Rosehill St., Philadelphia, Pa.

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CARTY, Thomas, (1924), Pres., Carty Htg. Corp., 29 Audubon Ave., and 635 West 174th St., New York, N. Y.

CARY, Albert A.,* (Charter Member), (Bd. of Mgrs. 1894-1899; Council 1896), Consulting Engr., 95 Liberty St., New York, N. Y.

CASE, Edward W., (Associate 1916), Chrm. of Bd., W. A. Case & Son Mfg. Co., 220 Delaware Ave., Buffalo, N. Y.

CASEY, Byron L., (1921), Sales Engr., (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, and 501 Clifton Ave., Park Ridge, Ill.

CASH, Tidie T., (Associate 1925), Pres., (for mail), Cash Co., 240 Seventh Ave., S., and 20 Groveland St., Minneapolis, Minn.

CASSELL, John D.,* (1913), Supt. of Bldgs., (for mail), Board of Public Education, Keystone School Bldg., 19th and Chestnut Sts., and 2007 Chestnut St., Philadelphia, Pa.

CASSERLY, T. D., (Associate 1923), Mech. Engr., Weil-McLain Co., Michigan City, Ind., and (for mail), 5339 Winthrop Ave., Chicago, Ill.

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CAVILEER, James V., (Associate 1921), Sales Engr., (for mail), York Htg. & Vtg. Corp., 1502 Locust St., and 2938 North 27th St., Philadelphia, Pa.

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CHAPMAN, Frank T., (1909), (Board of Governors 1913; Council 1914-1916; 2nd Vice-Pres. 1915; 1st Vice-Pres. 1916), E. Davey Dodd, 137 Forest Ave., Glen Ridge, N. J.

CHAPPELL, Temple Archer, (1926), Pres. and Gen. Mgr., (for mail), Weldon Sheet Metal Works, Inc., and P. O. Box 143, Weldon, N. C.

CHASE, John M., (Associate 1916), Vice-Pres. and Eastern Repr., (for mail), W. A. Case & Son Mfg. Co., 50 East 42nd St., and 468 Riverside Drive, New York, N. Y.

CHENOWETH, William H., (1911), Dist. Mgr., (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 256 Keystone Ave., River Forest, Ill.

CHERRY, Lester A., (1921), Industrial Planning Corp., (for mail), 45 Court St., and 155 Euclid Ave., Hertel Sta., Buffalo, N. Y.

CHERVEN, Victor W., (Associate 1920), Chief Engr., (for mail), Holland Furnace Co., and 326 Maple Ave., Holland, Mich.

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CHOFFIN, C. C., (1919), Secy. and Treas., W. J. Scholl & Co., Mahoning Ave. and Hogue St., Youngstown, O.

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CHURCH, Herbert John, (1922), Mgr., (for mail), Darling Bros., Ltd., 77 York St., Toronto, and 358 Main St., Weston, Ont., Can.

CLAFFEY, Edward J., (1913), Pres., (for mail), E. J. Claffey Co., 10 W. Illinois St., and 439 Melrose St., Chicago, Ill.

CLARE, Fulton Warren, (1927), Mgr., (for mail), Clare & Co., 354 Marietta St., and 1316 North Ave., N.E., Atlanta, Ga.

CLARK, E. H., (1922), Br. Mgr., J. D. Swartwout Co., 482 Penobscot Bldg., and (for mail), Apt. 26, 132 Pingree St., Detroit, Mich.

CLARK, Fred C., (1923), Pres., F. C. Clark Htg. Co., 5941 Baum Blvd., and 505 N. Sheridan Ave., Pittsburgh, Pa.

CLARK, Homer J., (1919), Dist. Mgr., B. F. Sturtevant Co., 1042 Wrigley Bldg., Chicago, Ill.

CLARK, W. Chas. M., (1915), Consulting Engr., (for mail), 130 Engrs. Bldg., and 2165 Cottage Grove Drive, Cleveland, O.

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COX, W. F., (1924), Specialty Engr., (for mail), Crane Co., 1532 Grand Ave., and 5212 Rockhill Rd., Kansas City, Mo.

COX, William W., (1923), Consulting Engr., (for mail), Warren Webster & Co., 326 Columbia St., and 5416 Kirkwood Place, Seattle, Wash.

CRANNELL, Chas A., (1922), Charles A. Crannell Co., (for mail), 7253 Cottage Grove Ave., and 8336 Paxton Ave., Chicago, Ill.

CRAWFORD, William B., (1921), Mgr. Specialty Dept., (for mail), J. P. Marsh & Co., 114 S. Clinton St., and 1516 N. Mayfield Ave., Chicago, Ill.

CRIQUI, Albert A., (1919), Chief Engr., Htg. and Vtg. Dept., Buffalo Forge Co., 490 Broadway, and (for mail), 250 Blaine Ave., Buffalo, N. Y.

CROFT, Terrell, (1924), Directing Engr., Apartado 275, Merida, Yucatan, Mexico.

CRONE, Charles E., Jr., (1922), Secy. and Treas., (for mail), Wendt & Crone Co., 1131 N. Wells St., and 5432 Woodlawn Ave., Chicago, Ill.

CRONE, Thomas E., (1920), Dist. Sales Mgr., W. A. Russell & Co., 5037 Grand Central Terminal Bldg., and (for mail), 235 West 71st St., New York, N. Y.

CRUTCHLEY, Edward, Jr., (1920), Htg. Contractor., (for mail), Edward Crutchley, Jr., 477–83rd St., and 78–89th St., Brooklyn, N. Y.

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CULLEN, Harry J., (1923), Htg. and Vtg. Engr., Warren & Wetmore, 16 West 47th St., New York, and (for mail), 15 Scott Place, Jamaica, N. Y.

CULLYFORD, Francis S., (1915), Pres. and Mgr., (for mail), Cullyford Plbg. & Htg. Co., 1210 California St., and 517 Josephine St., Denver, Colo.

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CUMMINGS, Charles A., (Junior 1926), (for mail), Capitol Testing Laboratory, U. S. Radiator Corp., 127 Campbell Ave., and 1554 W. Grand Blvd., Detroit, Mich.

CUMMINGS, G. J., (1923), Supt., Scott Co., 113 Tenth St., and 4100 Lyon Ave., Oakland, Calif.

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CURRIER, Charles H., (1919), Vice-Pres., (for mail), Drying Systems, Inc., 50 Church St., and 322 West 72nd St., New York, N. Y.

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DONNELLY, Russell, (1923), Sales Engr., (for mail), Nash Engrg. Co., Graybar Bldg., 43rd St. and Lexington Ave., New York, N.Y., and Stamford, Conn.

DONNELLY, Webster C., (Junior 1922), 3 Broadway, Lynbrook, L. I.

DONOGHUE, James J., (Associate 1924), Mgr., (for mail), Natl. Radiator Co., 47 West 42nd St., New York, N. Y., and 1957 Boulevard, Jersey City, N. J.

DONOHUE, Edmund S., (Associate 1924), Salesman, (for mail), American Radiator Co., 400 Barium Bldg., and 53 E. Euclid Ave., Detroit, Mich.

DONOVAN, James E., (Junior 1923), Htg. Engr., 45 Glen Ave., Port Chester, N. Y.

DOODY, Catherine A., (1924), Mgr., Silent Automatic Corp., 255 Meldrum Ave., Detroit, Mich., and 64 High St., Canton, Mass.

DORNHEIM, G. A., (Junior 1906; 1912), (for mail), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, and 15 Hamilton Ave., Bronxville, N. Y.

DORSEY, Francis C., (1920), Htg. Plbg. and Elec. Contracting, Francis C. Dorsey, 110 Prospect Ave., Roland Park, Baltimore, Md.

DOUD, Malcolm P., (Associate 1921), (for mail), M. P. Doud, 419 Widener Bldg., Philadelphia, and 226 Rutledge Ave., Rutledge, Pa.

DOUGHERTY, P. J., (1926), Dist. Mgr., Hoffman Specialty Co., 747 Warehouse St., Los Angeles, and (for mail), Rose Mary Apt., 208 E. Lomita Ave., Glendale, Calif.

DOUGHTY, Charles John, (1925), Managing Director and Treas., (for mail), C. J. Doughty & Co., 7 Jinkee Rd., and 160 Route Mayen, Shanghai, China.

DOUGLASS, Thomas C., (1922), Thos. J. Douglass & Co., 352 Whiting St., Chicago, Ill.

DOWNE, Henry S., (1895), Vice-Pres. and European Director, (for mail), American Radiator Co., 149, Boulevard Haussmann, and 5 Rue Verdi, Paris, France.

DOWNES, Nate W., (1917), Engr., (for mail), School Dist. of Kansas City, 601 Finance Bldg., and 2119 East 68th St., Kansas City, Mo.

DOWNEY, Frank E., (1921), Pres., (for mail), Downey Supply Co., 613 Clybourn St., and 1188 Prospect Ave., Milwaukee, Wis.

DOWNEY, Paul C., (Junior 1926), Pres. and Treas., (for mail), Downey Heating Co., 256 11th St., and 2328 Prairee St., Milwaukee, Wis.

DOYLE, William J., (1920), Designing Engr., Williamson Heater Co., 4558 Marburg Ave., Oakley, and (for mail), 3766 Hyde Park Ave., Cincinnati, O.

DRAKE, George H., (1919), (for mail), 218 Lexington Ave., and 353 Norwood Ave., Buffalo, N. Y.

DRESEN, William D., (Junior 1926), Sales Engr., (for mail), Johnson Service Co., 312 E. Ohio St., Indianapolis, and 112 Gale Ave., River Forest, Ill.

DRIGGS, Leland L., (1918), Htg. Engr., Louis T. Klauder, 1300 Bankers Trust Bldg., Philadelphia, Pa., and (for mail), 208 E. Clinton Ave., Oaklyn, N. J.

DRINKER, Philip, (1922), Asst. Prof. of Ventilation and Illumination, (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston, and 128 Gardner Rd., Brookline, Mass.

DRISCOLL, William H., (1904), (Presidential Member), (Council 1918-1926; Treas. 1923; 2nd Vice-Pres. 1924; 1st Vice-Pres. 1925; Pres. 1926), Vice-Pres., (for mail), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, N. Y., and 23 Boyd Ave., Jersey City, N. J.

DRUCE, John J., (1922), Vice-Pres. and Mgr., McKelvey & Birch, Ltd., 69 Brock St., and (for mail), 26 Alice St., Kingston, Ont., Can.

DUBE, Wilbrod, (1925), Consulting Engr., (for mail), Raoul Chenevert, Archt., 20½ D'Aiguillon St., and 157 Cremazie St., Quebec, Can.

DUBRY, Ernest E., (1924), Asst. Supt. Central Htg., (for mail), Detroit Edison Co., 2000 Second Ave., and 9116 Dexter Blvd., Detroit, Mich.

DUDFIELD, Alvin, (1920), Pres., Dudfield Mfg. Co., 116 W. Kansas St., Liberty, Mo.

DUDLEY, William Lyle, (1922), Vice-Pres., (for mail), Western Blower Co., 1800 Ninth Ave., S., and 2525 Second Ave., W., Seattle, Wash.

DUEMLER, Franklin C., (Junior 1926), Dist. Mgr., J. K. Petty & Co., Inc., 507 Harrison Bldg., and (for mail), 1032 E. Rittenhouse St., Philadelphia, Pa.

DUFF, Kennedy, (1915), Mgr. Eastern Territory, (for mail), Johnson Service Co., 118 East 28th St., New York, N. Y., and 9 Park Ave., Maplewood, N. J.

DUFFIELD, Thomas Jefferson, (Associate 1927), Executive Secy., (for mail), New York Commission on Ventilation, 370 Seventh Ave., and 400 West 119th St., New York, N. Y.

DUGAN, Thomas M., (1920), Htg. and Vtg. Engr., National Tube Co., 4th Ave. and Locust St., and (for mail), P. O. Box 318, McKeesport, Pa.

DUNCAN, George W., Jr., (1923), Consulting Mech. Engr., U. S. Veterans Hospital, Camp Kearney, and (for mail), 2132 Derby St., Berkeley, Calif.

DUNCAN, John M., (1924), Mech. Engr., Atmospheric Nitrogen Corp., Syracuse, N. Y.

DUNHAM, Clayton A., (1911), Pres., (for mail), C. A. Dunham Co., 450 E. Ohio St., Chicago, and 150 Maple Hill Rd., Glencoe, Ill.

DUNLAP, Ralph L., (1917), Chief Engr. and Gen. Supt., (for mail), J. H. Kitchen & Co., Pioneer Trust Bldg., 1016 Baltimore Ave., and 5533 Holmes St., Kansas City, Mo.

DUNLEVY, Thomas Ross, (1925), Mgr., Anthracite Coal Service, 75 Westminster St., and (for mail), 170 Alabama Ave., Edge Sta., Providence, R. I.

DUQUET, Asa M., (1923), Htg. and Vtg. Engr., (for mail), Moss-Chase Co., 263 Summer St., Boston 32, and 109 Blake St., Wallaston, Mass.

DURAND, William L., (1921), Engr., (for mail), Clark, McMullen & Riley, 101 Park Ave., New York, and 242 Lafayette Ave., Brooklyn, N. Y.

DUSOSSOIT, Edmond A., (1920), Treas., (for mail), Lynch & Woodward, Inc., 202 Harrison Ave., Boston, and 16 Hancock Ave., Newton Centre, Mass.

DWYER, John Vincent, (Associate 1922), Asst. Factory Mgr., (for mail), Peninsular Stove Co., Fort St., W., Detroit, and 372 Lakeland Ave., Grosse Pointe Village, Mich.

DWYER, Thomas F., (1923), Mech. Engr., (for mail), Board of Education, Flatbush Ave. and Concord St., Brooklyn, and 282 Cypress Ave., New York, N. Y.

DYER, Orville K., (1919), Mgr. Blower Dept., (for mail), Buffalo Forge Co., 490 Broadway, and 11 Russell Ave., Buffalo, N. Y.

DYER, William Saul, (Associate 1927), Pres., Dyer Heating Co., 408 Graham Ave., Brooklyn, N. Y.

E

EADIE, John G., (1909), Consulting Engr., (for mail), Eadie, Freund & Campbell, 110 West 40th St., New York, N. Y., and 11 Blackburn Rd., Summit, N. J.

EAGAN, George A., (1917), Pres., (for mail), Eagan & Beahm, Inc., 304 Stephen Girard Bldg., Philadelphia, Pa., and Hunter St., and Bayard Ave., Woodbury, N. J.

EAGAN, Walter H., (1926), Pres., Walter H. Eagan & Co., Stephen-Girard Bldg., Philadelphia, Pa.

EAGAR, R. Frank, (1922), Consulting Engr., (for mail), Eagar, Coombs & Co., Ltd., P. O. Box 904, 138 Lower Water St., and Bedford, Halifax County, Nova Scotia.

EARLY, George David, (Associate 1927), Bus. Repr., Steam Fitter, Rm. 102 Labor Temple, and 7803 W. Green St. Way, Seattle, Wash.

EASTERBROOKS, Clifton C., (1922), Sales Engr., (for mail), Koithan & Pryor, 39 Cortlandt St., and 2735 Sedgewick Ave., New York, N. Y.

EASTWOOD, Everett Owen, (1921), Prof. Mech. Engrg. (for mail), Univ. of Washington, and 4702 12th Ave., N.E., Seattle, Wash.

EASTWOOD, Harry Fuller, (1925), Consulting Combustion Engr., also Engineering Dept., (for mail), Newton Coal Co., 5138 Walnut St., Philadelphia, and 138 Edgemont Ave., Ardmore, Pa.

EATON, Byron K., (Associate 1919; 1920), Gen. Sales Mgr., Winslow Boiler & Engr. Co., 208 S. LaSalle St., Chicago, and (for mail), 522 N. Fifth Ave., La Grange, Ill.

EATON, Phillips, (1927), Salesman, H. B. Smith Co., 640 Main St., Cambridge, Mass., and (for mail), 40 Caldwell St., Woodfords, Me.

EATON, Roy, (Associate 1925), 100 Boylston St., Boston, Mass.

EBERLE, Carl Frederick, (Junior 1926), Owner, (for mail), Eberle's Little Plumber, 121 N. Main St., and Clay St., Zelienople, Pa.

EBERT, William A., (1920), Engr. and Estimator, A. H. Shafer, 418 St. May St., and (for mail), P. O. Box 1280, San Antonio, Tex.

EBIN, Louis,* (1924), Htg. and Vtg. Engr., (for mail), Phillips-Getschow Co., 130 W. Kinzie St., and 3801 Ainslie St., Chicago, Ill.

ECKARDT, Charles A. T., (Associate 1924), Sales Engr., The Whitlock Coil Pipe Co., 726 Commercial Trust Bldg., and 5822 Girard Ave., Philadelphia, Pa.

ECKART, Claude H., (1915), Secy., (for mail), Eckart Bros., Inc., 320 Westlake Ave., N., and R. F. D. No. 4, P. O. Box 263, Seattle, Wash.

ECKLES, Robert Arthur, (1926), Architectural Engr., (for mail), W. G. Eckles Co., L. S. and T. Bldg., and 501 Winter Ave., New Castle, Pa.

EDGAR, A. C., (Charter Member), (Council 1920), Pres., (for mail), Edgar Htg. Co., 1705 Alter St., Philadelphia, and Newton Sq., Delaware Co., Pa.

EDWARDS, Clarence H., (Associate 1924), Prop., R. M. Edwards & Son, 4 N. Central Ave., Canonsburg, Pa.

EDWARDS, Daniel F., (1920), Co-partner, (for mail), D. F. Edwards Htg. Co., 2340 Pine St., St. Louis, Mo., and R. No. 1, Millstadt, Ill.

EDWARDS, Paul A., (1919), Pres., (for mail), G. F. Higgins Co., 606 Wabash Bldg., Pittsburgh, and 1254 Mississippi Ave., Dormont, Pa.

EELLS, Henry B., (1926), Sales Repr., Barnes & Jones, 300 Madison Ave., New York, and (for mail), 1049 East 27th St., Brooklyn, N. Y.

EGGLESTON, Lewis W., (1921), Mgr., (for mail), American Radiator Co., 5961 Lincoln Ave., Detroit, Mich., and Harris Hill Rd., Williamsville, N. Y.

EGGLY, Harry J., Jr., (1925), Consulting Engr., (for mail), 2021 Chancellor St., and 5903 N. Sixth St., Philadelphia, Pa.

EHRENZELLER, Adolphe, (1924), Mgr. Htg. Dept., Walker & Pratt Mfg. Co., 31 Union St., Boston, and 23 Parlevale Rd., W. Roxbury, Mass.

EHRLICH, M. William,* (1916), Branch Mgr., Trane Co., Room 2332 Park Row Bldg., New York, N. Y., and (for mail), 56 Ridge Rd., Lyndhurst, N. J.

EICHER, Hubert C., Dr., (1922), State Director, Bureau of School Bldgs., Dept. of Public Instruction, State Capitol, and (for mail), 103 South St., Harrisburg, Pa.

EICHLER, Alvin, (1919), (for mail), Eichler Htg. Co., 2010 Railway Exch. Bldg., and 5449 Enright Ave., St. Louis, Mo.

EISERT, Hermann,* (1920), Consulting Engr., 404 St. Paul Place, and (for mail), 4007 Bateman Ave., Baltimore, Md.

ELLIS, Ernest E., (1922), Mgr., (for mail), Fred A. Ellis & Son, 840 Center St., and 998 Chatfield St., Winnetka, Ill.

ELLIS, Frederic R., (1913), Buerkel & Co., Htg. and Vtg. Engrs., 18 Union Park St., Boston, Mass.

ELLIS, Harry W., (Associate 1909; 1923), Pres. and Gen. Mgr., Johnson Service Co., 149 Michigan St., Milwaukee, Wis.

ELLIS, John Edwin, (Associate 1921), (for mail), U. S. Radiator Corp., 1412 West 12th St., and 3030 Oak St., Kansas City, Mo.

ELLIS, Walter C., (Associate 1923; 1925), Mech. Engr., (for mail), 64 W. Randolph St., Chicago, and 324 Ninth Ave., LaGrange, Ill.

ELLIS, Wilbur H., (Junior 1926; Associate 1927), Htg. and Vtg. Estimator, J. L. Murphy, Inc., 238 West 108th St., and (for mail), 672 Ft. George Ave., New York, N. Y.

ELLISON, J. Huyler, (1919), Pres., Ellison & Co., Inc., 211 West 126th St., New York, and (for mail), 41 Wallace St., Freeport, N. Y.

ELY, F. Ernest, (Associate 1925), Mgr. New York Office, (for mail), Taylor Instrument Co., 31 Union Sq., New York, N. Y., and 54 Early St., Morristown, N. J.

EMERICK, Stanley H., (Junior 1923; Associate 1925), Mech. Engr., Louis Kamper, Archt., 3729 Cass Ave., and (for mail), 5471-15th St., Detroit, Mich.

EMERSON, Ralph R., (1922), Sales Engr., (for mail), Hoffman Specialty Co., 25 West 45th St., New York, and 660-59th St., Brooklyn, N. Y.

EMERY, William D., (1923), Pres., (for mail), Blest & Emery Co., 784 Coney Island Ave., and 496 Argyle Rd., Brooklyn, N. Y.

EMMERT, Luther D., (1919), Repr., (for mail), Buffalo Forge Co., 562 W. Washington Blvd., Chicago, and 1704 Hinman Ave., Evanston, Ill.

EMPKEY, George J., (1919), Secy., (for mail), The Schneider Plbg. Co., 4420 Euclid Ave., and 9812 North Blvd., Cleveland, O.

EMSWILER, John E.,* (1917), Prof. Mech. Engrg., (for mail), Univ. of Michigan, 231 Engrg. Bldg., and 1303 Granger Ave., Ann Arbor, Mich.

ENGLE, Alfred, (Associate 1923), Asst. Sales Mgr., Jenkins Bros., 80 White St., and 60 West 190th St., New York, N. Y.

ENGLISH, Alpheus T., (Associate 1926), Dist. Mgr., Columbus Htg. & Vtg. Co., 503 Wabash Bldg., Pittsburgh, Pa.

ERICKSON, Harry A., (1917), 815 East 14th St., Brooklyn, N. Y.

ERICKSON, Martin E., (Associate 1926), Chief Engr. and Supt. of Bldgs., Board of Education, and (for mail), 587-66th Ave., West Allis, Wis.

ERON, Lewis John, (1925), Mgr., (for mail), Eron Plbg. & Htg. Co., Mead-Witter Block, and 931 Gardner St., Wisconsin Rapids, Wis.

ERTMAN, Bernard Rust, (1920), Htg. Engr. and Mgr., A. F. Ertman, 309 N. Main St., Herkimer, N. Y.

EVANS, C. A., (1919), 218 Lexington Ave., Buffalo, N. Y.

EVANS, Edwin C., (1919), Dist. Mgr., Reed Air Filter Co., 841 Oliver Bldg., and (for mail), 2953 Zephyr Ave., Corliss Sta., Pittsburgh, Pa.

EVANS, James Howard, (1926), Sales Engr., Howard Evans Engrg. Specialties, 401 Hernando Bldg., Lexington, Ky.

EVANS, John, (1919), Archt., (for mail), 30 Water St., and 15 Ball Ave., Galt, Ont., Can.

EVANS, William A., (1918), Dealer in Hot Water Equipment, (for mail), 401 Military Bldg., Newark, and 24 Woodland Rd., Maplewood, N. J.

EVELETH, Charles F.,* (1911), C. W. Colby & Co., 2341 Carnegie Ave., Cleveland, O.

F

FABER, Guy Stanley, (1926), Chief Engr., Art Metal Radiator Co., 1732 N. Kolmar Ave., and (for mail), 4721 N. Kilpatrick Ave., Chicago, Ill.

FAHNESTOCK, Maurice Kendall, (Junior 1927), Specialty Research Asst., Engrg. Experiment Sta., University of Illinois, 104 M. E. Laboratory, Urbana, Ill.

FALVEY, John D., (1922), Sales Engr., (for mail), Hester-Bradley Co., 4200 Forest Park Blvd., and 5762a McPherson Ave., St. Louis, Mo.

FARLEY, J. W., (Associate 1921), Mgr., Farley, Sleeve & Hanger Co., 3748 East 71st St., Cleveland, O.

FARNHAM, Roswell, (1920), Dist. Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 711 W. Delavan Ave., Buffalo, N. Y.

FARRAR, Cecil W., (Associate 1918; 1920), Vice-Pres., (for mail), Excelso Specialty Works., Inc., 65 Clyde Ave., and 429 Norwood Ave., Buffalo, N. Y.

FAULKNER, Dwight H., (1926), Engr., The H. B. Smith Co., 10 East 39th St., New York, and (for mail), 46 Parsons Drive, Hempstead, N. Y.

FAY, Francis C., (1925), Engr., (for mail), Raisler Htg. Co., 129 Amsterdam Ave., New York, and 12–21st St., Elmhurst, L. I., N. Y.

FEBREY, Ernest J., (1903), Senior Member, (for mail), E. J. Febrey & Co., 616 New York Ave., N.W., and 1610 Riggs Place, N.W., Washington, D. C.

FEEHAN, J. B., (1923), Pres. and Treas., John B. Feehan, Inc., 471 Union St., and 24 Tudor St., Lynn, Mass.

FEHLIG, John B., (1918), Pres., (for mail), Excelsior Htg. Supply Co., 528 Delaware St., and 2927 Brooklyn Ave., Kansas City, Mo.

FEIGE, Henry W., (1922), Sales Mgr., (for mail), Powers Regulator Co., 1206 Colonial Trust Bldg., Philadelphia, Pa., and Oaklyn, N. J.

FELDMAN, Abram M.,* (1903), Consulting Engr., 145 West 45th St., New York, N. Y.

FELS, Arthur B., (1919), Pres., (for mail), The Fels Co., 60 Union St., Portland, and P. O. Box 33, Yarmouth, Me.

FELTWELL, R. H., (1905), Dist. Mgr., D. & T. Mfg. Co., St. Louis, Mo., and (for mail), 1040 S. Frazier Ter., Philadelphia, Pa.

FENNER, Nicholas Paul, (Junior 1927), Dist. Office Mgr., (for mail), Hoffman Specialty Co., 130 N. Wells St., Chicago, and 295 Addison St., Elmhurst, Ill.

FENSTERMAKER, Sidney E., (1909), Pres., (for mail), S. E. Fenstermaker & Co., 821 Hume-Mansur Bldg., and 3102 Washington Blvd., Indianapolis, Ind.

FERGUSON, Ralph R., (Junior 1925), Sales Engr., (for mail), American Blower Co., 1221 Boatman's Bk. Bldg., and 6243 Southwood Ave., St. Louis, Mo.

FEST, Leon T., (1919), Phila. Mgr., Pierce, Butler & Pierce Mfg. Corp., 31st and Oxford Sts., and (for mail), 6646 North 18th St., Philadelphia, Pa.

FESTORAZZI, Angelo O., (Junior 1925), Engr., (for mail), C. A. Dunham Co., 507 North 22nd St., and 1525 Ninth Ave., S., Birmingham, Ala.

FIEDLER, Harry W., (1923), Chief Engr., (for mail), Burnham Boiler Corp., 30 East 42nd St., New York, and 19 Archer Ave., White Plains, N. Y.

FIELDING, Howard H., (1904), (Council 1918-1919), Htg. and Vtg. Engr., (for mail), Warren Webster & Co., 1226 California St., and 1515 E. Ninth Ave., Denver, Colo.

FILSON, Foster E., (1924), Htg. Contractor, (for mail), 116 S. Second St., Harrisburg, and 19 N. Second St., Womleysburg, Pa.

FINAN, Edward John, (Associate 1926), Stationary Engr., Board of Education, and (for mail), 7149 Euclid Ave., Chicago, Ill.

FINAN, James J., (1923), Supervising Engr., Board of Education, City of Chicago, 630 S. Clark St., and (for mail), 7149 Euclid Ave., Chicago, Ill.

FIRESTONE, James F., (Associate 1925), Chief Engr., (for mail), The Beckwith Co., and 506 Green St., Dowagiac, Mich.

FIRSCHING, Frank J., (1921), Engr., (for mail), Warren Webster & Co., 1005 Empire Bldg., and 6951 Frankstown Ave., Pittsburgh, Pa.

FITCH, Walter S., (1926), Construction Engr., (for mail), Dennison Mfg. Co., 300 Howard St., Framingham, and 27 Summit Rd., Wellesley, Mass.

FITZ, Jean Chandler, (1925), Htg. Engr. and Estimator, Louis J. Sommer & Son, 2436 Brown St., and (for mail), 4213 Darien St., Philadelphia, Pa.

FLEISHER, Walter L.,* (1914), Vice-Pres., (for mail), Cooling & Air Conditioning Corp., 31 Union Sq., W., and 126 Waverly Place, New York, N. Y.

FLEMING, James P., (1923), Engr., Custodian, (for mail), Board of Education, 1410 N. Rockwell St., and 4035 N. Keystone Ave., Chicago, Ill.

FLEMING, Ralph A., (1926), Member of Firm, Floyd L. Benedict, Inc., 960 College Ave., and (for mail), 137 E. Tompkins St., Columbus, O.

FLEMING, Thomas C., (1919), Asst. Mgr., Crane Co., 245 Master St., and 5239 North 15th St., Philadelphia, Pa.

FLETCHER, Saxton W., (1923), Sales Engr., (for mail), J. O. Ross Engrg. Co., 30 East 42nd St., New York, and 67 S. Broadway, White Plains, N. Y.

FLETT, Henry R., (Associate 1915; 1915), Mgr., (for mail), Taylor-Forbes Co., Ltd., 1088 King St., W., and 170 Indian Rd., Toronto, Ont., Can.

FLINK, Carl H., (1923), Chief Engr., (for mail), Gas Utilization, American Radiator Co., 40 West 40th St., New York, and 192 Baynes St., Buffalo, N. Y.

FLINT, Coll T., (1919), Sales Mgr., (for mail), H. B. Smith Co., 640 Main St., Cambridge, and 56 Brantwood Rd., Arlington, Mass.

FLORENCE, William E., Jr., (Junior 1924; Associate 1925), Engr., Acme Htg. & Vtg. Co., 13 Hawkins St., Boston, and (for mail), Weston Rd., Reading, Mass.

FOISY, George A., (1923), Engr., (for mail), Winchester Repeating Arms Co., New Haven, Conn.

FOLEY, William J., (Associate 1923), Pres. and Mgr., (for mail), Wm. J. Foley Htg. Service Co., 230–15th St., and 360 Colorado Blvd., Denver Colo.

FORFAR, Donald M., (1917), Mech. Engr., Croft & Boerner, Inc., 1004 Marquette Ave., and 4825 Emerson Ave., S., Minneapolis, Minn.

FORGAN, Donald M., (Associate 1923), Mgr., (for mail), American Radiator Co., 4201 Duncan Ave., and N. Denny Rd., St. Louis, Mo.

FORGEE, Frederick A., (1919), Consulting Engr., (for mail), 141 East 29th St., New York, N. Y., and Ridgewood, N. J.

FORSBERG, William, (1919), Secy., (for mail), Hopson & Chapin Mfg. Co., 231 State St., New London, and Quaker Hill, Conn.

FOSTER, Charles, (1923), Consulting Engr., (for mail), 512 Sellwood Bldg., and 2831 E. First St., Duluth, Minn.

FOSTER, James M., (Associate 1920), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 1421 Syndicate Trust Bldg., and 7021 Lindell Blvd., St. Louis, Mo.

FOSTER, William M., (Associate 1914), Vice-Pres. and Gen. Mgr., (for mail), The Leggett-Doll-Foster Co., 16508 Woodward Ave., Highland Park, and 19 Claudelia Ave., Pleasant Ridge, Mich.

FOUILHOUX, J. Andre, (1915), Archt. and Engr., Raymond Hood, Godley & Fouilhoux, 40 West 40th St., New York, N. Y., and (for mail), Short Hills, N. J.

FOULDS, Powys A. L., (1916), Mech. Engr., (for mail), Hollis French & A. Hubbard, 210 South St., Boston, and 854 N. Shore Rd., Revere, Mass.

FRANCIS, Isaac H., (1907), Consulting Engr., (for mail), 1520 Locust St., Bonbright Bldg., Philadelphia, and Devon, Pa.

FRANCIS, William C., (1919), Htg. Engr., Jas. P. Wood Htg. Co., 320 New St., and (for mail), 1623 W. Westmoreland St., Philadelphia, Pa.

FRANK, George W., (1919), Pres. and Treas., (for mail), Frank & Miller, Inc., 79 Best St., and 136 High St., Buffalo, N. Y.

FRANK, John M., (Associate 1912; 1918), Vice-Pres., (for mail), Ilg Elec. Vtg. Co., 2850 N. Crawford Ave., Chicago, and 1152 Chatfield Rd., Hubbard Woods, Ill.

FRANK, Olive E., (1919), Pres., (for mail), O. E. Frank Heater & Engr. Co., 20 Milburn St., and 296 Norwalk Ave., Buffalo, N. Y.

FRANKEL, Gilbert, (1926), Sales Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 567 Delaware Ave., Buffalo, N. Y.

FRANKLIN, Ralph S., (1919), Pres. and Treas., (for mail), Albert B. Franklin, Inc., 25 Haverhill St., Boston, and 320 Grove St., Melrose, Mass.

FRANZHEIM, Geo. W., (1924), Pres. and Gen. Mgr., Universal Smokeless Boiler Co., Ravenna, O.

FRASER, William G., (1916), Vice-Pres., (for mail), Power Efficiency Corp., 137 Arthur St., and 1515 Amherst St., Buffalo, N. Y.

FRENCH, Donald E., (1926), Mgr. Htg. Dept., (for mail), York Heating & Ventilating Corp., 1502 Locust St., Philadelphia, and Rockland Ave., Merion, Pa.

FRIEDMAN, Abraham, (1922), Htg. Contractor, (for mail), 217 East 47th St., New York, and 2529 Erickson St., E. Elmhurst, L. I., N. Y.

FRIEDMAN, Ferdinand J., (1921), Mech. Engr., (for mail), McDougall, Pease & Friedman, 85 Osborne St., and 670 Sherbrooke St., W., Montreal, Que., Can.

FROST, Robinson V.,* (1921), Research Engr., 48 Curren Arcade, Norristown, Pa.

FRUTCHEY, Marcus Peter, Jr., (Junior 1927), Pres. and Chief Engr., Heat & Power, Inc., 19 William St., Newark, and (for mail), 25 Trinity Pl., Montclair, N. J.

FRUTCHY, Asel E., (Junior 1920; 1924), Vice-Pres., (for mail), Frutchy-Barnes Co., 104 W. Second St., and 864 Euclid Ave., Elmira, N. Y.

FRY, J. D., (Junior 1924), Asst. Engr., (for mail), McDougall, Pease & Friedman, 85 Osborne St., Montreal, and 16 Thornhill Ave., Westmount, Que., Can.

FRYER, Frederick G., (1918), Director, Rowntree & Co., Ltd., York, England.

FUKUI, Kunitaro, (1927), Director, (for mail), Fukui & Co., Tokio Kaijo Bldg., Marunouchi, and Shiba, Tokyo, Japan.

