E. Werts

DUNHAM

GENERAL PRODUCTS BULLETIN OF LOW PRESSURE STEAM HEATING APPLIANCES

DIFFERENTIAL VACUUM HEATING SYSTEMS AND CONTROL EQUIPMENT

BULLETIN 634
C. A. DUNHAM COMPANY CHICAG

The DUNHAM HEATING SERVICE

Who is DUNHAM?

THE name Dunham stands for progress in the science of heating, for quality in products, for integrity in manufacture and in service, and for conservative business principles which are as clean-cut as they are resourceful. FOR over forty years the Company, through a national organization of research and specialized engineering, has been engaged solely in the problem of making steam an easily managed and economical servant in every conceivable type of building. THROUGHOUT these four decades the products and inventions bearing the name Dunham have won and held the high esteem of architects, consulting engineers and owners. IN the towering skyscrapers of Rockefeller Center (Radio City), New York, as in buildings which pierce the skyline of cities from coast to coast; in U. S. Defense Program Projects; in Housing Projects like Parkchester, the world's largest housing project, in famous hotels and apartment buildings; in churches, schools and hospitals; in homes from the stately mansion to the modest bungalow—Dunham heating is giving satisfying heat-comfort. IN the United States and Canada, in the United Kingdom and Europe, the heating requirements of varying climates are being met by Dunham equipment and Dunham service. THE prestige of a good name, in any field of endeavor, is a priceless boon. It is hard to achieve; it is quick to depart if not justly deserved. Dunham prestige is interpreted to the owner in heating service. That is what he buys. He invests his money in certain equipment not that he may possess it but that he may possess that which it makes possible. OWNER satisfaction is the yardstick for every installation.

THE DUNHAM DIFFERENTIAL VACUUM HEATING SYSTEM

THE DUNHAM DIFFERENTIAL VACUUM HEATING SYSTEM is a simple two-pipe system using steam at variable sub-atmospheric pressures to balance the heat loss from a building under changing weather conditions. In addition to the standard radiators, pipe, fittings, etc., used with a two-pipe system, it comprises Dunham Differential Traps and Valves, Dunham Differential Vacuum Pumps with Differential Controller and Dunham Control Equipment.

* * * *

The related problems solved by the Dunham Differential System are:

1. The maintenance of positive, continuous steam circulation, with complete venting of air and removal of condensate and with no short-circuiting of steam from supply to return piping.

2. The proportional distribution of steam to each unit of radiation under all rates of supply.

3. The control of the rate of heat output from system in accord with the variable rate of heat requirement *caused* by outside temperatures, wind, sun, cloudiness and moisture and modified by the heat stored in building (thermal capacity) and rate of heat transfer through the building itself.

The Dunham Differential Vacuum Heating System coordinates all essential functions of circulation, distribution and control to provide heating satisfaction economically. Pages which follow contain a brief description of the component parts of the System. Complete technical data will be found in Bulletin 631, a copy of which will be sent upon request.

THE DUNHAM DIFFERENTIAL *Vacuum*

Convectors or Radiators

Radiation and piping may be any of the types and sizes in common use with other steam heating system.

Control Panel

The Control Panel is the centralized operating station at which all control adjustments and settings are made and from which remote readings of room temperatures, control valve openings and percentage of heat output as measured by the Heat Balancer may be obtained.

Temperature Control Equipment

The Temperature Control Equipment appraises the heat demand of the building utilizing the resistance thermometer principle of operation. The Resistance Thermometers comprise coils of metal conductors whose electrical resistance varies with variations in their temperature connected in a Wheatstone Bridge circuit. Such temperature sensitive elements have no moving parts, nothing to wear out, clog, or to require—or get out of—adjustment. All moving parts are contained in the Panel and in the Control Valve.

The basic control of the Differential Temperature Control Equipment balances the heat supply (measured by the Heat Balancer) with the heat demand (measured by the Selector). Compensating or limiting features are provided by the room Resistance Thermometer units. Since this room thermometer is not depended upon to perform the function of the conventional room thermostat, it is not as limited in its application. It can be used to register room temperatures from any location regardless of the type of occupancy of the room.

Control Valve

The Control Valve regulates the admission of a **continuous** flow of steam into the heating main, and the Differential System equipment distributes this steam proportionately to all radiators. When the requirements for heat are great, the quantity of steam admitted is sufficient to fill the system with pressure up to two pound gage with corresponding steam temperature to approximatly 218° F. When the heat requirements are less, the smaller quantities of steam admitted are expanded into larger volumes at pressures below that of the atmosphere and, due to the relatively constant differential in pressures between the steam and return lines, the radiators are filled with steam. The expansion of the steam at subatmospheric pressure is accompanied by a lowering of the temperature, thereby resulting in a reduction in the heat given off by the radiators.

Partial Filling

When the admission of steam into the system has been reduced to the point at which the maximum operating vacuum is reached, then any additional reduction in the supply of steam results in the radiators being partially filled. As partial filling progresses with the reduction in the steam supply, each radiator receives less steam, in proportion to its capacity, up to the point at which the demand for heat ceases and the Control Valve closes off completely.

Packless Radiator Inlet Valve

Radiator Inlet Valves with externally adjustable or internally fixed orifices at each radiator inlet give balanced steam distribution throughout the building. The resistance to flow at the orifice of these regulating devices results in the small pressure gradient essential to balance distribution under partial filling conditions.

Thermostatic Radiator Trap

Radiator Traps allow air and water to leave radiators and prevent steam from entering the returns under the entire range of sub-atmospheric pressures employed. The thermostatic disc is at all times exposed to and controlled by the conditions of pressure and temperature within the radiator, whether trap is open or closed.

Drip Trap

The trap is installed at drip points to which large volumes of condensate flow, it is a combination of a thermostatic trap and a float trap. It keeps steam mains and risers free from water and air, and return mains free from steam, thus making circulation rapid and noiseless. It has high water handling and air venting capacity for heating-up periods.

Vacuum Pump

The Differential Vacuum Pump exhausts air and vapor from the return piping, keeping the pressures therein below that in the supply, as required to maintain the pressure difference necessary to cause a positive circulation of steam throughout the system. The Differential Vacuum Pump also operates to handle the condensate from the System. This water gravitates to the accumulator tank from which it is lifted and returned to the boiler by the pump.

Differential Controller

The Pump is controlled by the Differential Controller which is connected to the supply and return piping and is actuated by the pressure differential. The Controller starts the pump when the pressure difference between the supply and return tends to fall or disappear, and stops it when this pressure differential is restored.

In order to appraise the full value of Differential Heating, using sub-atmospheric steam, it is necessary to understand the functions performed by each of the operative items of heating equipment comprising the System. The simplicity and effectiveness of the Dunham Differential Vacuum Heating System is attained through their coordinated action. The functions of the various units, indicated on opposite page, are as follows:

Heating System

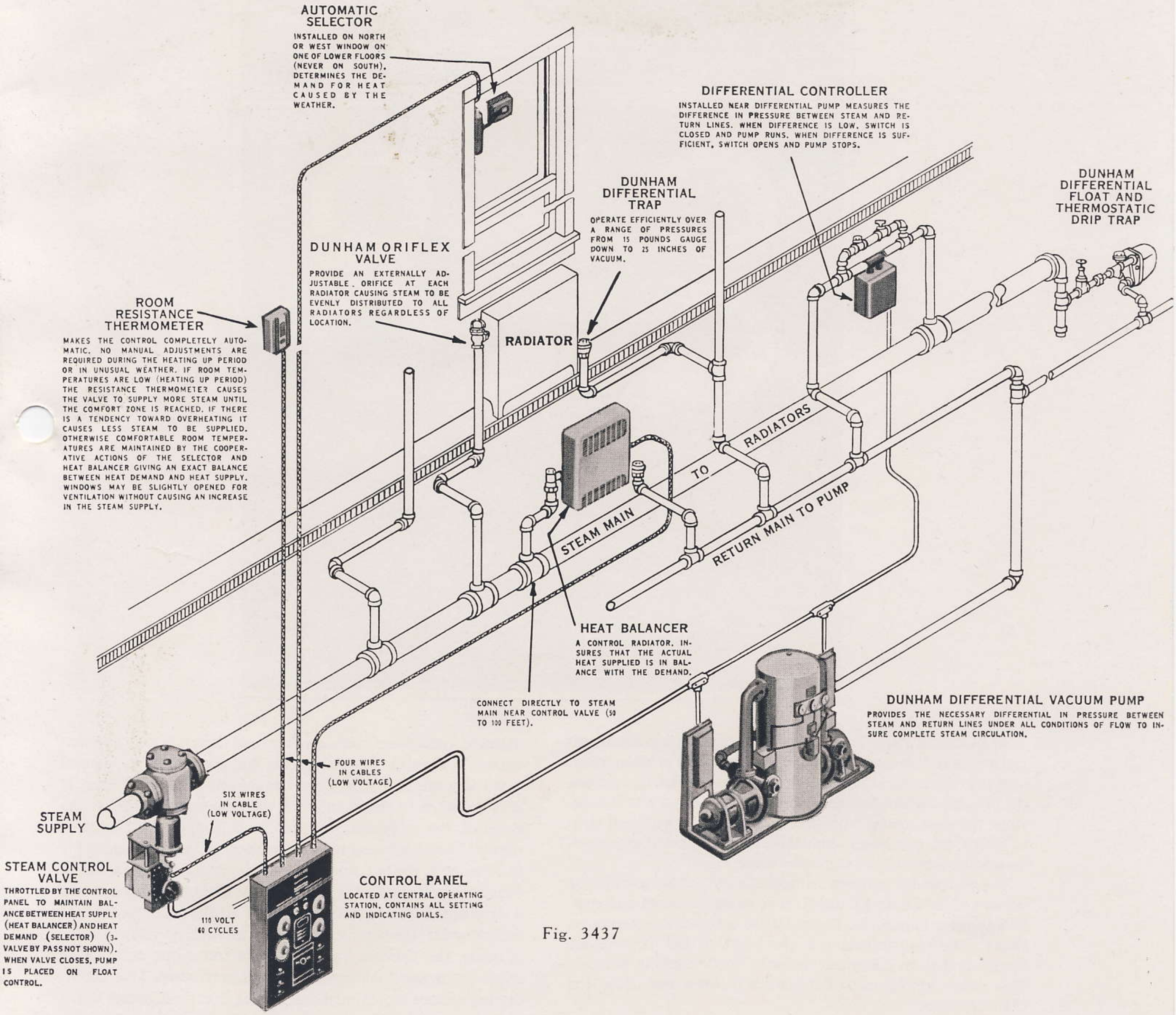
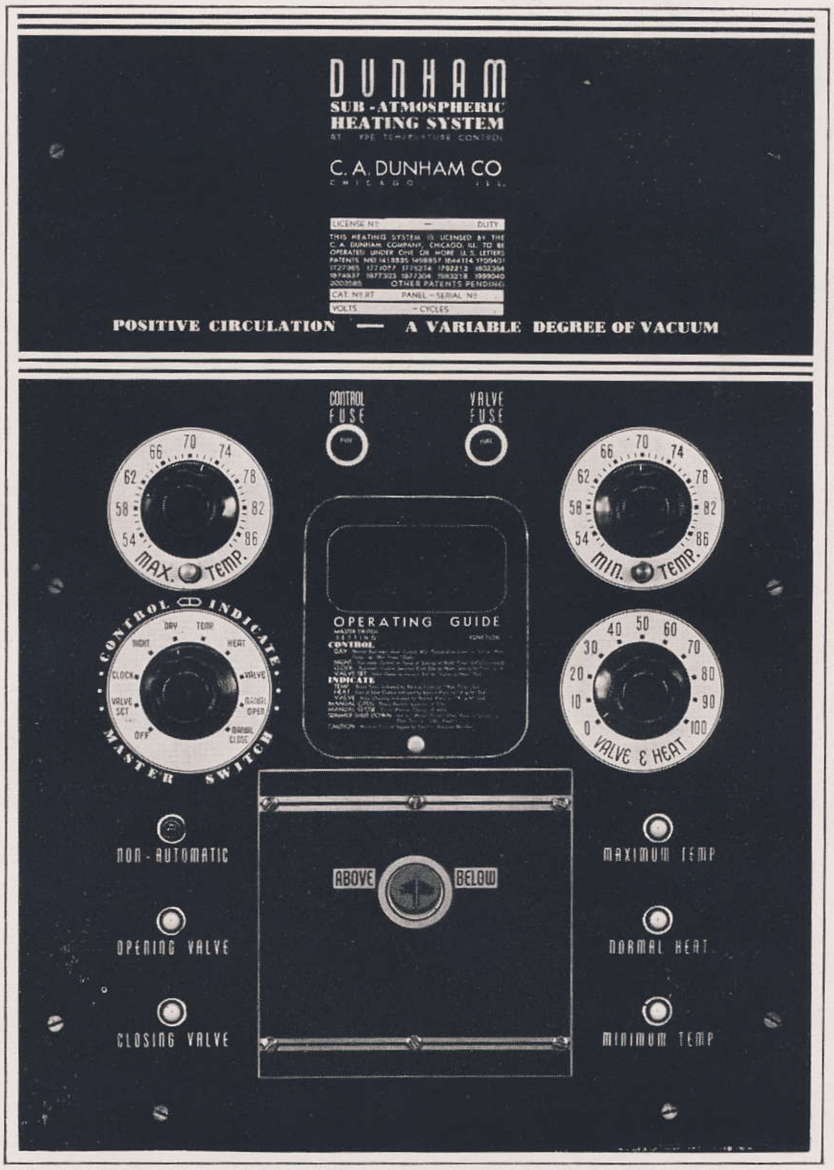


Fig. 3437

Dunham Differential Control Equipment

The Control Panel



The Control Panel is the central control station where adjustments and all control settings are made, and at which readings of system operating conditions may be taken. It contains the primary control elements which are connected into Wheatstone Bridge circuits, terminating in the upper terminal strip to which are connected the cables from the resistance thermometer units and the Control Valve.

The Galvarelay is mounted behind a removable plate in the bottom of the Control Panel. It is separately housed and completely interchangeable. It consists of a Galvanometer and a Relay. The Galvanometer is the heart of the Wheatstone Bridge and is an electrical "balance" or "weighing device". The Relay functions to automatically open and close the Control Valve.

When the Master Switch of the Control Panel is at a "control" station, a "feeler" bar of the Galvarelay is operated by a solenoid and a synchronous motor, and determines at frequent intervals whether the Galvarelay indicator is at its central point or whether it is deflected toward one side or the other. If it is deflected to the right, then the heat supply is *below* the demand, one relay contact is made and the Control Valve is opened a small amount to increase the supply. If the indicator is deflected to the left, then the heat supply is *above* the demand, the other relay contact is made and the Control Valve is closed a small amount to decrease the supply. If the indicator is at its central point, the supply equals the demand, no relay contact is made, the Control Valve does not move but remains at whatever position it may have taken previously. This checking for balance is continual and insures that the Control Valve is always at the proper position to maintain balance between heat supply and heat demand.

Dunham Differential Control Equipment

Model RSTT—Fully Automatic

Consisting of a Panel, a Control Valve, one or more Resistance Thermometer Units, a Selector and a Heat Balancer, for indicating and controlling steam supply in proportion to the demand as measured by weather conditions and limited by room temperatures.

(Recommended for all heating systems using direct radiators or convectors.)

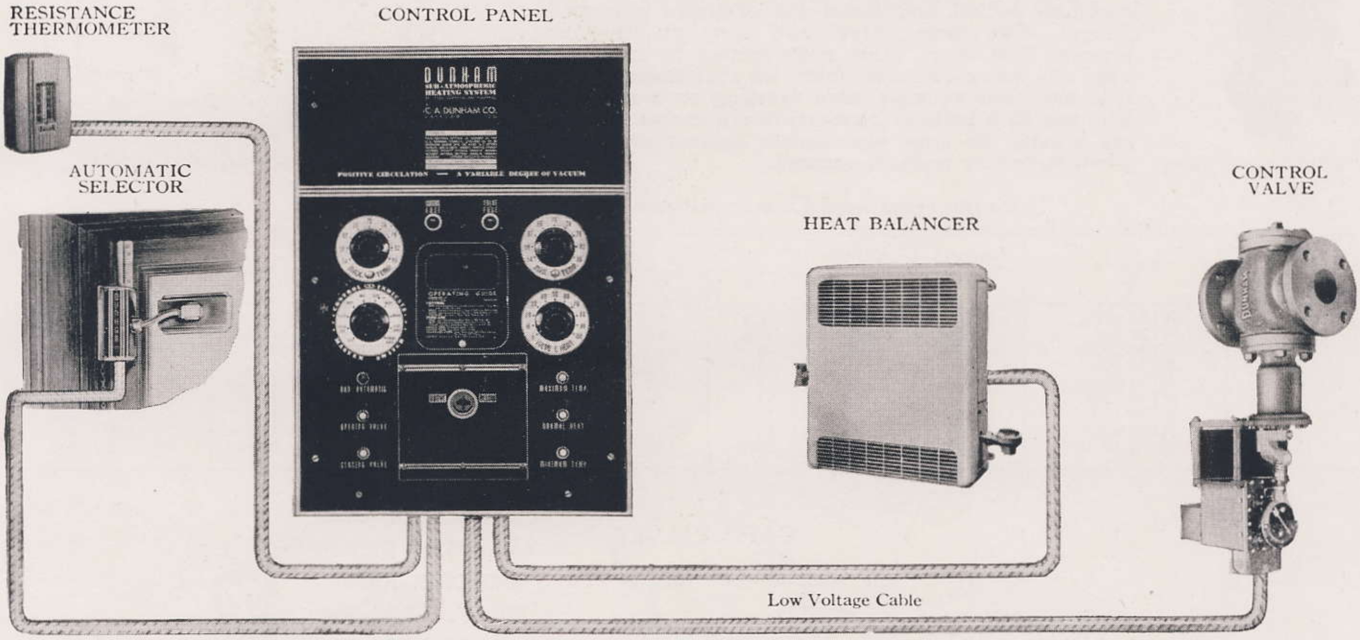


Fig. 1962

Dunham Model RSTT Control

The Model RSTT insures continuous heat supply in exact accordance to outside weather conditions. This supply is checked in cycles of three different measurements of the demand.

The "Normal Heat" measurement is the basic control and provides a check of the heat supply as measured by the Heat Balancer in comparison with the demand as measured by the Selector. In this phase of the control, the relay can either open or close the Control Valve depending on whether a greater or less supply of heat is required.

The Selector is a window mounted Resistance Thermometer Unit, the temperatures surrounding which are affected by outside temperature, wind velocity and other weather conditions. It provides a measure of heat demand.

The Heat Balancer, which is a control radiator, measures the actual heat supply. There are two Resistance Thermometer coils, one—below the heating element—measures the average temperature of the incoming air while the second—above the heating element—measures the average temperature of the air after it has been heated. The difference between these two temperatures is a measure of the heat supply.

The Control Panel includes a measuring or weighing device for determining the balance between the heat demand (Selector) and heat supply (Heat Balancer). This device is the Galvanometer which governs through a relay the opening and closing of the Control Valve which is made in small increments. When the heat supply is less than the demand, the Valve is slightly opened to increase the supply. When the supply is greater than the demand, the reverse occurs. As stated above this is the basic control feature.

The Panel also functions to check the actual room temperatures and determines if they are within definite established limits.

The "Maximum Temperature" measurement provides a check of the heat supply as determined by the Valve opening with the demand as measured by the room Resistance Thermometer Unit(s). This phase of the operation is a maximum limiting control and the relay can close the Valve only if temperatures are high; it cannot open it.

The "Minimum Temperature" measurement also provides a check of the heat supply as determined by the Valve opening with the demand as measured by the room Resistance Thermometer Unit(s). This phase of the operation is a minimum limiting control and the relay can open the Valve only if temperatures are low; it cannot close it. This phase of the control is particularly effective during the heating-up period.

DUNHAM RTM CONTROL VALVE

RTM Control Valve

The Control Valve is operated, in response to variations in heat demands, by adjustable amounts which are small. No noises are set up by changes of rate in steam flow. The Control Valve is operated to change flow rates only as required, and by a small fraction each minute. Thus the changes in flow rate are sufficiently slow to permit the compensating effect (upon room temperature and demand) of the changed rate to be secured with minimum valve change.

The Valve is operated by a low voltage reversing motor controlled from the Panel. Adjustable limit switches open the circuit when the motor has traveled to its limit in either direction.

All Valves have cast iron bodies with flanged connections drilled and faced for standard companion flanges. The inner valves and seats are of steam bronze. The inner valve construction is such as to keep the valve removed from its seat during operation and thus reduces wire drawing to a minimum. The use of a bellows connection eliminates all packing around the stem and insures against air leakage when operating under a vacuum.

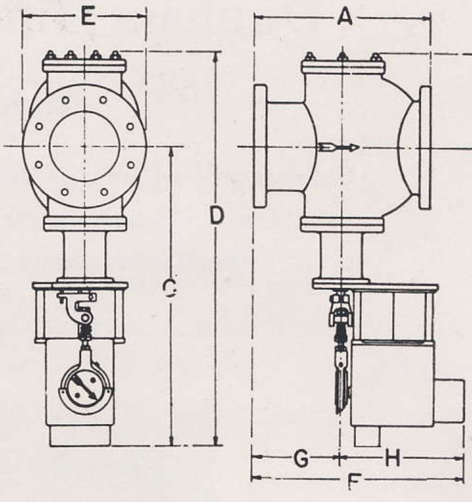


Fig. 3214 Roughing in Dimensions RTM Valve

Capacities and Dimensions—RTM Control Valve

Control Valve Size, Inches	Catalog No.	Capacity Sq. Ft. EDR	Size of Bypass Inches	Dimensions in Inches							
				A	B	C	D	E	F	G	H
1½	RTM 131½	1,300	1	7¾	4¼	19⅝	23⅞	5	12	3⅞	8⅛
2	RTM 202	2,000	1¼	8⅜	4 7/16	19 13/16	24¼	6	12 5/16	4 3/16	8⅛
2½	RTM 302½	3,000	1½	9	5	20⅜	25⅜	7	12⅝	4½	8⅛
3	RTM 453	4,500	2	10¼	5⅜	20¾	26⅛	7½	13¼	5⅛	8⅛
4	RTM 804	8,000	3	12	6¾	21⅞	28⅝	9	13 13/16	5 11/16	8⅛
5	RTM 1205	12,000	3	13	7½	22⅝	30⅛	10	14⅝	6½	8⅛
6	RTM 1806	18,000	4	14¾	8 7/16	23 9/16	32	11	14⅛	6	8⅛
8	RTM 3208	32,000	5	19	10 7/16	25⅜	35 13/16	13½	16¾	8⅝	8⅛
10	RTM 50010	50,000	6	19½	12 3/16	26 13/16	39	16	15 15/16	7 13/16	8⅛

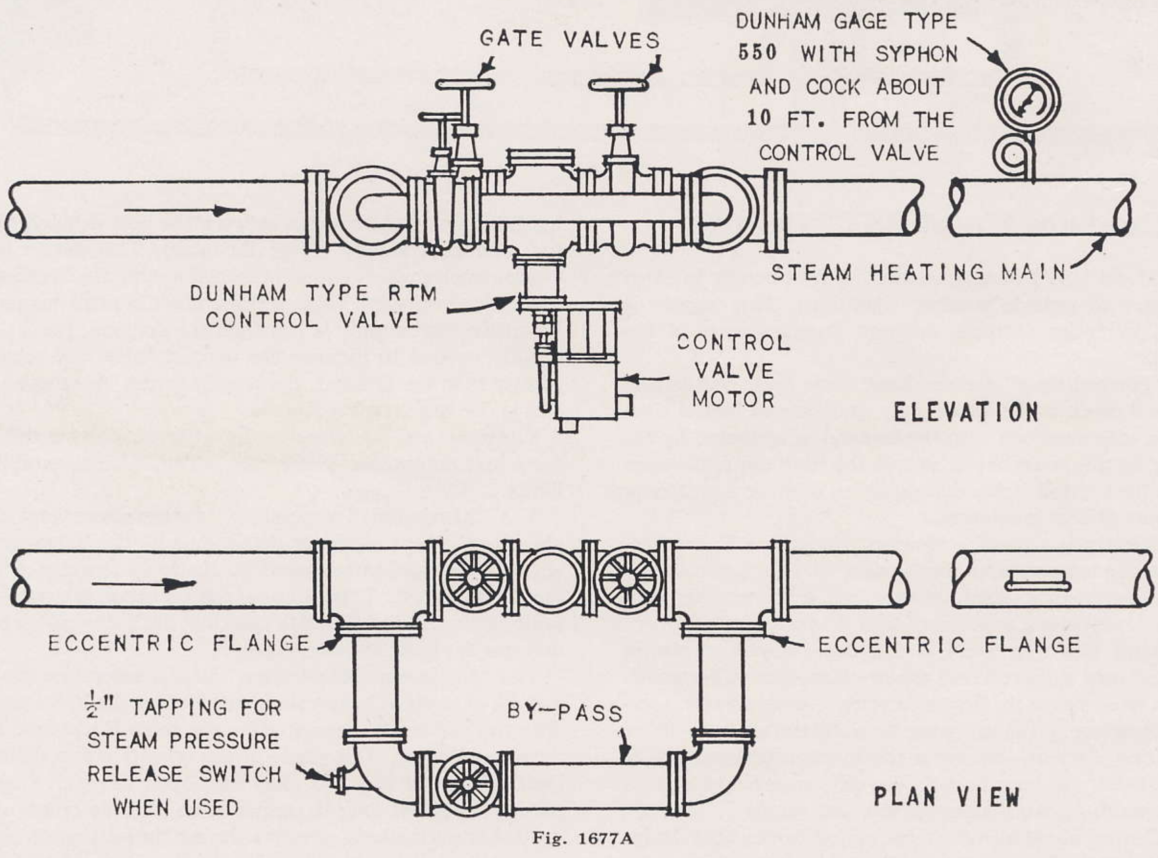
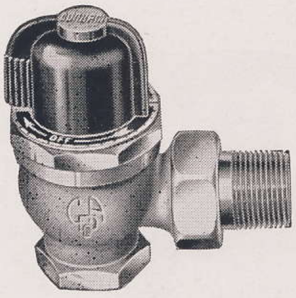


Fig. 1677A

DUNHAM "ORIFLEX" VALVES



Type 175—"Oriflex"

When ordering specify size of Radiator and Valve Size.

Type 175 "Oriflex" is a self-contained adjustable orifice valve for proportioning the steam supply to each radiator. It has a unique "handle movement" which eliminates graduated opening or closing. It need only be turned "on" or "off". The adjustable orifice within the valve, not the position of the handle, controls the maximum steam flow.

With "Oriflex" there is no need to disconnect the valve when making an adjustment. Merely remove the handle, insert the key on the adjustment stem, adjust the orifice (calibrated guide surrounds stem) to the exact setting needed for perfect balance.

Like all Dunham Packless Radiator Valves, Oriflex is really "packless". It 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.

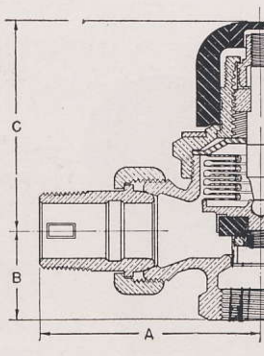


Fig. 1815

Size Inches	Catalog No.	Rated Capacities Sq. Ft. EDR	Net Weight, Lbs. A.P.	Dimensions in Inches					Code
				A	B	C	D	E	
½	NWLR ½" A	30	1½	3	1⅛	2⅝	⅝	1⅜	Antflexha
¾	NWLR ¾"	120	1$\frac{11}{16}$	2⅞	1¼	2⅝	¾	1⅝	Antflextf
1	NWLR 1" A	160	2⅛	3	1½	2⅞	1	1⅞	Antflexon
1¼	NWLR 1¼" A	240	2$\frac{11}{16}$	3½	1⅝	3	1⅛	2$\frac{1}{16}$	Antflexongr

The ¾ size valve can be supplied with 30, 60 or 120 sq. ft. maximum capacities.

See Figs. 3521 and 3529 below for D and E dimensions

PACKLESS RADIATOR VALVES SERIES 1140

Wheel Handle

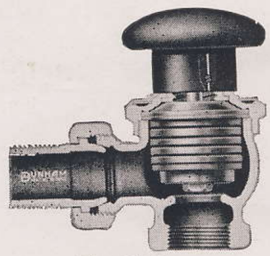


Fig. 3520

Suitable for all types of low pressure steam heating systems. The bellows construction, the non-rising stem, low bonnet, heat-resistant, composition handle requiring less than one turn to open the valve fully, recommend this valve for services in which long-wearing quality, absolute tightness and attractive design are desired.

Bodies and bonnets are brass castings, rough finish. The valves are furnished with heavily constructed brass union nuts and nipples. The expansion member is the built-up type of bellows, fabricated from tinned phosphor bronze giving maximum resiliency and wear. The expansion member not only prevents leakage of steam, air and water, but also prevents steam, water and dirt from clogging and corroding the spindle nut and screw.