FULLER, J. Lansing, (Associate 1916), Dist. Sales Mgr., (for mail), Hart & Crouse Co., 315 E. Adams Ave., and 1745 Chicago Blvd., Detroit, Mich.

FUNCK, Elmer H., (Junior 1926), Sales Engr., Johnson Fan & Blower Co., 1319 W. Lake St., and (for mail), 4346 N. Hermitage Ave., Chicago, Ill.

G

GABY, Frederick A., (1926), Hydro Elec. Power Comm. of Ontario, Toronto, Ont., Can.

GALE, Thomas J. C., (Associate 1920; 1921), Htg. and Piping Contractors, 324 Oddfellow Bldg., and (for mail), 4264 Botanical, St. Louis, Mo.

GALLAHER, A. J., (1926), Pres., (for mail), Gallaher Boiler Co., 508 Star Bldg., and 3943 Cleveland Ave., St. Louis, Mo.

GALLAHER, James Ed., (Junior 1923; Associate 1923; 1927), Engr., Smith, Hinchman & Grylls, Marquette Bldg., Detroit, Mich.

GALLIGAN, Andrew B., (1921), Mgr., (for mail), Galligan Bros., 716 South 51st St., and 5231 Race St., Philadelphia, Pa.

GALLIGAN, John H., (1923), Engr., Marine Galligan Co., 1830 Ludlow St., and (for mail), 1930 South 56th St., Philadelphia, Pa.

GANNON, James E., (1918), Pres. and Treas., (for mail), Gannon & Carey Co., 903 Parade St., and 508 West 11th St., Erie, Pa.

GANT, H. P., (1915), (Presidential Member), (Pres. 1923; Council 1918; 1924; 2nd Vice-Pres. 1921; 1st Vice-Pres. 1922), Vice-Pres., York Heating & Ventilating Corp., 1502 Locust St., Philadelphia, Pa.

GARDNER, B. F., (1924), Plbg. and Htg. Contr., 322 Myrtle Ave., and (for mail), 277 Carlton Ave., Brooklyn, N. Y.

GARDNER, S. Franklin, (1911), Member of Firm, (for mail), Standard Engrg. Co., 2129 Eye St., N.W., and 3805 Kanawha St., Washington, D. C.

GARDNER, W., Jr., (Associate 1921), Sales Mgr., (for mail), Gardner City Fan Co., 1842 McCormick Bldg., and 7836 Loomis St., Chicago, Ill.

GAULIN, Richard P., (Junior 1925), 323 Madison Ave., Scranton, Pa.

GAUSMAN, Carl E., (1923), G. M. Orr & Co., 816 Second Ave., S., Minneapolis, and 1528 Iglehart Ave., St. Paul, Minn.

GAUVIN, Leon Gough, (1926), Engr., Power Efficiency Corp., 137 Arthur St., and (for mail), 45 E. Delavan Ave., Buffalo, N. Y.

GAWTHROP, Fred H., (1919), Pres. and Treas., (for mail), Gawthrop & Bro. Co., 705 Orange St., and 2211 Shallcross Ave., Wilmington, Del.

GAYLOR, William S., (1919), Htg. and Vtg. Engr., Starrett & Van Vleck, 8 West 40th St., New York, and (for mail), 42 Mayhew Ave., Larchmont, N. Y.

GAYLORD, F. H., (1921), Br. Mgr., Hoffman Specialty Co., 130 N. Wells St., and 5234 Kimbark Ave., Chicago, Ill.

GEDNEY, Kenneth H., (1923), Architect and Engr., (for mail), K. H. Gedney Co., Osborn Bldg., and No. 3 Park Court, Hastings, Nebr.

GEIGER, Irvin H., (1923), Registered Professional Engr. and Mfgrs. Rep., (for mail), P. O. Box 83, 600 N. Second St., and 240 Maclay St., Harrisburg, Pa.

GEMENY, William J., (1919), Pres., (for mail), W. J. Gemeny Co., 2528 W. Madison St., and 7601 Normal St., Chicago, Ill.

GERRISH, Harry E., (1910), (Council 1919), Partner, (for mail), Morgan-Gerrish Co., 800 LaSalle Ave., and 4534 S. Freemont Ave., Minneapolis, Minn.

GETSCHOW, Geo. M., (1906), Pres. and Treas., (for mail), Phillips-Getschow Co., 130 W. Kinzie St., and 4542 Beacon St., Chicago, Ill.

GETSCHOW, Roy M., (1919), Secy., (for mail), Phillips-Getschow Co., 130 W. Kinzie St., and 1336 Arthur Ave., Chicago, Ill.

GIBBONS, M. J., Jr., (1914), Secy., (for mail), M. J. Gibbons Supply Co., 601 E. Monument Ave., and 22 Oxford Ave., Dayton, O.

GIBBS, Edward W., (1919), (for mail), The Smith-Gibbs Co., 11 S. Main St., and 61 President Ave., Providence, R. I.

GIBBS, Frank C., (1921), Vice-Pres., (for mail), C. W. Colby & Co., 415–13th St. and 1937 Parkdale Ave., Toledo, O.

GIBSON, John H., (1921), 726 S. Highland Ave., Merion, Pa.

GIESECKE, F. E.,* (1913), Dir. Engrg. Experiment Sta., Agricultural and Mechanical College of Texas, College Sta., and 901 East 24th St., Austin, Tex.

GIFFORD, Robert L., (1908), Pres., Illinois Eng. Co., 21st St. and Racine Ave., Chicago, Ill., and (for mail), 1231 S. El Molino Ave. Pasadena, Calif.

GIGUERE, Geo. H., (1920), Mech. Engr., State Architect, Ann Arbor, and (for mail), 13002 Greiner Ave., Detroit, Mich.

GILBERT, Maxwell F., (Associate 1915), Mgr., (for mail), Richardson & Boynton Co., 1308 Arch St., Philadelphia, and 138 Fenbrook Ave., Wyncote, Pa.

GILBOY, John P., (1924), Htg. and Vtg. Engr., (for mail), Herman Nelson Corp., 407 Miller Bldg., and 718 Prescott Ave., Scranton, Pa.

GILDEA, Thomas Emmett, (1907), 127 Coolidge Ave., Syracuse, N. Y.

GILES, Edward H., (1919), Dist. Mgr., (for mail), Pierce, Butler & Pierce Mfg. Corp., 31st and Oxford St., and 47th and Pine Sts., Philadelphia, Pa.

GILL, William Augustus, (Associate 1926), Contract Mgr., (for mail), Tuttle & Bailey Mfg. Co., 441 Lexington Ave., New York, N. Y., and 135 Connett Place, South Orange, N. J.

GILLESPIE, Raymond B., (1924), Sales Repr., (for mail), American Radiator Co., 24th and Blake Sts., and Denver Athletic Club, Denver, Colo.

GILLETT, Merriman C., (1916), Engr., Standard Heater Co., Walnut St., Williamsport, and (for mail), 660 Rising Sun Ave., Philadelphia, Pa.

GILLHAM, Walter E.,* (1917), (Treas. 1926; Council 1924-1926), Consulting Engr., (for mail), 409 Interstate Bldg., and 3427 Bellefontaine, Kansas City, Mo.

GILLING, William F., Jr., (Associate 1919), Asst. Mgr., American Radiator Co., 129 Federal St., Boston, and (for mail), 29 Abbott Rd., Wellesley Hills, Mass.

GILMORE, Frank P., (1923), Sales Engr., (for mail), Peerless Unit Ventilation Co., Room 838, 100 Boylston St., Boston, and 21 Highland Ave., Somerville, Mass.

GILMORE, R. E., (1923), Mech. Engr., (for mail), 4243 Sheridan Rd., and 3917 Rokeby St., Chicago, Ill.

GIVIN, Albert W., (Associate 1925), Mgr., (for mail), Taylor Forbes Co., Ltd., 1070 Homer St., and 2849–42nd Ave., W., Vancouver, B. C.

GLASSEY, J. Wilbur, (1922), Partner, (for mail), Vapor Engrg. Co., 10 South 18th St., and Wyndmoor, Chestnut Hill, Philadelphia, Pa.

GLEASON, Gilbert H., (1923), 25 Huntington Ave., Boston, and 43 Clyde St., Newtonville, Mass.

GLORE, Evins Foree,* (Associate 1916), Pres., Evins F. Glore & Son, Inc., 5619 Grand Central Terminal, and (for mail), 715 Riverside Drive, New York, N. Y.

GODFREY, Foskett H., (1921), Pres., (for mail), Steam Appliance Co., 2021 L. C. Smith Bldg., Seattle, and Tacoma, Wash.

GOETHEL, Alfred C., (Associate 1926), Pres., (for mail), Alfred C. Goethel Co., 829–31st St., and 140 Wright St., Milwaukee, Wis.

GOLDBERG, Harry M., (Junior 1923), Mfgs. Unit Ventilators, 405 Lexington Ave., New York, N. Y., and 73 Willow Ave., N. Plainfield, N. J.

GOLDSCHMIDT, Otto E., (1915), Consulting Engr., (for mail), 116 West 39th St., and 350 West 55th St., New York, N. Y.

GOLDSTEIN, A. M., (1923), Managing Owner, (for mail), Federal Htg. Co., 310–13th St., N.W., and 1501 Varnum St., Washington, D. C.

GOMBERS, Henry B., (Associate 1901), Secy., (for mail), Htg. and Piping Contractors Natl. Assn., 50 Union Sq., New York, N. Y., and 160 Halsted St., E. Orange, N. J.

GOMERSALL, William H., (Associate 1921), Sales Engr., (for mail), Sherman Engrg. Co., 245 South 15th St., Philadelphia, and 7500 Limekiln Pike, Mt. Airy, Philadelphia, Pa.

GOOD, Macy S., (1921), Mgr., Chicago Territory, (for mail), C. A. Dunham Co., 450 E. Ohio St., and 6360 Greenwood Ave., Chicago, Ill.

GOODLOE, Alfred M., (1924), Vice-Pres., Midwest Air Filters, Inc., Bradford, Pa.

GOODNOW, Wallace F., (1912), Special Repr., (for mail), Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., and 260 West 11th St., New York, N. Y.

GOODRICH, Charles F., (1919), Andrews & Goodrich, Inc., 98 Friend St., Boston, Mass.

GOODWIN, Samuel L., (1924), Consulting Engr., 644 Eighth Ave., New York, N. Y., and (for mail), 247 Madison Ave., Hasbrouck Hgts., N. J.

GORDON, Edward B., Jr., (1908), Chas. L. Pillsbury Co., Capital Natl. Bk. Bldg., St. Paul, and (for mail), 3115 Girard Ave., S., Minneapolis, Minn.

GORDON, Edward G., (1923), Robert Gordon, Inc., 1355 W. Washington Blvd., and (for mail), 1621 Lunt Ave., Chicago, Ill.

GORMLY, John,* (Charter Member; Honorary Member; Presidential Member), (Pres. 1906; Council 1899; Board of Governors 1900-1903; 1st Vice-Pres. 1904), 410 E. Marshall St., Norristown, Pa.

GORMLY, P., (1919), Consulting Engr., R. D. No. 5, Norristown, Pa.

GORNSTON, Michael H., (Associate 1923), Engr., Board of Education, P. S. 109, 430 Dumont Ave., and (for mail), 251 Crescent St., Brooklyn, N. Y.

GORTNER, John W., (1919), Htg., Vtg. and Sanitary Plumber, (for mail), A. W. Gortner & Son, 318 Sunbury St., and 42 N. Sixth St., Shamokin, Pa.

GORTON, G. H., (Associate 1924), W. B. Young Supply Co., 208 Delaware St., Kansas City, Mo.

GOSS, Matthew H., (1921), Estimator and Engr., The Brown Co., 1053 Baltimore Ave., W., and (for mail), 4415 Helen Ave., Detroit, Mich.

GOSSETT, Earl J., (1923), Pres., (for mail), Bell & Gossett Co., 3000 S. Wallace St., and 6719 Newgard Ave., Chicago, Ill.

GOTTWALD, C., (Associate 1916), Pres., (for mail), The Ric-Wil Co., 1573 Union Trust Bldg., and 2225 Stillman Rd., Cleveland, O.

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GRAHAM, William D., (Junior 1923; Associate 1925), Dist. Mgr., (for mail), York Htg. & Vtg. Corp., 1502 Monadnock Bldg., 52 W. Jackson Blvd., Chicago, Ill., and 1549 Cordova Ave., Lakewood, O.

GRAHAME, Dallas Forrest, (1925), Supervisor of Bldg., (for mail), Bell Telephone Co., of Can., 118 Notre Dame St., W. Montreal, and 532 Grosvenor Ave., Westmount, Que., Can.

GRANFIELD, John Joseph, (Associate 1925), Dist. Htg. Engr., Socony Burner Corp., 895 Boylston St., Boston, and (for mail), 52 Tesla Ave., Medford Hillside, Mass.

GRASSLER, Edmund, (Associate 1919), Grassler & Gezelschap, (for mail), 214 Third St., and 750 Summit Ave., Milwaukee, Wis.

GRAVES, Clarence C., (Associate 1925), Secy., (for mail), Heating Service Co., 3047 Sheffield Ave., and 4110 N. Kilbourn Ave., Chicago, Ill.

GRAVES, Ralph E., (Associate 1923), Factory Representative, (for mail), Fulton Co., 1014 Holland Bldg., St. Louis, Mo., and 8516 Florence Ave., Webster Groves, Mo.

GRAVES, Willard B., (1906), Pres., (for mail), W. B. Graves Htg. Co., 162 N. Desplaines St., Chicago, and 254 Edgewood Place, River Forest, Ill.

GRAY, George A., (1924), (for mail), C. A. Dunham Co., Ltd., 205 Roy Bldg., and 17 Walnut St., Halifax, N. S.

GRAY, William E., (1922), Sales Engr., 2237 Greenwood St., Harrisburg, Pa.

GREBE, Henry W., (1919), Pres., (for mail), Central Asbestos & Magnesia Co., 214 W. Grand Ave., and 2650 Wilson Ave., Chicago, Ill.

GREEN, John E., (Associate 1926), Owner and Prop., 11820 Brush St., Detroit, Mich.

GREEN, William C., (1906), Br. Mgr., (for mail), Warren Webster & Co., 919 Provident Bk. Bldg., and 244 Erkenbrecher Ave., Cincinnati, O.

GREENE, Walter C., (1921), Mgr., (for mail), W. C. Greene Co., 1629 Union Trust Bldg., Cleveland, and 2400 Demington Drive, Cleveland Hgts., O.

GRETZINGER, Franklin, (1919), Mech. Engr., Land Title Bldg., and (for mail), 2124 North 17th St., Philadelphia, Pa.

GRIER, William, (1908), P. O. Box 75, Cincinnati, O.

GRIFFIN, Frank A., Jr., (1917), Sales Engr., (for mail), Kellogg-Mackay Co., 2030 Walnut St., and 3930 S. Benton St., Kansas City, Mo.

GRIFFIN, Porter C., (1923), Supt. of Plbg. and Htg., Hutton Bros. Co., 9 Union St., and (for mail), 151 Oak St., Winsted, Conn.

GRILL, Guido E., (Junior 1922), Designer, (for mail), Clark, McMullen & Riley, 101 Park Ave., New York, and 90 Alter Ave., Dongan Hills, S. I., New York.

GROOM, Stanley L., (1920), Managing Director, Buffalo Forge Co., Ltd., 24 Buckingham Gate, and (for mail), Homstead Thrale Rd., Streatham, London, Eng.

GROSS, R. A., (1923), Ben Rigby, Inc., 604 W. Lake St., Chicago, and (for mail), 527 N. Washington St., Park Ridge, Ill.

GROSSMAN, Howard M., (1922), Dist. Sales Mgr., Burnham Boiler Corp., 701 Griest Bldg., and (for mail), 634 Race Ave., Lancaster, Pa.

GROSVOLD, Fred E., (1917), Plbg. and Htg., 411 Grand Ave., E., and (for mail), 603 Main St., Eau Claire, Wis.

GROTZ, Arthur B., (1921), Treas., Patterson-Kelly Co., 101 Park Ave., New York, and (for mail), 42 Fenimore Rd., Scarsdale, N. Y.

GRUMBEIN, Irwin F.,* (1915), Pres., (for mail), Natl. Htg. & Vtg. Co., 736 Drexel Bldg., Philadelphia, and Lebanon, Pa.

GUEST, Peyton L., (1921), Pres., Smith & Guest, 19 Houston St., and (for mail), 247 McLinden St., Atlanta, Ga.

GUNN, Joseph F., (1924), Pres., Heckel-Gunn Htg. Co., 3685 Olive St., and 4325 North 21st St., St. Louis, Mo.

GUNTHER, Felix A., (1925), Supt. of Distribution (for mail), Allegheny County Steam Htg. Co., 435 Sixth Ave., and P. O. Box 137, R. F. D. No. 9, South Hills Branch, Pittsburgh, Pa.

GUSTAFSON, T. E., (Junior 1923), U. S. Radiator Corp., 500 N. Dearborn St., Chicago, Ill.

H

HAAS, Samuel L., (1923), Pres. and Treas., (for mail), American Htg. Co., 117 N. Desplaines St., and 1513 Fargo Ave., Chicago, Ill.

HAAS, William, (1915), Pres. and Treas., (for mail), The William Haas Co., 429 E. Third St., and 1632 S. Wayne Ave., Dayton, O.

HACKETT, Charles P., (Associate 1921), Dist. Steam Mgr., Republic Radiator Co., 2401 Chestnut St., Philadelphia, and (for mail), 56 W. Eagle Rd., Upper Darby, Pa.

HACKETT, H. Berkeley, (1921), Mech. and Consulting Engr., 505 Chestnut St., Philadelphia, Pa.

HACKNEY, Henry, (Associate 1919), Contractor and Engr., (for mail), 34 W. Fifth St., and 1514 E. Seventh St., Charlotte, N. C.

HADDOCK, Isaac T., (Associate 1926), Vice-Pres., (for mail), Cambridge Gas Light Co., 719 Massachusetts Ave., Cambridge, and 133 Barnard Ave., Watertown, Mass.

HADEN, George N., (Junior 1922), Director, (for mail), G. N. Haden & Son, and Owens Cottage, Hilperton, Trowbridge, Eng.

HADEN, William N., (1902), Managing Director, (for mail), G. N. Haden & Sons, Ltd., Silver St., and Homefield House, Trowbridge, Eng.

HADESTY, Alfred L., Jr., (1921), 130 E. Broad St., Tamaqua, Pa.

HAGAN, William Vincent, (Junior 1926), Secy., V. J. Hagan Co., 508 Pearl St., Sioux City, Iowa.

HAGEDON, Charles H., (1919), Secy. and Treas., S. E. Fenstermaker & Co., 821 Hume Mansur Bldg., and 4156 Broadway, Indianapolis, Ind.

HAILEY, Syd Houston, (1925), Asst. Engr., N. C. & St. L. Ry., 924 Broadway, and (for mail), 3737 Harding Rd., Nashville, Tenn.

HAINES, John J., (1915), Vice-Pres. and Secy., (for mail), The Haines Co., 1933 W. Lake St., Chicago, and 623–17th Ave., Maywood, Ill.

HALE, John F.,* (1902), (Presidential Member), (Pres. 1913; Board of Governors 1908, 1910; 1st Vice-Pres. 1912; Council 1913), Dist. Repr., (for mail), Aerofin Corp., Rm. 1531, Burnham Bldg., Chicago, and 408 S. Brainard Ave., LaGrange, Ill.

HALEY, Harry S.,* (1914), Consulting Engr., (for mail), Leland & Haley, 58 Sutter St., and 735 21st Ave., San Francisco, Calif.

HALL, Cortice H., (1927), Chief Engr., Domestic Stoker Co., 7 Dey St., New York, N. Y., and (for mail), 250 Hamilton Ave., Glen Rock, N. J.

HALLETT, Edwin S.,* (1918), (Council 1921; 1923), Chief Engr., (for mail), Board of Education, Board of Education Bldg., and 5156 Cabanne Ave., St. Louis, Mo.

HALLEY, Wilson H., (Junior 1923; 1925) Htg. Engr., Salesman, (for mail), Langenberg Mfg. Co., 4519 N. Euclid Ave., and 6134 W. Park Ave., St. Louis, Mo.

HALLIDAY, Leo, (Associate 1926), Vice-Pres. and Gen. Mgr., (for mail), Newport Boiler Co., Rm. 800, 529 S. Franklin St., and 7242 E. End Ave., Chicago, Ill.

HAMJY, Paul W., (1924), Owner, (for mail), 611 Mohawk St., and 612 Steele Place, Utica, N. Y.

HAMLET, F. Aylmer, (1922), Draughtsman and Estimator, W. J. Evans, 4 Park Ave., Montreal, and (for mail), Provincial Hotel, Gananoque, Ont., Can.

HAMLET, Thomas F., (1920), Sales Engr., Darling Bros., Ltd., 120 Prince St., and (for mail), 34 Burton Ave., Westmount, Montreal, Que. Can.

HAMLIN, Harry A., (Associate 1916), Detroit Mgr., (for mail), Johnson Service Co., 427 Brainard St., Detroit, and 120 Winona Ave., Highland Park, Mich.

HANCHETT, James H., (Associate 1926), Mgr., Minneapolis Office, (for mail), The Trane Co., 923 Nicollett Ave., and 1622 West 31st St., Minneapolis, Minn.

HANCOCK, James Reynolds, (Junior 1926), Asst. Mech. Engr., D. X. Murphy & Bro., 714 Louisville Trust Bldg., Louisville, Ky., and (for mail), 131 W. Chestnut St., Jeffersonville, Ind.

HANKIN, Richard, (1898), Vice-Pres., John Hankin & Bros., 228 Cherry St., New York, N. Y., and (for mail), 279 Main Ave., Passaic, N. J.

HANLEY, John H., Jr., (1923), Vice-Pres. and Chief Engr., Reed Engrg. Co., 50 Church St., New York, and (for mail), 1718 East 26th St., Brooklyn, N. Y.

HANSEN, J., (1921), 2611 Kimball Ave., Chicago, Ill.

HANSON, E. W., (1922), Engr. and Estimator, (for mail), W. N. Sauer Co., 806 Chestnut St., and 919 Eldora Place, Pittsburgh, Pa.

HARBISON, Earl J., (Associate 1924), J. E. Harbison, 211¼ Union St., and (for mail), 15 Brickwood Blvd., Schenectady, N. Y.

HARBULA, M. G., (1921), Consulting Engrs., Air Conditioning Specialists, 213 S. LaSalle St., Chicago, Ill., and (for mail), 1564 Broadway, New York, N.Y.

HARDING, Louis A.,* (1911), (Council 1922; 1924), Pres., (for mail), L. A. Harding Construction Co., 1335 Main St., and 85 Cleveland Ave., Buffalo, N. Y.

HARE, Edgar S., (1920), Pres., (for mail), William Hare's Sons Co., 46–14th St., Wheeling, W. Va., and W. Alexander, Pa.

HARMS, Wm. T.,* (1917), Htg. Contractor, 1173 Clark Ave., Detroit, Mich.

HARPER, Samuel H., (Associate 1927), Prop., (for mail), 304 Oliver Bldg., Pittsburgh, and 223 Dalzell Ave., Ben Avon, Pittsburgh, Pa.

HARRIGAN, Edward M., (1915), Gen. Mgr., (for mail), Harrigan & Reid Co., 1365 Baker St., and 7459 LaSalle Blvd., Detroit, Mich.

HARRINGTON, Charles, (1923), 160 Grenadier Rd., Toronto, Ont., Can.

HARRIS, Henry W., (Associate 1924), Salesman, J. R. Brockenan Mfg. Co., 617 N. Second St., and 4296 Washington Blvd., St. Louis, Mo.

HARRIS, Jesse B., (1918), Partner, (for mail), Rose & Harris, Engrs., 15th and Oak Grove Sts., and 3620 Colfax Ave., S., Minneapolis, Minn.

HARRISON, Burt S., (1918), Vice-Pres. and Chief Engr., McCann-Harrison Corp., 5005 Euclid Ave., and 1956 East 84th St., Cleveland, O.

HARRISON, James M., (1919), Vice-Pres., (for mail), McCann-Harrison Co., 5005 Euclid Ave., and 2061 East 96th St., Cleveland, O.

HART, Harry M., (1912), (Presidential Member), (Pres. 1916; Council 1914; 1917; 1st Vice-Pres. 1915), Pres., (for mail), L. H. Prentice Co., 1048-50 W. Van Buren St., and 5409 Winthrop Ave., Chicago, Ill.

HART, Thomas Henry, (Junior 1927), Mech. Engr., Jos. C. Llewellyn Co., 38 S. Dearborn St., and (for mail), 9000 Bishop St., Auburn Pk. Sta., Chicago, Ill.

HARTER, Baxter B., (Junior 1926), Htg. Engr., (for mail), Warren Webster & Co., 549 W. Washington Blvd., and 4420 Magnolia, Chicago, Ill.

HARTMAN, Frank E.,* (1924), Chief Chemist, U. S. Ozone Co., 500 N. Dearborn St., Chicago, Ill.

HARTMAN, John Milton, (1927), Testing Engr., (for mail), Kewanee Boiler Co., and 719 Henry St., Kewanee, Ill.

HARTPENCE, Charles C., (1923), Htg. and Vtg., Engr., (for mail), P. O. Box 337, and 922 Peachtree St., Columbus, Ga.

HARTWELL, Joseph C., (1922), Dept. Mgr. and Engr., (for mail), Grinnell Co., Inc., 260 W. Exchange St., and 16 Freeman Parkway, Providence, R. I.

HARVEY, Alexander D., (Junior 1925), Asst. to Sales Mgr., (for mail), Nash Engrg. Co., S. Norwalk, and Suburban Club, Stamford, Conn.

HASEY, Charles E., (1919), C. W. Hasey Co., (for mail), 726 Fourth St., S., and 2613 Third Ave., S., Minneapolis, Minn.

HASKELL, Benj. E., (1925), Engr., Arthur B. Fels, 42 Union St., Portland, and (for mail), 539 Brighton Ave., Woodfords, Me.

HASKINS, Arthur L., (Associate 1927), Sales Engr., American Radiator Co., 1897 Elmwood Ave., Buffalo, N. Y.

HATTIS, Robert E., (1926), Mech. Engr., W. L. Fergus & Co., 1509 Fisher Bldg., and (for mail), 4152 N. Mozart St., Chicago, Ill.

HAUSS, Charles F., (1922), Special Representive for Far East, (for mail), American Radiator Co., 4 Yuen Ming Yuen Rd., Shanghai, China, and 40 West 40th St., New York, N. Y.

HAWES, Herbert R., (1926), Treas., Edwin Hawes Co., 806 Main St., and (for mail), 22 Elmwood St., Worcester, Mass.

HAYES, James J., (1920), Sales Engr., (for mail), Stannard Power Equipment Co., 926 Monadnock Block, and 7443 Jeffery Ave., Chicago, Ill.

HAYES, Joseph G., (1908), Mgr. and Engr., (for mail), Hayes Bros., Inc., 236 W. Vermont St., and 2849 N. Capitol Ave., Indianapolis, Ind.

HAYES, Patrick M., (Associate 1923), 4324 Erskine St., Omaha, Nebr.

HAYNES, Charles V., (1917), (Council 1926), Vice-Pres. and Gen. Sales Mgr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 115 Llanfair Rd., Ardmore, Philadelphia, Pa.

HAYWARD, Ralph B., (1909), Pres., (for mail), R. B. Hayward Co., 1714 Sheffield Ave., Chicago, and 201 S. Stone Ave., La Grange, Ill.

HEAGERTY, William H., (Associate 1923), Gen. Mgr., Oil City Boiler Works, P. O. Box 137, Oil City, Pa.

HEAGLER, John M., (1922), Engr. and Mgr., (for mail), American Foundry & Furnace Co., 508 Guardian Life Bldg., and 1646 Iglehart, St. Paul, Minn.

HEAP, Walter E., (1920), Mgr., (for mail), Charles R. Heap & Son, 26 Roe St., and 412 Delafield Ave., W. New Brighton, N. Y.

HEATH, Frederick R., (1913), Sales Engr., E. B. Badger & Sons Co., 75 Pitts St., Boston, and (for mail), 89 Trowbridge St., Cambridge, Mass.

HEATHERTON, James M., (Associate 1904), Pres., (for mail), Plumbers Trade Journal Publishing Co., 239 West 30th St., New York, and 395 Clinton Ave., Brooklyn, N. Y.

HECK, George L., Jr., (Associate 1921), Sales Engr., (for mail), Garden City Fan Co., 1842 McCormick Bldg., and 7522 Cornell Ave., Chicago, Ill.

HECKEL, Edmund P., (1918), Vice-Pres., (for mail), Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, and 314 Cuttriss Place, Park Ridge, Ill.

HEDGES, H. Berkley,* (1919), Dist. Sales Mgr., (for mail), York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y., and 1021 Park Lane, Plainfield, N. J.

HEDLEY, Park S., (1923), Sales Engr., (for mail), 374 Delaware Ave., Buffalo, and 31 Westgate Rd., Kenmore, N. Y.

HEEBNER, Walter M., (1922), Sales Engr., Warren Webster & Co., 15 West 34th St., New York, N. Y., and (for mail), 362 Highwood St., Bogota, N. J.

HEILES, F. C., (1914; 1920), Perry West Consulting Engr., Newark, and (for mail), 34 Boyden Parkway, Hilton, N. J.

HEILMAN, Russell H.,* (1923), Sr. Industrial Fellow, (for mail), Mellon Institute, and 7108 Willard St., Pittsburgh, Pa.

HEINLE, Earl L., (1920), Secy. and Treas., The Kain-Petersen-Heinle Co., 1364 East 34th St., Cleveland, and (for mail), 2176 Edgewood Rd., Cleveland Heights, O.

HELBURN, I. B., (Junior 1927), Engrg. Dept., (for mail), Reed Air Filter Co., 215 Central Ave., and Argonne Hotel, Louisville, Ky.

HELLERMAN, Harry H., (1902), Pres., (for mail), Treas., The Penn Engrg. Co., 312 Cherry St., and 49th St. and Monument Ave., Philadelphia, Pa.

HELPHINGSTEIN, Otto, (1919), Br. Mgr., (for mail), Cullyford Plbg. & Htg. Co., 119 W. Sixth St., and 907 Jefferson St., Amarillo, Tex.

HELWIG, Gunther Albert, (1927), Prop., National Htg. & Vtg. Co., 920 Cass Ave., and 4851 LeDuc St., St. Louis, Mo.

HENION, Hudson D., (Associate 1923), Sales Mgr., (for mail), C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 338 Spadina Rd., Toronto, Ont., Can.

HENNINGS, William A., (1926), Estimator and Engr., Dewar & Carrington, 153 N. Desplaines St., and (for mail), 1445 Summerdale Ave., Chicago, Ill.

HENRICH, George A., (1914), Pres., (for mail), Geo. A. Henrich Co., 702 N. Wells St., and 548 Fullerton Parkway, Chicago, Ill.

HENRICI, Hermann C., (1925), Pres., Henrici Lowry Engrg. Co., 401 Security Bldg., and (for mail), 430 West 58th St., Kansas City, Mo.

HEPBURN, George V., (Associate 1926), Sales Engr., (for mail), Herman Nelson Corp., Builders and Traders Exch., and Oakwood Manor, Grand Rapids, Mich.

HERBACZEK, Edward, (Junior 1925), 4905 N. Whipple St., Apt. 1-B, Chicago, Ill.

HERENDEEN, Frederick W., (1920), Secy., (for mail), The Natl. Boiler & Radiator Mfrs. Assn., 29 Seneca St., and 815 S. Main St., Geneva, N. Y.

HERLIHY, George F., (1922), Vice-Pres., (for mail), J. J. Herlihy, Inc., 810 W. Congress St., and 212 East 109th St., Chicago, Ill.

HERLIHY, Jermiah J., (1914), Pres., (for mail), J. J. Herlihy, Inc., 810 W. Congress St., and 3634 N. Keeler Ave., Chicago, Ill.

HERMAN, Harry H., (Junior 1925), Chief Engr., (for mail), Warren Webster Co., 1226 California St., and 612 Milwaukee St., Denver, Colo.

HERRICK, Daniel A., (1923), Factory Mgr., (for mail), Julian d'Este Co., 2 Spice St., Charlestown, and 27 Agassiz St., Cambridge, Mass.

HERRING, Edgar, (1919), Managing Director, (for mail), J. Jeffreys & Co., Ltd., Barron's Place Waterloo Rd., London, S.E., and "Kenia," Keowick Rd., Putney, London, S.W., 15, Eng.

HERSH, G. Willis, (1917), Gen. Mgr., Hersh Bros. Co., 2510 Chew St., Allentown, Pa.

HERSKE, Arthur R., (1926), Mgr., Heating & Piping Contractors Assn., 408 Chester Twelfth Bldg., and 17010 Kenyon Rd., Cleveland, O.

HERTZ, H. Porter, (1924), Engr., (for mail), Routledge & Hertz, Archts., 303 State Exch. Bk., and 314–12th Ave., Hutchinson, Kan.

HESS, Horace L., (1924), Salesman, H. B. Smith Co., 49th and Grays Ave., W. Philadelphia, and (for mail), 214 Nedro Ave., Olney, Philadelphia, Pa.

HESTER, Thomas J., (1919), Vice-Pres. and Treas., (for mail), Hester, Bradley Co., 4200 Forest Park Blvd., and 67 Aberdeen Place, St. Louis, Mo.

HETHERINGTON, Edward T., (1919), Sales Engr., (for mail), 1718 Sansom St., and 3311 North 16th St., Philadelphia, Pa.

HEYDON, Charles G., (Associate 1923), Sales Engr., (for mail), Wright-Austin Co., 315 Woodbridge St., W., and 2737 Hooker St., Detroit, Mich.

HEYMSFIELD, Herbert R., (Associate 1926), 673 Wales Ave., Bronx, N. Y.

HIBBS, Frank C., (1917), Htg. Engr., The H. B. Smith Co., 49th and Grays Ave., and (for mail), 3203 Columbia Ave., Philadelphia, Pa.

HIGGINS, John M., (1922), Salesman, H. B. Smith Co., 640 Main St., Cambridge 39, and (for mail), 28 Monmouth Ave., W. Medford, Mass.

HIGGINS, Thomas J., (Junior 1923), Vice-Pres. and Mgr., Ross Engrg. Co. of Can., Ltd., New Birks Bldg., Montreal, Que., Can.

HILL, E. G. T., (1922), E. G. Hill & Co., 20 Vermont Crescent, Newland Hill, E. Yorke, Eng.

HILL, E. Vernon,* (Associate 1912; 1914) (Presidential Member), (Pres. 1920; Council 1915; 1917; 1921; 2nd Vice-Pres. 1918; 1st Vice-Pres. 1919), Pres., (for mail), E. Vernon Hill Co., 121 N. Clark St., and 4415 Hazel Ave., Chicago, Ill.

HILL, Newell J., (1916), Consulting Engr., (for mail), 708 Architects Bldg., and 1737 Atkinson Ave., Detroit, Mich.