TABLE FOR 1140 SERIES

Size, In.	Type No.	Pattern	Net Wgt., Lb.	Dimensions, Inches					Code	Size, In.	Type No.	Pattern	Net Wgt., Lb.	Dimensions, Inches					Code
				A	B	C	D	E						A	B	C	D	E	
½	1140 1142 1143 1146	AP RH LH ST	1⅝ 1¾ 1¾ 1¾	3	1⅛	2⅞	⅝	1⅜	Apwpa Riwpa Lhwpa Stwpa	1¼	1140 1142 1143 1146	AP RH LH ST	3¼ 3¾ 3¾ 3¾	3½	1⅝	3⅜	1⅛	2$\frac{1}{16}$	Apwpo Riwpo Lhwpo Stwpo
¾	1140 1142 1143 1146	AP RH LH ST	1¾ 2 2 2	2⅞	1¼	3	¾	1⅝	Apwpe Riwpe Lhwpe Stwpe	1½	1140 1142 1143 1146	AP RH LH ST	4¼ 4¾ 4¾ 4¾	3¾	1⅞	3¾	1¼	2$\frac{5}{16}$	Apwpu Riwpu Lhwpu Stwpu
1	1140 1142 1143 1146	AP RH LH ST	2¼ 2¾ 2¾ 2¾	3	1½	3¼	1	1⅞	Apwpi Riwpi Lhwpi Stwpi										

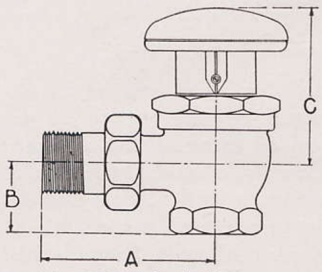


Fig. 3535—Angle Pattern, Type 1140

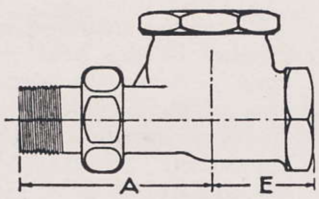


Fig. 3521—Straight-thru Pattern Type 1146

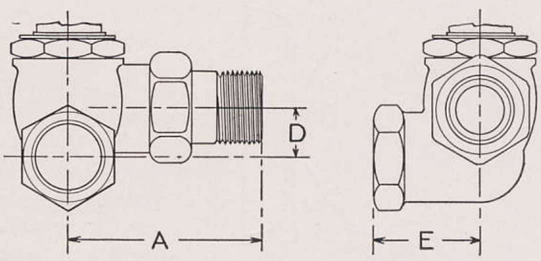
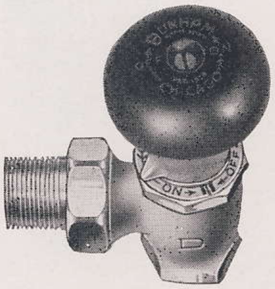


Fig. 3529—Right Hand Corner Pattern (Left Hand Pattern Similar)

740 SERIES DUNHAM RADIATOR VALVE
(SPRING PACKED)



Type 740

Designed for Low Pressure Steam Heating Service

Bodies are brass castings, rough finish. The valves are equipped with heavily constructed brass union nuts and nipples. All pipe threads and tapings are carefully machined and checked to standard gages. Non-rising stem, requires less than one turn of handle to open the valve fully. Dial shows direction and amount of opening. Heavy bronze spring keeps a constant pressure on a special graphited asbestos composition ring to maintain a tight seal around the valve stem.

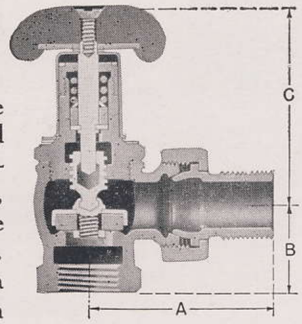


Fig. 3394A

Size Ins.	Type No.	Pattern	Net Wgt. Lb.	Dimensions, Inches A	B	C	D	E	Code
½	740 742 743 746	AP RH LH ST	1⅝ 1¾ 1¾ 1¾	2⅜	1⅛	3⅛	⅝	1⅜	Anwha Riwha Lewha Stwha
¾	740 742 743 746	AP RH LH ST	1 15/16 2⅛ 2⅛ 2⅛	2 13/16	1¼	3⅛	¾	1⅝	Anwhe Riwhe Lewhe Stwhe
1	740 742 743 746	AP RH LH ST	2½ 2 13/16 2 13/16 2 13/16	3 1/16	1 7/16	3⅝	1	1⅞	Anwhi Riwhi Lewhi Stwhi
1¼	740 742 743 746	AP RH LH ST	3⅛ 3½ 3½ 3½	3½	1⅝	3¾	1⅛	2 1/16	Anwho Riwho Lewho Stwho
1½	740 742 743 746	AP RH LH ST	4¼ 4¾ 4¾ 4¾	3 13/16	1⅞	3⅞	1¼	2 5/16	Anwhu Riwhu Lewhu Stwhu
2	740 742 743 746	AP RH LH ST	6⅛ 7 7 7	4⅜	2¼	4⅛	1½	2 11/16	Anwhy Riwhy Lewhy Stwhy

Also available in lever handle, 700 Series.

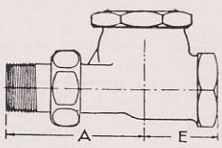


Fig. 3521
Straight-thru Pattern
Type 746

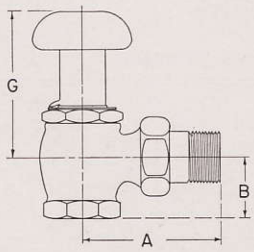


Fig. 3217
Angle Pattern

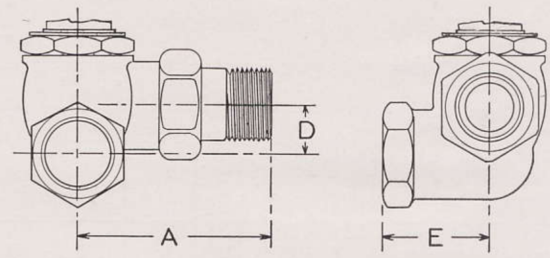


Fig. 3529
Right Hand Corner Pattern (Left Hand Pattern Similar)

DUNHAM REGULATING PLATES

For Two Pipe System Application
Showing Regulating Plate in place in Valves

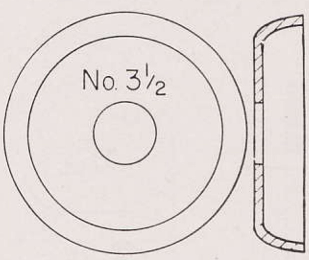
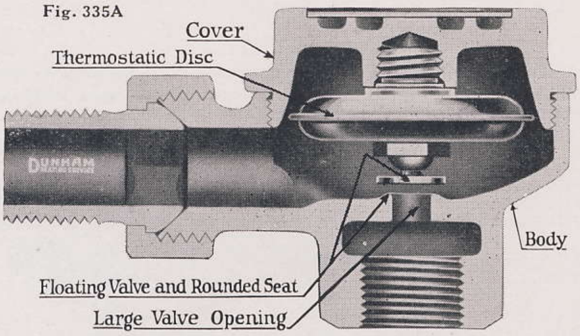


Fig. 3537
Regulating Plate, Type 192

The Dunham Regulating Plates are installed in all radiator inlet valves in accordance with radiator capacities or the heat requirements of the space to be heated by the radiator. They perform the triple function of establishing a steam condition in the steam piping, of governing the steam flow into each radiator in proportion to its heat output requirement, and thus give controlled steam distribution under partial filling operation. The Regulating Plates are easily inserted in the union connections of the radiator inlet valves. As a general rule, they should not be installed until after the heating system has been cleaned.

Fig. 335A



DUNHAM THERMOSTATIC TRAPS

For Operating Pressures Up to 15 Lb. PSI Gage

DESIGN—Design of the Dunham Trap provides for (a) efficient differentiation between steam and air-and-water, (b) simple rugged construction, (c) freedom from clogging, (d) minimum depositing of incustrants on valve seat, (e) thorough draining of radiators by gravity and, (f) minimum wear on working parts. These features ensure dependable service.

The standard trap operates efficiently on pressures up to 15 lbs. gage and is used on all types of lowpressure steam heating systems.

CONSTRUCTION—The trap consists of a cast bronze body with the valve seat and a cast bronze cover containing the expansion thermostat. The disc is made from monel metal sheet. The corrugations are shaped to reduce hinge action at the rim of the disc and to distribute disc motion uniformly. The filling nozzle and the valve assembly are attached to their respective halves fo the disc by threaded nuts making tight screwed joints which are further reinforced, locked and sealed by sweating with solder.

A crimped ring, which prevents disc vibration, is inserted and the two halves of the disc are joined by a special welding process. The disc is then filled and sealed under vacuum.

The valve is flat and is attached to the disc by a ball swivel joint to ensure its seating squarely and tightly without causing localized stresses on the disc. The valve opening is exceptionally large and the passage of water or dirt out of the trap is not obstructed by a guide as none is necessary with the Dunham design.

The valve seat is raised slightly and rounded to minimize the depositing of incrustants.

The trap is non-adjustable, permanent adjustment for correct operation is built into the element. The thermostatic elements for traps of the same size are interchangeable without adjutsment. Spare thermostatic elements, when placed in the trap cover and the cover properly secured to the body, are automatically correctly placed and distanced from the valve seats. The thermostatic elements may be readily removed for examination without breaking the inlet and outlet connections. The covers may be removed from the trap body while hot without danger of the thermostatic elements being distorted so as to affect the operation of the trap.

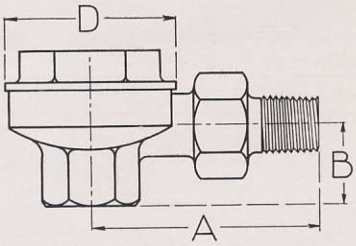


Fig. 805-1—Angle Pattern
Nos. 1C, 2E and 3C Traps

NOTE: All traps have union nut and nipple at inlet and right hand female pipe tapped outlet.

Specify Type Number or Catalog Number and size on order. When not otherwise stipulated on order, the standard Angle Pattern Trap of size called for will be furnished.

Up to 15 Lb. PSI Gage			Pattern	Tapping	*Cap. Sq. Ft. E.D.R.	Net Wgt.	Dimensions in Inches				
Size No.	Cat. No.	Code					A	B	C	D	E
1C	TL2A ½	Atom	AP	½"	200	1¼	3¼	1⅛	...	2 7/16	...
	TL2S ½	Atude	SW			1⅜	3¼	...	1¾	2 7/16	½
	TL2R ½	Attos	RH			1⅜	3¼	...	1¾	2 7/16	½
	TL2L ½	Atwan	LH			1⅜	3¼	...	1¾	2 7/16	½
	TL2V ½	Atypie	VS			1¼	For Dimensions see Fig. 1834				
2E	TL4A ¾	Acacia	AP	¾"	400	1⅞	3 5/16	1⅛	...	3 1/16	...
	TL4S ¾	Acaleph	SW			1⅞	3 5/16	...	1¾	3 1/16	½
3C	TL7A1	Alp	AP	1"	700	2	3 7/16	1⅛	...	3 1/16	...

*Ratings are based on ¼ lb. condensation per sq. ft. of equivalent direct radiation per hour and a 1½ lb. pressure differential.

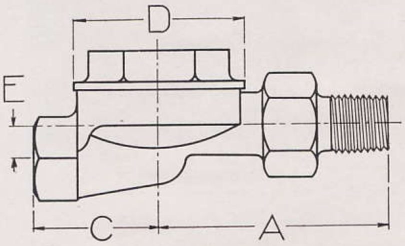
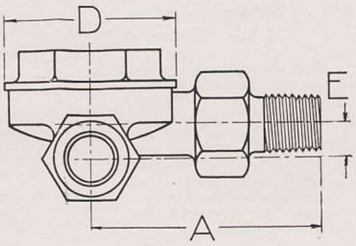


Fig. 805-2—Straight Angle Pattern
Nos. 1C and 2E Traps



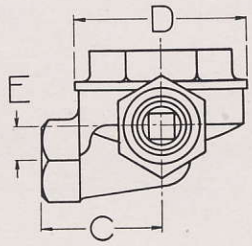


Fig. 805-4
Right Hand Corner Pattern

Fig. 805-3
(Left Hand Pattern
Similar No. 1C Trap only)

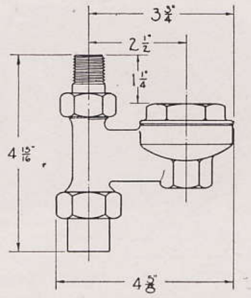


Fig. 1834—Vertical SW Pattern
No. 1C Trap Only

TYPE TH SERIES—THERMOSTATIC STEAM TRAPS

25 Lbs. to 100 Lbs. Working Pressure

These traps are of the thermostatic fluid expansion type, operating in response to the pressure caused by partial vaporization of the liquid within the thermostatic member. The trap consists of two principal parts, a body with renewable valve seat and a cover containing the thermostatic disc. The trap is non-adjustable; permanent adjustment for correct operation is built into the thermostatic disc.

The heavy bodies and covers as well as the union nut and nipples are brass. The thermostatic disc is fabricated from monel metal sheet using a special welding process, and is designed to reduce the movement at the rim and to distribute the disc motion uniformly.

The valve and seat are of special heat treated stainless steel. The spherical valve is swiveled to insure its seating tightly without causing localized stresses on the thermostatic disc.

The valve opening is exceptionally large and the passage of water or dirt is not obstructed by a guide.

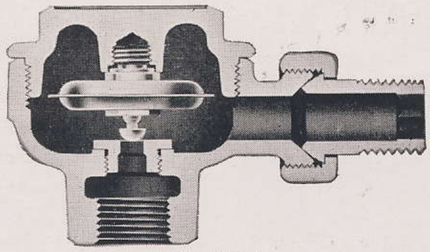


Fig. 3518A
Sectional Type THI-A

CAPACITY POUNDS CONDENSATE PER HOUR

Trap Size	Working Pressure (Lbs. per sq. in. gage)			
	25	35	50	100
TH1A	1200	1550	1950	2600
TH2A	1800	2200	2600	3500
TH3A	2500	2900	3400	4500

Traps shall start discharging with a temperature differential (i.e., difference between temperature of discharging water and that of saturated steam of same pressure as that on the trap) of about 30° to 40° F.

Trap Size	Size Conn., Inches	Net Weight, Lbs.	Dimensions, Inches				Code
			A	B	C	D	
TH1A	½	2	3¼	1⅜	2⅝	2¾	Nude
TH2A	¾	2¾	3⅜	1 9/16	3½	2¾	Humb
TH3A	1	3	3½	1¾	3 9/16	2¾	Nurse

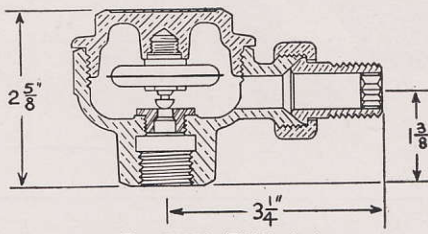


Fig. 3427A (TH Series)

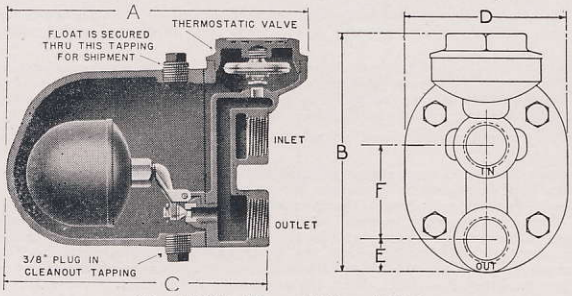
TRAPS & STRAINERS

DUNHAM FLOAT and THERMOSTATIC TRAP

30 Series—Operating Pressures Up to 15 Lbs. Gage

Rated capacities are in accordance with the standards as adopted by the Steam Heating Equipment Manufacturers Association to provide for the continuous elimination of air.

It is comprised of a cover, mechanism assembly and body. Thermostatic disc and valve controls flow through a cored passage between trap body and discharge tapping for release of air. The float is cuprous material. Float valve and seat are monel metal. Thermostat elements are interchangeable. Trap body readily removed without disturbing piping connections to fully expose working parts for inspection. All traps are tapped so that gage glass set may be applied but traps are shipped plugged. Bottom plug can be used for flushing out trap



Capacities are based on a rate of ¼ lb. condensate per sq. ft. of EDR per hour, at a pressure difference between inlet and outlet of 2 lb. gage. Where pressure difference is constantly maintained greater than 2 lb., capacity is increased. Table of capacities at various pressure differences furnished on request. Connections are female right-hand threaded inlet and outlet.

Fig. 1656B—Traps 30-2 and 30-4

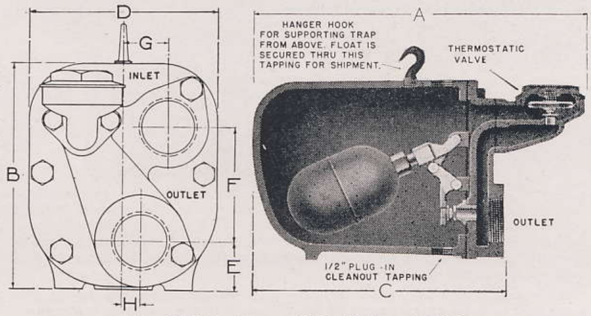


Fig. 1162D—Traps 30-5, 30-7 and 30-8

Type No.	Catalog No.	Capacity Sq. Ft. EDR	Size Conn. In.	Net Weight, Lbs.	DIMENSIONS IN INCHES							
					A	B	C	D	E	F	G	H
30-2A	FT 8¾	800	¾	6¾	7¼	6⅛	6 5/16	3½	11/16	2	*	*
30-4	FT 281	2,000	1	9¼	8¾	6⅛	7⅜	4⅞	15/16	2½	*	*
30-5	FT 481¼	4,800	1¼	17¼	12	6⅜	9⅛	5½	1 5/16	3¼	1 5/16	9/16
30-7	FT 961½	9,600	1½	36	15⅞	11	12½	7⅞	3⅝	4⅞	1⅞	*
30-8	FT 2002	20,000	2	60	19	12	15⅜	9⅛	2¼	6⅞	1⅜	*

* On Center Line.

DUNHAM CLOSED FLOAT TRAP

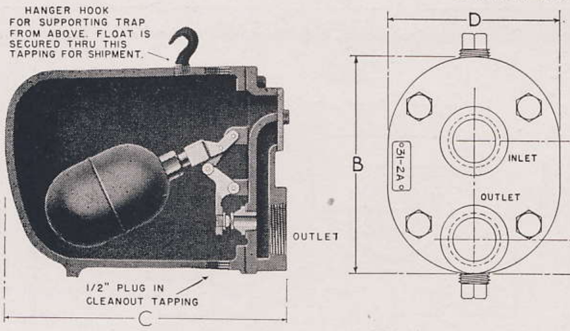


Fig. 16?8B—Traps 31-2A and 31-4

31 Series

For Operating Pressures Up to 15 Lbs. Gage

It is designed to release water only from low pressure steam installations. It may be used for dripping rise in steam main, and other applications where no air is to be handled. They are similar in design to the Float and Thermostatic Trap except the thermostatic feature is omitted.

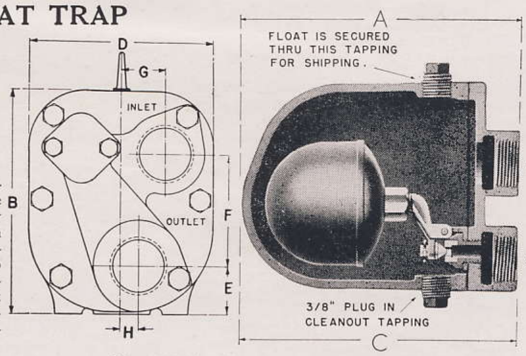


Fig. 1725A—Traps 31-5, 31-7 and 31-8

Type No.	Catalog No.	Capacity Sq. Ft. EDR	Size Conn., In.	Net Weight, Lbs.	DIMENSIONS IN INCHES							
					A	B	C	D	E	F	G	H
31-2A	FC 8¾	800	¾	6½	6⅛	5½	5¾	4⅞	15/16	2½	*	*
31-4	FC 281	2,000	1	8½	7¾	5½	7⅜	4⅞	15/16	2½	*	*
31-5	FC 481¼	4,800	1¼	15	....	6⅜	9⅛	5½	1 5/16	3¼	1 5/16	9/16
31-7	FC 961½	9,600	1½	31	....	11	12½	7⅞	3⅜	4⅞	1⅞	*
31-8	FC 2002	20,000	2	40	....	12	15⅜	9⅛	2¼	6⅞	1⅜	*

* On Center line.

DUNHAM STRAINER—For Operating Pressures Up to 125 Lbs. Gage

Strainer

It is iron casting with removable cover and sieve. Sieve formed of perforated brass sheet with .045" diameter holes, 233 psi. Sieve is inserted from bottom and held in position by recesses in body casting and cover. All sizes have right-hand female pipe tappings.

Type No.	Cat. No.	Connection	Net Weight Lbs.	Dimensions in In.			
				A	C	E	Overall Width
211-½"	SS½	Screwed	1¾	½	3½	2⅝	2¼
211-¾"	SS¾	Screwed	3	¾	4½	3¾	2¾
211-1"	SS1	Screwed	3½	1	4¾	3⅞	2¾
211-1¼"	SS1¼	Screwed	5	1¼	5⅝	4½	3¼
211-1½"	SS1½	Screwed	10	1½	6⅝	5½	4⅛
211-2"	SS2	Screwed	10	2	6⅝	5½	4⅛

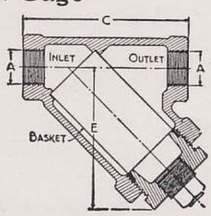
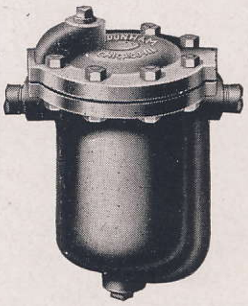


Fig. 3331

DUNHAM INVERTED BUCKET TRAPS

Type OBS—For Operating Pressures Up to 150 Lbs.
Type OB—For Operating Pressures Up to 250 Lbs.



CONSTRUCTION—The Type OB Series vents air and drains water from steam lines, heat exchangers and processing equipment operating at their respective pressure ranges. These traps are particularly adapted to clearing high pressure distribution lines of condensate and to draining unit heaters, blast coils and other high pressure applications such as garment presses, ironing machines, coffee urns, cooking kettles, vulcanizers and dry kilns.

Body and cover are of high test semi-steel castings and are provided with a plugged opening at the lowest point of the body. Trap connections are standard right hand pipe tapping.

The valve and seat, which are renewable and interchangeable, are constructed of especially hardened, corrosion resisting steel. Bucket is formed from sheet copper. Cover cap screws are steel.

Integral strainer and manual by-pass are each optional features of this trap.

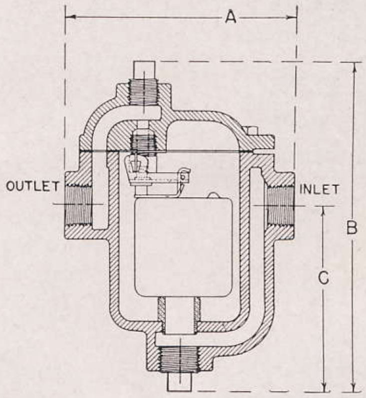


Fig. 3454
Type OBS Trap also Available with Integral Strainer and/or Bypass

OB TRAP—SIZE ½"							OB TRAP—SIZE ¾"						
Seat Symbol	A	B	C	D	E	G	C	D	E	F	G	I	K
Press. Diff.	Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished						Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished						
	250	125	80	60	30	15	250	175	125	80	60	30	15
250	2125	......	......	......	......	......	3650	......	......	......	......	......	......
225	2040	......	......	......	......	......	3475	......	......	......	......	......	......
200	1950	......	......	......	......	......	3300	......	......	......	......	......	......
175	1850	......	......	......	......	......	3100	3680	......	......	......	......	......
150	1745	......	......	......	......	......	2900	3425	......	......	......	......	......
125	1625	2200	......	......	......	......	2675	3180	3725	......	......	......	......
100	1470	2020	......	......	......	......	2440	2900	3400	......	......	......	......
90	1400	1940	......	......	......	......	2325	2760	3290	......	......	......	......
80	1340	1850	2210	......	......	......	2210	2640	3125	3500	......	......	......
70	1270	1750	2100	......	......	......	2100	2500	2975	3310	......	......	......
60	1190	1650	1975	2350	......	......	1975	2350	2800	3110	3550	......	......
50	1100	1540	1840	2175	......	......	1840	2175	2600	2900	3300	......	......
40	1000	1410	1675	2010	......	......	1675	2010	2400	2675	3050	......	......
30	895	1255	1510	1800	2175	......	1510	1800	2175	2420	2750	3250	......
20	770	1070	1325	1575	1900	......	1325	1575	1900	2125	2400	2825	......
15	695	960	1200	1450	1720	2180	1200	1450	1720	1950	2180	2590	3500
10	600	820	1025	1260	1460	1890	1025	1260	1460	1700	1890	2320	3100
5	400	550	710	850	1000	1340	710	850	1000	1140	1340	1650	2300
2	170	270	380	420	518	600	380	420	518	560	600	925	1350
1	100	145	220	245	310	450	220	245	310	340	450	600	880

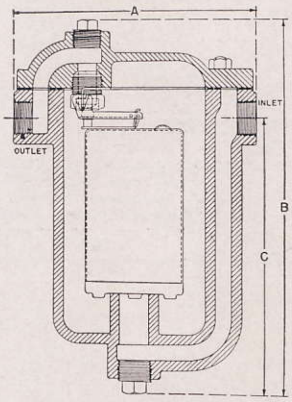


Fig. 3423
Type OB Trap
Type OB Traps can be furnished with integral strainer also with manual by-pass if so ordered.

OB TRAP—SIZE 1"								OB TRAP—SIZE 1¼"					
E	F	G	H	I	K	L	Seat Symbol	F	G	H	I	J	L
Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished							Press. Diff.	Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished					
250	175	125	80	60	30	15		250	175	125	80	60	30
5010	......	......	......	......	......	......	250	5700	......	......	......	......	......
4800	......	......	......	......	......	......	225	5410	......	......	......	......	......
4580	......	......	......	......	......	......	200	5175	......	......	......	......	......
4400	4890	......	......	......	......	......	175	4890	5550	......	......	......	......
4050	4580	......	......	......	......	......	150	4580	5200	......	......	......	......
3725	4220	4800	......	......	......	......	125	4220	4800	5300	......	......	......
3400	3850	4350	......	......	......	......	100	3850	4350	4800	......	......	......
3290	3690	4175	......	......	......	......	90	3690	4175	4600	......	......	......
3125	3500	3975	4400	......	......	......	80	3500	3975	4400	4800	......	......
2975	3310	3775	4150	......	......	......	70	3310	3775	4150	4510	......	......
2800	3110	3550	3900	4250	......	......	60	3110	3550	3900	4250	5050	......
2600	2900	3300	3600	3925	......	......	50	2900	3300	3600	3950	4650	......
2400	2675	3050	3300	3600	......	......	40	2675	3050	3300	3600	4290	......
2175	2420	2750	2950	3250	4400	......	30	2420	2750	2950	3250	3800	5025
1900	2125	2400	2550	2825	3820	......	20	2125	2400	2550	2825	3300	4350
1720	1950	2180	2350	2590	3500	3950	15	1950	2180	2350	2590	3000	3950
1460	1700	1890	2060	2320	3100	3520	10	1700	1890	2060	2320	2700	3520
1000	1140	1340	1475	1650	2300	2600	5	1140	1340	1475	1650	2000	2600
518	560	600	820	925	1350	1500	2	560	600	820	925	1150	1500
310	340	450	520	600	880	1025	1	340	450	520	600	780	1025

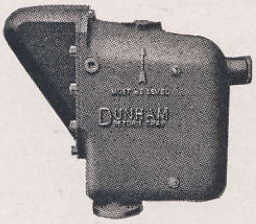
DIMENSION TABLE

Trap No.	Size Tapping Inches	Weight Lbs.	Dimensions in Inches A	*B	C
OBS ½	½	5¼	4⅝	6¾	3⅞
OBS ¾	¾	6	4¾	7¾	4¾
OB ½	½	13½	6 3/16	10 3/16	7¼
OB ¾	¾	21½	7 7/16	11⅞	8 11/16
OB 1	1	30	8 5/16	13½	10
OB 1¼	1¼	46	9 9/16	14⅞	10⅞

*Manual By-Pass increases B by 2" approx.