HILLIARD, Charles Ernest, (Junior 1927), Sheet Metal Contr., (for mail), 27 B St., South Boston, and 13 Weir St., Auburndale, Mass.

HILLS, Arthur H., (1924), Htg. Engr., C. A. Dunham Co., 805-806 Hill Bldg., 17th and Eye Sts., N.W., Washington, D.C., and (for mail), 3 G, Rochelle Ter. Apts., Mt. Vernon, N. Y.

HINCHMAN, E. G., (1923), Secy., (for mail), E. G. Hinchman Co., 1263 Atlantic Ave., and 547 Eastern Parkway, Brooklyn, N. Y.

HINKLE, Edwin C., (1911), Pres. Atlantic Htg. & Engrg. Co., Second Natl. Bk. Bldg., and (for mail), 170 Franklin Ave., Hempstead, N.Y.

HIRES, J. Edgar, (1927), Consulting Engr. and Pres., Hires, Castner & Harris, Inc., 1110 Land Title Bldg., Philadelphia, and (for mail), 107 Linwood Ave., Ardmore, Pa.

HIRST, James Noble, (Junior 1927), Chief Draftsman, (for mail), York Htg. & Vtg. Corp., 1502 Locust St., and 2913 Popular St., Philadelphia, Pa.

HITCHCOCK, Frederick P., (1917), Sales Repr., (for mail), 309 Lathrop Bldg., and 4938 Forest Ave., Kansas City, Mo.

HITNER, Frank Morris, (Junior 1925), Salesman, (for mail), Ilg Elec. Vtg. Co., 950 Century Bldg., Pittsburgh, and 126 Washington Ave., Oakmont, Pa.

HOBBS, J. Clarence, (1920), Supt. of Power, Diamond Alkali Co., and (for mail), 126 Wood St., Painesville, O.

HOBEN, Robert J., (1919), Plbg. and Htg. Contractor, (for mail), 258 S. Van Pelt St., and 5112 Spruce St., Philadelphia, Pa.

HOCHULI, Henry W., (1925), Sales Engr., National Radiator Co., 47 West 42nd St., New York, N. Y., and (for mail), 113 Chester Ave., Bloomfield, N. J.

HODGDON, Harry A., (1919), Htg. and Vtg. Engr., Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and (for mail), 153 Norfolk St., Wollaston, Mass.

HOERSTING, Frank J., (1921), Hoersting & Holtmann, 1133 W. Third St., Dayton, O.

HOFFMAN, Charles F., (Junior 1925), Sales Engr., (for mail), International Heater Co., 1114 Dime Savings Bk. Bldg., and 80 W. Euclid Ave., Detroit, Mich.

HOFFMAN, Charles S., (1924), Vice-Pres., (for mail), 576 Greenwich St., New York, N. Y., and 19 Belvidere Place, Montclair, N. J.

HOFFMAN, George D.,* (1906), Hoffman Specialty Co., 512 Fifth Ave., New York, N. Y.

HOFFMAN, James D.,* (1903), (Presidential Member), (Pres. 1910; 1st Vice-Pres. 1908; Board of Governors 1911, 1912), Prof. of Practical Mechanics, Head of Dept., Director of Practical Mech. Lab., (for mail), Purdue University, and 323 University St., W. Lafayette, Ind.

HOFT, Paul J., (Associate 1924; 1925), Prop., Plbg. and Htg. Contractor, (for mail), 245 S. Eighth St., and 1119 Wyoming Ave., Philadelphia, Pa.

HOGAN, Edward L., (1911), Consulting Engr., (for mail), American Blower Co., 6004 Russell St., and 1700 Seward, Detroit, Mich.

HOIER, William V., (1917), Mgr., (for mail), Wm. V. Hoier Co., 701 N. Wells St., and 5960 Kenmore Ave., Chicago, Ill.

HOISINGTON, Ned P., (Associate 1923), 102 Summit Ave., Bywood Heights, Upper Darby P. O., Pa.

HOLBROOK, Frank M., (1923), Armstrong Cork Co., Linoleum Div., Lancaster, Pa.

HOLLOWAY, Robert B., (Junior 1923; Associate 1926), Salesman, (for mail), Gurney Heater & Mfg. Co., 21st St. and Washington Ave., Philadelphia, and 26 W. Rockland St., Germantown, Pa.

HOLMBERG, John A., (1924), 122 E. Lincoln, Lindsborg, Kans.

HOLMES, Joseph, (1921), Htg. Engr., 1902 Freeman St., Toledo, O.

HONIBALL, Charles R.,* (1911), Pres., Charles R. Honiball Co., 156 Boundary St., Liverpool, Eng.

HOOK, C. Howard, (1915), Pres., Peerless Heater Co., 5602 Baum Blvd., Pittsburgh, Pa.

HOOK, Maurice G., (1919), *Mgr., (for mail),* C. A. Dunham Co., 101 Park Ave., New York, and 11 Henry St., Tuckahoe, N. Y.

HOOVER, H. Earl, (Associate 1922), Vice-Pres., The Hoover Co., 1407 Railway Exch., Chicago, and 1801 Green Bay Rd., Glencoe, Ill.

HOPKIN, William E., (1919), Pres. and Treas., (for mail), Chas. E. Hopkin Co., 107 Bethlehem Pike, and 514 Wyndmoor Ave., Chestnut Hill, Philadelphia, Pa.

HOPSON, William T., (1915), Hopson & Chapin Mfg. Co., New London, Conn.

HORNUNG, John C., (1914), Engr., (for mail), 343 S. Dearborn St., Chicago, and 854 Bluff St., Glencoe, Ill.

HORTON, Homer F., (1925), Sales Repr., (for mail), National Regulator Co., 2301 Knox Ave., Chicago, and 343 Green Bay Rd., Glencoe, Ill.

HOSTERMAN, Charles O., (1924), Supt., The McMurrer Co., 303 Congress St., Boston, and (for mail), 25 Bales Rd., Dorchester, Mass.

HOUGHTEN, Ferry C.,* (1921), (Secy. 1924; 1925), Director of Research Lab., (for mail), A. S. H. & V. E., U. S. Bureau of Mines, 4800 Forbes St., and 1136 Murray Hill Ave., Pittsburgh, Pa.

HOUPT, George A., (1916), Engr., Philadelphia Piping & Equipt. Co., 1605 Rockland St. Philadelphia, Pa.

HOWATT, John,* (1915), Chief Engr., (for mail), Board of Education, 650 S. Clark St., and 7006 Bennett Ave., Chicago, Ill.

HOWELL, Frank B., (1920), Institution of Thermal Research, American Radiator Co., 40 West 40th St., 20th Floor, New York, and (for mail), Westbrook Apts., N., at Delaware, Buffalo, N. Y.

HOWELL, Lloyd, (1915), Chief Engr., (for mail), American Foundry & Furnace Co., 915 E. Washington St., and 1203 E. Jefferson St., Bloomington, Ill.

HOYT, William B., (1919), Sales Mgr. and Secy., National Pipe Bending Co., River and Lloyd Sts., New Haven, and 39 Clifford St., Whitneyville, Conn.

HUBBARD, Allen, (1919), Consulting Engr., (for mail), Hollis French & Allen Hubbard, 210 South St., Boston, and 51 Montvale Rd., Newton Center, Mass.

HUBBARD, G. W., (1911), Mech. Engr., (for mail), Graham, Anderson, Probst & White, 1417 Railway Exch., Chicago, and 331 Bonnie Brae, River Forest, Ill.

HUBBARD, Nelson B., (1919), Consulting Engr., (for mail), Rm. 1005, 1346 Broadway, and 2985 Blaine Ave., Detroit, Mich.

HUBERT, Jack W., (1924), Vice-Pres., Barron Hubert Co., 126 West 64th St., New York, N. Y.

HUCH, Aloysius J., (1919), Gen. Mgr. of Sales, (for mail), Central Supply Co., 312 S. Third St., and 4037 Harriet Ave., Minneapolis, Minn.
HUCKEL, Frank, Jr., (1920), Mgr. Htg. Dept., Keystone Supply & Mfg. Co., 907 N. Ninth St., Philadelphia, and (for mail), 5335 Wingohocking Ter., Germantown, Pa.
HUCKER, Joseph H., (1921), Sales Engr., (for mail), Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, and 715 Stanbridge St., Norristown, Pa.
HUETHER, Charles G. L., (Junior 1923; 1924), Htg., Vtg., Air Conditioning, Power and Mech. Equipment, Atlantic Engrg. Co., 109 E. Pleasant St., and 3814 Kate Ave., Forest Park, Baltimore, Md.
HUGHES, Willard C., (1921), (for mail), Wicks-Hughes & Co., 224 Genesee St., and 16 Cottage Place, Utica, N. Y.
HUGHSON, Harry Henry, (1927), Engrg. Salesman, The Coon-DeVisser Co., 2051 W. Lafayette Blvd., Detroit, Mich.
HUMPHREY, Dwight E., (1921), Htg. and Vtg. Engr., (for mail), Goodyear Tire & Rubber Co., Akron and 121 Harrison Ave., Cuyahoga Falls, O.
HUMPHREYS, Aurelius E., (1911), Mgr., (for mail), O'Mara Heating Co., 504 Victoria Bldg., and 4121 Flora Blvd., St. Louis, Mo.
HUNGER, Robert F., (1927), Sales Engr., (for mail), Buffalo Forge Co., 1302 Land Title Bldg., Philadelphia, and 107 Long Lane, Stonehurst, Pa.
HUNT, Phil M., (1922), Htg. and Vtg. Engr., Crane Co., 90 South St., Newark, N. J.
HUNT, Richard B., (1912). Sales Engr., American Radiator Co., 414 S. Fourth Ave., Mt. Vernon, N. Y.
HUNTER, H. R., (Associate 1925), Bldg. Supt., (for mail), Jewelers Building Corp., 36 West 47th St., New York, N. Y., and 209-74–112th Ave., Bellaire, L. I.
HUNTER, Wallace S., (Associate 1924), Vice-Pres., (for mail), United Plumbers Supply Co., Inc., 441 Exterior St., and 254 East 202nd St., New York, N. Y.
HURLEY, Joseph C., (1915), Pres., (for mail), Petroleum Fuel Engine Co., 4028 Filbert St., and 21 South 61st St., Philadelphia, Pa.
HUSBAND, Edward Woods, (1922), Htg. Engr., Geo. Frederic Hall, Archt., 807 Union Trust Co., Bldg., and (for mail), 114 Corinth St., Providence, R. I.
HUTCHINSON, J. Edward, (1921), Engr., (for mail), Isaac Hathaway Francis, 1520 Locust St., and 5129 Newhall St., Philadelphia, Pa.
HUTTON, William, (1919), Pres., (for mail), Hutton Bros. Co., 9 Union St., and 28 Spring St., Winsted, Conn.
HUTZEL, A. F., (1916), (for mail), Hutzel & Co., 119 E. Washington St., and 722 W. Washington St., Ann Arbor, Mich.
HUTZEL, Hugo F., (1918), (for mail), American Radiator Co., 1807 Elmwood Ave., Buffalo, and 64 N. Long St., Williamsville, N. Y.
HUTZEL, Max H., (1923), Vice-Pres. and Secy., (for mail), Hutzel & Co., Hutzel Bldg., and 731 N. Elm St., Muncie, Ind.
HUTZEL, Victor C., (1923), Treas., (for mail), Hutzel & Co., Hutzel Bldg., and 715 N. Elm St., Muncie, Ind.
HUZZARD, Edward C., (Associate 1924), Mgr. and Asst. Treas., Fleck-Marshall Co., Hazel and Water Sts., and (for mail), 710 New Holland Ave., Lancaster, Pa.
HYMAN, Wallace M., (1920), Vice-Pres., (for mail), Reis & O'Donovan, Inc., 253 West 28th St., and 210 West 70th St., New York, N. Y.
HYNES, Lee P.,* (1919), 30 Church St., New York, and 50 S. Mansing Blvd., Albany, N. Y.

I

ICKERINGILL, John, (1923), Sales Engr., Standard Heater Co., Otis Bldg., Philadelphia, and 235 Rector St., Roxborough, Pa.
IDDLES, Alfred, (1921), Chief Power Engr., (for mail), Day & Zimmermann, Inc., 1600 Walnut St., Philadelphia, and 304 Conestoga Rd., Wayne, Pa.
IMPEY, Paul F., (Junior 1921; Associate 1925), Htg. Engr., John C. Moninger Co., 2221 S. Rockwell St., Chicago, and (for mail), 2623 Crescent Drive., Elmwood Park, Ill.
INGALLS, F. D. B., (1906), Htg. and Sales Engr., (for mail), 136 Federal St., Boston, and 1 Hopkins St., Reading, Mass.
INGELS, Margaret M.,* (Junior 1918; 1923), Research Engr., New York Commission on Ventilation, (for mail), 120 W. Genesee St., Syracuse N. Y.
***INNIS, Helen R.**, (Junior 1918; 1921), 170 New York Ave., Brooklyn, N. Y.
IRELAND, Thomas Hilton, (1923), Sales Engr., Crane Co., 23 West 44th St., New York, and (for mail), 69 Cedar Ave., Rockville Center, L. I., N. Y.
IRWIN, Clarence W., (1924), 412 Clark Bldg., Jacksonville, and Jacksonville Beach, Fla.
ISSERTELL, Henry G., (Associate 1912; 1913), Supervising Engr., General Elec. Co., (for mail), 120 Broadway, and 825 West 180th St., New York, N. Y.

J

JACKSON, Charles H., (1923), Sales Engr., Bayley Mfg. Co., 732 Greenbush St., and 614 Farwell Ave., Milwaukee, Wis.
JACKSON, Charles J., (Associate 1912), Local Mgr., (for mail), Jenkins Bros., 646 W. Washington Blvd., Chicago, and 323 Hazel Ave., Glencoe, Ill.
JACKSON, Jonathan William, (Associate 1927), Mgr., (for mail), Pierce Co., 41 W. Spring St., and 12 West Ave., Gainesville, Ga.
JACKSON, Marshall S., (1919), Repr., (for mail), 232 Delaware Ave., and 108 Larchmont Rd., Buffalo, N. Y.
JACKSON, Tandy L., (Junior 1926), Pres. and Gen. Mgr., (for mail), Tandy L. Jackson Co., Mutual Bldg., and 3524 Campbell St., Kansas City, Mo.
JACOBUS, David S., Dr., (1916), Advisory Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.
JALIEN, John J., (1922), Staff Engr., (for mail), 552 Seventh Ave., and 365 West 118th St., New York, N. Y.
JANES, Arthur, (1919), Pres., Arthur Janes Co., 990 Post Rd., Scarsdale, N. Y.
JANET, Harry L., (1920), Engr., (for mail), Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, N. J., and 688 Decatur St., Brooklyn, N. Y.
JARDINE, Douglas Connell, (Associate 1926), Plbg. and Htg. Contr., Jardine & Knight Plbg. & Htg. Co., 312 N. Custer, and 509 N. Nevada, Colorado Springs, Colo.
JARVIS, George E., (1923), Secy., Htg. and Vtg. Engr., A. E. Holmes & Bros. Co., (for mail), 911 Banks Ave., and 1626 Baxter Ave., Superior, Wis.
JAYNES, Eubertis L., (1918), (for mail), Apt. 3 B, 6418 N. Richmond St., Chicago, Ill.
JELLETT, Stewart A.,* (Charter Member; Presidential Member), (Pres. 1895; Board of Managers 1896-1897; Secy. 1898; Board of Managers 1899), Pres., Stewart A. Jellett Co., 1200 Locust St., Philadelphia, and 6701 Lincoln Drive, Mount Airy, Philadelphia, Pa.
JENKINS, Harry E., (Associate 1923), Sales Mgr., Radiator Div., (for mail), Winchester Repeating Arms Co., New Haven, Conn., and 343 High St., Lowell, Mass.
JENNINGS, Irving C., (1924), Pres., (for mail), Nash Engrg. Co., and 138 Flax Hill Rd., S. Norwalk, Conn.
***JENNINS, Harry H.**, (1901), Managing Director, E. Oldroyd & Co., Ltd., and (for mail), 15 Grange View, Leeds, Eng.
JENSON, Jean S., (1912), 431 S. Dearborn St., Chicago, Ill.
JOHN, Benjamin F., (1920), Pres., (for mail), Benjamin F. John Co., 1003 Race St., and 881 North 24th St., Philadelphia, Pa.

JOHNS, Harold Byron, (Junior 1927), Mgr., House Htg. Div., Peoples Gas, Light & Coke Co., 122 S. Michigan Ave., Chicago, and (for mail), 543 N. Elmwood Ave., Oak Park, Ill.
JOHNSEN, Henry, (Associate 1927), Htg. Contractor, 51 Raleigh Ave., W. New Brighton, S. I., N. Y.
JOHNSON, Carl W., (1912), Pres., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., and 1809 Morse Ave., Chicago, Ill.
JOHNSON, Edgar Engman, (1926), Sales Engr., (for mail), *Buffalo Forge Co., 490 Broadway*, and 200 Loring Ave., Buffalo, N. Y.
JOHNSON, Edward B., (1919), Sales Engr., Staten Island Supply Co., 1390 Richmond Ter., and (for mail), 154 Wardwell Ave., W. New Brighton, N. Y.
JOHNSON, Fred W., (1916), Vice-Pres., (for mail), Johnson, Larsen & Co., 693-703 Monroe Ave., Detroit, and R. F. D. No. 4, Birmingham, Mich.
JOHNSON, Helge Samuel, (Junior 1927), Sales Engr., (for mail), The Coon-DeVisser Co., 2051 W. Lafayette Blvd., and Lee Crest Apts., Detroit, Mich.
JOHNSON, Paul H., (Associate 1924), Engr., E. H. Sheldon Co., and (for mail), 205 Washington Ave., Muskegon, Mich.
JOHNSON, Ralph B., (1922), Sales Engr., (for mail), 1100 E. Douglas Ave., Wichita, Kans., and 2117 East 68th St. Ter., Kansas City, Mo.
JOHNSON, Tracy R., (1924), Mgr., Engr. Dept., The Trane Co., and 315 Y. M. C. A., LaCrosse, Wis.
JOHNSTON, James Ambler, (1912), Member of Firm, Carneal & Johnston, Architects and Engrs., 806 Electric Bldg., and 1411 Grove Ave., Richmond, Va.
***JOHNSTON, R. E.**, (Associate 1926), Htg. Engr., Taylor Forbes Co., 1070 Homer St., Vancouver, B. C.
JOHNSTON, William B., (Associate 1916; 1921), Vice-Pres., (for mail), Ideal Furnace Co., 2995 E. Grand Bldg., and 1667 Atkinson Ave., Detroit, Mich.
JOHNSTON, William H., (1924), Pres., (for mail), Johnston Htg. Co., 332 East 47th St., New York, and 19 Magnolia Ave., Larchmont, N. Y.
JONES, Alfred L., (1926), Supt., Htg. and Power Constr., Alfred Penovi & Sons, 112 Willett Ave., Port Chester, N. Y., and (for mail), R. F. D. No. 28, Cos Cob, Conn.
JONES, Dwight C., (Associate 1924), (for mail), Hoffman Specialty Co., 200 Builders Exchange, and 4508–29th Ave., S., Minneapolis, Minn.
JONES, Edwin, (Junior 1924), Watt Plbg., Htg. & Supply Co., Box 582, Tulsa, Okla.
JONES, Edwin A., (1919), Contracting Engr., L. J. Mueller Furnace Co., 197 Reed St., and 1695 Frederick, Milwaukee, Wis.
JONES, Edwin F., (1923), Consulting Engr., (for mail), 301 Zenith Bldg., and 116 E. Fourth St., St. Paul, Minn.
JONES, Ernest, (Associate 1925), Dist. Mgr., (for mail), B. F. Sturtevant Co., 423 Dwight Bldg., and 4630 Wornall Rd., Kansas City, Mo.
JONES, Ernest F., (1923), Mgr. Htg. Dept., (for mail), Kellogg-Mackay Co., 1351 West 37th Place., and 3325 Warren Ave., Chicago, Ill.
JONES, Harold L., (1920), Asst. Supt., The W. W. Farrier Co., (for mail), 44 Montgomery St., Jersey City, and 11 Cambridge Rd., Glen Ridge, N. J.
JONES, Ivor R., (Junior 1923), (for mail), Isaac H. Francis, 1520 Locust St., Philadelphia, and 344 Taylor Terrace, Chester, Pa.
JONES, Louis T., (1921), Salesman, 3700 Highland Ave., Drexel Hill, Delaware Co., Pa.
JONES, Raymond E., (1919), Pres., (for mail), Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, Pa., and 39 W. End Ave., Haddonfield, N. J.
JONES, William T., (1915), (Council 1925-1926), Partner, Barnes & Jones, 126 Brookside Ave., Jamaica Plain, and (for mail) ,11 Rossmere St., Newtonville, Mass.
JOYCE, Walter P., (Associate 1924), Htg. Engr., 2039 Hardesty Ave., Kansas City, Mo.
JUNG, John S., (Associate 1923), Htg. Contractor, 554 Layton Blvd., Milwaukee, Wis.
JUNKERS, Prof. Hugo, (1925), Pres., (for mail), Junkers Corp. of America, 342 Madison Ave., New York, N. Y., and 21 Kaiser Platz, Dessau, Germany.
JUTTNER, Otto J., (1915), Pres., (for mail), Juttner Heating Co., 43 Jefferson St., Milwaukee, and 496 Newton Ave., Shorewood, Wis.

K

KAISER, Harry S., (Junior 1924), Htg. and Vtg. Engr., Hanley & Co., 6 N. Clark St., and (for mail), 3608 Wilson Ave., Chicago, Ill.
KAMMAN, Arnold R., (Junior 1921; Associate 1925), Engr., John W. Danforth Co., 72 Ellicott St., Buffalo, and (for mail), Wanakah, Erie Co., N. Y.
KAMMERER, William C., (1923), Mech. Engr., Hadlow, Hughes, Hick & Conrad, 1301 Union Mortgage Bldg., Cleveland, and (for mail), 13963 Clifton Blvd., Lakewood, O.
KAPPEL, George W. A., (1921), Pres. and Treas., (for mail), Camden Heating Co., 8 Market St., Camden, and 347 King's Highway W., Haddonfield, N. J.
KAPPLER, Herman C., (1927), Htg. and Vtg. Engr., Smith, Hinchman & Grylls, 800 Marquette Bldg., and (for mail), 185 McLean Ave., Detroit, Mich.
KARLSON, Alfred F., (1918), Chief Engr., (for mail), Parks-Cramer Co., 970 Main St., Fitchburg, and 186 Prospect St., N. Leominster, Mass.
KARR, Theo., Jr., (1921), (for mail), Karr Supply Co., 129 W. Main, and 325 S. High St., Belleville, Ill.
KASTELLO, August, (1923), Mgr., (for mail), C. A. Dunham Co., Ltd., 904 New Birks Bldg., and 112 Rutland Ave., Town of Mt. Royal, Montreal, Que., Can.
KATSUMOTO, Eijiro, (1926), Pres., (for mail), Katsumoto & Co., Engrs. and Contractors, 29, Awajicho, and 3 Kirishimacho, Darien, S. Manchuria, China.
KAUFFMAN, Rufus, (1921), Htg. Engr. and Contractor, (for mail), 4308 N. Broad St., and 326 W. Seymour St., Philadelphia, Pa.
KAUFFMANN, Frederick F., (1922), Consulting Engr., (for mail), 13 North 13th St., Philadelphia, Pa., and 909 Pine St., Camden, N. J.
KAYSING, Harry C., (1926), Designer and Engr., Hester-Bradley Co., 4200 Forest Park Blvd., St., Louis, Mo.
KEASBEY, Aertsen Parry, (1922), Vice-Pres., (for mail), Robert A. Keasbey Co., 445 West St., New York, N. Y., and 298 Park St., Montclair, N. J.
KEENAN, P. Frank, (Associate 1921), Pres., (for mail), Leo Flush Valve Co., 331 Madison Ave., New York, and 283 Burns St., Forest Hills, L. I.
KEENEY, Frank P., (Associate 1915), Pres., Domestic Engrg., 1900 Prairie Ave., and 70th St. *and The Lake*, Chicago, *Ill.*
KEHM, August, (1901), (Board of Governors 1908; 1911; 1st Vice-Pres. 1909), Pres., Kehm Bros. Co., 51 E. Grand Ave., Chicago, Ill.
KEISER, Walter, (Associate 1920), Vice-Pres., (for mail), Keiser Equipment & Engrg. Co., 580 Arcade Bldg., and Wydom Blvd. and Bolland Drive, St. Louis, Mo.
KELLEY, James J., (Associate 1924), Vice-Pres., (for mail), Ballard Oil Co., 535 Commonwealth Ave., Boston, and 142 Governors Ave., Medford, Mass.
KELLOGG, Alfred,* (1916), (Council 1920-1921; 1923-1924), (for mail), *89 Franklin St.*, Boston, and 6 Hawthorne St., Waverly, Mass.
KELLOGG, Hosford D., (Associate 1916), Mgr., (for mail), H. B. Smith Co., 17th and Arch Sts., Philadelphia, and Haverford, Pa.
KELLOGG, Thomas M., (Associate 1923), Mgr. Htg. Dept., (for mail), The Bishop & Babcock Co., 444 Lafayette St., New York, and 23 Roxbury Rd., Scarsdale, N. Y.

KELLY, Hugh, (1927), Managing Director, (for mail), H. Kelly & Co., Ltd., 10041-101 A Ave., and 10235-124th St., Edmonton, Alberta, Can.

KELLY, John G., (Associate 1919), Plbg. and Htg. Specialties, 210 East 45th St., New York, and (for mail), 55 Cornell Ave., Yonkers, N. Y.

KENT, Laurence F., (Junior 1924), Vice-Pres. and Engr., Moncrief Furnace Co., P. O. Box 1673 Atlanta, and R. F. D. No. 2, Smyrna, Ga.

KERN, Raymond T., (1927), Chief Engr., Jennison Co., Fitchburg, and (for mail), 51 Claflin St., Leominster, Mass.

KERNEY, Thomas F., (Junior 1925), Engr., (for mail), H. Berkeley Hackett, Consulting Engr., 1001 Public Ledger Bldg., and 2115 W. Ontario St., Philadelphia, Pa.

KERSHAW, Melville G., (Junior 1921; Associate 1926), Designing Engr., du Pont Engrg. Co., Wilmington, Del., and 3957 N. Percy St., Philadelphia, Pa.

KERSJES, William, (1922), Pres. and Gen. Supt., Wheeler Blaney Co., 249 N. Burdick St., and (for mail), 728 Clinton St., Kalamazoo, Mich.

KEYS, George Walter, (Associate 1927), Mech. Draftsman, Louis T. Klauder, Consulting Engr., 1300 Bankers Trust Bldg., Philadelphia, and (for mail), 518 Van Kirk St., Crescentville, Philadelphia, Pa.

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KIEWITZ, Conway, (1907), Engr., N. Y. Board of Education, Flatbush Ave. and Concord St., Brooklyn, and 70 King St., Floral Park, L. I., N. Y.

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KILLIAN, Maurice A., (1922), Pres., Glanz & Killian Co., 1761 Forest Ave., W., and 4400 Leslie Ave., Detroit, Mich.

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KINEALY, John H.,* (Charter Member; Presidential Member), (Pres. 1901; 1st Vice-Pres. 1898; Board of Governors 1902), Consulting Engr., 503 Granite Bldg., St. Louis, Mo.

KING, Thomson, (1923), Sales Mgr., (for mail), Gas Boiler Dept., Peerless Heater Co., 5602 Baum Blvd., and 209 N. Lang Ave., Pittsburgh, Pa.

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KINNER, J. E., (1924), Bryant Heater & Mfg. Co., 952 East 72nd St., and 1453 East 116th St., Cleveland, O.

KIPE, J. Morgan, (1919), Br. Mgr., (for mail), Spencer Heater Co., 609 Otis Bldg., Philadelphia, and 801 Homestead Ave., Beechwood, Delaware Co., Pa.

KIRK, Charles D., (1909), Mgr., Chas. D. Kirk Co., Sargent and Colleen Sts., and 774 McMillan Ave., Winnipeg, Manitoba, Can.

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KISSICK, J. J., (1918), Chief of Bureau of Operation, Board of Education, Sixth and Rockwell Ave., and (for mail), 1768 Wayside Rd., Cleveland, O.

KITAURA, Shigeyuki, (1918), Mech. Engr., Monopoly Bureau, Dept. of Finance, Tokyo, Japan.

KITCH, Stanley B., (Junior 1925), Sales Engr., The Trane Co., 844 Rush St., Chicago, and (for mail), 3330 Wesley Ave., Berwyn, Ill.

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KLEIN, Albert R., (1920), Mgr., Carrier Luftechnische Gesellschaft, Langestrasse 61, and (for mail), Panoramastrasse 23, Stuttgart, Germany.

KLEIN, Edward W., (1917), S. E. Dist. Mgr., (for mail), Warren Webster & Co., 618 Atlantic Trust Bldg., and 227 Myrtle St., Atlanta, Ga.

KLIE, Walter, (1915), Pres., (for mail), The Smith & Oby Co., 6107 Carnegie Ave., Cleveland, and 18411 S. Woodland Rd., Shaker Heights, Cleveland, O.

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KLONOWER, Arthur A., (1920), Mgr., J. S. Cassedy Co., 133 Austin St., and 244 Brattle St., Cambridge, Mass.

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KOITHAN, William S., (1913), Sales Engr., (for mail), Koithan & Pryor, 39 Cortlandt St., New York, N. Y., and 46 Linden Place, Summit, N. J.

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KOTTCAMP, Horace A., (1915), Pres. and Gen. Mgr., Chambersburg Construction Co., 139 N. Second St., and (for mail), Philadelphia Ave., and Kenwood Rd., Chambersburg, Pa.

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KREITNER, William, (Junior 1926), Htg. Estimator, Alvord & Swift, Grand Central Terminal, New York, and (for mail), 108 Linden St., Brooklyn, N. Y.

KRESSLY, Maurice E., (1922), Htg. and Vtg. Engr., Bureau of School Bldgs., Dept. of Public Instruction, Harrisburg, Pa., and (*for mail*), 239 Church and Maine, Orlando, Fla.

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LANDERS, John J., (Junior 1924), Engr., U. S. Radiator Corp., 517 Dime Bk. Bldg., and (for mail), 156 Margaret St., W., Detroit, Mich.

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LEES, Herbert K., (Junior 1912; 1924), Estimator, William Lees, 548 W. Washington Blvd., and 4946 Christiana Ave., Chicago, Ill.

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LIVINGSTON, Bernard B., (1927), Gas Engr., Dept., of Public Utilities, City of Richmond, and (for mail), P. O. Box 976, Richmond, Va.

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LOEFFLER, Frank X., (1914), Pres., (for mail), Frank Loeffler Supply Co., 710 N. Hudson St., and 320 West 26th St., Oklahoma City, Okla.

LONDON, Irving, (Junior 1924), Engr. and Estimator, (for mail), Raisler Heating Co., 129 Amsterdam Ave., New York, and 1660 Union St., Brooklyn, N. Y.

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LORD, Frank Russell, (1922), Mgr. Htg. Dept., (for mail), Walworth Mfg. Co., 245 Arch St., Philadelphia, Pa., and Delanco, N. J.

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LOVELACE, James A., (1920), Vice-Pres. and Gen. Supt., R. L. Spitzley Heating Co., 246 Larned St., W., Detroit, Mich.

LOWNSBERY, Benjamin F., (1920), Htg. Engr., Benjamin F. Shaw Co., Second and Lombard Sts., and (for mail), 21 S. Sycamore St., Wilmington, Del.

LUCE, G. D., Jr., (1919), Mech. Engr., D. H. Burnham Co., Archts., 1900 Burnham Bldg., and (for mail), 3633 N. Harding Ave., Chicago, Ill.

LUCK, Alexander W.,* (1919), Pres. and Gen. Mgr., Reading Heater & Supply Co., Church and Woodward Sts., Reading, Pa.

LUCKE, C. E., (1924), Prof. Mech. Engrg., Executive Htg. Dept., (for mail), Columbia University, and 845 West End Ave., New York, N. Y.

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LYLE, Ernest T., (1919), Engr., (for mail), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and The Braemore, 466 Commonwealth Ave., Boston, Mass.

LYLE, J. Irvine, (1911), (Pres. 1917), (Council 1918), Treas. and Gen. Mgr., (for mail), Carrier Engrg. Corp., Newark, and 1200 W. Seventh St., Plainfield, N. J.

LYMAN, Samuel E., (Associate 1924), Erecting Supt., Air Conditioning, 2021 Land Title Bldg., and (for mail), 132 North 49th St., Philadelphia, Pa.

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McCREERY, Hugh J., (1922), Mgr., (for mail), Combustion Engrg. Corp., Ltd., Bank Bldg., and 1355-12th Ave., W., Vancouver, B. C.

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MacKENZIE, Burt, (1924), Htg. and Vtg. Contractor, 349 N. Elm St., and P. O. Box 353, Greensboro, N. C.

MacKENZIE, John J., (1925), McNaughton & MacKenzie, 1029 Shaw St., and (for mail), 664 Shaw St., Toronto, Ont., Can.

MACKIE, James, (1917), Mgr., James Mackie Plbg. & Htg. Co., 357 Langside St., and 254 Montrose St., Winnipeg, Man.

MADISON, Richard D., (1926), Research Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 133 Lisbon Ave., Buffalo, N. Y.

MAGINN, Peter F., (1908), P. F. Maginn & Co., 207 Fulton Bldg., Pittsburgh, Pa.

MAHONEY, David John, (Associate 1926), Br. Mgr., (for mail), Johnson Service Co., 503 Franklin St., and 546 Delaware Ave., Buffalo, N. Y.

MAIER, George M., (1921), Engr., Planning and Research Dept., (for mail), American Radiator Co., 40 West 40th St., New York, and Apt. 54, Peldean Court, Pelham, N. Y.

MAIER, Herman F., (1926), Designing Engr., New York Blower Co., 2246 S. Halsted St., and (for mail), 7124 Morgan St., Chicago, Ill.

MALLIS, William, (1914), Architect and Engr., (for mail), 326 Lyon Bldg., and North Gate Apts., First Ave., Seattle, Wash.

MALONE, Dayle G., (Associate 1925), Htg. Engr., Hardin-Lavin Co., 121-139 W. Pershing Rd., and (for mail), 5417 Dorchester Ave., Chicago, Ill.

MANAHAN, James E., (Junior 1926), Asst. Engr., (for mail), Bradley Htg. Co., 3834 Olive St., and 6732 Oakland Ave., St. Louis, Mo.

MANDEVILLE, Edgar W., (1914), E. W. Mandeville, Inc., 623 Parkside Ave., and (for mail), 1171 East 37th St., Brooklyn, N. Y.

MANN, Carl P., (1924), Construction Engr., Beverly, N. J.

MANSELL, P. C., (1921), (for mail), Purdy-Mansell, Ltd., 63 Albert St., and 26 Grassmere Rd., Toronto, Ont., Can.