OBS TRAP—SIZE ½"						OBS TRAP—SIZE ¾"						
Seat Symbol	AA	A	B	C	D	Seat Symbol	AA	A	B	C	D	E
Press. Diff.	Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished					Press. Diff.	Max. Working Press. Lbs. per Sq. In. for Seat Size Furnished					
	150	80	60	30	15		150	125	80	60	30	15
150	800	......	......	......	......	150	880	......	......	......	......	......
125	760	......	......	......	......	125	850	1040	......	......	......	......
100	690	......	......	......	......	100	770	950	......	......	......	......
90	660	......	......	......	......	90	730	910	......	......	......	......
80	640	770	......	......	......	80	700	880	1090	......	......	......
70	610	730	......	......	......	70	670	840	1040	......	......	......
60	580	690	880	......	......	60	630	790	990	1230	......	......
50	540	650	830	......	......	50	590	730	920	1190	......	......
40	510	600	770	......	......	40	550	680	850	1090	......	......
30	470	550	700	850	......	30	510	620	770	1000	1110	......
20	420	490	620	770	......	20	450	550	680	880	1000	......
15	380	440	560	690	880	15	410	500	610	800	920	1060
10	340	400	500	610	780	10	360	450	550	710	820	950
5	300	340	420	530	660	5	310	390	470	600	720	830
2	160	170	270	380	420	2	160	170	270	380	420	520
1	90	100	145	220	245	1	90	100	145	220	245	310

DUNHAM RETURN TRAP—For Operating Pressures Up to 15 Lbs. Gage



Return Trap

Made in 3 sizes. The operating principle of all these is similar. On lifting service they may be used for pressure differences up to the equivalent of 15 lbs.

Type No.	Cat. No.	TAPPING, IN.				Net Weight, Lb.	DIMENSIONS IN IN.				
		I	II	III	IV		A	B	C	D	Width Overall
8A	FR15	1¼	1¼	⅜	½	50	10¾	8 7/16	16¼	16½	6½
9A	FR30	2	1½	½	1	125	12¼	13⅜	23⅜	20	9¼
10A	FR50	3	2	½	1	155	13⅞	14½	25⅜	21¼	9¼

Capacities EDR at 6 in. between BWL and bottom of trap FR15—1500 ft.; FR30—3,000 ft.; FR50—5,000 ft.

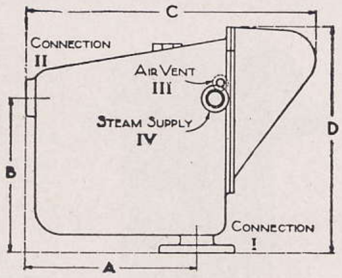


Fig. 863A

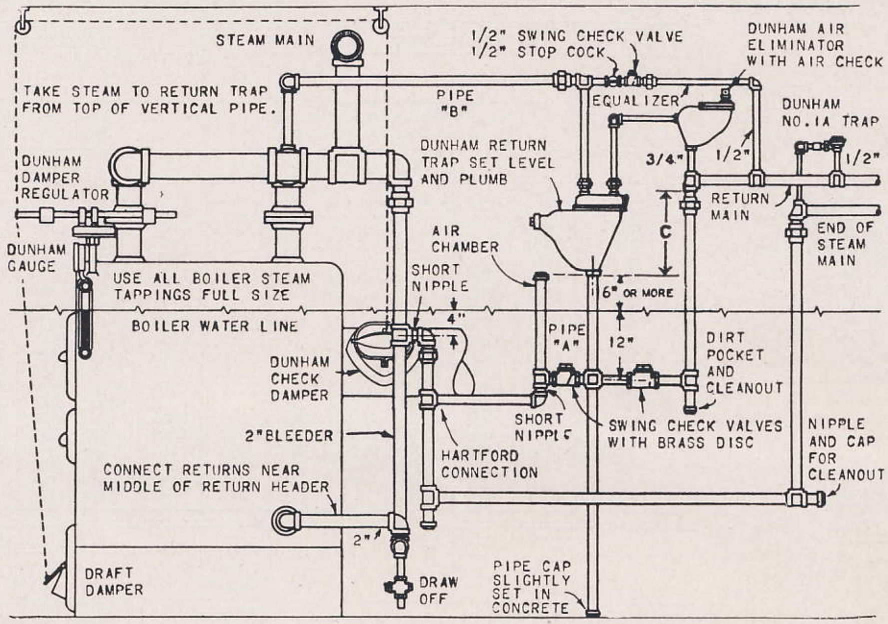


Fig. 1585

TYPICAL BOILER CONNECTIONS FOR
Nos. 8A-9A (Fig. 1585)

Size of Trap	Size of Pipe		Minimum Height "C" Bottom of Trap to Bottom of Return Main
	"A"	"B"	
8A	1¼"	¾"	14"
9A	1½"	1¼"	18"

TYPICAL BOILER CONNECTIONS FOR
No. 10A (Fig. 963B)

Size of Trap	Size of Pipe		Minimum Height "C" Bottom of Trap to Bottom of Return Main
	"A"	"B"	
10A	2"	1¼"	20"

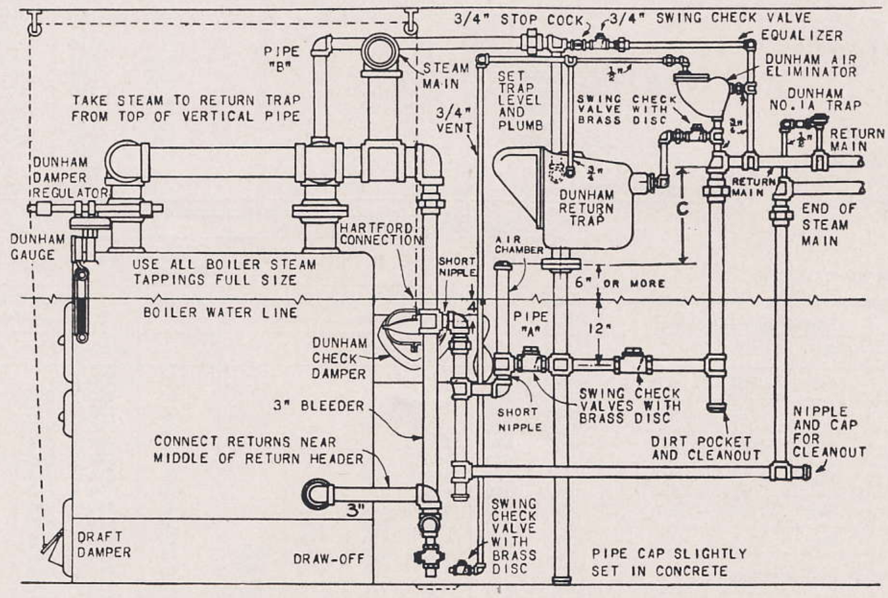


Fig. 963B

PIPE SIZING TABLES

(FOR VACUUM RETURN LINE AND DIFFERENTIAL SYSTEMS)

See Tables on page 14 for Vapor and Return Trap Systems

Steam Mains

Pipe Sizes Inches	Capacities in Square Feet of Equivalent Direct Cast Iron Radiation (EDR) for Each Length of Run — †Length of Runs in Feet										
	100	200	300	400	500	600	800	1,000	1,500	2,000	3,000
2	1,130	800	650	570	500	450	400	350	300	250	200
2½	2,100	1,470	1,200	1,050	925	840	735	650	550	460	380
3	3,800	2,660	2,160	1,900	1,670	1,520	1,330	1,180	990	830	680
3½	5,500	3,850	3,140	2,750	2,420	2,200	1,920	1,700	1,430	1,210	990
4	7,750	5,400	4,400	3,900	3,400	3,100	2,700	2,400	2,000	1,700	1,400
5	13,800	9,650	7,800	6,900	6,100	5,500	4,800	4,300	3,600	3,040	2,480
6	22,200	15,500	12,600	11,000	9,800	8,900	7,800	6,900	5,700	4,900	4,000
8	46,000	32,000	26,200	23,000	20,200	18,400	16,100	14,200	12,000	10,100	8,300
10	80,700	56,500	46,000	40,300	35,500	32,200	28,200	25,000	21,000	17,700	14,500
12	127,000	89,000	72,500	63,500	56,000	51,000	44,500	39,400	33,000	28,000	23,000
14	164,000	115,000	93,500	82,000	72,000	65,600	57,400	51,000	42,600	36,100	29,500
16	234,000	164,000	133,400	117,000	103,000	93,600	82,000	72,600	61,000	51,500	42,100

†The equivalent length is the distance along piping from the *Dunham Control Valve to the farthest radiator plus allowances for elbows and valves (see table "Allowances for Resistance to Flow") and plus 25 feet allowance for last radiator connection.

Do not reduce any steam main below 2 inches in size at its end.

*For Vacuum Return Line Systems "length" is the distance from boiler, pressure reducing valve or central station service main to the farthest radiator.

Return Mains

Pipe Sizes, Inches		1	1¼	1½	2	2½	3	3½	4	5	6
Capacity in Square Feet per Length of Run in Feet	**400 ft.**	800	1,600	4,000	11,000	21,000	38,000	55,000	78,000	138,000	220,000
	1,000 ft.	500	1,000	2,500	7,000	13,000	23,500	34,000	48,000	86,000	138,000
	2,000 ft.	350	800	1,800	5,000	9,000	16,000	24,000	34,000	60,000	98,000
	3,000 ft.	300	600	1,500	4,000	7,500	13,500	20,000	28,000	50,000	80,000

The length is the distance along piping from Pump to the farthest radiator plus allowances for elbows and valve (see table "Allowances for Resistance to Flow").

Vertical Risers

Pipe Sizes, Inches		Steam Risers									Return Risers		
		¾	1	1¼	1½	2	2½	3	3½	4	¾	1	1¼
Capacity in Square Feet per Length of Run in Feet	**200 ft.**	66	133	290	450	920	1,510	2,660	3,850	5,400	1,000	2,000	4,500
	400 ft.	47	95	210	325	655	1,080	1,900	2,750	3,900	800	1,600	3,400
	600 ft.	38	76	166	260	525	865	1,520	2,200	3,100	640	1,200	2,500
	1,000 ft.	29	59	129	200	410	670	1,180	1,700	2,400	500	1,000	2,100
	2,000 ft.	20	42	92	143	290	475	830	1,210	1,700	350	700	1,500

Determine the length of run of each riser exactly the same as for Steam Mains, that is from the source of steam supply to the farthest radiator supplied by the riser. Springpieces are the connections from steam mains to risers. Springpieces to upfeed risers are taken off the top of steam mains at 45 degrees and must be at least one pipe size larger than bottom of the riser.

Springpieces to downfeed risers may be taken off the bottom of of the steam main at 90 degrees and should be same size as top of the riser, grading downward with the direction of steam flow so that the main will be drained of condensate. If springpieces to downfeed risers are taken off the top of steam main at 45 degrees, then the main must be provided with drips and traps to drain it of condensate.

Springpieces to upfeed risers or horizontal offsets in risers, when over 8 feet long, should be made two pipe sizes larger than the riser to which they connect.

Springpieces from return risers to return mains should be same size as bottom of the return risers.

Radiator Connections

Square Feet of Direct Radiation	Supply			Return		
	Size Inlet Valve, Inches	Vertical Pipe to Inlet Valve Inches	Horizontal Runout to Riser or Springpiece to Main from a First Floor Radiator, Inches	Trap No.	Stub to Trap and Size of Trap Inches	Horizontal Runout to Riser or First Floor Radiator, Inches
1– 25	½	½	¾	**D1**	½	¾
26– 80	¾	¾	1	**D1**	½	¾
81–100	¾	¾	1¼	**D1**	½	¾
101–140	¾	¾	1¼	**D1**	½	¾
141–170	¾	¾	1½	**D1**	½	¾

If horizontal connections, springpieces and runouts are over 8 feet long, use pipes one size larger than given above.

Grade horizontal connections, both steam and return, with a fall of not less than ½ inch per foot.

Allowances for Resistance to Flow in Feet of Pipe

Pipe Size—Ins.	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14
Standard Elbow	2	2	3	4	5	5	7	8	9	11	13	17	21	27	30
Gate Valve	1	1	1	1	1	2	2	2	3	3	3	4	5	6	7

In sizing pipes, the length of the pipe must be ascertained, and the frictional resistance of fittings and valves considered. It is customary to reduce the resistance to equivalent length of straight pipe, as in the above table, which must be added to the actual measured length of run.

Always measure the entire length of pipe from the source of steam supply to the farthest radiator or heating unit, adding to the measured distance the allowance in feet for each elbow and valve as given in above table. Use the pipe capacities given in the column under that length which is nearest the estimated length. For example, suppose the longest main to farthest radiator including the riser measures 170 feet, and the allowance for elbows in that line to the farthest radiator is 65 feet, the total equivalent length is 235 feet. This main must then be sized on the 300-foot length columns.

In sizing riser determine the distance from source of the steam supply including allowances, to the base of each riser; add height of riser plus an allowance of 25 feet covering the resistance including elbows, valve and entrance into radiator for the farthest radiator. Size each riser, using pipe capacities given for nearest greater length same as for mains.

Pipe Sizing

For Return Heating Systems Using Return Trap or Condensation Pump

The pipe sizes for this system are based upon an initial operating pressure of 1 to 2 pounds gauge, although pressures up to 15 pounds may be used if desired. No smaller piping should be used than shown in the following tables, and care should be taken to ascertain the length of all runs with allowances added, in determining sizes.

Steam Mains

Pipe Sizes Inches	Capacities in Square Feet of Direct Cast Iron Radiation for Each Length						
	*Length in Feet						
	100	200	300	400	500	600	800
2	670	570	470	410	360	330	290
2½	1,090	930	760	670	590	530	470
3	1,930	1,650	1,340	1,170	1,030	940	820
3½	2,810	2,400	1,950	1,710	1,510	1,370	1,200
4	3,900	3,340	2,720	2,380	2,100	1,900	1,670
5	7,000	5,950	4,850	4,260	3,740	3,400	2,980
6	11,200	9,550	7,780	6,830	6,000	5,460	4,780
8	23,400	20,000	16,250	14,250	12,540	11,400	10,000
10	40,800	34,800	28,400	24,800	21,900	19,900	17,400

*Length equals distance along piping from source of steam supply to top of farthest riser or radiator on main plus allowances for elbows, valves and plus 25 feet allowance for radiator connection.

Return Mains

Pipe Sizes Inches	1	1¼	1½	2	2½	3	3½	4	5
	Capacity in Square Feet of Direct Cast Iron Radiation								
Mains under 400 ft. long	400	1,400	2,700	5,500	9,000	16,000	23,000	32,000	57,000
Mains over 400 ft. long	300	1,000	1,700	3,400	5,500	10,000	14,000	20,000	35,000

Steam Main Drips

Pipe Sizes	1¼	1½	2	2½	3	3½	4	5
Capacity in Sq. Ft.	1,400	2,700	5,500	9,000	16,000	23,000	32,000	57,000

Riser Sizes

Pipe Sizes	Steam							Return	
	¾	1	1¼	1½	2	2½	3	¾	1
*Length, 200 feet	45	90	190	290	570	930	1,650	600	1,200
*Length, 400 feet	30	60	136	200	410	670	1,170	430	850
*Length, 600 feet	25	50	110	165	330	530	940	340	670
*Length, 1000 feet	20	40	85	130	250	410	730	260	530

*Length equals distance along piping from source of steam supply to top of each riser plus allowance for elbows, valves (page 84) and plus 25 feet allowance for radiator connection.

Radiator Connections

Square Feet of Direct Radiation	Supply			Return		
	Size Inlet Valve Inches	Vertical Pipe to Inlet Valve Inches "A"*	Horizontal Runout to Riser or Spring-piece to Main from a First Floor Radiator, Inches "B"	Trap No.	Stub to Trap and Size of Trap Inches	Horizontal Runout to Riser to First Floor Radiator Inches "C"
1– 25	½	½	¾	1	½	¾
26– 80	¾	¾	1	1	½	¾
81–100	¾	¾	1¼	1	½	¾
101–140	¾	¾	1¼	1	½	¾
141–170	¾	¾	1½	1	½	¾

*"A," "B" and "C" refer to typical connections shown in Figs. 813B and 809C, page 81. If horizontal connections, springpieces and runouts are over 8 feet long, use pipes one size larger than given above. Grade horizontal connections, both steam and return, with a fall of not less than ½ inch per foot.

Pipe Sizes for Homes and Small Buildings

For Vapor Heating Systems

The following pipe sizing tables should be followed:

Steam Mains

Pipe Sizes, Inches	Capacities in Square Feet of Direct Cast Iron Radiation for Each Length				
	Length in Feet				
	200	300	400	500	600
2	320	282	248	218	200
2½	560	456	400	352	320
3	1000	810	710	625	570
3½	1500	1180	1035	910	830
4	2000	1640	1440	1270	1150
5	3600	2940	2580	2260	2060
6	5780	4700	4130	3640	3300

Steam Main Drips

Pipe Sizes	1¼ Inch	1½ Inch	2 Inch	2½ Inch
Capacity in Sq. Ft.	1000	2000	4000	6000

Return Mains

Pipe Sizes	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch
Capacity in Sq. Ft.	300	1000	1700	3300	5400

Riser Sizes

	Steam					Return
Pipe Sizes	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	¾ Inch
*Length, 100 ft.	40	80	160	250	400	500
*Length, 200 ft.	25	55	115	175	320	320
*Length, 400 ft.	20	40	80	125	240	250

*The length equals the distance along piping from boiler to top of each riser plus allowance for elbows (see page 64) and plus 25 feet allowance for last, or top, radiator connection.

Springpieces, that is, connections from steam main to risers supplying second floor and up must always be made one size larger than the riser. Return springpieces make same size as return riser.

Method of Looping for Obstructions

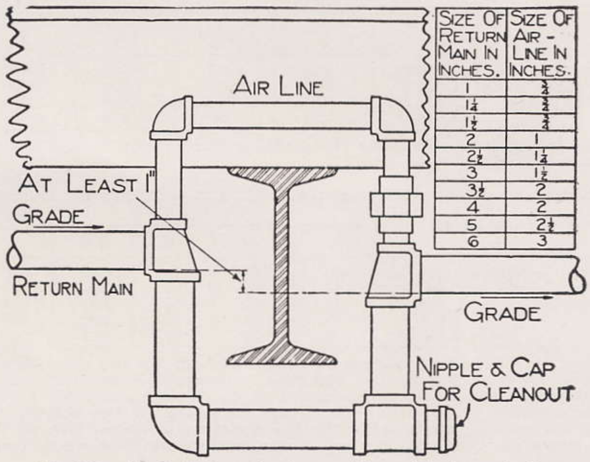


Fig. 948. Method of crossing beam without dripping to boiler or using separate return

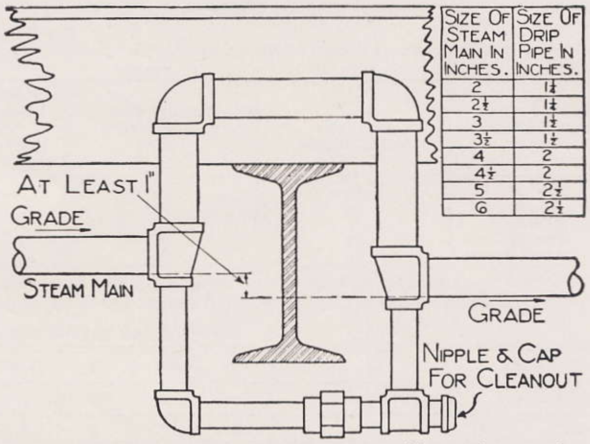
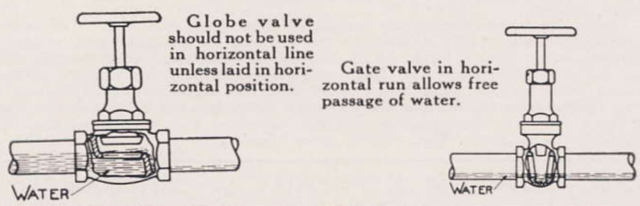
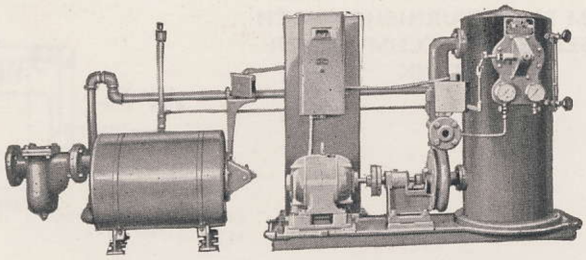


Fig. 949. Method of looping Steam main around beam, door, opening or other obstruction



DUNHAM VACUUM PUMPS

Type VR pumps are furnished as single or duplex units with a separate accumulator tank to take care of low returns. Each automatic pump has its own control panel wired through to motor and will efficiently maintain desired range in vacuum on return lines and deliver water of condensation direct to low pressure boiler. Selector switch on panel permits pump to operate on full vacuum and float control, float control only for night operation or continuous operation as desired.



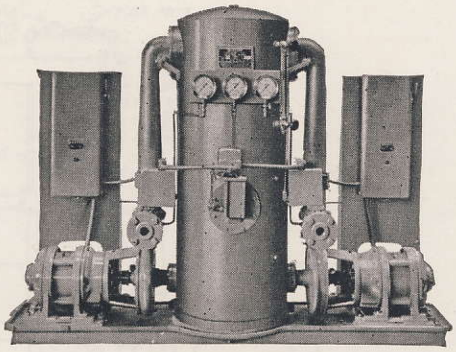
Type VR, with Accumulator Tank and Strainer—9 Sizes

Type VRD pumps meet the requirements for a duplex pump all mounted on one base. Either or both pumps can be operated as desired, and the unit is completely wired ready for operation as received. Should return lines be at low level, a separate accumulator tank can be furnished ahead of the pump to provide float control, in which case the installation is referred to as Type VRDA.

Both Type VR and Type VRD pumps are made in nine sizes, to be applied in accordance with EDR load, and no allowance is necessary for piping.

Standard units are tested and rated in accordance with the "Code for Vacuum Heating Pumps" of the A.S.H.V.E. and the Heating Manufacturers Section of the Hydraulic Institute. They are built for 20 pounds discharge at the pump, also for 50, 40 or even higher pressure according to requirements

All of these standard pumps are capable of producing 20 inches of vacuum hence can easily handle the requirements of any job up to rated capacity. The need of special units for greater air and water capacity are not necessary where Dunham Vacuum Pumps are installed, although such special units can be built on order.



Types VRD-DVD, 9 Sizes

Standard Water and Air Capacities

Water in gpm at 160° F. from 5.5" Vacuum to Required Discharge Pressure. Air in cfm at 160° F. and 5.5" Vacuum.

Size of Pump and EDR Load.	Sq. Ft.	2500	5000	10000	15000	20000	25000	30000	40000	65000
Water Only	Water	3.8	7.5	15.0	22.5	30.0	37.5	45.0	60.0	97.5
Simultaneous Air and Water	Water	1.3	2.5	5.0	7.5	10.0	12.5	15.0	20.0	32.5
	Air	1.3	2.5	4.0	5.4	6.8	8.3	9.7	12.6	19.8

The bronze fitted, enclosed impeller, centrifugal pump is mounted in straight line assembly with air separating tank and heavy duty motor on the bed plate. The pump is of special design capable of avoiding steam-binding under high water temperatures and cannot become air-bound. The pump impeller of bronze is statically balanced, keyed and locked to a shaft of non-corrosive metal. The shaft rotates on two heavy ball bearing assemblies enclosed in a single housing which is dust proof and has sufficient lubricant so as to require attention but once or twice yearly. The packing used in stuffing box is lubricated metal foil and asbestos formed in rings.

The motor is connected to the Type VR pump by a Hardy disc flexible coupling, and operates at a speed of 1750 rpm. The VRD and DVD pumps and motors are directly connected, using no coupling.

Directly above the centrifugal pump is mounted the multi-stage Exhauster and discharge valve. The design and arrangement of the multiple nozzles and delivery tubes of the Exhauster provide efficient operation over a wide range in temperatures and create a powerful suction whenever the centrifugal pump is in operation independently of water being discharged to the boiler.

Discharge valve is of the balanced type, single seat construction, with an auxiliary stainless steel valve and seat for minimum flow. The discharge valve is actuated by a seamless copper float through the float head mechanism mounted on the tank.

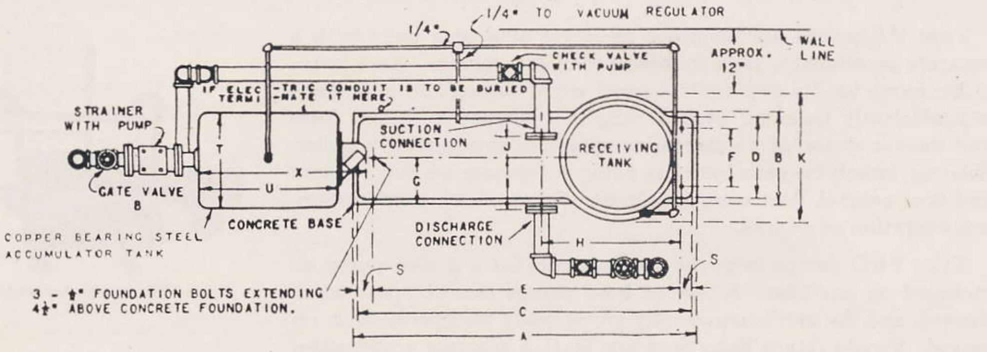
Fully enclosed electric control panel affords full protection to the motor and to the operating engineer since the disconnect switch handle is outside of cabinet. The push button for resetting the thermal relays that provide protection to the motor against overload and phase failure, also the selector switch, are on the front of the cabinet. Electric panel is wired through to motor, ready for operation when connected to source of power.

Reference to pages 22-25 illustrating typical installations of VR Pump, discloses how the need to place the vacuum pump in a pit is avoided. For every automatically operated pump a separate accumulator tank with float switch and saddles is furnished, and the installation of this receiving tank at a level low enough for return mains to gravitate into it is all that is necessary to obtain proper float operation of the pump and keep condensate out of return mains and in the boiler. It is the Accumulator Tank—not the VR Pump—that is installed in a pit if found to be necessary.

All necessary accessories are included, such as pressure and vacuum gauges, tested check valves for suction, discharge and vent lines of pump, strainer for suction line, air check release for receiving or accumulator tank, and complete installation and operating instructions.