MAPPETT, Alfred S., (Charter Member), Treas., Fowler & Wolfe Mfg. Co., 621 Bulletin Bldg., Philadelphia, Pa.

MARION, Charles A., (Associate 1926), Engr., 4155 Cass Ave., and (for mail), 742 Burlingame Ave., Detroit, Mich.

MARSCHALL, Peter J., (Junior 1927), Engr., (for mail), E. Vernon Hill Co., 121 N. Clark St., and 8228 Langley Ave., Chicago, Ill.

MARSHALL, H. Hall, (1923), Consulting Engr., (for mail), 37 West 43rd St., New York, and 63 Pine St., Garden City, N. Y.

MARTENIS, John V., (1918), Associate Prof. of Mech. Engrg., Mech. Engrg. Dept., University of Minnesota, and (for mail), 416 Harvard St., S.E., Minneapolis, Minn.

MARTIN, Albert B., (1917), Dist. Sales Mgr., (for mail), Kewanee Boiler Co., 822 W. Washington Blvd., Chicago, and 997 Vine St., Winnetka, Ill.

MARTIN, George W., (1911), Pres., (for mail), New York Service Co., 141 East 29th St., New York, N.Y., and 314 Prospect St., Ridgewood, N. J.

MARTIN, Jeremiah F., (1926), Estimator and Supt. of Construction, H. L. Graham, 66 Exchange St., and (for mail), 166 Glenwood Ave., Pawtucket, R. I.

MARTIN, O. Waldemar, (1925), Chicago Mgr., (for mail), Flax-li-num Insulating Co., 228 N. LaSalle St., Chicago, and 2235 Forest View Rd., Evanston, Ill.

MASON, James J., (1918), Sales Repr., (for mail), Herman Nelson Corp., 832 Atlas Bldg., and 1944 Guilford Rd., Upper Arlington, Columbus, O.

MASON, Ray B., (1925), Engr., (for mail), Kewanee Boiler Co., 2014 Wyandotte St., and 2940 Forest Ave., Kansas City, Mo.

MATCHETT, James C., (1923), Vice-Pres. and Mgr., (for mail), Illinois Engrg. Co., Racine Ave., at 21st St., and 9936 W. Winchester Ave., Chicago, Ill.

MATHEY, Nicholas J., (1915), Htg. and Vtg. Engr., Mathey Plbg. Co., 31 Third Ave., N.E., LeMars, Iowa.

MATHIS, Eugene, (1922), Pres., (for mail), A. Mathis & Sons, Inc., 3155 Shields Ave., and 9151 S. Hoyne Ave., Chicago, Ill.

MATHIS, Henry, (1921), New York Blower Co., 2248 S. Halsted St., and (for mail), 143 West 71st St., Chicago, Ill.

MATHIS, Julien W., (Associate 1921), Pres., New York Blower Co., 2248 S. Halsted St., and (for mail), 7003 S. Peoria St., Chicago, Ill.

MATHY, Joseph, Jr., (1925), Chief Engr. and Gen. Supt., (for mail), R. B. Hayward Co., 1714 Sheffield Ave., and 3415 West 61st Place, Chicago, Ill.

MATSON, Taylor, (Associate 1925), Mech. Engr., Taylor Matson Co., 6141 Girard Ave., Philadelphia, Pa.

MATTHEWS, Charles Russell, (1924), Htg. Engr., (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and 48 Dana St., Cambridge, Mass.

MATTHEWS, John K., (1923), Morgan Htg. & Plbg. Co., P. O. Box 843, Charleston, W. Va.

MATTHIESSEN, H. G. F., (1923), Sales Engr., Hoffman Specialty Co., 512 Fifth Ave., New York, N. Y., and (for mail), 179 Renner Ave., Newark, N. J.

MATZEN, Harry B., (1919), Mgr., Carrier Engrg. Corp., 923 Union Trust Bldg., and 2642 N. Moreland Blvd., Cleveland, O.

MAUER, William J., (1919), Sales Engr., Dwyer Equipment Co., 4534 W. North Ave., Chicago, and (for mail), 2624 Central St., Evanston, Ill.

MAURER, Edward D., (1921), Secy. and Treas., Maurer Bros. Co., 8600 Detroit Ave., Cleveland, and (for mail), 1527 Mars Ave., Lakewood, O.

MAY, Edwin A., (1906), 171 N. Kenilworth Ave., Oak Park, Ill.

MAYER, Robert S., (1911), Br. Sales Mgr., (for mail), Heggie-Simplex Boiler Co., 2026 East 22nd St., and 9327 Amesbury Ave., Cleveland, O.

MAYETTE, Charles Edgerton, (1926), Squad Chief, Dwight P. Robinson & Co., Inc., 125 West 46th St., New York, and (for mail), 4 Westminster Rd., Brooklyn, N.Y.

MEAD, Edward A., (1926), Sales Dept., (for mail), Nash Engrg. Co., S. Norwalk, and 2 East Ave., Norwalk, Conn.

MEAD, Walter R., (1924), Dist. Repr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 711 Highland Ave., San Mateo, Calif.

MEADOWS, Frank H., (1923), The Meadows Heating Co., 94 Second St., Milwaukee, Wis.

MEARA, John J., (Junior 1925), Engr., Hunt Htg. Co., 1515 Olive St., and 5046 Wabada Ave., St. Louis, Mo.

MEDWAY, Fred J., (Associate 1919), Mgr., (for mail), Johns-Manville, Inc., Madison Ave. and 41st St., New York, N. Y., and 803 Boulevard, E., Weehawken, N. J.

MEHAFFEY, William Chambers, (1922), Engr., Chambersburg Construction Co., Chambersburg, Pa.

MEHRING, George, (Charter Member), Pres., Mehring & Hanson, 162-166 N. Clinton St., Chicago, Ill.

MEIER, Konrad,• (1916), Consulting Engr., Rychenbergstrasse 57, Winterthur, Switzerland.

MELLON, James T. J., (1911), (Council 1915), Owner, Mellon Co., (for mail), 4419 Ludlow St., and 431 North 63rd St., Philadelphia, Pa.

MENK, Rudolph W., (1919), Mgr., Htg. Systems Div., Robinson Furnace Co., 205-207 W. Lake St. Chicago, and (for mail), 814 Clement St., Joliet, Ill.

MENSING, Frederick D., (1920), Consulting Engr., (for mail), Mensing & Co., 928 Presser Bldg., and 2845 Frankford Ave., Philadelphia, Pa.

MENZIES, Frederick Robert, (Junior 1926), New Haven Mgr., (for mail), The Trane Co., 410 Temple St., New Haven, and Long Hill, Woodbridge, Conn.

MERKEL, Fred P., (1924), Prop., (for mail), 131 South 12th St., Newark, and 2 Garfield Place, E. Orange, N. J.

MERRELL, Spencer Atkins, (Associate 1927), Pres., (for mail), Merrell & Co., Inc., 4424-26 Olive St., St. Louis, and 479 Algonquin Drive, Webster Groves, Mo.

MERRILL, Carl J., (1919), Treas., (for mail), C. J. Merrill, Inc., 54 St. John St., P. O. Box A, West End Sta., Portland, Me.

MERRITT, C. J., (1925), C. J. Doughty & Co., Inc., 30 Brenan Rd., W., 103-104, Shanghai, China.

MERTZ, Walter A., (1919), Secy., (for mail), Kehm Bros. Co., 51 E. Grand Ave., and 3753 N. Keeler Ave., Chicago, Ill.

MERVINE, Thomas R., (1922), Partner, Mervine Bros., 208 S. Seventh St., and (for mail), 5852 N. Fifth St., Philadelphia, Pa.

MERWIN, Gile E., (Junior 1923; 1924), Htg. Engr., (for mail), Rockford Brass Works, and 1303 Harlem Rd., Rockford, Ill.

MESSMER, George E., (Junior 1925), Htg. Engr., (for mail), Bridge & Beach Mfg. Co., 4204 N. Union Blvd., and 3020 Walton Place, St. Louis, Mo.

MESTON, A. B., (Associate 1925), 201 W. Second St., Des Moines, Ia.

MEWSHAW, James P., (1923), C. A. Dunham Co., 605-6 Hill Bldg., 17th and Eye St., N.W., and 2700–35th Place, N.W., Washington, D. C.

MEYER, Hans J., (1919), (Council 1922), Pres., (for mail), Combustion Engrg. Co., 200 Madison Ave., and Fifth Ave., Hotel, New York, N. Y.

MEYER, Henry C., Jr., (1898), (Council 1915; 1916), Consulting Engr., 101 Park Ave., New York, N. Y.

MEYER, John W., Jr., (1921), Mgr. Order and Credit Depts., (for mail), American Blower Co., 6004 Russell St., and Webster Hall, Detroit, Mich.

MEYER, Richard C., (1926), Sales Engr., Walter H. Eagan & Co., 315 Stephen Grand Bldg., and (for mail), 1705 Porter St., Philadelphia, Pa.

MEYERS, John, (Junior 1925), Br. Mgr., (for mail), Johnson Service Co., 911 Cathedral St., and 404 Wilmslow Rd., Baltimore, Md.

MEYERS, Samuel H., (Associate 1924), Meyers Bros., 219 Hale St., and 1502 Virginia St., Charleston, W. Va.

MEYERING, Archer S., (1922), Htg. and Vtg. Engr., (for mail), Br. Mgr., C. A. Dunham Co., 2023 L. C. Smith Bldg., Seattle, Wash.

MICHAEL, L. A., (1921), Htg. and Vtg. Engr., 414 W. Colfax Ave., Denver, Colo.

MILES, James C., (1914), Vice-Pres., The Warm Air Furnace & Fan Co., 6511 Cedar Ave., Cleveland, O.

MILLAR, Rowland J., (1925), Vice-Pres. and Mgr., (for mail), Pease Foundry Co., Ltd., 118 King St., E., and 53 Oakmount Rd., Toronto, Ont., Can.

MILLER, Alan A., (Associate 1926), Htg. Engr., Bridgman Co., 120 South 30th St., Philadelphia, and (for mail), 731 Cornell Ave., Drexel Hill, Pa.

MILLER, Charles A., (Associate 1917), Salesman, (for mail), The H. B. Smith Co., 10 East 39th St., and 2178 University Ave., New York, N. Y.

MILLER, Charles W., (Junior 1908; 1919), Pres., (for mail), Rado Co., 192 Reed St., Milwaukee, and R 1, Box 62, Menomonee Falls, Wis.

MILLER, Edwin A., (Associate 1925), Coheen Corp., (for mail), 331 Madison Ave., and Emerson Hotel, 75th St., Amsterdam Ave., New York, N. Y.

MILLER, Floyd A., (1911), Inspection Engr., U. S. Treasury Dept., 477 Federal Bldg., Chicago, Ill.

MILLER, Harry M., (1920), Htg. and Vtg. Engr., 6089-91 Plankinton Bldg., Milwaukee, and 1290 Stowell Ave., Shorewood, Wis.

MILLER, Harvey N., (1921), Sales Engr., Illinois Engrg. Co., 744 Lafayette Ave., S. E., Grand Rapids, Mich.

MILLER, James E., (Junior 1912; 1914), Vice-Pres., (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., Chicago, and 2210 Colfax St., Evanston, Ill.

MILLER, John F. G., (1916), Vice-Pres. and Treas., American Blower Co., 6004 Russell St., Detroit, Mich.

MILLER, Leo B., (1926), Partner, (for mail), McDonnell & Miller, Wrigley Bldg., and Allerton Club, Chicago, Ill.

MILLER, Merl William, (Junior 1926), Experimental Dept., (for mail), Trane Co., and 1115 Main St., LaCrosse, Wis.

MILLER, Peter, (1926), Htg. Engr. and Estimator, Davidson & Miller, Htg. and Plbg. Contractors, 119 Broadway, Saranac Lake, N. Y.

MILLER, Robert B., (1922), Pres. and Mgr., (for mail), Miller & Brady, Inc., 210 East 38th St., New York, and 9405–95th St., Woodhaven, L. I., N. Y.

MILLER, Rowland Austin, (Associate 1927), Mgr., Pacific Coast Dist., (for mail), Chamberlin Metal Weather Strip Co., 1072 N. Wilton Place, Los Angeles, and 334 25th St., Santa Monica, Calif.

MILLER, Tolbert G., (Junior 1921), Piping Engr., Penna. R. R., Harrisburg, and (for mail), Wormleysburg, Pa.

MILLER, William C., (1918), Pres., (for mail), Htg. Specialties Co., 10 South 18th St., Philadelphia, and Collegeville, Pa.

MILLIKEN, James H., (1923), Chicago Mgr., (for mail), Reed Air Filter Co., 1916 Builders Bldg., 228 N. LaSalle St., Chicago, and 618 Hinman Ave., Evanston, Ill.

MILLIS, Linn W.,* (1918), Secy. and Treas., Security Stove & Mfg. Co., 17th and Oakland Sts., and (for mail), 3534 Wabash Ave., Kansas City, Mo.

MILWARD, Robert K., (Associate 1920), Br. Mgr., (for mail), U. S. Radiator Corp., 4004 Duncan Ave., St. Louis, and 434 Lee Ave., Webster Grove, Mo.

MINNICH, Harry S., (1921), Philadelphia Mgr., Richmond Radiator Co., 2241 N. American St., and (for mail), 4526 Walnut St., Philadelphia, Pa.

MITCHELL, Charles H., (1924), Engr., Barber Co., 26 Warrenton St., Boston, and (for mail), 179 Thatcher St., Mattapan, Mass.

MODIANO, Rene, (1925), Continental Sales Engr., Carrier Engrg. Co., Ltd., Elysee Bldg., Rue du Faubourg, St. Honore, and (for mail), 10, Rue Gustave Dore, Paris (17 eme), France.

MOFFETT, William S., (1907), Consulting and Construction Engr., Staunton, Va.

MOLER, William H., (Junior 1923; 1927), Sales Engr., Carrier Engrg. Corp., Rm. 1032, Burnham Bldg., Randolph and LaSalle Sts., Chicago, Ill.

MOLTZ, George N., (Associate 1925), Sales Engr., Standard Heater Co., 315 Pearl St., Hartford, Conn.

MONAGHAN, Thomas H., (1914), Pres., (for mail), Robert Gordon, Inc., 22 W. Austin Ave., and 623 Deming Place, Chicago, Ill.

MONDAY, Charles E., (1920), (for mail), Chas. E. Monday Co., 1320 Olive St., Philadelphia, Pa., and 15 N. Chelsea Ave., Atlantic City, N. J.

MONIN, E. H., (1923), E. H. Monin, Inc., 70 Delaware Ave., Buffalo, N. Y.

MONROE, Lewis O., (Junior 1917; Associate 1925), Gen. Mgr., (for mail), Clarage Fan Co., and 2415 S. Westnedge St., Kalamazoo, Mich.

MONTAGNA, C. J., (1924), Owner, (for mail), 2913 Colonial Ave., and 1215 DeBree Ave., Norfolk, Va.

MONTGOMERY, W. Ray, (Associate 1923), Secy. and Treas., Montgomery Bros., 500 N. Dearborn St., Chicago, Ill.

MOON, L. Walter, (1915), Engr., (for mail), Bradley Htg. Co., 3834 Olive St., and 6069 Cates Ave., St. Louis, Mo.

MOORE, H. Lee, (1919), Pittsburgh Mgr., Buffalo Forge Co., Union Trust Bldg., Pittsburgh, and 7065 Flaccus Rd., Ben Avon, Pa.

MOORE, Herbert S., (Associate 1923), Sales Mgr., The Atlas Engrg. & Mach. Co., Ltd., 23 River St., and 107 Clendenan Ave., Toronto, Ont., Can.

MOORE, Raymond Francis, (Associate 1926), Architect, Cedar Rapids, Ia.

MORAN, Frank E., (1922), Pres., (for mail), Ben Rigby, Inc., 2652 Elston Ave., Chicago, and 3034 S. Maple Ave., Berwyn, Ill.

MORAN, F. N., (1916), 128 W. Main St., Staunton, Va.

MORAN, Roger J., (1926), Prop., 1300 Jefferson Ave., Buffalo, N. Y.

MORGAN, C. Stanley, (Associate 1919), (for mail), 445 W. Larned St., and 14595 Harbord Rd., Detroit, Mich.

MORGAN, Francis H., (1912), Pres. and Treas., (for mail), J. F. Morgan & Son, Inc., 67 Blake St., and 194 Maple St., Lynn, Mass.

MORGAN, Glenn C., (1911), Vice-Pres. and Secy., (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., and 134 West 49th St., Minneapolis, Minn.

MORGAN, J. Scott, (Associate 1922), Mgr., (for mail), Morgan Bros., 7227 Tioga St., and 7031 Hamilton Ave., Pittsburgh, Pa.

MORGAN, Robert C., (1915), Chief Engr., (for mail), Stewart A. Jellett Co., Engrs., 1200 Locust St., and 314 W. Seymour St., Philadelphia, Pa.

MORRIS, C. Raymond, (1921), (for mail), 55 Lexington Ave., Passaic, and 381–20th Ave., Paterson, N. J.

MORROW, Charles F., (Associate 1919), Mgr., (for mail), National Radiator Co., 1509 Arrett Bldg., Wood and Fourth Ave., Pittsburgh, and Wampum, Pa.

MORSE, C. T., (1921), Sales Mgr., American Blower Co., 6004 Russell St., Detroit, Mich.

MOSHER, Clarence H., (Associate 1919), Dist. Sales Agent, American Schaeffer & Budenberg Corp., 338 Berry St., Brooklyn, and (for mail), 423 Ashland Ave., Buffalo, N. Y.

MOSHER, Roy Bradford, (Associate 1927), Mgr., N.W. Office, (for mail), Modine Mfg. Co., 354 Baker Bldg., and 3236 Irving Ave., S., Minneapolis, Minn.

MOSS, Edward, (1920), Supervisor, Plbg. and Htg., (for mail), New York Rapid Transit Corp., 1130 Atlantic Ave., Brooklyn, and 9053–204th St., Hollis, L. I., N. Y.

MOTEJL, J. A., (1917), Secy., (for mail), Board of Education, 705 First Ave., and 220–16th Ave., Cedar Rapids, Ia.

MOTT, Abram C., Jr., (1921), Pres., (for mail), Abram Cox Co., American and Dauphin Sts., Philadelphia, and "The Woods," Lansdale, Pa.

MOUAT, Thomas G., (1914), Pres., (for mail), The Mouat Vapor Htg. Co., 1246 W. Fourth St., and 360 East 105th St., Cleveland, O.

MOULDER, Albert W., (1917), Chief Engr., (for mail), Grinnell Co., Inc., Dana and Paige Ave., and 74 Roosevelt Ave., Warren, O.

MOULTON, David, (1926), Mech. Engr., (for mail), Monks & Johnson, 99 Chauncy St., and 30 Meridian St., Malden, Mass.

MOWER, William P., (1924), Htg. Engr., (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and 48 Middlesex Ave., Swampscott, Mass.

MOYNIHAN, John C., (Junior 1925; Associate 1926), 136 Myrtle St., Indian Orchard, Mass.

MUELLER, Paul E., (1919), Pres., (for mail), The Paul E. Mueller Co., 320 Park St., and 924 Summit Ave., Milwaukee, Wis.

MUIR, George A., (1917), Engr., Muir & Brooks, 136 W. Lake St., Chicago, and (for mail), 234 S. Scoville Ave., Oak Park, Ill.

MUNDER, J. F., Jr., (Junior 1924; 1927), Mgr., Trade. Div., (for mail), American Blower Co., 50 Church St., and 1738 University Ave., New York, N. Y.

MUNIER, Leon L., (Junior 1915; 1919), Secy. and Treas., (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and 610 Lafayette Ave., Mt. Vernon, N. Y.

MUNRO, Edward A., (1920), Htg. and Vtg. Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, and 118-66 Farmers Ave., St. Albans, N. Y.

MUNROE, Edward K., (1904), Engr. Salesman, Republic Boiler & Radiator Co., Union St., and 5924 Bellona Ave., Baltimore, Md.

MUNSON, Morris G., (1925), Sales Repr., Herman Nelson Corp., (for mail), 501 Essex Bldg., and 2811 Dean Blvd., Minneapolis, Minn.

MURPHY, Edward T.,* (1915), Vice-Pres. and Gen. Sales Mgr., (for mail), Carrier Engrg. Corp., 2021 Land Title Bldg., and 4621 Osage Ave., Philadelphia, Pa.

MURPHY, Howard C., (1923), Vice-Pres., (for mail), Reed Air Filter Co., Inc., 215 Central Ave., and 2114 Edgehill Rd., *Louisville, Ky.*

MURPHY, Joseph Richard, (Associate 1925), Asst. to Pres., Thermal Appliance Co., Inc., 342 Madison Ave., New York, and (for mail), Kew Beverly B-2, Kew Gardens, L. I., N. Y.

MURPHY, William A., (1926), Sales Engr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 310 N. Third St., Harrisburg, Pa.

MURPHY, William R., (1911), Pres. and Treas., *American Htg. & Vtg. Co.*, 804 Times Dispatch Bldg., Richmond, Va., Vice-Pres. and Treas., American Htg. & Vtg. Co., 1505 Race St., Philadelphia, and 226 Valley Rd., Merion Sta., Pa.

MURRAY, Thomas F., (1923), Engr., State Architect, and 300 Washington Ave., Albany, N. Y.

MUSAUS, John, Jr., (1923), Steam Htg. Contractor, (for mail), John Musaus Sons, 5912 New Utrecht Ave., and 1108–85th St., Brooklyn, N. Y.

MUTH, Herbert, (1912), Pres. and Treas., (for mail), Muth Htg. & Engrg. Co., 4338 N. Western Ave., and 4117 Greenview Ave., Chicago, Ill.

MYERS, David R., (1923), Mgr., (for mail), Merion, Pa., and 5629–32nd St. N.W., Washington, D. C.

MYERS, George W. F., (Junior 1923), Designing and Sales Engr., (for mail), 730 Wynnewood Rd., Ardmore, and 2233 South 15th St., Philadelphia, Pa.

MYRICK, James W. H., (1909), Vtg. Engr., Owner, (for mail), New England Air Conditioning Co., 53 Devonshire St., Boston, and 398 Columbia Rd., Dorchester, Mass.

N

NACEY, Harry M., (1908), Pres. and Gen. Mgr., (for mail), 927 S. State St., and 229 Lake Shore Drive, Chicago, Ill.

NADEN, Lester James, (Junior 1925), Sales Engr., 349 Southern Blvd., Albany, N. Y.

NAROWETZ, Louis L., Jr., (Associate 1912), Contracting, Secy., (for mail), Narowetz Htg. & Vtg. Co., 1711-1717 Maypole Ave., Chicago, and Park Ridge, Ill.

NASON, George Lewis, (Junior 1927), Dist. Htg. Engr., Socony Burner, 275 Pleasant St., Worcester, and (for mail), 31 N. Franklin St., Holbrook, Mass.

NATKIN, Benjamin, (Junior 1907; 1909), Pres., (for mail), Natkin Engrg. Co., 208 Mutual Bldg., and 3725 Tracy Ave., Kansas City, Mo.

NAYLOR, Ben C., (Associate 1922), Vice-Pres. and Sales Mgr., (for mail), Standard Asbestos Mfg. & Insulation Co., and 3204 Windsor Ave., Kansas City, Mo.

NEALE, Laurance I., (Associate 1927), Sales Mgr., (for mail), Atlantic Gypsum Product Co., 40 Rector St., and 49 West 57th St., New York, N. Y.

NEILER, Samuel G., (1898), (for mail), Neiler, Rich & Co., Consulting & Designing Engineer, 431 S. Dearborn St., Chicago, and 737 N. Oak Park Ave., Oak Park, Ill.

NEITZEL, Carl W., (1921), Mgr., The C. W. Neitzel Co., 1327 East 105th St., Cleveland, and Belvoir Bldg., S. Euclid, O.

NELSON, Frank, Jr., (1923), Partner, (for mail), Frank Nelson & Son, 1826 Cherry St., and 6349 Greenway Ave., Philadelphia, Pa.

NELSON, George O., (1923), Carstens Bros., Ackley, Ia.

NELSON, Harold A., (1926), Supervising Engr., Nelson & Wylie, Sixth and Olive Sts., Los Angeles, and (for mail), 236 S. LaPere St., Beverly Hills, Calif.

NELSON, Herman W., (1909), Pres., (for mail), Herman Nelson Corp., 1824 Third Ave., and 2500–11th St., Moline, Ill.

NELSON, Ralph L., (Junior 1913; 1917), Engr. and Sales Repr., Ralph L. Nelson, 506 Empire State Bldg., and (for mail), N. 3823 Normandie, Spokane, Wash.

NESBIT, David M.,* (1895), (Board of Governors 1900), Chairman, Ashwell & Nesbit, Ltd., Ashwell Lodge, Barkby Lane, Leicester, Eng.

NESBITT, Albert J.,* (1921), Secy. and Treas., (for mail), John J. Nesbit, Inc., State Rd. and Rhawn St., Holmesburg Junction, Philadelphia, and Jenkintown-Manor, Pa.

NESBITT, John J., (1923), Pres., (for mail), J. J. Nesbitt, Inc., State Rd. and Rhawn St., Holmesburg Junction, Philadelphia, and Rockfield Farm, Ambler, Pa.

NESDAHL, Ellert, (1915), Sales Engr., Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, Ill.

NEWCOMB, Raymond, (Junior 1924), New England Mgr., Kewanee Boiler Co., Inc., 1140 Little Bldg., Boston, and (for mail), 15 Walnut St., Newtonville, Mass.

NEWPORT, Charles F.,* (1906), Sales Engr., Weil-McLain Co., Michigan City, Ind., and (for mail), 10001 Longwood Drive, Chicago, Ill.

NICELY, John Eyster, (Associate 1925), Sales Mgr., Corbit Bros. Plbg. & Htg. Co., 147-151 N. Fifth St., and (for mail), 1208 Marion St., Reading, Pa.

NICHOLLS, Percy,* (1920), Supervising Engr., Fuel Section, (for mail), U. S. Bureau of Mines, and 273 N. Craig St., Pittsburgh, Pa.

NICHOLS, George B., (1915), (Council 1919-1920), Engr., Hegerman & Harris, Tribune Tower, Chicago, Ill., and (for mail), 5 Alden Ave., Colonial Heights, Tuckahoe, N. Y.

NICOL, Norman C., (1923), Field Engr., C. H. Station, P. O. Box 542, New York, N. Y.

NIESTRATH, W. H., (Associate 1921), Jas. P. Marsh & Co., 3324 S. Jefferson Ave., St. Louis, Mo.

NILSON, Andrew, (1917), Pres., Eureka Smokeless Furnace Co., 3222 N. Halsted St., and (for mail), 5407 Wayne Ave., Chicago, Ill.

NILSON, Karl A., (Junior 1926), Engr. and Salesman, Nilson Bros., 3222 N. Halsted St., and (for mail), 1463 Summerdale Ave., Chicago, Ill.

NOBBS, Walter W., (1919), 50 Fairhazel Gardens, London, N.W., 6, Eng.

NOBIS, Harry M., (1914), Htg. Engr., 1827 Stanwood Rd., E. Cleveland, O.

NOBLE, Milner, (Junior 1924), (for mail), Aerofin Corp., 750 Frelinghuysen Ave., and 80 Broad St., Newark, N. J.

NOLAND, Lloyd U., (1915), Pres., (for mail), Virginia Engrg. Co., 322-330–28th St., and 319 54th St., Newport News, Va.

NOLAND, Ralph W., (1914), Consulting and Mech. Engr., 824 Lafayette Life Bldg., and 1001 Roberts St., Lafayette, Ind.

NOLL, William F., (1924), The Paul E. Mueller Co., 320 Park St., and (for mail), 1188–48th St., Milwaukee, Wis.

NORDINE, Louis F., (1914), Sales Engr., Herman Nelson Corp., and (for mail), 1170–25th St., Moline, Ill.

NORMAN, Mehrold A., (1926), Htg. Engr., Warren Webster & Co., Rm. 506, 549 W. Washington St., Chicago, Ill.

NORRIS, Edward, (1909), Utica Heater Co., Utica, N. Y.

NORRIS, James K., (1920), Vice-Pres., (for mail), Utica Heater Co., and 1 Jewett Place, Utica, N. Y.

NORTON, Frederick W., (Junior 1922; Associate 1925), Engr., Gillis & Geoghegan, 537 W. Broadway, New York, and (for mail), 47 Rokeby Place, Livingston, S. I., N. Y.

NULSEN, Carl A., (1919), Mfg. Htg. Dept., (for mail), Hanley & Co., 6 N. Clark St., and 931 Ainslie St., Chicago, Ill.

NUSBAUM, Lee.,* (1915), Owner, (for mail), Penna. Engrg. Co., 1119 N. Howard St., and 315 Carpenter Lane, Philadelphia, Pa.

O

OAKS, Orlon O., (1917), Chief Engr., N. Y. Div., (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 13 Russell Place, Summit, N. J.

OBERT, Casin W., (1916), (Secy. 1916-1923), Secy. to A. S. M. E. Boiler Code Committee, 29 West 39th St., New York, and (for mail), 122 N. Columbus Ave., Mt. Vernon, N. Y.

O'BRIEN, J. H., (1923), Chicago Dist. Mgr., (for mail), American Blower Co., 140 S. Dearborn St., and 6525 Glenwood Ave., Chicago, Ill.

O'CONNELL, Edward D., (Associate 1925), Htg. Engr., Robt. Scott, Inc., 1512 Vine St., and (for mail), 1432 North 53rd St., Philadelphia, Pa.

O'CONNELL, Presly M., (1916), Repr., Hoffman Specialty Co., and (for mail), 5749–31st Ave., N.E., Seattle, Wash.

O'CONNOR, Joseph M., (1923), C. A. Dunham Co., 302 Orpheum Bldg., and (for mail), 421 Sedgwick Bldg., Wichita, Kans.

O'DONNELL, Thomas J., (1920), Secy. and Treas., (for mail), William H. McKiever, Inc., 247 West 13th St., and 31 Park Terrace West, New York, N. Y.

ODROBINA, Stephen Robert, (1927), Engr., Richardson & Boynton, 260 Fifth Ave., New York, and (for mail), 289 Fifth Ave., Long Island City, N. Y.

OFFNER, Alfred J., (1922), Consulting Engr., (for mail), 1182 Broadway, New York, and Beechhurst, L. I., N. Y.

OGELSBY, William P., (1923), Sales Mgr., Oil City Boiler Works, 1043 Real Estate Trust Bldg., Philadelphia, Pa.

OHMES, Arthur K.,* (1913), (Council 1915; 2nd Vice-Pres. 1916; 1st Vice-Pres. 1917), Consulting Engr., 101 Park Ave., New York, N. Y.

OLSEN, A. J., (Junior 1924), 1107 Park St., Jacksonville, Fla.

OLSEN, Carlton F., (Junior 1920; Associate 1925), Combustion Engr., Kewanee Boiler Co., 822 W. Washington, and (for mail), 6238 Evans Ave., Chicago, Ill.

OLSON, Arvid E., (1925), Engr., Board of Education, 1009 Milton St., and (for mail), 3133 N. Keating Ave., Chicago, Ill.

OLSON, Robert G., (1923), Milwaukee Mgr., (for mail), American Blower Co., 911 Majestic Bldg., and 245 Prospect Ave., Milwaukee, Wis.

OLVANY, William J., (1912), Engr. and Contractor, 100 Charles St., New York, N. Y.

O'NEILL, James Walter, (Junior 1925), Chief Engr., The Trane Co., 21-23 River St., and (for mail), 207 McRobert Ave., Toronto, Ont., Can.

O'NEILL, Peter, (1920), Treas. and Mgr., Bartley-O'Neill Co., 224 Third Ave., Pittsburgh, Pa.

ORR, Fred B., (1924), Asst. to Vice-Pres., (for mail), Illinois Maintenance Co., 72 W. Adams St., and 457 Fullerton Parkway, Chicago, Ill.

ORR, Merrill J., (1917) Pres., and Mgr., (for mail), Orr Co., 513 Jackson St., and 1815 Jackson St., Sioux City, Ia.

ORTH, John W., (1919), Pres., Orth Plbg. Co., 509 Columbia St., Lafayette, Ind.

OSBORNE, Gurdon H., (1922), Gen. Mgr., (for mail), The Vtg. & Blow Pipe Co., Ltd., 144 Inspector St., and 275 Addington St., Apt. No. 7, Montreal, Que., Can.

OSBORNE, Maurice M., (1925), Advertising Counsel for Technical Products, Osborne & Co., 755 Boylston St., and (for mail), 367 Beacon St., Boston, Mass.

OSMON, Thomas R., (1916), Htg. and Vtg. Engr., *Spohn Htg. & Vtg. Co.*, 1775 East 45th St., and (for mail), 851 Paxton Rd., Cleveland, O.

OSTRANDER, Lewis F., (1923), Vice-Pres. and Htg. Engr., O-E Specialty Mfg. Co., 8-12 Keefe Ave., and (for mail), 701 Lake St., Milwaukee, Wis.

OSWALD, Walter L., (1919), Sales Engr., Crane Co., 23 West 44th St., New York, and (for mail), 562 Hutchinson Blvd., Mt. Vernon, N. Y.

OTIS, Gerald E., (1922), Vice-Pres., (for mail), The Herman Nelson Corp., and 1921 23rd Ave., Moline, Ill.

OTT, Oran W., (1925), Consulting Mech. Engr., (for mail), 13004 Washington Bldg., and 123 S. Virgil Ave., Los Angeles, Calif.

OTTO, Robert W., (1912), Chief Engr., Andrews Heating Co., 2529 University Ave., S.E., Minneapolis, and (for mail), 2147 Carroll Ave., St. Paul, Minn.

P

PADGINTON, George, (1919), Supt. of Htg. and Plbg., Board of Education, 1409 Genessee Bldg., and (for mail), 73 Huntington Ave., Buffalo, N. Y.

PAETZ, Herbert E., (1922), Sales Engr., (for mail), American Blower Co., 2539 Woodward Ave., and 2506 Cadillac Ave., Detroit, Mich.

PAGE, Harry W., (1923), 119 Warren Ave., Wauwatosa, Wis.

PAGE, Sidney H., (1923), Co-partner, Page & Hooker Co., 707 Torrey Bldg., and (for mail), 5407 London Rd., Duluth, Minn.

PAINE, Kenneth A., (Junior 1925), Mgr., Paine Heating Co., 217 S. State St., and (for mail), P. O. Box, 13, Jackson, Miss.

PAINE, Leonard G., (1920), Philadelphia Mgr., (for mail), Dunham Vacuum Heating System, 112 South 16th St., and 5915 Carpenter St., Philadelphia, Pa.

PAINTER, David H., (Associate 1924), Salesman, Hoffman Specialty Co., and (for mail), 3124 Forest Ave., Sioux Apts., Kansas City, Mo.

PALMER, Geo. J., (1923), (for mail), 14-16 W. Market St., and 419 Walnut St., W. Chester, Pa.

PARKER, Philip, (1915), Engrg. Dept., Braman Dow & Co., 239 Causeway St., Boston, and (for mail), 8 Middle St., Woburn, Mass.