VR SINGLE VACUUM RETURN LINE PUMP—PIPING CONNECTIONS AND DIMENSIONS

A SINGLE AUTOMATIC VACUUM PUMP FURNISHED WITH SEPARATE ACCUMULATOR TANK



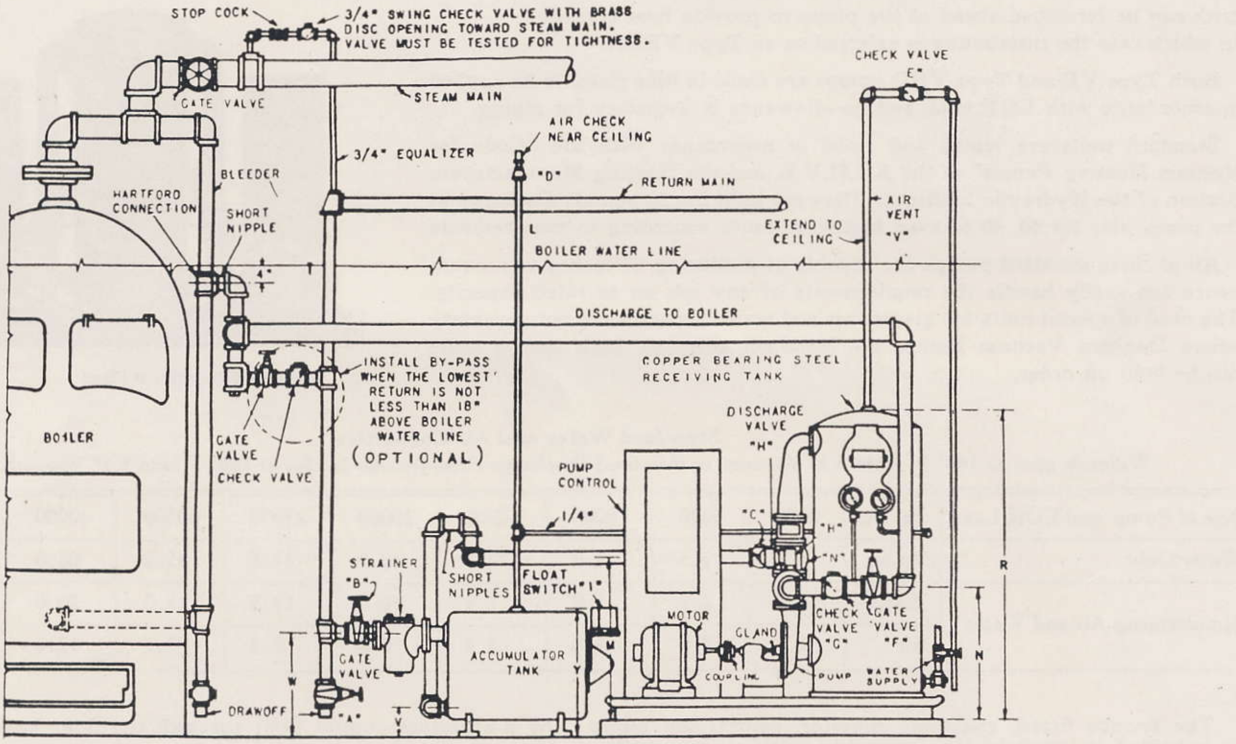


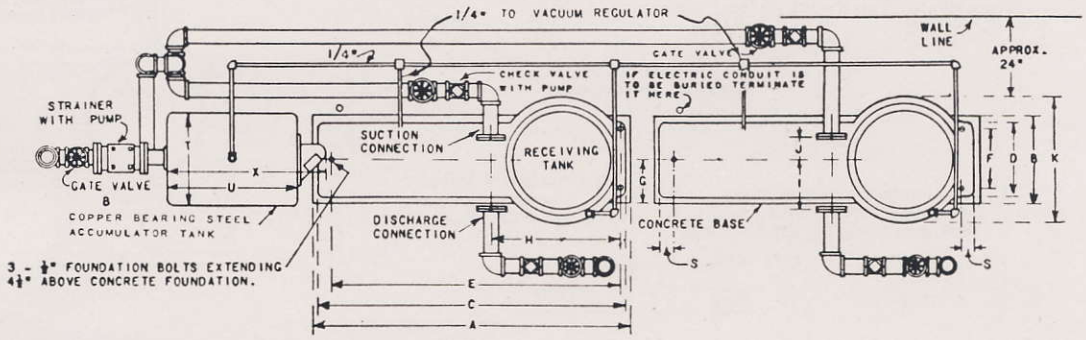
Fig. 1522A

Pump No.	Capacity	Motor H. P.	Dimensions in Inches															Approx. Shipping Weight (Lbs.).
			A	B	C	D	E	F	G	H	I	J	K	M	N	R	S	
VR2½	2,500	¾	59	16½	57⅝	14⅝	52⅞	10¼	8¼	21 11/16	8¼	3¼	21	24⅜	20	40	2⅜	840
VR5	5,000	¾	59	16½	57⅝	14⅝	52⅞	10¼	8¼	21 11/16	8¼	3¼	21	24⅜	20	40	2⅜	965
VR10	10,000	1½	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24⅞	8¼	3¼	24	26⅝	21⅞	47½	2 5/16	1095
VR15	15,000	1½	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24⅞	8¼	3¼	24	26⅝	21⅞	47½	2 5/16	1095
VR20	20,000	2	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24⅞	9½	4	24	26⅝	21⅞	47½	2 5/16	1178
VR25	25,000	3	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24⅞	12½	4	24	27	22⅛	53½	2 5/16	1238
VR30	30,000	3	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24⅞	12½	4	24	27	22⅛	53½	2 5/16	1286
VR40	40,000	5	61¾	16⅞	60⅜	15	55¾	10¾	8 7/16	24¾	12⅝	6	24	29¼	23½	60	2 5/16	1370
VR65	65,000	5	68¼	21⅝	66⅞	19¾	62	15¼	10 13/16	25⅞	12⅝	6	26	29½	23¾	60½	2 7/16	1525

The above data for standard 20-lb. Discharge Pressure Pumps. Use tabulated data for D V pumps of similar capacity.

VR DUPLEX VACUUM RETURN LINE PUMP—PIPING CONNECTIONS AND DIMENSIONS

TWO AUTOMATIC VACUUM PUMPS, FURNISHED IN DUPLICATE IN EVERY DETAIL AND COMPLETE WITH (ONE) ACCUMULATOR TANK.



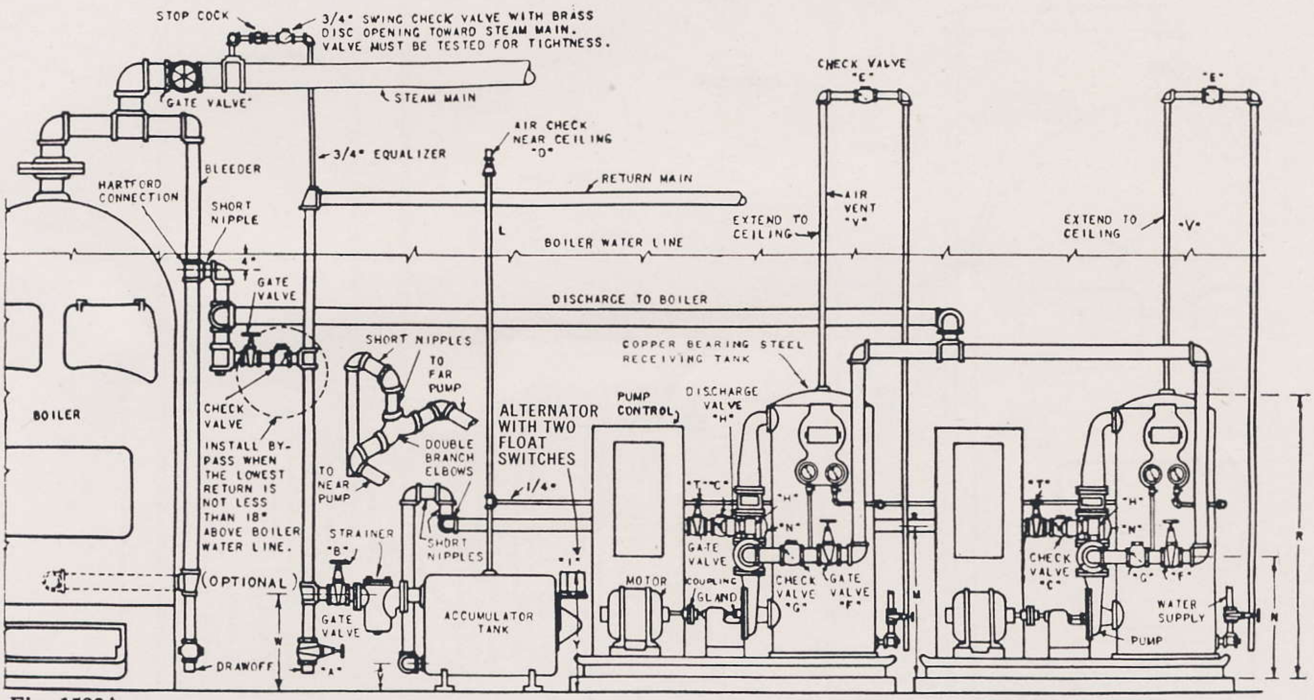


Fig. 1523A

Pump No.	Accumulator Tank Dimensions in Inches						Size of Pit if Required	Tapping Sizes—Inches					Capacity	Approx. Shipping Weight (Lbs.)
								Pump			Accum. Tank			
	T	U	V	W	X	Y		Suc'n	Disch.	Vent (V)	Inlet	Out.		
VR2½	12	14	4¼	11¼	18	30	3′-0″x5′-0″	¾	¾	1	1½	¾	2,500	1590
VR5	12	14	4¼	11¼	18	30	3′-0″x5′-0″	¾	¾	1	1½	¾	5,000	1840
VR10	16	18	5½	15½	22	32	3′-6″x5′-0″	1	1	1	2	1	10,000	2070
VR15	16	18	5½	15½	22	32	3′-6″x5′-0″	1¼	1¼	1	2	1¼	15,000	2070
VR20	16	24	5½	15½	28	32	3′-6″x5′-6″	1¼	1¼	1	2½	1¼	20,000	2220
VR25	16	24	5½	15½	28	32	3′-6″x5′-6″	1¼	1¼	1	2½	1¼	25,000	2340
VR30	16	36	5½	15½	40	32	3′-0″x6′-8″	1½	1½	1	3	1½	30,000	2440
VR40	16	36	5½	15½	40	32	3′-6″x6′-8″	1½	1½	1½	3	1½	40,000	2600
VR65	24	36	6½	23⅜	44	36	4′-0″x6′-8″	2	2	1½	4	2	65,000	2700

TYPE VRD VACUUM RETURN LINE PUMP—PIPING CONNECTIONS AND DIMENSIONS

DUPLEX ASSEMBLY COMPLETE ON ONE BASE recommended for use where return lines are at a high enough level to permit condensation to gravitate into inlet connection of receiver.

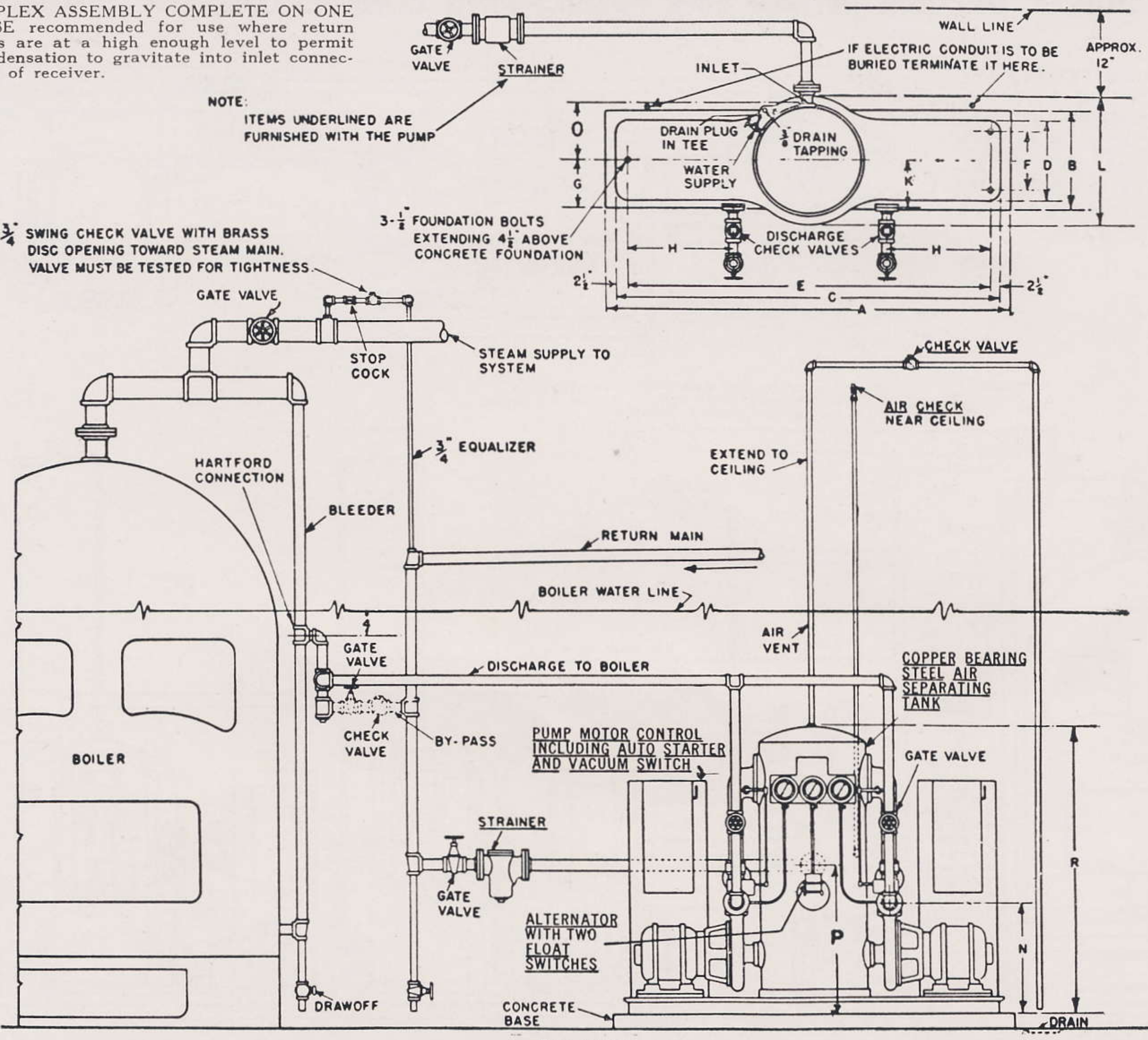


Fig. 1958A

Pump No.	Capacity Sq. Ft. EDR	M't'r H. P.	Pump Dimensions in Inches																VRD Pump Tapping in Inches			Approx. Shipping Weight (Pounds)
			A	B	C	D	E	F	G	H	J	K	I	M	N	O	P	R	Suc'n	Dis.	Vent	
VRD2½-VRDA2½	2,500	¾	77½	15¾	76	13¾	71	9¼	7⅞	21⅝	3¼	8¼	22	24⅛	19¾	9½	25⅞	54¾	1½	¾	1	1255
VRD5-VRDA5	5,000	¾	77½	15¾	76	13¾	71	9¼	7⅞	21⅝	3¼	8¼	22	24⅛	19¾	9½	25⅞	54¾	1½	¾	1	1255
VRD10-VRDA10	10,000	1½	77½	15¾	76	13¾	71	9¼	7⅞	21⅝	3¼	8¼	22	24⅜	19⅝	9½	25⅞	54¾	2	1	1	1375
VRD15-VRDA15	15,000	1½	79½	17	78	15	73	10½	8½	21⅝	3¼	8¼	24	24⅜	19⅝	10¾	27⅝	58½	2	1¼	1	1385
VRD20-VRDA20	20,000	2	79½	17	78	15	73	10½	8½	21⅝	4	9½	24	24½	19¾	10¾	27¾	58½	2½	1¼	1	1420
VRD25-VRDA25	25,000	3	87½	18½	86	16½	81	12	9¼	23⅝	4	12½	28	25⅞	21	13	29¼	68	2½	1¼	1	1765
VRD30-VRDA30	30,000	3	87½	18½	86	16½	81	12	9¼	23⅝	4	12½	28	25⅞	21	13	29¼	68	3	1½	1	1790
VRD40-VRDA40	40,000	5	87½	18½	86	16½	81	12	9¼	23⅝	6	12½	28	28⅞	23⅛	13	32¼	68	3	1½	1½	1930
VRD65-VRDA65	65,000	5	87½	18½	86	16½	81	12	9¼	23⅝	6	12½	28	28⅞	23⅛	13	32¼	68	4	2	1½	2085

The above printed data is for standard 20-lb. Discharge Pumps. Use. tabulated data for DVD or DVDA pumps of similar capacity.

TYPE VRDA VACUUM RETURN LINE PUMP—PIPING CONNECTIONS AND DIMENSIONS

DUPLEX ASSEMBLY OF VACUUM PUMPS ON ONE BASE WITH SEPARATE ACCUMULATOR TANK to connect to return lines at low level.