PARKHILL, David, (1915), Supt., (for mail), The Graff Furnace Co., 116 Wooster St., New York, and 197 Rutland Rd., Brooklyn, N. Y.

PARKS, Vernon H., (1918), Mgr., Meyer Furnace & Supply Co., 1051 St. Louis, and (for mail), 4321 Charlotte St., Kansas City, Mo.

PARKS, William N., (Associate 1927), Mgr., Minnesota Br., (for mail), U. S. Radiator Corp., 688 Hampden Ave., St. Paul, and 3436 Pillsbury Ave., Minneapolis, Minn.

PARROTT, Lyle G., (1922), Consulting Engr., McColl, Snyder & McLean, 2348 Penobscot Bldg., and (for mail), 3788 Gladstone Ave., Detroit, Mich.

PARTER, Samuel C., (Junior 1907; 1909), Secy., James H. Merritt & Co., Inc., 207 Water St., and (for mail), 642 West 172nd St., New York, N. Y.

PARTLAN, James W., (1916), (for mail), 13900 Goddard Ave., and 478 Algonquin Ave., Detroit, Mich.

PASK, Raymond J., (Junior 1924), Consulting Engr., Crytser & Pask, Tribune Tower, and (for mail), 14 S. Homan Ave., Chicago, Ill.

PATERSON, G. E., (1926), Owner, (for mail), Paterson Htg. Co., 28 Waugoo St., and 511 *Main St., Oshkosh, Wis.*

PATERSON, James S., (1922), Htg. Engr., (for mail), Board of Education, 155 College St., and 23 Norton Ave., Toronto, Ont., Can.

PATORNO, Sullivan A. S., (1923), Htg. and Vtg. Engr., (for mail), Meyer, Strong & Jones, Inc., 101 Park Ave., and 150 East 50th St., New York, N. Y.

PATTERSON, D. Finley, (Junior 1925), Engr., Vapor Htg. Co., (for mail), 215 South 17th St., and 6428 N. Woodstock St., Philadelphia, Pa.

PATTON, Roy Lee, (1927), Treas. and Sales Mgr., (for mail), Federal Steam Specialty Co., 120 E. Main St., and 1111 West 38th St., Oklahoma City, Okla.

PAULDING, Lewis Grant, (1926), Treas., (for mail), Frank Paulding & Son, 405 Lexington Ave., New York, and 8630 123rd St., Richmond Hill, N. Y.

PAULSEN, Carl Emil, (Associate 1926), Archt. Engr., (for mail), Mann & Co., 722 Rorabaugh-Wiley Bldg., and 511 N. Poplar, Hutchinson, Kan.

PEACOCK, James K., (1921), New York Mgr., (for mail), Hoffman Specialty Co., 512 Fifth Ave., New York, and 440 Fowler Ave., Pelham Manor, N. Y.

PEAK, Alexander M., (Junior 1927), Sales Engr., 629 Chestnut St., and (for mail), 5802 N. Fifth St., Philadelphia, Pa.

PEARCE, C. E., (1911), Chief Engr., Guilbert & Betelle, Architects, Chamber of Commerce Bldg., Newark, and (for mail), 1255 Clinton Place, Elizabeth, N. J.

PEARSON, Fred L., (1925), Consulting Engr., (for mail), 6 N. Michigan Ave., and 7702 Eastlake Terrace, Chicago, Ill.

PEARSON, Harry D., (1917), Pres. and Mgr., (for mail), Michigan Warming & Vtg. Co., 363 Houseman Bldg., and 700 College St., S.E., Grand Rapids, Mich.

PEASE, Harrison H., (Associate 1922), Commercial Trust Bldg., and (for mail), 8409 Shawnee St., Chestnut Hill, Philadelphia, Pa.

PEASE, John G., (1917), Owner, John G. Pease Co., 310 Minor Bldg., and 1718 East 59th St., Kansas City, Mo.

PECKHAM, Randolph R., (1919), Supt., (for mail), 650 W. Baltimore Ave., Detroit, Mich.

PEEBLES, John K., (Junior 1924; Associate 1925), Peebles & Ferguson, 733 Law Bldg., Norfolk, Va.

PENCE, Millard Davis, (Junior 1927), Htg. Engr., C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.

PENHALLEGON, R. L., (1925), Mgr., Burnham Boiler Corp. of Calif., 1385 Harrison St., San Francisco, Calif.

PENNELL, S. Howard, (1925), Member of Firm, (for mail), William Macy Stanton, Archt., Land Title Bldg., Philadelphia, Pa.

PENSINGER, Luther C., (Associate 1925), Partner, Burdick Pensinger Co., 3409 East 18th St., and 19 West 42nd St., Kansas City, Mo.

PERHAM, Stanley H., (1920), Associate Engr., (for mail), Charles R. Ammerman, Consulting Engr., 925 Continental Bk. Bldg., and 4507 Carrollton Ave., Indianapolis, Ind.

PERKINS, Fred C., (Associate 1923), Perkins-LeNoir Co., 1068 Drexel Bldg., Philadelphia, Pa.

PETERKIN, Stuart MacC., (1922), Engr., C. A. Dunham Co., 229 College St., and (for mail), 71 Deloraine Ave., Toronto, Ont., Can.

PETERMAN, Robert M., (1917), Engr., School Dist., of Philadelphia, 19th St., above Chestnut St., Philadelphia, and (for mail), 205 Lauriston St., Wissahickon, Pa.

PETERS, Harry G., (Associate 1924), Prop., (for mail), Peters Htg. Co., P. O. Box 763, and 638 N. Congress St., Jackson, Miss.

PETERSEN, Gustave, (Associate 1916), Treas. and Mgr., (for mail), Htg. and Vtg. Magazine, 1123 Broadway, New York, N. Y., and 216 11th St., Hoboken, N. J.

PETHERICK, David H., (Associate 1916), Salesman, U. S. Radiator Corp., 517 Dime Bk. Bldg., Detroit, and (for mail), 9 Kenberton Drive, Pleasant Ridge, Mich.

PFEIFFER, Benjamin J., (Junior 1925), Htg. Contractor, 435 West 41st St., and (for mail), 30 West 112th St., New York, N. Y.

PFEIFFER, John Frederick, (Junior 1925), Mech. and Htg. Engr., (for mail), Spencer Heater Co., and 346 Louisa St., Williamsport, Pa.

PFUHLER, John L., (Junior 1923; Associate 1925), Plbg. and Htg., 600 Manor Rd., Staten Island, N. Y.

PHELPS, Harold Roy, (Junior 1927), Sales Engr., American Blower Co., 409 First Natl. Bk., and (for mail), 2105 Fainam St., Davenport, Iowa.

PHILLIPS, Frank T., (1919), Sales Engr., (for mail), American Radiator Co., 25th and Reed Sts., Philadelphia, Pa., and 827 Belmont Ave., Collingswood, N. J.

PHILLIPS, Frederic W., Jr., (1921), Engr., (for mail), E. W. Mandeville, Inc., 623 Parkside Ave., and 825 East 38th St., Brooklyn, N. Y.

PHILLIPS, Lee, (1920), Htg. Engr., 308 Ferguson Bldg., 319 Third Ave., Pittsburgh, and Terrace Ave., Carnegie, Pa.

PICKER, Frederick C., (Associate 1926), Pres., The Air Conditioning & Engrg. Co., 2914 S. Jefferson Ave., and 4568 Tower Grove Place, St. Louis, Mo.

PICKETT, Clinton A., (Associate 1923), Sales Repr., (for mail), Herman Nelson Corp., 510 Rialto Bldg., St. Louis, and 7300 Melrose Ave., University City, Mo.

PIERCE, Edward F., Jr., (Junior 1925), Sales Engr., Hoffman Specialty Co., 72 Lynn Fells Parkway, Melrose, Mass.

PINDER, Percy H., (1919), (for mail), Standard Steam Specialty Co., 366 Third Ave., New York, N. Y., and 12 Forest Rd., Ridgewood, N. J.

PINES, Sidney, (1920), Asst. Mgr., (for mail), Natkin Engineering Co., 208 Mutual Bldg., and 5012 Forest Ave., Kansas City, Mo.

PIPER, Albert, (1920), Plbg. and Htg. Contracting, (for mail), Piper Bros., 340-346 N. Broad St., Trenton, N. J.

PISEL, Joseph W., (Junior 1921; Associate 1926), Engr., I. H. Francis, Consulting Engr., 1520 Locust St., Philadelphia, and (for mail), 53 Brookline Blvd., Upper Darby P. O., Pa.

PITCHER, Lester J., (Junior 1924), Chief Draftsman, Illinois Engrg. Co., 21st and Racine Ave., and (for mail), 7214 E. End Ave., Chicago, Ill.

PITTELKOW, Arthur G., (1907), Pres., Pittelkow Htg. & Engrg. Co., (for mail), 2340 W. Lafayette Blvd., and 355 Chalmers Ave., Detroit, Mich.

PIZIE, Stuart G., (Associate 1926), Partner, B. J. Pizie & Son, Millbrook, N. Y.

PLACE, Clyde R., (1924), Consulting Engr., (for mail), Grand Central Terminal, and 53 East 66th St., New York, N. Y.

PLACE, Herman R., (1924), Vice-Pres., Sprague, Bates, Place Co., 28 Union St., Boston, and (for mail), 835 Watertown St., W. Newton, Mass.

PLAYFAIR, George A., (Associate 1924), Mgr., (for mail), Johnson Temperature Regulating Co., 147 Church St., and 6 Kingsmere Rd., Toronto, Ont, Can.

PLEWES, Stanley E., (1917), Philadelphia Mgr., (for mail), Johnson Service Co., 258 S. Van Pelt St., Philadelphia, and Evergreen Rd., Jenkintown, Pa.

PLUNKETT, John H., (1925), Chief of Inspections, Dept. of Public Safety, Bldg. and Boiler Inspection, Rm. 24, State House, Boston, and (for mail), 81 Woodrow Ave., Dorchester, Mass.

POLDERMAN, Lambert H., (1927), Br. Mgr., Carrier Engrg. Corp., 911 Mateo St., Los Angeles, and 1330 Colorado Blvd., Eagle Rock, Calif.

POOL, Sterling H., (1913), Pres., (for mail), Howard F. Pool Co., 22 Market St., Lynn, and 39 Pinckney St., Boston, Mass.

POOLE, Ernest F., (1921), Engr., (for mail), F. P. Sheldon & Son, 1009 Hospital Trust Bldg., and 74 Farragut Ave., Providence, R. I.

POPE, S. Austin, (1917), Contracting Engr., (for mail), 26 N. Jefferson St., Chicago and 410 Ashland Ave., River Forest, Ill.

POPE, William A., (1906), Contracting Engr., 26 N. Jefferson St., Chicago, and 293 Keystone Ave., River Forest, Ill.

PORTRUDE, William M., (Junior 1926), Dept. Head, Andersen Meyer & Co., and 1458 Ave. Joffre, Shanghai, China.

POSEY, James, (1919), Consulting Engr., (for mail), 201 W. Franklin St., and 4005 Liberty Heights Ave., Baltimore, Md.

POTTINGER, C. T., (1917), Dist. Mgr., American Blower Co., 614-615 Bona Allen Bldg., Atlanta, Ga.

POWERS, Fred I., (1920), Salesman, P. O. Box 324, Bozeman, Mont.

POWERS, Fred W., (1911), (Council 1918-1919), Treas. and Gen. Mgr., (for mail), The Powers Regulator Co., 2720 Greenview Ave., and 900 Castlewood Terrace, Chicago, Ill.

PRATT, Edwin D., (1922), Asst. to Gen. Mgr., Childs Restaurants, 200 Fifth Ave., New York, and (for mail), 283 Glen Ave., Port Chester, N. Y.

PREBLE, J. Jarvis, (1919), Vice-Pres., (for mail), Spray Engrg. Co., 60 High St., Boston, and 38 Bowdoin St., Newton Highlands, Mass.

PRENTICE, Oliver J., (Associate 1927), Publicity Mgr., (for mail), C. A. Dunham Co., 450 E. Ohio St., and Allerton Club, 701 N. Michigan Ave., Chicago, Ill.

PRESDEE, Cliff W., (Associate 1926), Western Mgr., (for mail), Htg. & Vtg. Magazine, 105 S. Dearborn St., and 7909 Eberhard Ave., Chicago, Ill.

PRICE, Frank E., (Associate 1922), Mgr. Htg. Dept., Standard Sanitary Mfg. Co., 1720 Blake St., and (for mail), 1544 Jasmine St., Denver, Colo.

PRICE, William Henry, Jr., (1927), Mgr. New England Office Territory, York Htg. & Vtg. Corp., 46 Cornhill, Rm. 508, Boston, Mass.

PROBST, Alfred H., (1919), Sales Engr., (for mail), Morgan-Gerrish Co., 808 LaSalle Ave., and 2902 James Ave., S., Minneapolis, Minn.

PROX, Robert F., (Junior 1922; 1923), Vice-Pres., (for mail), Frank Prox Co., P. O. Box 61, and 1608 S. Fourth St., Terre Haute, Ind.

PRYOR, Frederick L., (1913), Advisory, (for mail), National Silk Dyeing Co., 5 Colt St., Paterson, and Towaco, Morris Co., N. J.

PRYOR, Robert W., Jr.,* (1913), (Council 1919-1920), Mech. Engr., (for mail), Koithan & Pryor, 39 Cortlandt St., New York, N. Y., and 199 Roseville Ave., Newark, N. J.

PURCELL, Arthur J., (1914), Htg., Plbg. and Steam Specialty Engr., 631 New Britain Ave., Hartford, Conn.

PURCELL, Frederick C., (1926), Mgr., (for mail), National Regulator Co., and F. C. Purcell & Co., 2847 Grand River Ave., and 2025 Palmer Park Blvd., Detroit, Mich.

PURCELL, Robert E., (1916), Htg., Vtg. and Plbg. Contractor, 1735 Willis Ave., W., and (for mail), 128 Avery Ave., Detroit, Mich.

PURDY, Alexander K., (1922), Pres., (for mail), Purdy, Mansell, Ltd., 63 Albert St., and 30 Glenrose Ave., Toronto, Ont., Can.

PURINTON, Dexter J., (Associate 1923), Head of Mech. Dept., (for mail), McKenzie, Voorhees & Gauline, 342 Madison Ave., New York, N. Y., and 23 Sachem Rd., Greenwich, Conn.

PURSELL, H. E., (1919), Br. Mgr., Kewanee Boiler Co., 1226-28 California St., Denver, and (for mail), 212 S. Tremont St., Kewanee, Ill.

PYLE, John W., (1919), Supt., (for mail), Peru Htg. Co., 30 W. Canal St., and 371 W. Third St., Peru, Ind.

Q

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QUENTIN, Edward H., (Associate 1919), Mgr., (for mail), Johnson Heat Regulating Co., 2328 Locust St., and 3259 Geyer Ave., St. Louis, Mo.

QUESNEL, N. W., (1925), C. A. Dunham Co., Ltd., 14 Struchen Ave., and (for mail), 23 Carey Rd., Toronto, Can.

QUIGLEY, William J., (1920), Salesman, (for mail), Gurney Heater Mfg. Co., P. O. Box 184, Buffalo, and 27 Knowlton Ave., Kenmore, N. Y.

QUIRK, Clinton H., (Junior 1915; 1916), Sales Engr., Vtg. Div., (for mail), American Radiator Co., 40 West 40th St., New York, and 36 Kilburn Rd., Garden City, N. Y.

R

RAE, Thos. W., (1924), Salesman, (for mail), American Radiator Co., P. O. Box 882, and James Hotel, Oklahoma City, Okla.

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RAINGER, Wallace F., (Junior 1924), Chief Draftsman, Jaros & Baum, Consulting Engrs., 116 West 39th St., New York, and (for mail), 68 Livingston Ave., Yonkers, N. Y.

RAISLER, Louis, (1925), Raisler Htg. Co., 129 Amsterdam Ave., New York, N. Y.

RAISLER, Samuel, (1921), Pres., Raisler Htg. & Sprinkler Co., 129 Amsterdam Ave., and (for mail), 173 Riverside Drive, New York, N. Y.

RALSTON, Louis T. M., (1926), Consulting Engr., (for mail), Ralston & Hattenhof, Inc., 52 Vanderbilt Ave., and 875 W. End Ave., New York, N. Y.

RANDOLPH, Charles H., (Junior 1926), Sales Engr., American Foundry & Furnace Co., Rm. 400, 15 Michigan St., and (for mail), 567 Stowell Ave., Milwaukee, Wis.

RASMUSSEN, Einar, (Junior 1925; Associate 1926), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 414 Whitney Ave., Wilkinsburg, Pa.

RATHER, Max F., (1919), Cleveland Mgr., Johnson Service Co., 2028 East 22nd St., Cleveland, and 3098 Huntington Rd., Shaker Heights, O.

REARDON, J. Albert, (1921), Pres., (for mail), Reardon Bros. Co., 341 Union St., Lynn, and 18 Marion Rd., Clifton, Mass.

RECH, Philip Doerr, (Associate 1927), Sales Engr., Hoffman Specialty Co., Inc., 25 West 45th St., New York, N. Y., and (for mail), 240 E. Ninth St., Plainfield, N. J.

RECK, Anders B.,* (1899), Pres., (for mail), Reck Htg. Co., Ltd., 15, Esromgade, Copenhagen, and 16, Christiansvej, Hellerup, Denmark.

RECK, William Ernst, (1927), Vice-Pres., (for mail), The Reck Htg. Co., Ltd., 15 Esromgade, Copenhagen, and 16 Lundvej, Hellerup, Denmark.

REDERER, Benedict S., (1922), Mgr., (for mail), B. S. Rederer & Co., 513 Arrott Bldg., and 1515 Rockland Ave., Pittsburgh, Pa.

REED, John F., (Associate 1923), Vice-Pres., (for mail), Reed Air Filter Co., 50 Church St., New York, N. Y., and 63 Watchung Ave., Montclair, N. J.

REED, William M., (1927), Pres., (for mail), Reed Air Filter Co., 215 Central Ave., and 1422 Goddard Ave., Louisville, Ky.

REEDER, Charles L., (1911), Consulting Engr., (for mail), 916 N. Charles St., Baltimore, and 222 Longwood Rd., Roland Park, Md.

REEDER, Frank C., (Associate 1919), Factory Repr., The Fulton Co., and (for mail), 204 E. Oklahoma Ave., Knoxville, Tenn.

REESE, Henry L., (1923), Pres. and Gen. Mgr., (for mail), Keystone Plbg. & Htg. Co., 229 N. Sixth St., Reading, and Bernharts, Pa.

REEVES, Charles G., (1916), 257 W. Clapier St., Germantown, Philadelphia, Pa.

REICHWALD, Charles W., (1923), Htg. Engr., (for mail), C. W. Reichwald, Inc., 763 Paterson Ave., Jersey City, and 22 Adelina Place, North Bergen, N. J.

REID, Henry Probasco, (Associate 1927), Specialty Engr., (for mail), Universal Portland Cement Co., Rm. 1520, 210 S. LaSalle St., Chicago, and 3507 Oak Park Ave., Berwyn, Ill.
REPP, Harry L., (1922), Br. Mgr., U. S. Radiator Corp., 908 N. Senate Ave., and 525 S. Central Circuit, Indianapolis, Ind.
REUSS, Edward H., Jr., (Associate 1919; 1921) Htg. Contractor, (for mail), Edward H. Reuss, Jr., 30th and Race Sts., and Bryn Mawr and Woodbine Ave., Philadelphia, Pa.
REYNOLDS, Harry A., (1925), Engr., S. J. Reynolds Co., Inc., 2223 Ogden Ave., and 721 N. Lotus Ave., Chicago, Ill.
REYNOLDS, Henry M., (1915), Vice-Pres., General Boilers Co., Waukegan, Ill.
REYNOLDS, Thurlow W., (1922), Engr., Clyde R. Place, Consulting Engr., Grand Central Terminal, and 1657 Montgomery Ave., New York, N. Y.
RHODES, Solomon V., (1921), Supt. of Htg., (for mail), Farrell Htg. & Plumbing Co., 25 Houston St., and 45 E. Cain St., Atlanta, Ga.
RIBLET, William H., (Associate 1921), Eastern Div. Mgr., (for mail), C. A. Dunham Co., 101 Park, Ave., and 32 West 40th St., New York, N. Y.
RICE, Clarence J., (Associate 1923), Sales Mgr., (for mail), Modine Mfg. Co., and 729 Lake Ave., Racine, Wis.
RICE, William W., (1915), Contracting Engr., Mellon Co., 4417-19 Ludlow St., Philadelphia, and (for mail), 830 Morgan Ave., Upper Darby, Del. Co., Pa.
RICHARDS, Samuel F., (1915), Eastern Sales Repr., H. A. Thrush & Co., Peru, Ind., and (for mail), 335 W. Riverview Ave., Bellevue Br., Pittsburgh, Pa.
RICHARDSON, D. Rait,* (1915), Pres., (for mail), Richardson & Boynton Co., 260 Fifth Ave., and 299 Park Ave., New York, N. Y.
RICHTMANN, William Muir, (Junior 1926), Instructor in Steam and Gas Engrg., University of Wisconsin, Rm. 71B, Engrg. Bldg., and (for mail), 1709 Adams St., Madison, Wis.
RICKER, John J., (1925), Pres., (for mail), Ricker & Kneblin, Inc., 528-530 Jefferson St., 40–18th St., W. New York, N. J.
RICKLY, Francis Andrew, (Associate 1927), Mgr., St. Louis Br., (for mail), American Radiator Co., 4201 Duncan Ave., and 5616 Pershing Ave., St. Louis, Mo.
RIETZ, Elmer W., (1923), Asst. Sales Mgr., (for mail), Powers Regulator Co., 2720 Greenview Ave, Chicago, and 940 Glenwood Ave., Winnetka, Ill.
RILEY, Champlain L.,* (1906), (Presidential Member), (Pres. 1921; Council 1918-1922; 1st Vice-Pres. 1920), (for mail), Clark MacMullen & Riley, 101 Park Ave., New York, N. Y., and Plainfield, N. J.
RILEY, DeWitt H., (1921), Engr., Research Dept., American Radiator Co., 1807 Elmwood Ave., and (for mail), 815 Tonawanda St., Buffalo, N. Y.
RINKENBERGER, George, (1924), Sales and Htg. Engr., (for mail), Paul Plumbing & Htg. Co., 811 Railroad St., and 831 Franklin St., Johnstown, Pa.
RITCHIE, Edmund J., (1923), Gen. Sales Mgr., (for mail), 183 Madison Ave., New York, and 19 Grace St., Brooklyn, N. Y.
RITCHIE, William, (1909), 17 Van Reipen Ave., Jersey City, N. J.
RITTER, Arthur, (1911), N. Y. Mgr., (for mail), American Blower Co., 50 Church St., New York, and 589 Fourth St., Brooklyn, N. Y.
RIVARD, Melvin M., (Junior 1926), Sales Engr., American Radiator Co., and (for mail), 1324 East 38th St., Kansas City, Mo.
ROBB, John M.,* (1913), Htg. Engr., 1513 Columbia Terrace, Peoria, Ill.
ROBBINS, Loring G., (1907), Robbins, Gamwell & Co., 68 West St., Pittsfield, Mass.
ROBERTS, Henry L., (1916), Engr. and Contractor, 228 North 16th St., Philadelphia, Pa.
ROBERTS, J. H., (1926), c/o Mrs. E. C. Fell, Upper Lake St., (Carrier No. 19), Elmira, N. Y.
ROBERTSON, George A., (1902), Supervising Inspector Htg. and Vtg., Div., (for mail), Board of Education, Bureau of Plant Operation, 131 Livingston St., and 1081 East 39th St., Brooklyn, N. Y.
ROBERTSON, John M., (Junior 1926), Sales Engr., (for mail), E. K. Campbell Htg. Co., 6220 Delmar Blvd., and 7321 Zephyr Place, St. Louis, Mo.
ROBINSON, Albert G., (1924), (for mail), 4 Thomson Block, and 18 Harrison Ave., Glen Falls, N. Y.
ROCKART, Edward R., (1921), Mech. Engr., Minneapolis Board of Education, 245 Ninth Ave., N., Minneapolis, and (for mail), 1173 Arkright St., St. Paul, Minn.
RODMAN, Robert W., (1922), Supt. of Plant Operation, (for mail), Dept. of Education, 500 Park Ave., and 2102 Broadway, New York, N. Y.
ROEBUCK, William, Jr., (1917), Sales Engr., (for mail), The R. T. Coe Cos., 522 Cutler Bldg., and 1625 East Ave., Rochester, N. Y.
ROGERS, A. Carle, (1921), Consulting Engr., 752 Euclid Ave., Toledo, O.
ROLLINS, Fred D., (1919), 4107 Washington Blvd., Chicago, Ill.
ROLLINS, Lewis M., (1916), Morris & Co., Union Stock Yards, and (for mail), 218 N. Milton St., St. Paul, Minn.
RONEY, Thomas G., (1916), (for mail), T. G. Roney Htg. Co., 3461 Fort St., W., and 748 25th St., Detroit, Mich.
ROONEY, Martin A.,* (Associate 1917; 1918), Sales Engr., (for mail), American Radiator Co., 1807 Elmwood Ave., Buffalo, and Eggertsville, N. Y.
ROSEBROUGH, Robert M., (1920), Br. Mgr., (for mail), L. J. Mueller Furnace Co., 4249 Forest Park Blvd., and 5502 Maple Ave., St. Louis, Mo.
ROSENBACH, Rudolph G., (1920), Sales Engr., (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 343 N. York St., Elmhurst, Ill.
ROSS, John O., (1920), Pres., (for mail), J. O. Ross Engrg. Corp., 30 East 42nd St., and 875 W. End Ave., New York, N. Y.
ROSS, Joseph F., (1926), Secy. and Treas., (for mail), Ross Boiler Co., 112 W. Adams St., and c/o James A. Ross, 614 West 71st St., Chicago, Ill.
ROSSMAN, Vincent D., (1919), Secy., (for mail), Modern Htg. Co., 3935 Olive St., and 2365 Klemm St., St. Louis, Mo.
ROTHROCK, John T., (1920), Supt. Mech. Engr., Thompson-Starrett Co., Packard Bldg., Philadelphia, Pa.
ROTZ, John M., (1918), Member of firm, (for mail), Snider & Rotz, Consulting Engrs., 703 Merchants Bk. Bldg., and 3930 Broadway, Indianapolis, Ind.
ROWE, William A., (1921), Chief Engr., American Blower Co., 6004 Russell St., and 1733 Virginia Park, Detroit, Mich.
ROWLEY, Frank Benj.,* (1918), Prof. of Mech. Engrg. and Dir. of Experimental Engrg. Laboratories, University of Minnesota, and (for mail), 63 Barton Ave., S.E., Minneapolis, Minn.
RUCKEL, John B., (Associate 1919), Pres., (for mail), J. H. Ruckel & Son, 81-83 Main St., and 183 Cleveland Ave., Buffalo, N. Y.
RUDDELL, Wm. H., (1921), Mgr., (for mail), West Coast Htg. Co., Inc., 505 Lloyd Bldg., Sixth Ave., and Stewart St., and 319 Garfield St., Seattle, Wash.
RUFF, DeWitt C., (1922), Co-Partner, (for mail), Healy-Ruff Co., 765 Hampden Ave., and 2211 St. Clair St., St. Paul, Minn.
RUGART, Karl F. K., (Associate 1924), Sales Engr., (for mail), Warren Webster & Co., Camden, N. J., and 5830 Willows Ave., W. Philadelphia, Pa.

RUGGLES, Robert F., (Junior 1926), Asst. Sales Mgr., DeBothezat Impeller Co., 1922 Park Ave., New York, and (for mail), 15 Gregg Place, Randall Manor, Tompkinsville, S. I., N. Y.
RUPPERT, E. H., (Associate 1923), (for mail), Excelso Specialty Works, 85 Eastern Parkway, Brooklyn, and 210 East 45th St., New York, N. Y.
RUSSEL, Donald Peters, (1925), Htg. and Vtg. Engr., Thomas Haverty Co., 316 E. Eighth St., Los Angeles, and 451 Edwards Ave., Wilmar, Calif.
RUSSELL, Hugh C., (1911), Inspector, Mech. and Elec. Engr., Supervising Arch. Office, (for mail), U. S. Treasury Dept., Post Office Bldg., and 909 E. Tenth St., Chattanooga, Tenn.
RUSSELL, Joseph N., (1899), Mgr., Rosser & Russell, Ltd., 37 Duke St., Oxford St., London, W. 1., Eng.
RUSSELL, W. A., (1921), Asst. Gen. Sales Mgr., (for mail), U. S. Radiator Corp., 500 N. Dearborn St., Chicago, Ill., and 2484 Pingree, Detroit, Mich.
RUSSELL, William Arthur, (Charter Member), Pres., W. A. Russell & Co., Grand Central Terminal Bldg., 70 East 45th St., New York, and 563 Palisade Ave., Yonkers, N. Y.
RUSSELL, William L. A., (Associate 1925), St. Louis Sales Mgr., (for mail), Skinner Bros. Mfg. Co., 1474 S. Vandeventer St., and 5605 Etzel Ave., St. Louis, Mo.
RYAN, Harry J., (1922), Consulting Engr., 47 Harris Ave., Albany, N. Y.

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SABIN, Edward R., (1919), Pres., (for mail), Edward R. Sabin Co., Htg. Contractors., 4710-12 Market St., Philadelphia, and Lansdowne, Pa.
SACHLEBEN, Edward H., (Associate 1921), (for mail), E. H. Sachleben & Co., 2829 Locust St., and 5814 Maple Ave., St. Louis, Mo.
ST. CLAIR, Charles W., (Junior 1927), Sales Engr., 507 Ariel Bldg., Erie, Pa.
SAKOUTA, Mathieu L., (1924), Consulting Engr. Expert, Gavan, Simanskaia 4, Leningrad, Russia.
SAMUELS, Sidney, (Junior 1925), Secy., (for mail), Wholesale Htg. Supplies, 262 West 145th St., and 1673 University Ave., New York, N. Y.
SANBERN, E. Nute, (1923), Engr., (for mail), Mensing & Co., 928 Presser Bldg., Philadelphia, Pa., and 119 Haviland Ave., Audubon, N. J.
SANBORN, Stephen H., (Associate 1924), S. H. Sanborn Engrg. Co., 123 E. Main St., P. O. Box 289, Middletown, N. Y.
SANFORD, Arthur L., (1915), Mech. Engr., (for mail), Board of Education, 245 Ninth Ave., N., and 301 East 48th St., Minneapolis, Minn.
SAULSON, Saul, (1916), Mech. Engr., Albert Kahn, Inc., 1000 Marquette Bldg., and 2491 W. Euclid, Detroit, Mich.
SAUNDERS, J. Chester, (1926), Estimator and Engr., (for mail), Crosby & Beard Co., 163 W. Harrison St., and 10921 Oakley Ave., Chicago, Ill.
SAVILLE, Thos. H., (1924), (for mail), International Correspondence Schools, 2009 N. Wabash Ave., and 1121 Lafayette St., Scranton, Pa.
SAWADE, Carl A., (Associate 1920), Mgr. Boiler Sales, (for mail), Continental Heater Corp., Dunkirk, and 35 Curtis Place, Fredonia, N. Y.
SAWDON, Will M., (1920), Prof. Exper. Engrg., (for mail), Cornell Univ., and 1018 E. State St., Ithaca, N. Y.
SCANLON, John J., (Associate 1924), Ames Iron Works, 1035 Commercial Trust Bldg., and 30 South 54th St., Philadelphia, Pa.
SCHANK, George E., (Associate 1926), 155 16th St., Buffalo, N. Y.
SCHANZE, A. G., (Associate 1925), Frank A. Holby Corp. of Mass., 782 Commonwealth Ave., Boston, and (for mail), 30 Willoughby St., Brighton, Mass.
SCHEER, Frederick W., (1922), Htg. Contractor, (for mail), 131 Hartwell Rd., and 12 Brayton St., Buffalo, N. Y.
SCHEIBEL, Albert H., (1919), Designing Engr., Stone & Webster, 49 Federal St., Boston, and (for mail), 92 Milton Ave., Hyde Park, Mass.
SCHEIDECKER, Daniel B., (Associate 1919), Salesman, (for mail), Bayley Mfg. Co., Rm. 1156, 38 S. Dearborn St., and 4626 N. Kilbourn Ave., Chicago, Ill.
SCHELLHAMMER, Alfred L., (1919), Schellhammer & Co., Warren, Ill.
SCHILDMILLER, George H., (1922), Asst. Mgr., (for mail), American Radiator Co., 400 Barlum Bldg., Detroit, and 908 Yorkshire Rd., Birmingham, Mich.
SCHIMMEL, Frederick W., (1926), Htg. Sales Engr., Modern Utilities Co., 140-42 S. Second St., Harrisburg, and (for mail), New Cumberland, Pa.
SCHLEY, Arthur A., (1920), Mgr., Htg. Dept., Schley & Nash Co., 709 Columbia Bk. Bldg., Pittsburgh, Pa.
SCHLOSS, Newton L., (1913), (for mail), 51 East 42nd St., and 3647 Broadway, New York, N. Y.
SCHMIDT, George G., (Junior 1912; 1914), Gen. Eastern Repr., Carrier Engrg. Corp., 39 Cortlandt St., New York, and 67 Burn St., Forest Hills, Long Island, N. Y.
SCHNEIDER, Charles, (1923), C. Schneider Co., 492 East 163rd St., New York, N. Y.
SCHNEIDER, Paul W., (1919), 305 LaFayette St., Utica, N. Y.
SCHOENIJAHN, Robert P., (1919), Consulting Engr., (for mail), 406 Industrial Trust Bldg., and 7 Crawford Circle, Wilmington, Del.
SCHOEPFLIN, Paul H., (1920), Pres., (for mail), Niagara Blower Co., 673 Ontario (Ontario at N. Y. C. Tracks), and 155 Fordham Drive, Buffalo, N. Y.
SCHOPP, Walter J., (1922), Partner, (for mail), General Engrg. & Construction Co., 419 Perry Bldg., and 1704 Ludlow St., Philadelphia, Pa.
SCHRADER, C. C.,* (Junior 1923; Associate 1925), Research Engr., (for mail), Armstrong Cork Co., Argo Laboratory, Gloucester, N. J., and 4842 N. Fifth St., Philadelphia, Pa.
SCHROTH, August H., (1911), Vice-Pres., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 90 S. Oraton Parkway., E. Orange, N. J.
SCHULZ, Howard I., (Associate 1915), Mgr., Crane Co., 1217 W. Broad St., Richmond, Va.
SCHULZE, Ben. H., (1921), Sales Engr., (for mail), Hester-Bradley Co., 4200 Forest Park Blvd., and 1914 Forest Ave., St. Louis, Mo.
SCHWAB, Henry E., (1923), Vice-Pres., (for mail), R. J. Schwab & Sons Co., 283 Clinton St., and 266 Juneau Ave., Apt. 210, Milwaukee, Wis.
SCOLLAY, Ulysses G., (Charter Member), (Council 1894; Board of Managers 1895; Treas. 1904; 1911), Pres., J. A. Scollay, Inc., 76 Myrtle Ave., Brooklyn, N. Y.
SCOTT, Charles E., (1907), Pres. and Treas., (for mail), Vapor Engineering Co., 489 Fifth Ave., New York, N. Y., and West Ave., Darien, Conn.
SCOTT, Clarence Earl, (Junior 1926), Research Engr., (for mail), York Htg. & Vtg. Corp., Bridgeport, and 611 Sinede St., Norristown, Pa.
SCOTT, Edwin A., (1912), Pres. and Treas., (for mail), Edwin A. Scott Publishing Co., 45 West 45th St., and 3224 Grand Concourse, New York, N. Y.
SCOTT, George M., (1915), Child & Scott Co., 108 Wooster St., New York, N. Y.
SEELIG, Alfred E., (1926), Pres. and Gen. Mgr., L. J. Wing Mfg. Co., 352 West 13th St., and (for mail), 310 Convent Ave., New York, N. Y.
SEELIG, Lester, (1925), 2630 N. Spaulding Ave., Chicago, Ill.
SEIDERS, John T., (1926), Rm. 214, 83 S. High St., Columbus, O.
SEKIDO, Kunisuke, (1903), Nakano, Tokio Suburb, Japan.
SELIG, Ernest T., (1926), Member of Firm, (for mail), Selig & Wilson, 707 Telegraph Bldg., and 920 North 16th St., Harrisburg, Pa.

SELLARS, Fred J., (1917), Pres., (for mail), Sell-Orr Heating Co., 311 N. Penn Ave., and 619 N. Ninth St., Independence, Kans.
SELLMAN, Niles T., (1922), Engr. of Utilization, (for mail), Consolidated Gas Co., 130 East 15th St., and 135 West 183rd St., New York, N. Y.
SELTZER, A. P., (1921), Show Rm. Mgr., (for mail), American Radiator Co., 820 S. Michigan Ave., Chicago, and Evanshire Hotel, Evanston, Ill.
SENIOR, Richard L., (1925), Engr. and Supt., J. Gescheidt & Co., Inc., 142 East 43rd St., New York, and (for mail), 73 Coligni Ave., New Rochelle, N. Y.
SETZER, Walter C., (Junior 1922; Associate 1926), Sales Engr., H. B. Smith Co., 49th and Grays Ave., and (for mail), Gillham St., Lawndale, Philadelphia, Pa.
SEWARD, Percival H.,* (Charter Member), Vice-Pres., Richmond Radiator Co., 1480 Broadway, New York, and (for mail), 369 Washington Ave., Brooklyn, N. Y.
SEWELL, John M., (1919), Htg. and Vtg. Engr., (for mail), Marine-Galligan Co., Inc., 1830 Ludlow St., Philadelphia, and Warren Ave., Berwyn, Pa.
SHANKLIN, John R., (1899), Htg. Engr., (for mail), W. Va. Htg. & Plbg. Co., 233 Hale St., and 1507 Quarrier St., Charleston, W. Va.
SHAW, Clinton E., (1921), Instr., (for mail), Northeast High School, Eighth and Lehigh Ave., and 6412 North 11th St., Philadelphia, Pa.
SHAW, Edgar, (1923), Pres., Lynch & Woodward, Inc., 202 Harrison Ave., Boston, and 51 Royal St., Wollaston, Mass.
SHAW, N. J. H., (Junior 1925), Sales Engr., Barnes & Jones, 5 Melrose St., Boston, and (for mail), 99 Melrose St., Arlington, Mass.
SHAW, Raymond E., (1921), Sales Mgr., (for mail), B. F. Sturtevant Co., Hyde Park, and Boston Athletic Assn., Boston, Mass.
SHAY, Russell A., (1924), Htg. Engr., 108 Linwood St., Brooklyn, N. Y.
SHEA, John R., (1925), Asst. Supt. of Mfg. Development, Western Elec. Co., Inc., Hawthorne Sta., Chicago, and 301 North Park Ave., River Forest, Ill.
SHEA, M. B., (1921), Mgr., (for mail), American Radiator Co., 417 S. Tenth St., and 3616 Lincoln Blvd., Omaha, Nebr.
SHEARS, Matthew W., (1922), Htg. Engr., C. A. Dunham Co., Ltd., 1523 Davenport Rd., and (for mail), 53 Sylvan Ave., Toronto, Ont., Can.
SHEFFIELD, Edward B., (1921), Sales Engr., (for mail), Armstrong Cork Co., 11 Brant St., Toronto, and Lambton Mills, Ontario, Can.
SHEFFLER, Morris, (1921), Member of Firm, (for mail), Sheffler-Gross Co., 205-211 Drexel Bldg., and 5451 Lebanon Ave., Philadelphia, Pa.
SHELDON, Nelson Edward, (1927), Sales Engr., (for mail), York Htg. & Vtg. Corp., 703 Temple Bldg., and 56 Turner Place, Rochester, N. Y.
SHEPPARD, Frank A., (1918), Kansas City Mgr., (for mail), Johnson Service Co., 411 E. Tenth St., and 4550 Mill Creek Blvd., Kansas City, Mo.
SHEPPARD, William G., (1922), Partner, (for mail), Sheppard & Abbott, 119 Harbord St., and 479 Dovercourt Rd., Toronto, Ont., Can.
SHERET, Andrew, (Associate 1925), Pres., (for mail), Andrew Sheret, Ltd., 1114 Blanchard St., and 1030 St. Charles St., Victoria, B. C.
SHERIFFS, Walter A., (1918), Mehring & Hanson Co., 162 N. Clinton St., Chicago, Ill.
SHERRY, Raymond Wilbur, (1927), Estimator and Supt., C. H. Sherry, 349 W. Broad St., and (for mail), 601 Peace St., Hazelton, Pa.
SHINOHARA, Shiro, (1924), Takata & Co., Marunouchi, and (for mail), 51 Iga Machi, Yotsuyaku, Tokio, Japan.
SHIPP, C. C., (1923), Owner, (for mail), C. C. Shipp & Co., 230 E. Ohio St., and 3405 Guilford Ave., Indianapolis, Ind.
SHODRON, John G., (1921), Research Engr., James Mfg. Co., 411 E. Milwaukee Ave., Ft. Atkinson, Wis.
SHORB, Will A., (1909), Treas., Field & Shorb Co., 133 W. William St., and (for mail), 3 Lincoln Place, Decatur, Ill.
SHOZO, Saito, (1923), Htg. and Vtg. Engr. and Contractor, (for mail), Marunouchi Bldg., and 171 Kitakamata, Tokio, Japan.
SHREINER, Dewey C., (Junior 1923; Associate 1926), Partner, Harry E. Shreiner & Son, 116 W. High St., and 608 Southern Blvd., Elkhart, Ind.
SHROCK, John H., (1924), Vice-Pres., (for mail), New York Blower Co., and Bellevue Apts., LaPorte, Ind.
SHUELL, Frank W., (Associate 1921), Pres. and Gen. Mgr., (for mail), Ever Hot Heater Co., 5241 Wesson Ave., and 360 E. Boston Blvd., Detroit, Mich.
SHULTZ, Earle, (Associate 1919), Vice-Pres., (for mail), Illinois Maintenance Co., Rm. 1136, Edison Bldg., and 1310 Birchwood Ave., Chicago, Ill.
SIEGEL, John F., (Associate 1915), Mgr., (for mail), Fuel Oil Burner Engrg. Co., 101 Park Ave., New York, and 220 Sheridan Ave., Mt. Vernon, N. Y.
SIEGEL, Leo, (Junior 1924; Associate 1925), Mech. Engr., Board of Education, Htg. and Vtg. Division, Flatbush and Concord Sts., and (for mail), 1507 Avenue U, Brooklyn, N. Y.
SIMPSON, William A., (1925), Mech. Engr., (for mail), Johnson & Morris, 538 West 23rd St., and 1269 Grand Concourse, New York, N. Y.
SIMPSON, William K., (1919), Secy., (for mail), Hoffman Specialty Co., 193 Grand St., and 61 Fiske St., Waterbury, Conn.
SKAGERBERG, R., (Junior 1921; 1924), Dept. Mgr., Drying Systems, Inc., 1800 Foster Ave., Chicago, Ill.
SKELLY, John F., (1921), Htg. Contractor, J. F. Skelly, 303 Catherine St., Ogdensburg, N. Y.
SKINNER, Henry W., (1920), Mech. Engr., (for mail), W. C. Hedrick, Archt., 1005 First Natl. Bk. Bldg., Ft. Worth, Tex.
SLADE, Arthur J., (Associate 1925), Director of Sales, (for mail), American District Steam Co., and Louise St., N. Tonawanda, N. Y.
SLIGHT, Irvin, (Junior 1925; Associate 1926), Slight Bros., Willow Grove, and Hartsville, Pa.
SMALL, John D., (1910), Consulting Engr., (for mail), 127 N. Dearborn St., Chicago, and 411 Maple Ave., Wilmette, Ill.
SMALLMAN, Edwin W., (1920), Htg. and Vtg. Engr., Monks & Johnson, 99 Chauncy St., and (for mail), 87 Essex St., Melrose, Mass.
SMALLMAN, William T., (1911), Treas., (for mail), Isaac Coffin Co., 52 Sudbury St., Boston, and 127 Rockland Ave., Malden, Mass.
SMITH, Gard Wentworth, (1927), Mgr., Furnace Dept., Jewel Div., (for mail), Detroit Stove Works, 6900 E. Jefferson Ave., and 2133 Montclair Ave., Detroit, Mich.
SMITH, John Colbourne, (Junior 1927), Sales Engr., Niagara Blower Co., 673 Ontario St., Buffalo, and (for mail), 95 Columbia Blvd., Kensmore, N. Y.
SMITH, Leslie L., (1919), Mech. Engr., (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., and 1931 Delaware Ave., Detroit, Mich.
SMITH, Milton S., (1919), Production Mgr., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), 13 North Terrace, Maplewood, N. J.
SMITH, Sidney S., (1926), Vice-Pres., (for mail), Andes Range & Furnace Corp., and 517 Castle St., Geneva, N. Y.
SMITH, Virgil A., (Junior 1923), Sales Engr., (for mail), C. A. Dunham Co., 2304 Cleveland Ave., Tampa, Fla.
SNELL, Ernest, (1920), Htg. and Vtg. Engr., 3914 LeMay Ave., Detroit, Mich.
SNYDER, Charles B. J., (1895), (Presidential Member), (Board of Governors 1900-1904; 2nd Vice-Pres. 1905; 1st Vice-Pres. 1906; Pres. 1907; Board of Governors 1908), 183 Madison Ave., New York, N. Y.

SNYDER, Jay W., (1917), Member of Firm, (for mail), McColl, Snyder & McLean, 2348 Penobscot Bldg., and 8987 Martindale Ave., Detroit, Mich.
SNYDER, Joseph S., (Associate 1925), Sales Engr., (for mail), American Radiator Co., 1807 Elmwood Ave., and 39 Granger Place, Buffalo, N. Y.
SODEMANN, Paul W., (Junior 1920; Associate 1925; 1926), Sales Engr., Fischer Htg. Co., 367-369 Adams St., and (for mail), 1307 Worthington Place, Memphis, Tenn.
SODEMANN, William C., (1919), Vice-Pres., Sodemann Htg. & Power Co., 2300 Morgan St., and 3510 University St., St. Louis, Mo.
SODERBERG, Charles H., (1919), Consulting Engr., (for mail), 608 Donovan Bldg., Detroit, and 220 Puritan Rd., Birmingham, Mich.
SOMERS, William Stuart, (Junior 1926), Supt., Success Heater Mfg. Co., and (for mail), 2807 Grand Ave., Des Moines, Ia.
SOMMER, Louis J., Jr., (1922), Sole Owner, Louis J. Sommer & Son, 2436 Brown St., and 4809 Chestnut St., Philadelphia, Pa.
SOPER, Horace A., (1916), Vice-Pres., (for mail), American Foundry & Furnace Co., and 1122 E. Monroe St., Bloomington, Ill.
SOPER, Ira N., (1919), Sales Engr., (for mail), Warren Webster & Co., 549 W. Washington St., and 6915 Harper Ave., Chicago, Ill.
SOULE, Lawrence C., (1908), Secy., and Sales Mgr., Aerofin Corp., 750 Frelinghuysen Ave., Newark, and 26 Wooton Rd., Essex Fells, N. J.
SOWERS, Paul E., (1922), Br. Mgr., Vapor Heating Co., 201 N. George St., and (for mail), P. O. Box 295, York, Pa.
SPECKMAN, Charles H., (1918), Htg. Engr., 375 Bourse Bldg., Philadelphia, Pa.
SPELLER, Frank N.,* (1908), Metallurgical Engr., (for mail), National Tube Co., 1810 Frick Bldg., and 6411 Darlington Rd., Pittsburgh, Pa.
SPERZEL, Henry J., (Associate 1918; 1919), N. W. Br. Mgr., Kewanee Boiler Co., 708 Builders Exch., and 4644 Bryant Ave., S., Minneapolis, Minn.
SPIELMAN, Gordon P., (Junior 1923), Treas., Harrison-Spielmann Co., Heating Contractors, 480 Milwaukee Ave., Chicago, and (for mail), 515 N. Prospect Ave., Park Ridge, Ill.
SPITZLEY, Ray L., (1920), Pres. and Gen. Mgr., (for mail), R. L. Spitzley Heating Co., 246 W. Larned St., and 1050 Yorkshire Rd., Grosse Pt., Detroit, Mich.
SPOFFORD, Harry H. R., (1923), Copper and Brass Research Assn., 25 Broadway, New York, N. Y.
SPOONER, Harold R., (1921), Engr. and Estimator, Atlas Heating Co., Inc., Jamacia, and (for mail), 33 Woodhull Ave., Hollis, L. I., N. Y.
SPRAGUE, Frank H., (1923), Sales Mgr., (for mail), Skidmore Corp., 1535 Dayton St., Chicago, and 1522 Forest Ave., Wilmette, Ill.
SPROULL, Howard E., (1920), District Mgr., American Blower Co., 905 Sycamore St., Cincinnati, O.
SPURGEON, Joseph H., (1924), Sales Engr., (for mail), Joseph H. Spurgeon Co., 224 Gen. Motors Bldg., and 818 Woodmere Ave., Detroit, Mich.
STACEY, Alfred E., Jr.,* (1914), Research Engr., Carrier Engrg. Corp., 750 Frelinghuysen Ave., Newark, and (for mail), Wootton Rd., Essex Fells, N. J.
STACK, Murle F., (Associate 1925), Vice-Pres., Sunkel Appliance Corp., 4511 Delmar Blvd., and (for mail), 308 N. Newstead, St. Louis, Mo.
STACKHOUSE, Raymond M., (Associate 1908; 1919), (for mail), 1294 East 55th St., and Parkside Dwellings, Cleveland, O.
STAMMER, Edward L.,* (1919), Supt., Htg. and Vtg. Repairs, St. Louis Board of Education, Ninth and Locust Sts., and 4430 Tennessee Ave., St. Louis, Mo.
STANFORD, Leland E., (1921), Mgr., Forbs-Stanford Co., 756 Upson St., and (for mail), 120 E. Cuyahoga Falls Ave., Akron, O.
STANGER, Ralph B., (1920), Mgr., (for mail), Robinson & Stanger, 917 Empire Bldg., and Pittsburgh Athletic Assn., Pittsburgh, Pa.
STANGLAND, B. F., (Charter Member), (Board of Managers 1895; 1899, Council 1896; 1897; Board of Governors 1905; 1906; 1909; 2nd Vice-Pres. 1908), Morton, N. Y.
STANNARD, James M.,* (1906), (Board of Governors 1913; Council 1914, 1917), Pres. and Treas., (for mail), Stannard Power Equipment Co., 926 Monadnock Block, Chicago, and 1402 Elinor Place, Evanston, Ill.
STAPLES, William H., (Associate 1924), Gillis & Geoghegan, 537 W. Broadway, and 137 West 96th St., New York, N. Y.
STARK, W. Elliott, (1926), Engr., Bryant Heater & Mfg. Co., 17825 St. Clair Ave., Cleveland, and (for mail), 1849 Windermere Ave., E. Cleveland, O.
STARKS, Verne E., (1921), Dist. Mgr., (for mail), Ilg Elec. Vtg. Co., 1314 Schofield Bldg., and 13502 Fourth Ave., Cleveland, O.
STEARNS, Walter I., (Associate 1926), Combustion Engr., W. I. Stearns Co., 560 North 16th St., Philadelphia, Pa.
STEARNS, William F., (Associate 1925), (for mail), Stearns & Eaton, 100 Boylston St., Boston, and 2 Salisbury Rd., Winchester, Mass.
STECKHAN, Louis, (Junior 1926), Estimator, (for mail), Crane Co., 30 South 16th St., and 3014 Indiana Ave., St. Louis, Mo.
STEDMAN, Charles N., (1921), Dist. Sales Mgr., (for mail), C. N. Stedman Co., 610 Wrigley Bldg., and 6917 Crandon Ave., Apt. 2D, Chicago, Ill.
STEIM, Charles J., Jr., (1923), Mgr. Htg. Dept., (for mail), Samuel Sloan & Co., 67 Exchange St., and 1291 University Ave., Rochester, N. Y.
STEINHORST, Theodore F., (1919), Engr. and Estimator, (for mail), Emil Steinhorst & Sons, 1158 Mohawk St., and West Shore R. R., and 1664 Brinckerhoff Ave., Utica, N. Y.
STEINKE, G. B., (1924), Pres., (for mail), 103 Park Ave., New York, and 2730 Decatur Ave., Brooklyn, N. Y.
STEINMULLER, J. M., (1925), 245 Hunters Point Ave., Long Island City, N. Y.
STEPHEN, Harold M., (Associate 1926), Sales Engr., James E. Degan Co., 622 First St., Detroit, Mich.
STEPHENSON, Lewis A., (1917), Mgr., (for mail), Powers Regulator Co., 409 East 13th St., and 801 West 57th St., Kansas City, Mo.
STERN, H. Richard, (1923), (for mail), Johnson & Morris, 538 West 23rd St., and 225 West 86th St., New York, N. Y.
STERNBERG, I. C., (1926), Chief Engr., (for mail), Arctic Nu-Air Corp., 110 East 42nd St., and 1271 Morris Ave., New York, N. Y.
STETSON, Lawrence R., (1913), (for mail), McMurrer Co., 303 Congress St., Boston, and 35 Bradfield Ave., Roslindale, Mass.
STEVENS, Frank H., (Associate 1924), Sales Engr., (for mail), Heggie Simplex Boiler Co., 622 First St., Detroit, Mich., and 2952 Monterey Ave., Detroit, Mich.
STEVENS, Harry L., (Junior 1924), Member of Firm, (for mail), M. M. Stevens Co., 108 W. Sherman St., and 111 West 16th St., Hutchinson, Kans.
STEWART, C. W., (Associate 1918; 1919), 644 Riverside Drive, Apt. 2F, New York, N. Y.
STEWART, Earl A., (1922), Associate Prof. Agriculture Physics, Univ. of Minnesota, University Farm, St. Paul, Minn.
STILL, Fred R.,* (1904), (Presidential Member), (Pres. 1918; 2nd Vice-Pres. 1917; Council 1916-1919), Vice-Pres. in charge of Export, (for mail), American Blower Co., Rm. 1510, 30 Church St., and 895 West End Ave., New York, N. Y.
STITT, Eugene W., (1917), Sales Repr., Hoffman Specialty Co., 1535 Park Blvd., Dormont, and P. O. Box 45, S. Hills Branch, Pittsburgh, Pa.
STITT, Howard B., (Associate 1922), Htg. Engr., 506 West 29th St., Indianapolis, Ind.

STOCK, Edward L., (Associate 1918), Sales Mgr., (for mail), Niagara Radiator & Boiler Co., 11-17 Investment Bldg., Washington, D. C., and Bradley Hills, Bethesda, Md.

STOCKENBERG, Ruben, (1922), Sales Engr., (for mail), Johnson Service Co., 1355 W. Washington Blvd., and 6813 Lakewood Ave., Chicago, Ill.

STOCKLY, Harold A., (1925), 240 S. El Molins St., Alhambra, Calif.

STOCKWELL, William R., (Junior 1901; 1903), Gen. Mgr., Weil-McLain Co., Michigan City, Ind.

STOKES, Ralph E., (1920), Residence Mgr., Vtg. Engr., (for mail), Ilg Elec. Vtg. Co., 1024 Bessemer Bldg., Pittsburgh, and 843 River Rd., Avalon Borough, Pa.

STOLTENBERG, Thomas R., (1922), Sales Repr., Htg. and Vtg. Engr., Glenwood Springs, Colo.

STONE, Eugene R., (1913), Pres., Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 86 Sea Ave., Quincy, Mass.

STONE, George F., (1918), Engr. and Estimator, Wm. H. Walters & Sons, 1314 N. Carlisle St., and 4520 N. Carlisle St., Philadelphia, Pa.

STOREY, Thomas G., (Associate 1925), Citizens Gas Fuel Co., Adrian, Mich.

STORM, Edwin S., (1916), Vice-Pres., (for mail), Hoffman Specialty Co., 130 N. Wells St., and 5220 Cornell Ave., Chicago, Ill.

STRANDWITZ, William J., (1919), Secy. and Treas., (for mail), Strandwitz & Scott, Inc., 537-49 S. Second St., Camden, and Hawthorne Ave., Haddonfield, N. J.

STRONG, Ralph C., (1919), Salesman, Pierce, Butler & Pierce Mfg. Corp., 31st and Oxford Sts., and (for mail), 4515 Larchwood Ave., Philadelphia, Pa.

STROUSE, Sidney B., (1921), Dist. Mgr., (for mail), Warren Webster & Co., 429 Guarantee Trust Bldg., and 22 S. Illinois Ave., Atlantic City, N. J.

STURGES, Heyward A., (Junior 1926), Detroit Mgr., International Heater Co., 1114 Dime Bk. Bldg., and (for mail), 8559 Quincy St., Detroit, Mich.

SUITS, George A., (1923), Mgr., Hoffman Specialty Co., 26 Stanley Ave., Medford, Mass.

SULLIVAN, Daniel A., (1923), Miller & Brady, Inc., 210 East 38th St., and 3178 Rochambeau Ave., New York, N. Y.

SUTCLIFFE, Arthur G., (Associate 1918; 1922), Engr., Ilg Elec. Vtg. Co., 2850 N. Crawford Ave., and (for mail), 4146 N. St. Louis Ave., Chicago, Ill.

SUTTERLEY, W. W., (1919), 503 North 52nd St., Philadelphia, Pa.

SWAIN, Wilbur A., (Associate 1926), Repr. and Engr., (for mail), Jenkins Bros., 80 White St., New York, N. Y., and 133 Evergreen Place, E. Orange, N. J.

SWAN, Thomas J., (Junior 1925), Sales Engr., Hoffman Specialty Co., and 23 Athelwold St., Dorchester, Mass.

SWANEY, Carroll R., (Junior 1921), Salesman, (for mail), Gilbert, Howe, Gleason, 25 Huntington Ave., Boston, and 24 Southgate Park, W. Newton, Mass.

SWARTWOUT, Jay D., (1917), Secy. and Treas., J. D. Swartwout Co., 349 S. Weadock Ave., 349 S. Weadock Ave., Saginaw, Mich.

SWEENEY, Sylvester H., (1915), Engr. and Contractor, S. H. Sweeney, Inc., 306 East 39th St., and 1916 Loring Place, New York, N. Y.

SZEKELY, Ernest, (1920), Consulting Engr., (for mail), 500 B. & R. T. Bldg., and 12537 Arliss Drive, Cleveland, O.

T

TAGGART, Ralph C., (1912), Chief Engr., Dept. of Arch., 14 Lyon Ave., Menands, Albany, N. Y.

TAIT, George M., (1909), Htg., Vtg. and Sanitary Engr., 34 W. First St., Mansfield, O.

TALIAFERRO, Robert R., (1919), Carrier Engrg. Corp., (for mail), 1402 Land Title Bldg., and Beechwood Park, Philadelphia, Pa.

TALLMADGE, Webster, (1924), 50 Church St., New York, N. Y.

TANGEMAN, Bruno W., (Associate 1919), Mgr., (for mail), A. Y. McDonald Mfg. Co., 822 Third St., S., and 2716 *Aldrich* Ave., S., Minneapolis, Minn.

TATE, Sidney, (Associate 1926), Htg. Contr., 14113 Orinoco Ave., E. Cleveland, O.

TAVERNA, Frederick F., (Junior 1924; Associate, 1927), Htg. and Vtg. Engr., Raisler Heating Co., 129 Amsterdam Ave., New York, N. Y., and (for mail), 406 Savoy St., *Union City*, N. J.

TAYLOR, Milton A., (Associate 1925), Asst. to Pres., (for mail), Taylor-Forbes Co., Ltd., and 178 Queen St., Guelph, Ont., Can.

TAYLOR, R. Frederick, (1915), Consulting Engr., R. F. Taylor, 1020 Western Indemnity Bldg., and 5742 Richmond Ave., Dallas, Tex.

TAYLOR, Thomas S., (1921), Chief Research Physicist, Bakelite Corp., (for mail), 230 Grove St., Bloomfield, and 96 Westville Ave., Caldwell, N. J.

TEASDALE, Lawrence Aldrich, (1926), Engr., Hollis French & Allen Hubbard, 210 South St., Boston, and 28 Ardmore St., E. Braintree, Mass.

TEMPLIN, Charles L., (1921), Chief Engr., American Htg. & Vtg. Co., P. O. Box 876, 801 Fayetteville St., Raleigh, N. C., and 608 Bona Allen Bldg., Atlanta, Ga.

TERRELL, Herbert A., (1915), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y., and (for mail), 19 Hampton St., Cranford, N. J.

TERRY, Frank W., (Associate 1923), Sales Engr., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 553 Gregory Ave., W. Orange, N. J.

THAIN, Arthur Edgar, (Associate 1926), Mgr., U. S. Radiator Corp., 1147 Wicomico St., and (for mail), 2116 Mt. Holly St., Baltimore, Md.

THATCHER, George S., (1919), Pres., (for mail), Thatcher Heating Co., 455 E. Exchange St., and 140 Morningside Drive, Arkon, O.

THEISEN, Edwin F., (1922), Pres. and Htg. Engr., Industrial Plumbing & Htg. Co., 606 Second St., and (for mail), 1835 Des Moines St., Ft. Madison, Ia.

THEORELL, Hugo G. T., (1902), Consulting Engr., 4 Skoldungatan, Stockholm, Sweden.

THINN, Christian A., (1921), Asst. Sales Mgr. and Engr., (for mail), C. A. Dunham Co., 450 E. Ohio St., and 1907 Nebraska Ave., Chicago, Ill.

THOMAS, Bernard A., (Junior 1923), Sales Engr., Crane Co., Jacksonville, and (for mail), 108 W. Howard St., Winter Haven, Fla.

THOMAS, Herbert G., (1917), Sales Engr., Warren Webster & Co., 549 W. Washington St., Chicago, and (for mail), 2312 Ridge Ave., Evanston, Ill.

THOMAS, Melvern F., (1909), Consulting Engr., (for mail), 229 College St., and 24 Ralph Ave., Toronto, Ont., Can.

THOMAS, R. H., (1920), Pres., (for mail), Economy Pumping Machine Co., 122-124 N. Curtis St., Chicago, and 426 Forest Ave., Oak Park, Ill.

THOMPSON, Charles, (Associate 1927), Salesman, Walworth California Co., Second and Tehama Sts., San Francisco, Calif.

THOMPSON, James, (1920), Pres., (for mail), Philadelphia Boiler Works, 1737 Filbert St., Philadelphia, and 158 Stoneway Lane, Bala, Pa.

THOMPSON, Nelson S.,* (Junior 1897; 1917), Chief Mech. and Elec. Engr., Office of Supervising Engr., U. S. Treasury Dept., and (for mail), 1615 Hobart St., N.W., Washington, D. C.

THOMPSON, Richard C., (1927), Sales Engr., (for mail), Power Equipment Co., 250 Stuart St., Boston, and Cohasset, Mass.

THOMPSON, William P., Jr., (1915), (for mail), Thompson Bros., 520 Buttonwood St., and 1349 Colwyn St., Philadelphia, Pa.

THOMSEN, William T., (1919), Secy. and Treas., (for mail), International Engrg. & Supply Co., Suite 609, Tower Bldg., and 3408 *Magnolia* Ave., St. Louis, Mo.

THOMSON, Thomas N., (1927), Technical Expert, Plumbers Trade Journal, 239 West 30th St., New York, and (for mail), 37 Irwin Place, Huntington, L. I., N. Y.

THORNTON, Roger T., (1919), Engr., (for mail), Buffalo Forge Co., 490 Broadway, and 46 Burbank Ter., Buffalo, N. Y.

THRUSH, Homer A., (1918), Pres., (for mail), H. A. Thrush & Co., 21-23 E. River St., and 271 S. Broadway, Peru, Ind.

THUEM, Adolph E., (Junior 1922), Htg. and Vtg. Engr., (for mail), Board of Education, Bureau of Construction and Maintenance, Htg. and Vtg. Div., Flatbush Ave., Extension and Concord St., Brooklyn, and 444 East 87th St., New York, N. Y.

TIBBETS, John C., (1920), Htg. and Vtg. Engr., B. & O. R. R. Co., 1303 B. & O. Central Bldg., Baltimore, and (for mail), Ellicott City, Howard Co., Md.

TILDEN, Elwyn E., (1924), (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and *Holbrook*, Mass.

TIMMERMAN, Manford M., (Junior 1921; 1925), *Supervisor, Works* Engrg Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 859 E. Hutchinson Ave., Swissvale, Pa.

TIMMIS, Pierce, (1920), Service Equipment Engr., (for mail), Dwight P. Robinson & Co., Inc., 125 East 46th St., New York, and 11 Little Neck Rd., Douglas Manor, L. I., N. Y.

TIMMIS, Walter S.,* (1911), (Presidential Member), (Pres. 1919; Council 1916; 1917; 1920; 1st Vice-Pres., 1918), Consulting Engr., (for mail), 315 Fifth Ave., New York, and Hillside and Homer Lee Aves., Jamaica, N. Y.

TIMMIS, William W., (Associate 1925), Sales Engr., M. E. Conran Co., Inc., Central Park, L. I., and (for mail), Oak Lane, Glen Cove., L. I., N. Y.

TINKER, William E., (Associate 1922), (for mail), Natl. Radiator Co., 121 N. Broad St., and 600 South 48th St., Philadelphia, Pa.

TISNOWER, William, (1923), Htg. Engr., 131 Livingston St., Brooklyn, N. Y.

TITZELL, J. Edgar, (1923), Vice-Pres., (for mail), Pacific Boiler Co., Inc., 101 Park Ave., and 27 West 95th St., New York, N. Y.

TJERSLAND, Alf, (Junior 1906; 1916), E. Sunde & Co., Christiania, Norway.

TOBIN, George J., (1905), Sanitary, Htg. and Vtg. Engr., (for mail), 187 North Ave., and 510 Grant Ave., Plainfield, N. J.

TODD, James, (1922), Pres., (for mail), Sterling Varnish Co., 528 Fulton Bldg., Pittsburgh, and Sewickley, Pa.

TOENNIGES, George C., (1915), Sales Engr., 1657 Addison St., Lakeview, Ill.

TOMLINSON, Malcolm C. W., (1924), Mech. Engr., Development Br., Western Elec. Co., Kearny, and (for mail), 106a *Euclid Ave., Loch* Arbour, N. J.

TOOKER, Charles C., (1918), Htg. Engr., 113 North 27th St., and (for mail), 208 Terry Ave., Billings, Mont.

TRANE, Reuben N., (1915), Pres., (for mail), The Trane Co., Htg. Specialty Mfgrs., and 1514 King St., LaCrosse, Wis.

TRUITT, Joseph E., (Associate 1911; 1920), Pres., Autovent Fan & Blower Co., 736 W. Monroe St., Chicago, Ill.

TRUMBO, Silas M., (Associate 1926), Sales Engr., Buffalo Forge Co., 562 W. Washington Blvd., Chicago, Ill.

TUCKER, Frank N., (1926), Field Engr., (for mail), Ilg Elec. Vtg. Co., Rm. 1108, 13 Park Row, and 9 West 28th St., New York, N. Y.

TURNO, Walter G. W., (Associate 1912; 1917), Engr. and Estimator, 71 Lafayette Ave., E. Orange, N. J.

TUSCH, Walter, (1917), Htg. and Vtg. Engr., Tenny & Ohmes, 101 Park Ave., New York, and (for mail), 881 Sterling Place, Brooklyn, N. Y.

TUTTLE, J. Frank, (1913), Mgr., (for mail), Warren Webster & Co., 220 Devonshire St., Boston, and Winchester, Mass.

TWIST, Charles F., (1921), Secy. and Treas., (for mail), Ashwell, Twist & Cook, Inc., 305 Bell St., and 2310 Tenth Ave., N., Seattle, Wash.

TYLER, Frank T., (1922), Asst. Sales Mgr., (for mail), Herman Nelson Corp., 1824 Third Ave., and 1615 Eighth Ave., Moline, Ill.

U

UHL, Edwin J., (1925), Sales Engr., Uhl Co., 132 S. Tenth St., Minneapolis, Minn.

UHL, Willard F., (1918), Sales Engr., (for mail), Uhl Co., 132 S. Tenth St., and 4716 Lyndale Ave., S., Minneapolis, Minn.

UHLHORN, W. J., (1920), Sales Engr., Drying Systems, Inc., 1800 Foster Ave., Chicago, and (for mail), 733 S. Highland Ave., O ak Park, Ill.

ULRICH, Kay Flemming, (Junior 1926), Mech. Engr., L. Ulrich, Smedegade, Slagelse, Denmark.

UNDERHILL, William W., (1913), Treas., (for mail), Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 15 Kinwood St., Brookline, Mass.

V

VALENTINE, Howard D.,* (1924), Director Sales Engrg., (for mail), Central Huckon Gas & Elec. Corp., 50 Market St., Poughkeepsie, N. Y.

VALIQUET, Harry H., (Associate 1926), Engr., Bayley Mfg. Co., Milwaukee, and (for mail), 310 Sixth Ave., Wauwatosa, Wis.

VAN ALEN, Walter T., (1924), Sales Engr., Htg. Dept., Standard Sanitary Mfg. Co., Pittsburgh, and (for mail), 1300 Darlington Rd., R. F. D. No. 1, Beaver Falls, Pa.

VANCE, Louis G., (1919), Owner, Vance & Vance, 1207 Garrett Bldg., and (for mail), 3601 Garrison Ave., Baltimore, Md.

VAN NORDEN, Ernest M., (1923), The New York Edison Co., 130 East 15th St., New York, and 168 Brixton Rd., Garden City, Nassau Co., N. Y.

VAN SICKLE, William B., (1915), Pres., (for mail), The W. B. Van Sickle Co., 707 Frankfort Ave., Cleveland, and 1530 Grace Ave., Lakewood, O.

VAN ZANDT, John H., (1914), Mfgrs. Agent, 1903 Santa Fe Bldg., and 4416 Bryan St., Dallas, Tex.

VAUX, Frederick J., (1919), Vice-Pres. and Gen. Mgr., Monitor Bi-Loop Radiator Co., and (for mail), 202 E. King St., Lancaster, Pa.

VAUX, Noble, (Associate 1923), Htg. Engr., R. T. Vaux & Son, 12 Fawcett St., and (for mail), 11 Holmelands Park S., Sunderland, Eng.

VER HALEN, Edward T., (Associate 1925), Edw. T. Ver Halen, Inc., 610 Milwaukee St., Milwaukee, Wis.

VERNER, William F.,* (1913), Mech. Engr., (for mail), Verner, Wilhelm & Molby, 824 Book Bldg., Detroit, and 908 Lincoln Ave., Ann Arbor, Mich.

VERNON, J. Rexford, (Associate 1926), Sales Engr., (for mail), Johnson Service Co., 1355 Washington Blvd., and 1563 Birchwood Ave., Chicago, Ill.

VIVARTTAS, Eugene A., (1910), Engr., J. Byers Holbrook, 70 East 45th St., New York, and (for mail), 84 Fenimore St., Brooklyn, N. Y.

VOGEL, Andrew, (1926), Plant Engr., (for mail), General Electric Co., and 611 Lenox Rd., Schenectady, N. Y.

VOGELBACH, Oscar, (1923), Htg. and Vtg. Engr., Guilbert & Betelle, Archts., Brandford Place, Chamber of Commerce Bldg., Newark, and 195 Devon St., Kearney, N. J.

VOGT, J. H., (Associate 1925), (for mail), 124 East 28th St., New York, and 87 Grant Ave., Brooklyn, N. Y.

VOIGT, Charles O., (1921), Sales Engr., The *Stearns Roger Mfg. Co., 1720 California St., and* 60 Albion St., Denver, Colo.
VOLK, Joseph H., (1923), Thos. E. Hoye Htg. Co., 1910 St. Paul Ave., Milwaukee, Wis.
VOORHEES, Guy A., (1922), Engr., Century Htg. Service Co., 32-36 W. Tenth St., and (for mail), 3451 Broadway, *Indianapolis*, Ind.

W

WACHTER, John A., (1914), Pres., 723-25 W. Pratt St., Baltimore, and 112 Ailsa Ave., Hamil*ton, Baltimore, Md.*
WADDINGTON, Bertram C., (1922), Engr., 805 World Herald Bldg., Omaha, Nebr.
WADE, Norman S., (1926), Asst. Supt., Steam Htg. Service Dept., (for mail), Edison Elec. Illuminating Co. of Boston, 39 Boylston St., Boston, Mass., and Salem, N. H.
WADLEY, Calvin Page, (1919), Pres., (for mail), Excelso Products Corp., P. O. Box 33, Sta. C. and 60 Agassiz Place, Buffalo, N. Y.
WAGNER, A. M., (Associate 1921), Mgr., American Radiator Co., 692 Prior Ave., N., St. Paul, and 1626 West 25th St., Minneapolis, Ind.
WAGNER, John P., (Associate 1921), The Stoker Co., 859 Church Lane, Philadelphia, Pa.
WALDON, Charles W., (Associate 1924), (for mail), American Larson Vtg. Co., 204 Keystone Bk. Bldg., Pittsburgh, Pa., and *1006 Ninth St.*, Portsmouth, O.
WALKER, Alex., (Associate 1925), Br. Mgr., (for mail), C. A. Dunham and Powers Regulator Co., 311 Dominion Bk. Bldg., Calgary, Alta, Can.
WALKER, George Francis, (Junior 1925), Sales Engr., (for mail), Spencer Heater Co., 307 McKinley Bldg., Buffalo, and 417 E. Fifth St., *Jamestown*, N. Y.
WALKER, James B., (1919), Treas., (for mail), Pittsburgh Htg. Co., 715 Magee Bldg., and 202 Iroquois Apt., Oakland, Pittsburgh, Pa.
WALKER, James H.,* (1916), Supt., Central Heating, (for mail), Detroit Edison Co., 2000 Second Ave., and 1520 Virginia Park, Detroit, Mich.
WALKER, William K., (Junior 1924), Htg. and Vtg. Engr., McKenzie, Voorhees & Gmelin, 342 Madison Ave., Rm. 2022, New York, and 191-02 Central Ave., St. Albans, L. I., N. Y.
WALLACE, Albert, (1921), Htg. Engr., A. Wallace & Co., 402 Jacobson Bldg., and (for mail), 2971 Irving St., Denver, Colo.
WALLACE, George J., (1923), Engr. and Contractor, 1006 First Ave., New York and (for mail), 27-36 Ericsson St., E. Elmhurst, L. I., N. Y.
WALLACE, John F., (1921), Secy. and Treas., Wallace Plumbing Co., 1238 California St., and 1320 S. Josephine St., Denver, Colo.
WALLICH, A. C., (1919), (for mail), Wallich Ice Machine Co., 517 E. Larned St., and 1211 E. Grand Blvd., Detroit, Mich.
WALSH, Arthur F., (Associate 1923), Htg. and Vtg. Contractor, A. F. Walsh, 7445 Exchange Ave., and 7536 S. Shore Drive, Chicago, Ill.
WALSH, John Henry, (Junior 1927), Partner of H. J. Walsh, Htg. & Vtg., 1484 St. Nicholas Ave., and (for mail), 10 Fairview Ave., New York, N. Y.
WALSH, Malcolm, (1924), Secy., (for mail), Walsh & Wertheim, 55 W. Houston St., New York, and 25 Sherman Ave., St. George, S. I., N. Y.
WALTERS, Arthur L., (Junior 1924; Associate 1925; 1926), Mgr., (for mail), E. B. Langenberg Co., 4519 N. Euclid Ave., St. Louis, and 7284 Richmond Place, Maplewood, Mo.
WALTERS, Victor, (Junior 1924), Engr., Wendt & Crone Co., *1131 N. Wells St.*, and *(for mail)*, 7049 St. Lawrence Ave., Chicago, Ill.
WALTERS, William T., (1917), Htg. and Vtg. Engr., Illinois Engrg. Co., N.E. Cor. 21st St. and Racine Ave., and (for mail), 6749 Dorchester Ave., Chicago, Ill.
WALTHER, Harry J., (1919), Mgr. Htg. Dept., *(for mail), Henry B. Pancoast Co.*, 946-62 N. Front St., and 1115 Duncannon Ave., Philadelphia, Pa.
WALTHER, Owen N., (1919), 753 College Ave., *Haverford*, Pa.
WALTHER, Vernon H., (Junior 1925), Asst. in Mech. Dept., C. W. & Geo. L. Rapp, *190 N.* State St., Rm. 1200, and (for mail), 6821 Osceola Ave., *Edison Park*, Chicago, Ill.
WALTHERTHUM, John J., (Associate 1922), J. J. Waltherthum, 173 East 62nd St., New York, N. Y., and 834 Grand St., Jersey City, *N. J.*
WALTON, Hiram L., (1916), Mech. Engr., (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, and 218 Monterey Ave., Highland Park, Mich.
WANDLESS, F. W., (1925), Chief Engr., (for mail), Haynes Selling Co., 2013 Sansom St., Philadelphia, and Berwyn, Pa.
WARD, George C., (1925), Inspector Bureau Industrial Hygiene, N. Y. State Dept. Labor, 124 East 28th St., New York, and 86-87th St., Brooklyn, N. Y.
WARD, Oscar G., (1919), Dist. Mgr., (for mail), Johnson Service Co., 1230 California St., and 1515 E. Ninth Ave., Denver, Colo.
WARREN, Clarence N., (1919), Vice-Pres. and Engr., Hayes Bros., Inc., 236 W. Vermont St., and *(for mail)*, 419 East 48th St., Indianapolis, Ind.
WASH, William Percy, (1923), Sales Engr., (for mail), Richmond Radiator Co., P. O. Box 381, and 131 Wellington Ave., Roanoke, Va.
WATERS, George G., (Associate 1926), Salesman, (for mail), American Blower Co., 604 Building and Loan Bldg., and 329 Gladstone, S.E., Grand Rapids, Mich.
WATSON, John Howard, (1925), Engr., Drying Systems, Inc., 1800 Foster Ave., and (for mail), 2021 Berwyn Ave., Chicago, Ill.
WATSON, Raymond E., (1925), Designer, Irving E. Brooke, 189 W. Madison St., and (for mail), 6037 N. Paulina St., Chicago, Ill.
WATTERS, Peter J., (1921), Mgr., John Watters, 55 Church St., and (for mail), 52 Ann St., Port Richmond, S. I., N. Y.
WEAGER, T. A., (1920), Cleveland Mgr., (for mail), Buffalo Forge Co., Rockefeller Bldg., Cleveland, and 3124 Berkshire Rd., Cleveland Heights, O.
WEBB, John S., (1920), Pres., (for mail), Willey & Calhoun Co., 46 Market St., Portland, Me., and 38 Cottage Farms Rd., Cape Elizabeth, Me.
WEBB, John William, (1926), Partner, Brierley-Webb Co., School St., Newton Heath, Manchester, and (for mail), 6 Meadows Rd., Heaton Chapel, Stockport, Eng.
WEBER, Erwin L., (1921), Consulting Engr., (for mail), 723 Seaboard Bldg., and 3046 18th Ave., S., Seattle, Wash.
WEBER, G. A., (1922), Htg. Engr., McGinness, Smith, McGinness Co., 527 First Ave., Pittsburgh, and 618 Chautauqua St., Bellevue, Pa.
WEBSTER, E. Kessler, (1915), Secy. and Asst. Gen. Mgr., (for mail), Warren Webster & Co., 17th and Federal Sts., Camden, and 320 Washington Ave., Haddonfield, N. J.
WEBSTER, Warren, (Associate 1899; 1906), Pres. and Gen. Mgr., Warren Webster & Co., 17th and Federal Sts., and 626 Cooper St., Camden, N. J.
WEBSTER, Warren, Jr., (Junior 1927), Asst. Secy., (for mail), Warren Webster & Co., 17th and Federal Sts., Camden, and 249 W. Summit Ave., Haddonfield, N. J.
WEGMANN, Albert, (1918), Blower and Vtg. Engr., A. and W. Wegmann, 2813 Fletcher St., and *(for mail)*, 2842 N. Bonsall St., Philadelphia, Pa.

WEIDER, Frederick J., (1919), Vice-Pres. and Treas., (for mail), *Barr & Creelman Co., 74* Exchange St., and 40 Kenwood Ave., Rochester, N. Y.
WEIL, Martin, (Associate 1925), Secy., (for mail), Weil-McLain Co., 641 W. Lake St., and 4259 Hazel Ave., Chicago, Ill.
WEIMER, Fred G., (Associate 1919), Milwaukee Mgr., Kewanee Boiler Co., 440 Barclay St., and (for mail), 1308 Stowell Ave., Milwaukee, Wis.
WEINSHANK, H. T., (Junior 1924), Sales Engr., (for mail), The New York Blower Co., 2246 S. Halsted St., and 2638 N. Spaulding St., Chicago, Ill.
WEINSHANK, Theodore,* (1906), Board of Governors 1913), 3301 Schubert Ave., Chicago, Ill.
WEISS, Carl A., (Associate 1924), Partner, Supt., (for mail), Kornbrodt Kornice Ko., 1811-13-15 Troost Ave., and 4920 Walrond, Kansas City Mo.
WELAMB, Victor N., (1918), Contractor, (for *mail*), *V. N. Welamb Co., 2313 Walnut St.*, and 1741 North 33rd St., Philadelphia, Pa.
WELSH, Harry S.,* (1906), Pres., The Boiler & Radiator Corp., 999 E. Main St., and 37 Flower City Park, Rochester, N. Y.
WELTER, Michael A., (Associate 1925), M. A. Welter & Co., (for mail), 2118 Lyndale Ave., S., and 4306 Garfield Ave., S., Minneapolis, Minn.
WENDT, Edgar F., (1918), Vice-Pres. and Treas., (for mail), Buffalo Forge Co., 490 Broadway, and 731 Lafayette Ave., Buffalo, N. Y.
WENDT, Henry W., (1917), Pres., (for mail), Buffalo Forge Co., 490 Broadway, and 120 Lincoln Parkway, Buffalo, N. Y.
WESCHLER, George A., (1923), Consulting Engr., and Prof. of Mech. Engrg., (for mail), 1010 Vermont Ave., and 2803 13th St., N.W., Washington, D.C.
WEST, Perry,* (1911), (Council 1920-1925; Treas. 1924-1925), Consulting Engr., (for mail), 13 Central Ave., and 322 Park Ave., Newark, N. J.
WHEELER, Charles W., (1916), Br. Mgr., (for mail), C. A. Dunham Co., 1104 May Bldg., Pittsburgh, and R. R. No. 1, Allison Park, Pa.
WHEELER, Otto J., (1923), Mgr. and Secy., The Samuel A. Esswein Htg. & Plumbing Co., 548 W. Broad St., and 504 Linwood Ave., Columbus, O.
WHELAN, William J., (1923), Harrigan Reid, 1705 First St., Detroit, Mich.
WHELLER, Harry S., (1916), Vice-Pres., L. J. Wing Mfg. Co., 352 West 13th St., New York, N. Y., and (for mail), 230 Stiles St., Elizabeth, N. J.
WHITAKER, Ernest C., (1925), Chief Engr., Buerkel & Co., Inc., 24 Union Park St., Boston, and (for mail), 35 Sherborn St., Arlington, Mass.
WHITBY, Stephen S., (Associate 1922), Treas., Culbert & Whitby Co., Inc., 2019 Rittenhouse St., Philadelphia, Pa., and *(for mail)*, 208 Yale Rd., Audubon, N. J.
WHITE, Elwood S., (1921), Pres., Thermal Appliance Co., 342 Madison Ave., and 21 Washington Sq., New York, N. Y.
WHITE, Everett A., (1921), Head of Engrg. Dept., Crane Co., 30 South 16th St., and 4611 Delor St., St. Louis, Mo.
WHITE, M. G., Jr., (1925), 128 Welan St., Brooklyn, N.Y.
WHITE, Walker G., (Associate 1925), Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.
WHITLEY, James, (1919), *Consulting Engr.*, Whiteley & Sanders, 3000 Grand River Ave., and 520 Navahoe Ave., Detroit, Mich.
WHITTEMORE, Edward H., (1920), Engr., (for mail), *Stone & Webster, 147 Milk St., Boston*, and 96 Church St., W. Roxbury, Mass.
WHITTEN, H. E., (1924), Pres. and Treas., (for mail), H. E. Whitten Co., 9 Federal Circuit, Boston, and *56 Highland Rd., W. Somerville*, Mass.
WHITTEN, Herbert W.,* (Associate 1908; 1909), *Htg. and Mech. Engr.*, Chamberlin Metal Weather Strip Co., 1644 Lafayette Blvd., W., Detroit, Mich.
WHOMES, Harry, (1926), 3269 N. Penna. St., Indianapolis, Ind.
WHY, H. Berkeley, (1919), Construction Engr., 312 Earlham Terrace, Germantown, Philadelphia, Pa.
WIDDICOMBE, R. A., (1903), 1120 Lake Shore Drive, Chicago, Ill.
WIEGNER, Henry B., (1919), Mgr., (for mail), Johnson Service Co., 31 Waltham St., Boston, and 77 Chester Rd., Belmont, Mass.
WIGGS, Gordon L., (Junior 1924), Mech. Engr., (for mail), Mechanics Supply Co., 80-90 St. Paul St., and 94 De Salaberry St., Quebec, P. Q.
WIGLE, Bruce M., (Associate 1926), Owner, Bruce Wigle Plumbing & Htg. Co., 9117 Hamil*ton Ave.*, and 855 Clairmont Ave., Detroit, Mich.
WILD, Walter H., (Associate 1921), Mfgrs. Agent, (for mail), 1212 Land Title Bldg., Philadelphia, and 122 Cynwyd Rd., Bala, Pa.
WILDE, Ray S. M., (1916), Consulting Engr., (for mail), 1216 Michigan Theatre Bldg., Detroit, and 194 *Connecticut Ave., Highland Park*, Mich.
WILDER, Edward L., (1915), Mgr. Industrial Sales Dept., (for mail), Rochester Gas & Electric Corp., 89 East Ave., and 16 Ericsson St., Rochester, N. Y.
WILEY, Charles S., (1921), Htg. and Vtg. Engr., *(for mail)*, Eastman Kodak Co., Kodak Park, and 239 Mulberry St., Rochester, N. Y.
WILEY, Edgar C., (1909), Consulting Engr., Wiley & Wilson, *Lynchburg*, Va.
WILLARD, Arthur C., (1914), (2nd Vice-Pres. 1926; Council 1925-1926), Prof. Htg. and Vtg., and Head of Dept. of Mech. Engrg., (for mail), University of Illinois, and 1208 W. *California* St., Urbana, Ill.
WILLIAMS, Allen W., (Associate 1915), Secy., National Warm Air Htg. & Vtg. Assn., 174 E. Long St., Columbus, O.
WILLIAMS, Jesse M., (Associate 1925), Pres., (for mail), Williams Radiator Co., 1864 W. Washington St., and 861 Harcourt Ave., Los Angeles, Calif.
WILLIAMS, John McFarland, Jr., (Junior 1927), Sales Engr., Pierce, Butler & Pierce Mfg. Co., Guilford Ave. and Saratoga St., and *(for mail)*, 2401 Garrison Ave., Baltimore, Md.
WILLIAMS, J. Walter, (1915), Pres. and Treas., Forest City Plumbing Co., 332 E. State St., Ithaca, N. Y.
WILLIAMS, Oliver L., (Associate 1925), Br. Mgr., (for mail), Bryant Heater & Mfg. Co., 1305 E. End Trust Bldg., and 814 N. Negley Ave., Pittsburgh, Pa.
WILLIAMS, Robert Eubank, (1926), Consulting Engr., *(for mail)*, 308 Home Insurance Bldg., and 2427 Broadway, Little Rock, Ark.
WILLIAMSON, Arthur H., (Associate 1915), Sales Mgr., (for mail), American Radiator Co. of Michigan, *Broadway and Grand River Ave.*, Barlum Bldg., and 2272 Glynn Court, Detroit, Mich.
WILLIAMSON, Fred W., (1914), Consulting Engr., 1418 East 34th St., Brooklyn, N. Y.
WILLIAMSON, George R., (1920), Sales Engr., The Mouat Vapor Heating Co., 1246 W. Fourth St. and 10113 Barton Ave., Cleveland, O.
WILLIS, Frederick H., (1921), Chief Engr., (for mail), W. N. Bowman Co., 612 Insurance Bldg., and 1110 Jackson St., Denver, Colo.
WILLIS, Roy C., (1927), Vice-Pres. and Secy., *(for mail)*, Vapor Engrg. Co., 489 Fifth Ave., and 227 Audubon Ave., New York, N. Y.
WILMOT, Chas. S., (1919), Phoenixville, Pa.
WILSON, Benjamin W., (1922), Htg. and Vtg. Engr., *(for mail)*, The Ballinger Co., S.E. Cor. 12th and Chestnut Sts., and 5935 Windsor Ave., W. Philadelphia, Pa.
WILSON, Charles H., (1920), Htg. and Vtg. Engr., Fuller & Warren Co., 1403 Park Blvd., Troy, N. Y.

WILSON, Ernest J. F., (1923), Partner, Wiley & Wilson, Consulting Engrs., 801 Main St., and Oakwood Place, Lynchburg, Va.
WILSON, Eugene K., (1919), Wilson & Co., (for mail), 1017 Duke St., and 12 Lafayette Blvd., Norfolk, Va.
WILSON, F. A., (1910), 20945-110 Ave., Bellair, L. I., N. Y.
WILSON, George T., (1925), Gurney Foundry Co., Ltd., 500 King St., Toronto, and (for mail), Tyre Ave., Islington, Ont., Can.
WILSON, Harry A., (1903), Box 1903, Washington, R. I.
WILSON, Howard M., (Associate 1925), Br. Mgr., (for mail), Standard Heater Co., 136 Federal St., Boston, and 15 Chestnut St., Wellesley Hill, Mass.
WILSON, J. J., (Charter Member), Consulting Engr., Most Supply Co., Fourth and Girard Ave., and (for mail), 5514 Paschall Ave., Philadelphia, Pa.
WILSON, William H., (Associate 1923), Wis. Mgr., (for mail), Johnson Service Co., 149-159 Michigan St., and 431 Olive St., Milwaukee, Wis.
WILSON, William S., (Associate 1924), Mgr. Lands Dept., The Lake Superior Corp., and 210 McGregor Ave., Sault Ste. Marie, Ontario, Can.
WINCH, Franklin R., (1925), Consulting Engr., (for mail), 1031 Broadway, and 5462 Carlin St., Los Angeles, Calif.
WINTERBOTTOM, John W., (1915), Vice-Pres. and Engr., Lock Box 2045, Sta. A., Waterloo, Ia.
WINTERBOTTOM, Ralph F., (Associate 1923), Mgr., Faultless Heater Mfg. Co., and (for mail), P. O. Box 2217, Sta. A, Waterloo, Ia.
WINTERER, Frank C., (1920), Htg. Dept., (for mail), Cochran-Sargent Co., Fifth and Sibley Sts., and 836 Juno St., St. Paul, Minn.
WINTERER, Raymond J., (1919), Mgr. Htg. Dept., Crane & Ordway Co., Fifth and Rosabel Sts., and (for mail), 197 S. Fairview St., St. Paul, Minn.
WISE, Frank W., (Associate 1918), Sales Engr., (for mail), General Boilers Co., 615 City Bk. Bldg., and 2751 Charlotte St., Kansas City, Mo.
WISE, Mason W., (1923), Prop., (for mail), M. W. Wise Co., 215 Glenn Bldg., and R. F. D. No. 2, Atlanta, Ga.
WITTLEDER, Edward A., (Junior 1926), Mech. Draftsman, Narowetz Htg. & Vtg. Co., 1711-17 Maypole Ave., and (for mail), 3429 Medill Ave., Chicago, Ill.
WOLF, J. C., (1923), Bayley Mfg. Co., 1367 Stowell Ave., Milwaukee, Wis.
WOLFF, Oscar H., (1926), Salesman, Hoffman Specialty Co., 1819 S. Newstead Ave., St. Louis, Mo.
WOLFF, Richard A., (Junior 1915;1919), Pres., (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and Hewlett, L. I., N. Y.
WOLFSFELD, Charles F., (1923), Chief Draftsman, Board of Education, Flatbush Ave. and Concord St., Brooklyn, and (for mail), Vista Ave., Bayside, L. I., N. Y.
WOOD, James Sydney, (1926), Estimator, (for mail), The Bennett & Wright Co., Ltd., 72 Queen St., E., Toronto, Ont., Can.
WOODLING, Miner D., (1926), Prop., (for mail), Miner D. Woodling Htg. & Vtg. Co., 428-30 Dwight Bldg., and 301 West 51st Terrace, Kansas City, Mo.
WOOLLEY, Thos. R., (1916), Sales Engr., Woolley Engineering Co., 2457 Woodward Ave., and (for mail), 3267 Tyler Ave., Detroit, Mich.
WOOLSTON, Alfred H., (1919), Member of Firm, (for mail), Bowers Bros. & Co., 2015 Sansom St., and 4815 North 12th St., Philadelphia, Pa.
WOOLSTON, C. Elmer, (1924), Bowers Bros. & Co., 2015 Sansom St., Philadelphia, Pa.
WORM, Amdi, (Associate 1924), Factory Repr., Flaxlinum Insulating Co., 1425 Grand Ave., and (for mail), 2424 East 68th St., Kansas City, Mo.
WORTH, William Ellison, (Associate 1927), Industrial Engr., (for mail), Minneapolis Heat Regulator Co., 5036-40 Grand Central Terminal, New York, and Apt. 6A, Pelham Gables, Pelham, N. Y.
WORTHING, E., (1923), Bayley Mfg. Co., 732 Greenbush St., and 56 Prospect St., Milwaukee, Wis.
WRIGHT, Charles Leslie, (1925), Mgr., Htg. and Vtg. Dept., (for mail), Geo. E. Gibson Co., Inc., 441 Lexington Ave., and 54 West 94th St., New York, N. Y.
WRIGHT, Harris H., (1917), Mgr., C. A. Dunham Co., Pacific Steel Boiler Co., 207 Davidson Bldg., and 1214 E. Gillham Rd., Kansas City, Mo.
WRIGHT, John C., (1926), Associate, Fletcher H. Burke—John C. Wright—Associate, 392 Franklin St., Buffalo, N. Y.
WRIGHT, Kenneth A., (1921), Mgr., (for mail), Johnson Service Co., 1113 Race St., Cincinnati, O., and 113 Orchard Rd., Ft. Mitchell, Ky.
WUNDERLICH, Milton S., (1925), Mech. Engr., Flaxlinum Insulating Co., Hampden and Wabash, (for mail), 1598 Laurel Ave., St. Paul, Minn.
WYLIE, Howard McW., (1917; 1925), Vice-Pres., In charge of Sales, (for mail), The Nash Engrg. Co., and 51 Elmwood Ave., South Norwalk, Conn.

Y

YAGER, John J., (1921), Pres. and Gen. Mgr., Goergen-Mackwirth Co., Inc., 817 Sycamore St., and (for mail), 272 Carlton St., Buffalo, N. Y.
YAGLOU, Constantin P.,* (1923), Instructor in Vtg. and Illumination, (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston 17, Mass., and 213 Aspinwall Ave., Brookline, Mass.
YAMASAKI, Kanjiro, (Associate 1923), Htg. Engr., Daiwa Kogyo Co., Ltd., First Mutual Bldg., Rm. 216, No. 53 chome Denmacho, Kyobashi-Ku, Tokio, Japan.
YARDLEY, Ralph W., (1920), Asst. Supt. of Construction, Ill. Penitentiary Comm., 717 Heggie Bldg., Joliet, and (for mail), 817 N. Dearborn St., Chicago, Ill.
YATES, Walter, (1902), Managing Dir., Matthews & Yates, Ltd., Swinton, Manchester, Eng.

Z

ZECK, Alex., (1904), Pres., Alex Zeck & Son Co., Morgantown, W. Va.
ZIEL, Herbert E., (1924), Albert Kahn, 1000 Marquette Bldg., Detroit, Mich.
ZINGSHEIM, George Godfrey, (1927), Br. Mgr., Richardson & Boynton Co., 301 N. Seventh St., and (for mail), 4011 Pleasant Ave., Minneapolis, Minn.
ZOKELT, C. G., (1921), (for mail), Northwest Engrg. Co., 414 Central Bldg., and 2355 16th Ave., S., Seattle, Wash.
ZORB, Henry Phillip, (1927), Master Fitter, (for mail), 2620 Fourth Ave., and 2334 Oakdale Ave., Detroit, Mich.
ZUEHLKE, Rudolph, (1923), (for mail), Zuehlke-Stoehr Htg. Co., 1701 Clybourn St., Milwaukee, and 579 15th Ave., Wauwatosa, Wis.

Summary of Membership

(Corrected to July 15, 1927)

UNITED STATES

Alabama	4	Missouri	106
Arkansas	1	Montana	3
California	22	Nebraska	7
Colorado	22	New Jersey	73
Connecticut	23	New York	392
Delaware	4	North Carolina	6
District of Columbia	7	Ohio	81
Florida	7	Oklahoma	5
Georgia	14	Oregon	1
Illinois	255	Pennsylvania	289
Indiana	31	Rhode Island	8
Iowa	14	Tennessee	8
Kansas	9	Texas	9
Kentucky	6	Utah	2
Maine	5	Vermont	3
Maryland	20	Virginia	19
Massachusetts	105	Washington	19
Michigan	118	West Virginia	5
Minnesota	50	Wisconsin	50
Mississippi	2		
			1805

FOREIGN COUNTRIES

Canada	68	Mexico	1
China	7	New Zealand	1
Denmark	3	Norway	1
England	17	Russia	1
France	4	Sweden	1
Germany	1	Switzerland	1
Ireland	1		
Japan	6		113

Total Membership 1918

SUMMARY OF MEMBERSHIP BY GRADES

Honorary Members	1
Presidential Members	20
Members	1413
Associate Members	343
Junior Members	141
	1918

LIST OF MEMBERS

Arranged Geographically

UNITED STATES

ALABAMA

Birmingham—
Boisclair, H. C.
Bunnell, E. W.
Festorazzi, A. O.
Lichty, C. P.

ARKANSAS

Little Rock—
Williams, R. E.

CALIFORNIA

Alhambra—
Arthur, H. W.
Stockly, H. A.

Huntington Park—
Berg, A. H.

Berkeley—
Duncan, G. W., Jr.

Glendale—
Dougherty, P. J.

Los Angeles—
Butler, C.
Davis, W. A.
Larimer, G. B.
Miller, R. A.
Nelson, H. A.
Ott, O. W.
Russel, D. P.
Williams, J. M.
Winch, F. R.

Oakland—
Cummings, G. J.

Pasadena—
Gifford, R. L.

San Francisco—
Haley, H. S.
Krueger, J. I.
Leland, W. E.
Penhallegon, R. O.
Thompson, C.

San Mateo—
Mead, W. R.

COLORADO

Denver—
Adams, C. W.
Bagnall, G. A.
Bradbury, G. L.
Brickey, J. P.
Cullyford, F. S.
Daly, J. H.
Deranleau, R. L.
Fielding, H. H.
Foley, W. J.
Gillespie, R. B.
Herman, H. H.
Larimer, W. M.
Michael, L. A.
Price, F. E.
Voigt, C. O.
Wallace, A.
Wallace, J. F.
Ward, O. G.
Willis, F. H.

Colorado Springs—
Bumstead, F. E.
Jardine, D. C.

Glenwood Springs—
Stoltenberg, T. R.

CONNECTICUT

Bridgeport—
Clement, E. R.

Cos Cob—
Jones, A. L.

Hartford—
Byrnes, T. F.
Moltz, G. N.
Purcell, A. J.

New Britain—
Cadwell, W. H.

New Haven—
Dibble, A. B.
Foisy, G. A.
Hoyt, W. B.
Jenkins, H. E.
Lockwood, E. H.
Menzies, F. R.

New London—
Forsberg, W.
Hopson, W. T.

Noroton Heights—
Ashley, E. E.

S. Norwalk—
Harvey, A. D.
Jennings, I. C.
Mead, E. A.
Wylie, H. M. W.

Springdale—
Broderick, J. F.

Waterbury—
Simpson, W. K.

Winsted—
Griffin, P. C.
Hutton, W.

DELAWARE

Wilmington—
Gawthrop, F. H.
Kershaw, M. G.
Lownsbery, B. F.
Schoenijahn, R. P.

DISTRICT OF COLUMBIA

Washington—
Coward, H.
Gardner, S. F.
Goldstein, A. M.
Mewshaw, J. P.
Stock, E. L.
Thompson, N. S.
Weschler, G. A.

FLORIDA

Jacksonville—
Denson, W.
Irwin, C. W.
Olsen, A. J.

Orlando—
Kressly, M. E.

Tampa—
Chapman, D. W
Smith, V. A.

Winter Haven—
Thomas, B. A.

GEORGIA

Atlanta—
Alger, R. W.
Baker, I. C.
Carder, W. W.
Clare, F. A.
Guest, P. L.
Kent, L. F.
Klein, E. W.
Lichty, A. J.
Pottinger, C. T.
Rhodes, S. V.
Wise, M. W.

Columbus—
Dexter, MacD.
Hartpence, C. C.

Gainesville—
Jackson, J. W.

ILLINOIS

Belleville—
Karr, T., Jr.

Berwyn—
Kitch, S. B.

Bloomington—
Howell, L.
Soper, H. A.

Champaign—
Brownell, C. D.

Chicago—
Abrahamson, P.
Allan, C. D.
Allen, H. D.
Amstein, A. W.
Andel, F. J.
Arenberg, M. K.
Armspach, O. W.
Ashenhurst, H. S.
Atkinson, R. E.
Baker, E. V.
Barrows, C. E.
Beery, C. E.
Beling, E. H.
Bennett, P. D.
Birkholz, H. A.
Birkholz, H. E.
Black, F. C.
Bloom, S. C.
Boswin, G. A.
Braun, L. T.
Brayton, W. M.
Brown, A. P.
Burger, J. C.
Burke, G. B.
Burns, W. A.
Burt, H. J.
Carnahan, G. C.
Cartland, S.
Casey, B. L.
Casserly, T. D.
Chenoweth, W. H.
Cheyney, C. C.
Claffey, E. J.
Clark, H. J.
Clow, M. T.
Cornell, H.
Coughlin, R. J.
Crannell, C. A.
Crawford, W. B.
Crone, C. E.
Cutler, J. A.
Cutter, E. H.
Davis, J. H.
Deland, C. W.
Dewar, J. G.
Dickinson, C. E.
Doherty, J.
Douglass, T. C.
Dunham, C. A.
Ebin, L.
Ellis, W. C.
Emmert, L. D.

Faber, G. S.
Fenner, N. P.
Finan, E. J.
Finan, J. J., Sr.
Fleming, J. P.
Frank, J. M.
Funck, E. H.
Gardner, W., Jr.
Gaylord, F. H.
Gemeny, W. J.
Getschow, G. M.
Getschow, R. M.
Gilmore, R. E.
Good, M. S.
Gordon, E. G.
Gossett, E. J.
Graham, W. D.
Graves, C. C.
Graves, W. B.
Grebe, H. W.
Gross, R. A.
Gustafson, T. E.
Haas, S. L.
Haines, J. J.
Hale, J. F.
Halliday, L.
Hansen, J.
Hart, H. M.
Hart, T. H.
Hartman, F. E.
Hattis, R. E.
Hayes, J. J.
Hayward, R. B.
Heck, G. L., Jr.
Heckel, E. P.
Hennings, W. A.
Henrich, G. A.
Herbaczek, E.
Herlihy, G. F.
Herlihy, J. J.
Hill, E. V.
Hoier, W. V.
Hoover, H. E.
Hornung, J. C.
Horton, H. F.
Howatt, J.
Hubbard, G. W.
Impey, P. F.
Jackson, C. J.
Jaynes, E. L.
Jenson, J. S.
Johnson, C. W.
Jones, E. F.
Jones, H. B.
Kaiser, H. S.
Keeney, F. P.
Kehm, A.
Keyes, R. E.
Kirk, G. H.
Kohlbry, E. G.
Kreissl, H. G.
Kroeger, A.
Lagodzinski, H. J.
Lang, L. P.
Larson, J. M.
Larson, W. C.
Lathrop, Dr. E. C.
Lautenschlager, F.
Lees, H. K.
Lenone, J. M.
Lewis, S. R.
Lippe, E. V.
Lippman, O. S.
Luce, G. D., Jr.
McCauley, J. H., Jr.
McClellan, J. E.
McDonnell, E. N.
McEvoy, W. J.
McFarland, W. P.
McGregor, G. H.
McLelland, H. B.
Maier, H. F.
Malone, D. G.
Marschall, P. J.
Martin, A. B.
Martin, O. W.
Matchett, J. C.
Mathis, E.
Mathis, H.
Mathis, J. W.
Mathy, J., Jr.
Mehring, G.
Mertz, W. A.
Miller, F. A.
Miller, J. E.
Miller, L. B.
Milliken, J. H.
Moler, W. H.
Monaghan, T. H.
Montgomery, W. R.
Moran, F. E.
Muth, H.
Nacey, H. M.
Narowetz, L. L., Jr.
Neiler, S. G.
Nesdahl, E.
Newport, C. F.
Norman, M. A.
Nilson, A.
Nilson, K. A.
Nulsen, C. A.
O'Brien, J. H.
Olsen, C. F.
Olson, A. E.
Orr, F. B.
Pask, R. J.
Pearson, F. L.
Pence, M. D.
Pitcher, L. J.
Pope, S. A.
Pope, W. A.
Powers, F. W.
Prentice, P. J.
Presdee, C. W.
Reid, H. P.
Reynolds, H. A.
Rietz, E. W.
Rollins, F. D.
Rosenbach, R. G.
Ross, J. F.
Saunders, J. C.
Scheidecker, D. B.
Seelig, L.
Seltzer, A. P.
Shea, J. R.
Sheriffs, W. A.
Shultz, E.
Skagerberg, R.
Small, J. D.
Soper, I. N.
Spielman, G. P.
Sprague, F. H.
Stannard, J. M.
Stedman, C. N.
Stockenberg, R.
Storm, E. S.
Sutcliffe, A. G.
Thinn, C. A.
Thomas, R. H.
Truitt, J. E.
Trumbo, S. M.
Vernon, J. R.
Walsh, A. F.
Walters, V.
Walters, W. T.
Walther, V. H.
Watson, J. H.
Watson, R. E.
Weil, M.
Weinshank, H. T.
Weinshank, T.
Widdicombe, R. A.
Wittleder, E. A.
Yardley, R. W.

Decatur—
Shorb, W. A.

Edwardsville—
Blackmore, F. H.

Evanston—
Cuyler, D. H.
Kilby, R. E.
Mauer, W. J.
Thomas, H. G.

Joliet—
Menk, R. W.

Kewanee—
Baker, E. E.
Bronson, C. E.
Dickson, R. B.
Hartman, J. M.
Pursell, H. E.

LaGrange—
Eaton, B. K.
Linn, H. R.

Lakeview—
Toenniges, G. C.

Moline—
Brady, J. L.
Nelson, H. W.
Nordine, L. F.
Otis, G. E.
Tyler, F. T.

Oak Park—
Alexander, A. D.
Barnes, R. B.
Blanding, G. H.
May, E. A.
Muir, G. A.
Uhlhorn, W. J.

Peoria—
Robb, J. M.

Rockford—
Merwin, G. E.

Urbana—
Day, V. S.
Fahnestock, M. K.
Kratz, A. P.
Willard, A. C.

Waukegan—
Reynolds, H. M.

Winnetka—
Ellis, E. E.

INDIANA

Elkhart—
Shreiner, D. C.

Evansville—
Bergner, W. G.
Legeman, R. E.

Jeffersonville—
Hancock, J. R.

Fort Wayne—
McCarthy, B. J.

Indianapolis—
Ammerman, C. R.
Cones, Benj.
Dresen, W. D.
Fenstermaker, S. E.
Hagedon, C. H.
Hayes, J. G.
LaFollette, B. F.
Perham, S. H.
Repp, H. L.
Rotz, J. M.
Shipp, C. C.
Stitt, H. B.
Voorhees, G. A.
Warren, C. N.
Whomes, H.

Lafayette—
Hoffman, J. D.
Noland, R. W.
Orth, J. W.

La Porte—
Shrock, J. H.

Michigan City—
Stockwell, W. R.

Muncie—
Hutzel, M. H.
Hutzel, V. C.

Peru—
Pyle, J. W.
Thrush, H. A.

South Bend—
Leusch, V. W.

Terre Haute—
Prox, R. F.

IOWA

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Nelson, G. O.

Cedar Rapids—
Moore, R. F.
Motejl, J. A.

Davenport—
Phelps, H. R.

Des Moines—
Bogardus, G. W.
Somers, W. S.

Dubuque—
Meston, A. B.

Fort Madison—
Theisen, E. F.

Le Mars—
Mathey, N. J.

Sioux City—
Hagan, W. V.
Orr, M. J.

Waterloo—
Bartley, J. S., Jr.
Winterbottom, J. W.
Winterbottom, R. F.

KANSAS

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Burnap, C. W.

Hiawatha—
Barnes, A. R.

Hutchinson—
Hertz, H. P.
Paulsen, C. E.
Stevens, H. L.

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Sellars, F. J.

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Holmberg, J. A.

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Cloud, O. E.
O'Connor, J. M.

KENTUCKY

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MAINE

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Woodfords—
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Huether, C. G. L.
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McCrea, L. W.
Meyers, J.
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Thain, A. E.
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Williams, J. M., Jr.

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Cooley, M. S.

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Brunett, A. L.

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Boynton, D. W.
Brinton, J. W.
Brooks, T. C.
Brown, R. H.
Bryant, Dr. A. G.
Cooper, F. I.
Cummings, C. K.
Dolan, W. H., Jr.
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Duquet, A. M.
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McKenna, Wm. N.
McLean, I. D.
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Mower, W. P.
Myrick, J. W. H.
Osborne, M. M.
Preble, J. J.
Price, W. H., Jr.
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Shaw, R. E.
Smallman, W. T.
Stearns, W. F.
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Stone, E. R.
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Thompson, R. C.
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Moulton, D.

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Granfield, J. J.

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Gallaher, A. J.
Graves, R. E.
Gunn, J. F.
Hallett, E. S.
Halley, W. H.
Harris, H. W.
Helwig, G. A.
Hester, T. J.
Humphreys, A. E.
Kaysing, H. C.
Keiser, W.
Kinealy, J. H.
Lane, A. M.
Langenberg, E. B.
Manahan, J. E.
Meara, J. J.
Merrell, S. A.
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Milward, R. K.
Moon, L. W.
Niestrath, W. H.
Picker, F. C.
Pickett, C. A.
Quentin, E. H.
Rickly, F. A.
Robertson, J. M.
Rosebrough, R. M.
Rossman, V. D.
Russell, W. L. A.
Sachleben, E. H.
Schulze, B. H.
Sodemann, W. C.
Stack, M. F.
Stammer, E. L.
Steckhan, L.
Thomsen, W. T.
Walters, A. L.
White, E. A.
Wolff, O. H.

MONTANA

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Tooker, C. C.

Bozeman—
Powers, F. I.

NEBRASKA

Hastings—
Gedney, K. H.

Omaha—
Davidson, H. MacD.
Hayes, P. M.
McCulley, D. E.
Shea, M. B.
Waddington, B. C.

Scottsbluff—
Davis, O. E.

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Audubon—
Whitby, S. S.

Beverly—
Mann, C. P.

Bloomfield—
Bartlett, C. D.
Hochuli, H. W.
Taylor, T. S.

Bogota—
Heebner, W. M.

Camden—
Kappel, G. W. A.
Lanning, E. K.
Strandwitz, W. J.
Webster, E. K.
Webster, W.
Webster, W., Jr.

Cranford—
Terrell, H. A.

East Orange—
Bolling, Esten
Merkel, F. P.
Schroth, A. H.
Turno, W. G. W.

Elizabeth—
Cornwall, G. T.
Pearce, C. E.
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Essex Fells—
Carrier, W. H.
Stacey, A. E., Jr.

Glen Ridge—
Chapman, F. T.

Glen Rock—
Hall, C. H.

Gloucester—
Schrader, C. C.

Grantwood—
Butler, P. D.

Haddonfield—
Dobbs, C. E.

Hasbrouck Heights—
Goodwin, S. L.

Hilton—
Heiles, F. C.

Jersey City—
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Jones, H. L.
Reichwald, C. W.
Ritchie, W.

Jobstown—
Allinson, O. H.

Kearney—
Vogelbach, O.

Lyndhurst—
Ehrlich, M. W.
Knapp, A. F.

Maplewood—
Smith, M. S.

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Binder, C. G.

Montclair—
Frutchey, M. P.
Tomlinson, M. C. W.

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Bailey, J. H.
Bentz, H.
Connolly, C. I.
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Hunt, P. M.
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Kieb, A. A.
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Lyle, J. I.
McCormick, E. T.
Noble, M.
Soule, L. C.
West, Perry

Passaic—
Boeker, C. H.
Hankin, R.
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Paterson—
Pryor, F. L.

Plainfield—
MacDougall, B. W.
Rech, P. D.
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Bilyeu, W. F.
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Black, J. J. A.
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Crutchley, E., Jr.
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Dyer, W. S.
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Frank, O. E.
Frankel, G.
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Wendt, H. W.
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Ellison, J. H.

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Herendeen, F. W.
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Millbrook—
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Ohmes, A. K.
Olvany, W. J.
Oswald, W. L.
Parkhill, D.
Parter, S. C.
Patorno, S. A. S.
Paulding, L. G.
Peacock, J. K.
Petersen, G.
Pfeiffer, B. J.
Pfuhler, J. L.
(W. New Brighton, S. I.)
Pinder, P. H.
Place, C. R.
Pryor, R. W., Jr.
Purinton, D. J.
Quirk, C. H.
Raisler, L.
Raisler, S.
Ralston, L. T. M.
Reed, J. F.
Reynolds, T. W.
Riblet, W. H.
Richardson, D. R.
Riley, C. L.
Ritchie, E. J.
Ritter, A.
Rodman, R. W.
Ross, J. O.
Ruggles, R. F.,
(Tompkinsville, S. I)
Russell, W. A.
Samuels, S.
Schloss, N. L.
Schmidt, G. G.
Schneider, C.
Scott, C. E.
Scott, E. A.
Scott, G. M.
Seelig, A. E.
Sellman, N. T.
Senior, R. L.
Siegel, J. F.
Simpson, W. A.
Snyder, C. B. J.
Spofford, H. H. R.
Spooner, H. R.
(Hollis, L. I.)
Staples, W. H.
Steinke, G. B.
Steinmuller, J. H.
(Long Island City)
Stern, H. R.
Sternberg, I. E.
Stewart, C. W.
Still, F. R.
Sullivan, D. A.
Swain, W. A.
Sweeney, S. H.
Tallmadge, W.
Thomson, T. N.
(Huntington, L. I.)
Timmis, P.
Timmis, W. S.
Timmis, W. W.
(Glen Cove)
Titzell, J. E.
Tucker, F. N.
Van Norden, E. M.
Vogt, J. H.
Walker, W. K.
Wallace, G. J.
Walsh, J. H.
Walsh, M.
Waltherthum, J. J.
Ward, G. E.
Watters, P. J.
(Port Richmond, S. I.)
White, E. S.
White, M. G.
White, W. G.
Willis, R. C.
Wilson, F. A.
(Bellair, L. I.)
Wolff, R. A.
Wolfsfeld, C. F.
(Bayside, L. I.)
Worth, W. E.
Wright, C. L.

N. Tonawanda—
Benedict, E. R.
Kline, W. J.
Slade, A. J.

Ogdensburg—
Skelly, J. F.

Port Chester—
Donovan, J. E.
Pratt, E. D.

Poughkeepsie—
Doherty, J. J.
Valentine, H. D.

Rochester—
Archer, F. S.
Aronwits, W.
Axeman, J. E.
Beasom, G. R.
Coe, I. B.
Coe, R. T.
Devendorf, W. F.
DeWolf, R. D.
Dobson, G. G.
Roebuck, W., Jr.
Sheldon, N. E.
Steim, C. J., Jr.
Weider, F. J.
Welsh, H. S.
Wilder, E. L.
Wiley, C. S.

Saranac Lake—
Miller, P.

Scarsdale—
Grotz, A. B.
Janes, A.
Longwell, H. E.

Schenectady—
Harbison, E. J.
Vogel, A.

Snyder—
Langley, F. P.

Syracuse—
Acheson, A. R.
Bradley, R. H.
Dennis, C. K.
Duncan, J. M.
Gildea, T. E.

Tuckahoe—
Nichols, G. B.

Troy—
Wilson, C. H.

Utica—
Brandeles, H. J.
Cantwell, W. T.
DeRosa, A.
Hamjy, P. W.
Hughes, W. C.
Norris, E.
Norris, J. K.
Schneider, P. W.
Steinhorst, T. F.

Wanakah, Erie Co.—
Kamman, A. R.

West Point—
Bryant, P. J.

White Plains—
Callahan, T. H.

Yonkers—
Brabbee, Dr. C.
Kelly, J. G.
Rainger, W. F.

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Hackney, H.

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Weldon—
Chappell, T. A.

Winston-Salem—
Bahnson, F. F.

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Sproull, H. E.
Wright, K.

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Starks, V. E.
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Babbitt, E. F.
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Nesbitt, J. J.
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Perkins, F. C.
Phillips, F. T.
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Reuss, E. H., Jr.
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Roberts, H. L.
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Shaw, C. E.
Sheffler, M.
Sommer, L. J., Jr.
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Stearns, W. I.
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Sutterley, W. W.
Taliaferro, R. R.
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Thompson, W. P.
Tinker, W. E.
Wagner, J. P.
Walther, H. J.
Wandless, F. W.
Wegmann, A.
Welamb, V. N.
Why, H. B.
Wild, W. H.
Wilson, B. W.
Wilson, J. J.
Woolston, A. H.
Woolston, C. E.

Phoenixville—
Wilmot, C. S.

Pittsburgh—
Aston, J.
Bowman, H. A.
Brauer, R.
Bushnell, C. D.
Chester, T.
Clark, F. C.
Clark, W. H.
Comstock, G. M.
Dibble, S. E.
Digby, H. E.
Edwards, P. A.
English, A. T.
Evans, E. C.
Firsching, F. J.
Gunther, F. A.
Hanson, E. W.
Harper, S. H.
Heilman, R. H.

Hitner, F. M.
Hook, C. H.
Houghten, F. C.
Ingels, M.
King, T.
Langdon, J. D.
Lloyd, E. C.
McGinness, J. E.
McGuigan, L. A.
McKenzie, P. C.
McIntosh, F. C.
McMurray, J.
Maginn, P. F.
Moore, H. L.
Morgan, J. S.
Morrow, C. F.
Nicholls, P.
O'Neill, P.
Phillips, L.
Rederer, B. S.
Richards, S. F.
Schley, A. A.
Speller, F. N.
Stanger, R. B.
Stitt, E. W.
Stokes, R. E.
Todd, J.
Waldron, C. W.
Walker, J. B.
Weber, G. A.
Wheeler, C. W.
Williams, O. L.

Reading—
Luck, A. W.
Nicely, J. E.
Reese, H. L.

Ridley Park—
Bartlett, C. E.
Davis, B. W.

Scranton—
Gaulin, R. P.
Gilboy, J. P.
Saville, T. H.

Sewickley—
Black, G. E.

Shamokin—
Gortner, J. W.

Swarthmore—
Clarke, H. W.

Swissvale—
Timmerman, M. M.

Tamaqua—
Hadesty, A. L., Jr.

Upper Darby, P. O.—
Hackett, C. P.
Hoisington, N. P.
Pisel, J. W.

Warren—
Schellhammer, A. L.

Washington—
McVehil, E. W.

West Chester—
Palmer, G. J.

Wilkinsburg—
Rasmussen, E.

Williamsport—
Chambers, W. E.
Klotz, A. W.
McLain, R. D.
Pfeiffer, J. F.

Willow Grove—
Slight, I.

Wissahickon—
Peterman, R. M.

Wormleysburg—
Miller, T. G.

York—
Lindemuth, N. R.
Sowers, P. E.

Zelienople—
Eberle, C. F.

RHODE ISLAND

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Coleman, J. B.
Dunlevy, T. R.
Gibbs, E. W.
Hartwell, J. C.
Husband, E. W.
Poole, E. F.

Pawtucket—
Martin, J. F.

Washington—
Wilson, H. A.

TENNESSEE

Chattanooga—
Russell, H. C.

Knoxville—
Reeder, F. C.

Memphis—
Allen, W. H.
Bevil, A. T.
Brewster, D. R.
Sodemann, P. W.

Nashville—
Brown, F.
Hailey, S. H.

TEXAS

Amarillo—
Helphingstein, O.

College Sta.—
Giesecke, F. E.

Dallas—
Taylor, R. F.
Van Zandt, J. H.

Fort Worth—
Burnett, E. S.
Skinner, H. W.

Houston—
Barnes, A. F.

San Antonio—
Diver, M. L.
Ebert, W. A.

UTAH

Salt Lake City—
Coogan, J.
Cooper, A. W.

VERMONT

Burlington—
Austin, F. L.
Raine, J. J.

N. Ferrisburg—
Breckenridge, L. P.

VIRGINIA

Lynchburg—
Cleland, J. E.
Doering, F. L.
Wiley, E. C.
Wilson, E. J. F.

Newport News—
Noland, L. U.

Norfolk—
Montagna, C. J.
Peebles, J. K.
Wilson, E. K.

Richmond—
Austin, W. E.
Bachler, L. J.
Beverley, R. C.
Carle, W. E.
Childress, W. L.
Johnston, J. A.
Livingston, B. B.
Schulz, H. I.

Roanoke—
Wash, W. P.

Staunton—
Moffett, W. S.
Moran, F. N.

WASHINGTON

Seattle—
Ayers, A. E.
Beggs, W. E.
Brasch, H. K.
Carsten, W. H.
Cox, W. W.
Dudley, W. L.
Early, G. D.
Eastwood, Prof. E. O.
Eckart, C. H.
Godfrey, F. H.
Mallis, W.
Meyring, A. S.
O'Connell, P. M.
Ruddell, W. H.
Twist, C. F.
Weber, E. L.
Zokelt, C. G.

Spokane—
DeLong, H. B.
Nelson, R. L.

WEST VIRGINIA

Charleston—
Matthews, J. K.
Meyers, S. H.
Shanklin, J. R.

Morgantown—
Zeck, A.

Wheeling—
Hare, E. S.

WISCONSIN

Eau Claire—
Grosvold, F. E.

Fond Du Lac—
Ahern, T. L.

Fort Atkinson—
Shodron, J. G.

Green Bay—
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La Crosse—
Anderegg, R. H.
Johnson, T. R.
Miller, M. W.
Trane, R. N.

Madison—
Larson, G. L.
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Milwaukee—
Berghoefer, V. A.
Berringer, S. H.
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Brown, W. H.
Cook, H. R.
Downey, F. E.
Downey, P. C.
Ellis, H. W.
Goethel, A. C.
Grassler, E.
Jackson, C. H.
Jones, E. A.
Jung, J. S.
Juttner, O. J.
Lovegren, H. M.
Meadows, F. H.
Miller, C. W.
Miller, H. M.
Mueller, P. E.
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Olson, R. G.
Ostrander, L. F.
Page, H. W.
Randolph, C. H.
Schwab, H. E.
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Volk, J. H.
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Wolf, J. C.
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Oshkosh—
Paterson, G. E.

Racine—
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Dannies, F. R.
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West Allis—
Erickson, M. E.

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Islington, Ont.—
Wilson, G. T.

Kingston, Ont.—
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Montreal—
Friedman, F. J.
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Hamlet, T. F.
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Osborne, G. H.

Ottawa, Ont.—
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LaPrairie, C.

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Purdy, A. K.
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Shears, M. W.
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Sheppard, W. G.
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AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

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3rd Vice-President ..... Chas. S. Onderdonk
Treasurer ..... Judson A. Goodrich
Secretary ..... L. H. Hart

Board of Managers

Chairman, Fred P. Smith
Henry Adams — A. A. Cary
Hugh J. Barron — James A. Harding
Edward P. Bates, *Pres.* — L. H. Hart, *Secy.*

Council

Chairman, R. C. Carpenter
Albert A. Cryer — Chas. W. Newton
F. W. Foster — Ulysses G. Scollay, *Secy.*

1895

President ..... Stewart A. Jellett
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2nd Vice-President ..... Chas. S. Onderdonk
3rd Vice-President ..... D. M. Quay
Treasurer ..... Judson A. Goodrich
Secretary ..... L. H. Hart

Board of Managers

Chairman, James A. Harding
Geo. B. Cobb — Ulysses G. Scollay
Wm. McMannis — B. F. Stangland
Stewart A. Jellett, *Pres.* — L. H. Hart, *Secy.*

Council

Chairman, R. C. Carpenter
Henry Adams — T. J. Waters
Edward P. Bates — Albert A. Cryer, *Secy.*

1896

President ..... R. C. Carpenter
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2nd Vice-President ..... Edward P. Bates
3rd Vice-President ..... F. W. Foster
Treasurer ..... Judson A. Goodrich
Secretary ..... L. H. Hart

Board of Managers

Chairman, Wm. M. Mackay
Hugh J. Barron — Stewart A. Jellett
W. S. Hadaway, Jr. — Wiltsie F. Wolfe
R. C. Carpenter, *Pres.* — L. H. Hart, *Secy.*

Council

Chairman, A. A. Cary
Albert A. Cryer — B. F. Stangland
Wm. McMannis — J. J. Blackmore, *Secy.*

1897

President ..... Wm. M. Mackay
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2nd Vice-President ..... Henry Adams
3rd Vice-President ..... A. E. Kenrick
Treasurer ..... Judson A. Goodrich
Secretary ..... H. M. Swetland

Board of Managers

Chairman, R. C. Carpenter
Edward P. Bates — Stewart A. Jellett
W. S. Hadaway, Jr. — Wiltsie F. Wolfe
Wm. M. Mackay, *Pres.* — H. M. Swetland, *Secy.*

Council

Chairman, Albert A. Cryer
John A. Fish — James Mackay
Wm. McMannis — B. F. Stangland

1898

President ..... Wiltsie F. Wolfe
1st Vice-President ..... J. H. Kinealy
2nd Vice-President ..... A. E. Kenrick
3rd Vice-President ..... John A. Fish
Treasurer ..... Judson A. Goodrich
Secretary ..... Stewart A. Jellett

Board of Managers

Chairman, Wm. M. Mackay
Thomas Barwick — A. C. Mott
John A. Connolly — Francis A. Williams
Wiltsie F. Wolfe, *Pres.* — Stewart A. Jellett, *Secy.*

Council

Chairman, R. C. Carpenter
Henry Adams — W. S. Hadaway, Jr.
Albert A. Cryer — Wm. McMannis
Wiltsie F. Wolfe, *Pres.* — Stewart A. Jellett, *Secy.*

1899

President ..... Henry Adams
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2nd Vice-President ..... A. E. Kenrick
3rd Vice-President ..... Francis A. Williams
Treasurer ..... Judson A. Goodrich
Secretary ..... Wm. M. Mackay

Board of Managers

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B. H. Carpenter — Wm. Kent
A. A. Cary — Wiltsie F. Wolfe
Henry Adams, *Pres.* — Wm. M. Mackay, *Secy.*

Council

Chairman, R. C. Carpenter
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W. S. Hadaway, Jr. — B. F. Stangland
Henry Adams, *Pres.* — Wm. M. Mackay, *Secy.*

1900

President ..... D. M. Quay
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2nd Vice-President ..... Francis A. Williams
Treasurer ..... Judson A. Goodrich
Secretary ..... Wm. M. Mackay

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R. C. Carpenter	D. M. Nesbit
John Gormly	Wm. M. Mackay, *Secy.*

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President ..... J. H. Kinealy
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2nd Vice-President ..... Andrew Harvey
Treasurer ..... Judson A. Goodrich
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, J. H. Kinealy

Wm. Kent, *Vice-Chm.*	John Gormly
R. C. Carpenter	C. B. J. Snyder
R. P. Bolton	Wm. M. Mackay, *Secy.*

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President ..... A. E. Kenrick
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2nd Vice-President ..... Robert C. Clarkson
Treasurer ..... Judson A. Goodrich
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, A. E. Kenrick

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R. C. Carpenter	C. B. J. Snyder
Wm. Kent	Wm. M. Mackay, *Secy.*

1903

President ..... H. D. Crane
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2nd Vice-President ..... R. P. Bolton
Treasurer ..... Judson A. Goodrich
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, H. D. Crane

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R. C. Carpenter	Geo. Mehring
John Gormly	Wm. M. Mackay *Secy.*

1904

President ..... Andrew Harvey
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2nd Vice-President ..... Robert C. Clarkson
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, Andrew Harvey

John Gormly	H. D. Crane
Robert C. Clarkson	A. E. Kenrick
J. J. Blackmore	C. B. J. Snyder
R. C. Carpenter	Wm. M. Mackay, *Secy.*

1905

President ..... Wm. Kent
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2nd Vice-President ..... C. B. J. Snyder
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, Wm. Kent

R. P. Bolton	James Mackay
C. B. J. Snyder	B. F. Stangland
B. H. Carpenter	J. C. F. Trachsel
A. B. Franklin	Wm. M. Mackay, *Secy.*

1906

President ..... John Gormly
1st Vice-President ..... C. B. J. Snyder
2nd Vice-President ..... T. J. Waters
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, John Gormly

C. B. J. Snyder, *Vice-Chm.*	A. B. Franklin
T. J. Waters	James Mackay
R. C. Carpenter	B. F. Stangland
Frank K. Chew	Wm. M. Mackay, *Secy.*

1907

President ..... C. B. J. Snyder
1st Vice-President ..... James Mackay
2nd Vice-President ..... Wm. G. Snow
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, C. B. J. Snyder

James Mackay, *Vice-Chm.*	Edmund F. Capron
Wm. G. Snow	Frank K. Chew
R. E. Atkinson	A. B. Franklin
R. C. Carpenter	Wm. M. Mackay, *Secy.*

1908

President ..... James Mackay
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2nd Vice-President ..... B. F. Stangland
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, James Mackay

Jas. D. Hoffman, *Vice-Chm.*	John F. Hale
B. F. Stangland	August Kehm
R. C. Carpenter	C. B. J. Snyder
Frank K. Chew	Wm. M. Mackay, *Secy.*

1909

President ..... Wm. G. Snow
1st Vice-President ..... August Kehm
2nd Vice-President ..... B. S. Harrison
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, Wm. G. Snow

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John R. Allen	B. F. Stangland
R. C. Carpenter	Wm. M. Mackay, *Secy.*

1910

President ..... Jas. D. Hoffman
1st Vice-President ..... R. P. Bolton
2nd Vice-President ..... Samuel R. Lewis
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. M. Mackay

Board of Governors

Chairman, Jas. D. Hoffman

R. P. Bolton, *Vice-Chm.*	Judson A. Goodrich
Samuel R. Lewis	John F. Hale
Geo. W. Barr	James Mackay
R. C. Carpenter	Wm. M. Mackay, *Secy.*

1911

President ..... R. P. Bolton
1st Vice-President ..... John R. Allen
2nd Vice-President ..... A. B. Franklin
Treasurer ..... Ulysses G. Scollay
Secretary ..... Wm. W. Macon

Board of Governors

Chairman, R. P. Bolton

John R. Allen, *Vice-Chm.*	James H. Davis
A. B. Franklin	Jas. D. Hoffman
John T. Bradley	August Kehm
R. C. Carpenter	Wm. W. Macon, *Secy.*

1912

President ..... John R. Allen
1st Vice-President ..... John F. Hale
2nd Vice-President ..... Edmund F. Capron
Treasurer ..... James A. Donnelly
Secretary ..... Wm. W. Macon

Board of Governors

Chairman, John R. Allen

John F. Hale, *Vice-Chm.*	Dwight D. Kimball
Edmund F. Capron	Samuel R. Lewis
R. P. Bolton	Wm. M. Mackay
Jas. D. Hoffman	Wm. W. Macon, *Secy.*

1913

President ..... John F. Hale
1st Vice-President ..... A. B. Franklin
2nd Vice-President ..... Edmund F. Capron
Treasurer ..... James A. Donnelly
Secretary ..... Edwin A. Scott

Board of Governors

Chairman, John F. Hale

A. B. Franklin, *Vice-Chm.*	James A. Donnelly
John R. Allen	Dwight D. Kimball
Edmund F. Capron	Wm. W. Macon
R. P. Bolton	James M. Stannard
Frank T. Chapman	Theodore Weinshank
Ralph Collamore	Edwin A. Scott, *Secy.*

1914

President ..... Samuel R. Lewis
1st Vice-President ..... Edmund F. Capron
2nd Vice-President ..... Dwight D. Kimball
Treasurer ..... James A. Donnelly
Secretary ..... J. J. Blackmore

Council

Chairman, Samuel R. Lewis

E. F. Capron, *Vice-Chm.*	John F. Hale
Dwight D. Kimball	Harry M. Hart
John R. Allen	Frank G. McCann
Frank T. Chapman	Wm. W. Macon
Frank I. Cooper	James M. Stannard
James A. Donnelly	J. J. Blackmore, *Secy.*

1915

President ..... Dwight D. Kimball
1st Vice-President ..... Harry M. Hart
2nd Vice-President ..... Frank T. Chapman
Treasurer ..... Homer Addams
Secretary ..... J. J. Blackmore

Council

Chairman, Dwight D. Kimball

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Frank T. Chapman	Frank G. McCann
Homer Addams	J. T. J. Mellon
Frank I. Cooper	Henry C. Meyer, Jr.
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Wm. M. Kingsbury	J. J. Blackmore, *Secy.*

1916

President ..... Harry M. Hart
1st Vice-President ..... Frank T. Chapman
2nd Vice-President ..... Arthur K. Ohmes
Treasurer ..... Homer Addams
Secretary ..... Casin W. Obert

Council

Chairman, Harry M. Hart

F. T. Chapman, *Vice-Chm.*	E. Vernon Hill
Arthur K. Ohmes	Dwight D. Kimball
Homer Addams	Henry C. Meyer, Jr.
Charles R. Bishop	Fred R. Still
Frank I. Cooper	Walter S. Timmis
Milton W. Franklin	Casin W. Obert, *Secy.*

1917

President ..... J. Irvine Lyle
1st Vice-President ..... Arthur K. Ohmes
2nd Vice-President ..... Fred R. Still
Treasurer ..... Homer Addams
Secretary ..... Casin W. Obert

Council

Chairman, J. Irvine Lyle

A. K. Ohmes, *Vice-Chm.*	Charles A. Fuller
Fred R. Still	Harry M. Hart
Homer Addams	E. Vernon Hill
Davis S. Boyden	James M. Stannard
Bert C. Davis	Walter S. Timmis
Milton W. Franklin	Casin W. Obert, *Secy.*

1918

President ..... Fred R. Still
1st Vice-President ..... Walter S. Timmis
2nd Vice-President ..... E. Vernon Hill
Treasurer ..... Homer Addams
Secretary ..... Casin W. Obert

Council

Chairman, Fred R. Still

W. S. Timmis, *Vice-Chm.*	J. Irvine Lyle
Homer Addams	E. Vernon Hill
William H. Driscoll	Frank G. Phegley
Howard H. Fielding	Fred. W. Powers
H. P. Gant	Champlain L. Riley
C. W. Kimball	Casin W. Obert, *Secy.*

1919

President.....Walter S. Timmis
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2nd Vice-President.....Milton W. Franklin
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, Walter S. Timmis

E. Vernon Hill, *Vice-Chm.*	Frank G. Phegley
Homer Addams	Fred. W. Powers
Howard H. Fielding	Robt. W. Pryor, Jr.
Milton W. Franklin	Champlain L. Riley
Harry E. Gerrish	Fred R. Still
George B. Nichols	Casin W. Obert, *Secy.*

1920

President.....E. Vernon Hill
1st Vice-President.....Champlain L. Riley
2nd Vice-President.....Jay R. McColl
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, E. Vernon Hill

C. L. Riley, *Vice-Chm.*	Jay R. McColl
Homer Addams	George B. Nichols
Jos. A. Cutler	Robt. W. Pryor, Jr
Wm. H. Driscoll	W. S. Timmis
A. C. Edgar	Perry West
Alfred Kellogg	Casin W. Obert, *Secy.*

1921

President.....Champlain L. Riley
1st Vice-President.....Jay R. McColl
2nd Vice-President.....H. P. Gant
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, Champlain L. Riley

Jay R. McColl, *Vice-Chm.*	E. S. Hallett
Homer Addams	E. Vernon Hill
Jos. A. Cutler	Alfred Kellogg
Samuel E. Dibble	E. E. McNair
Wm. H. Driscoll	Perry West
H. P. Gant	Casin W. Obert, *Secy.*

1922

President.....Jay R. McColl
1st Vice-President.....H. P. Gant
2nd Vice-President.....Samuel E. Dibble
Treasurer.....Homer Addams
Secretary.....Casin W. Obert

Council

Chairman, Jay R. McColl

H. P. Gant, *Vice-Chm.*	L. A. Harding
Homer Addams	E. E. McNair
Jos. A. Cutler	H. J. Meyer
Samuel E. Dibble	C. L. Riley
Wm. H. Driscoll	Perry West
E. S. Hallett	Casin W. Obert, *Secy.*

1923

President.....H. P. Gant
1st Vice-President.....Homer Addams
2nd Vice-President.....E. E. McNair
Treasurer.....Wm. H. Driscoll
Secretary.....C. W. Obert

Council

Chairman, H. P. Gant

Homer Addams, *Vice-Chm.*	E. S. Hallett
W. H. Carrier	Alfred Kellogg
J. A. Cutler	Thornton Lewis
S. E. Dibble	J. R. McNair
Wm. H. Driscoll	Perry West

Casin W. Obert, *Secy.*

1924

President.....Homer Addams
1st Vice-President.....S. E. Dibble
2nd Vice-President.....William H. Driscoll
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, Homer Addams

S. E. Dibble, *Vice-Chm.*	W. E. Gillham
F. Paul Anderson	L. A. Harding
W. H. Carrier	Alfred Kellogg
J. A. Cutler	Thornton Lewis
William H. Driscoll	Perry West
H. P. Gant	F. C. Houghten, *Secy.*

1925

President.....S. E. Dibble
1st Vice-President.....Wm. H. Driscoll
2nd Vice-President.....F. Paul Anderson
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, S. E. Dibble

Wm. H. Driscoll, *Vice-Chm.*	W. T. Jones
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F. Paul Anderson	J. H. Walker
W. H. Carrier	Perry West
J. A. Cutler	A. C. Willard
W. E. Gillham	F. C. Houghten, *Secy.*

1926

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1st Vice-President.....F. Paul Anderson
2nd Vice-President.....A. C. Willard
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, W. H. Driscoll

F. Paul Anderson, *Vice-Chm.*	C. V. Haynes
W. H. Carrier	W. T. Jones
J. A. Cutler	E. B. Langenberg
S. E. Dibble	Thornton Lewis
W. E. Gillham	J. F. McIntire

A. C. Willard

1927

President.....F. Paul Anderson
1st Vice-President.....A. C. Willard
2nd Vice-President.....Thornton Lewis
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, F. Paul Anderson

A. C. Willard, *Vice-Chm.*	John Howatt
H. H. Angus	W. T. Jones
W. H. Carrier	J. J. Kissick
W. H. Driscoll	E. B. Langenberg
Roswell Farnham	Thornton Lewis
H. H. Fielding	J. F. McIntire
W. E. Gillham	H. Lee Moore
C. V. Haynes	F. B. Rowley

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