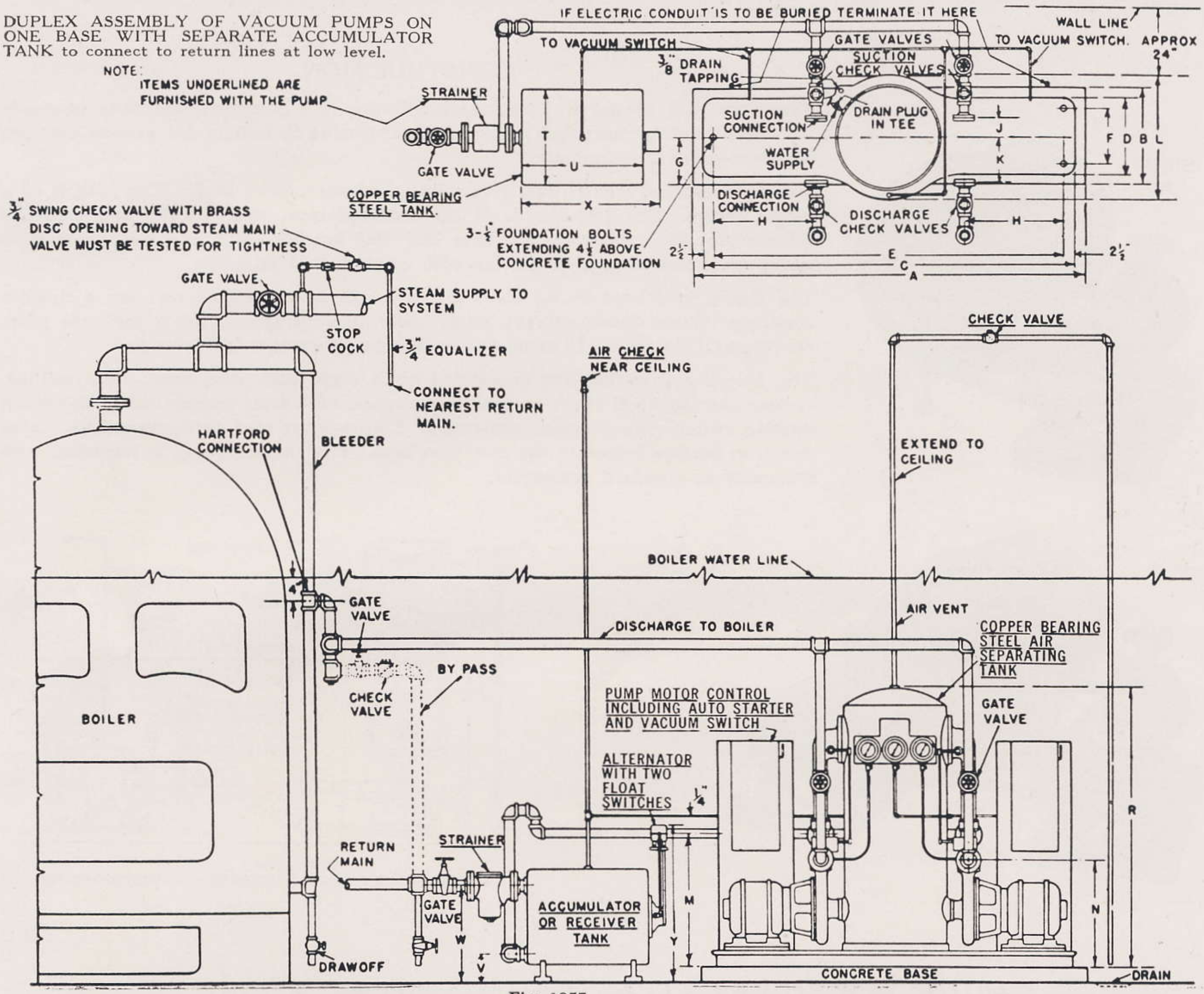
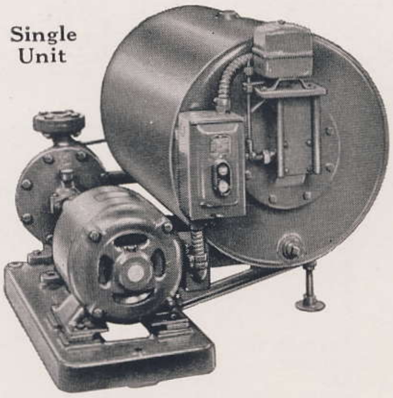


Fig. 1957

Pump No.	Pump Tappings, Inches			Accumulator Tank									Approx. Shipping Weight (Pounds)
				Dimensions in Inches						Pit if Required	Tappings		
	Suction	Discharge	Vent	T	U	V	W	X	Y		Inlet	Outlet	
VRDA2½	¾	¾	1	12	14	4¼	11¼	18	30	3′-0″x5′-0″	1½	¾	1280
VRDA5	¾	¾	1	12	14	4¼	11¼	18	30	3′-0″x5′-0″	1½	¾	1280
VRDA10	1¼	1¼	1	16	18	5½	15½	22	32	3′-6″x5′-0″	2	1¼	1420
VRDA15	1¼	1¼	1	16	18	5½	15½	22	32	3′-6″x5′-0″	2	1¼	1420
VRDA20	1¼	1¼	1	16	24	5½	15½	28	32	3′-6″x5′-6″	2½	1¼	1520
VRDA25	1¼	1¼	1	16	24	5½	15½	28	32	3′-6″x5′-6″	2½	1¼	1860
VRDA30	1½	1½	1	16	36	5½	15½	40	32	3′-6″x6′-8″	3	1½	1910
VRDA40	1½	1½	1½	16	36	5½	15½	40	32	3′-6″x6′-8″	3	1½	2010
VRDA65	2	2	1½	24	36	6½	23⅜	44	36	4′-0″x6′-8″	4	2	2285

CONDENSATION PUMP AND RECEIVER—TYPE CH, MODEL B

Single Unit



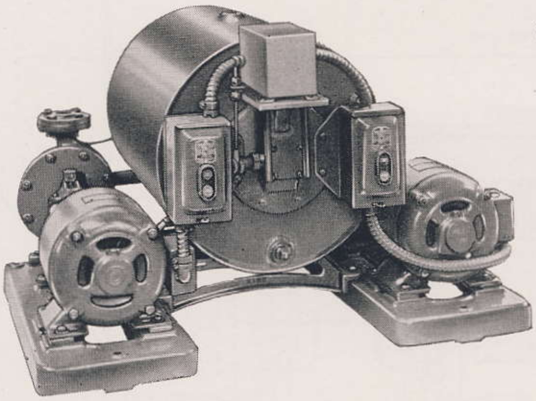
CONSTRUCTION

The Type CH Model B Condensation Pump is a complete, compact assembly for automatically returning water of condensation to boilers for gravity systems or steam process equipment.

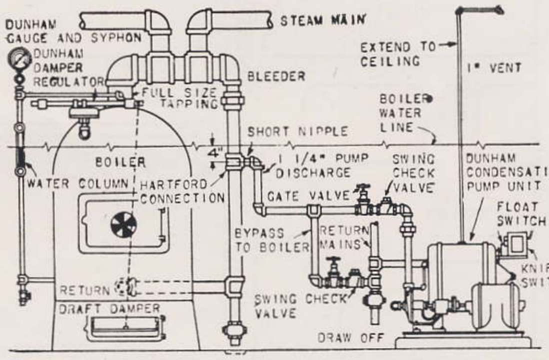
The bronze-fitted Centrifugal Pump has a non-corrosive shaft. The case is of a volute design. The Impeller is of the enclosed type, hydraulically and statically balanced for high efficiency and long life. Ball bearings of liberal size are used to insure maximum length of service with minimum of attention.

The Pump is driven by an electric motor direct connected through a flexible coupling. When direct current, or 60 cycle alternating current is used, the units operate at 1750 r.p.m., 25 or 50 cycle alternating current at 1450 r.p.m.

The Pump and motor are assembled on a rigid cast iron base. The welded, copper bearing steel receiver tank is equipped with float switch and push button starting switch with overload protection. The receiver tank is supported by malleable iron saddles bolted to the cast iron base. The Duplex pump is furnished with alternator as standard equipment.



Duplex Unit



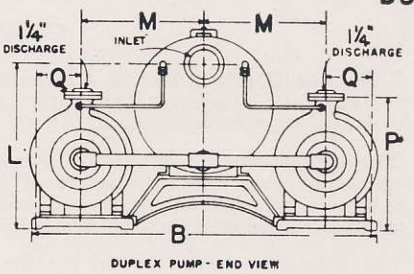
DETAIL NO. 1
CONNECTIONS AND DIMENSIONS HORIZONTAL (CH) CONDENSATION PUMP

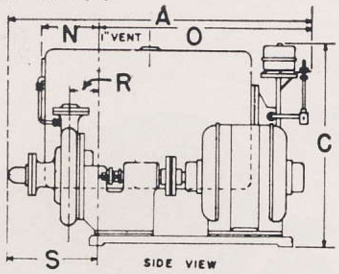
MOTOR HORSEPOWER, CAPACITIES AND SHIPPING WEIGHT

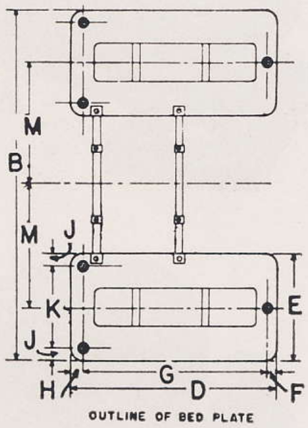
Catalog Numbers and Motor Horsepower						Pump Inlet Tapping Inches	Capacity Sq. Ft. EDR	GPM Rad'n Will Condense	GPM Capacity of Pump	Size of Receiver, Ins.		Capacity Receiver Gals.	Approximate Floor Space, Inches		Approx. Shpg. Weights, Lbs.	
10 Lb.	H. P.	15 Lb.	H. P.	20 Lb.	H. P.					Diam.	Length		Single	Duplex	Single	Duplex
CH 210 B	¼	CH 215 B	½	CH 220 B	½	2	2000	1	3	16	18	15¾	27¼x27	38⅛x30½	315	530
CH 410 B	¼	CH 415 B	½	CH 420 B	½	2	4000	2	6	16	18	15¾	27¼x27	38⅛x30½	315	530
CH 610 B	¼	CH 615 B	½	CH 620 B	¾	2	6000	3	9	16	18	15¾	27¼x27	38⅛x30½	325	530
CH 810 B	⅓	CH 815 B	½	CH 820 B	¾	3	8000	4	12	16	24	20¾	29¾x33	43½x36½	345	560
CH1010 B	⅓	CH1015 B	½	CH1020 B	¾	3	10000	5	15	16	24	20¾	29¾x33	43½x36½	345	580
CH1510 B	½	CH1515 B	¾	CH1520 B	1	4	15000	7½	22½	16	36	31½	29¾x45	43½x48½	350	590
CH2010 B	½	CH2015 B	¾	CH2020 B	1	4	20000	10	30	16	36	31½	29¾x45	43½x48½	360	600
CH2510 B	¾	CH2515 B	¾	CH2520 B	1	4	25000	12½	37½	16	36	31½	29¾x45	43½x48½	370	600
CH3010 B	¾	CH3015 B	1	CH3020 B	1½	4	30000	15	45	16	36	31½	29¾x45	43½x48½	380	600
CH4010 B	1	CH4015 B	1½	CH4020 B	1½	4	40000	20	60	16	48	41½	29¾x57	43½x60½	390	620
CH5010 B	1	CH5015 B	1½	CH5020 B	2	4	50000	25	75	16	48	41½	29¾x57	43½x60½	400	690
30 Lb.	H. P.	40 Lb.	H. P.	50 Lb.	H. P.											
CH 230 B	1½	CH 240 B	1½	CH 250 B	3	2	2000	1	3	16	18	15¾	29¾x27	43½x30½	375	640
CH 430 B	1½	CH 440 B	2	CH 450 B	3	2	4000	2	6	16	18	15¾	29¾x27	43½x30½	375	640
CH 630 B	1½	CH 640 B	2	CH 650 B	3	2	6000	3	9	16	18	15¾	29¾x27	43½x30½	375	640
CH 830 B	1½	CH 840 B	2	CH 850 B	3	3	8000	4	12	16	24	20¾	29¾x33	43½x36½	390	660
CH1030 B	1½	CH1040 B	2	CH1050 B	3	3	10000	5	15	16	24	20¾	29¾x33	43½x36½	390	660
CH1530 B	1½	CH1540 B	2	CH1550 B	3	4	15000	7½	22½	16	36	31½	29¾x45	43½x48½	420	690
CH2030 B	2	CH2040 B	3	CH2050 B	3	4	20000	10	30	16	36	31½	29¾x45	43½x48½	420	690
CH2530 B	2	CH2540 B	3	CH2550 B	5	4	25000	12½	37½	16	36	31½	29¾x45	43½x48½	440	720
CH3030 B	2	CH3040 B	3	CH3050 B	5	4	30000	15	45	16	36	31½	29¾x45	43½x48½	450	720
CH4030 B	3	CH4040 B	3	CH4050 B	5	4	40000	20	60	16	48	41½	29¾x57	43½x60½	460	780
CH5030 B	3	CH5040 B	5	CH5050 B	5	4	50000	25	75	16	48	41½	29¾x57	43½x60½	460	780

THE DUNHAM CONDENSATION PUMP AND RECEIVER—TYPE CH MODEL B—(Cont.)

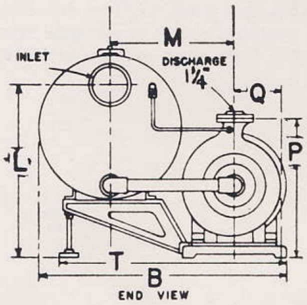
DUPLEX UNIT

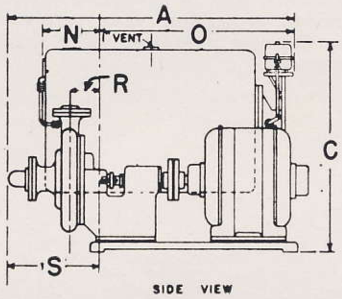






SINGLE UNIT





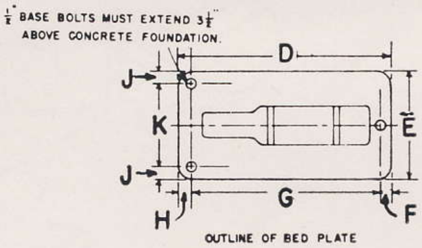


Fig. 3244

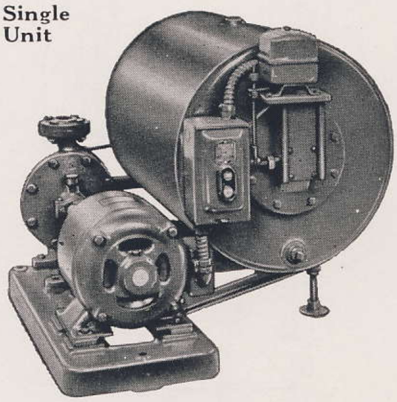
DIMENSIONS

Catalogue Number	Unit	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T
		Dimensions in Inches																		
CH210B—CH410B—CH610B CH215B—CH415B—CH615B CH220B—CH420B—CH620B	Single	27	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	20⅛	14	4¾	2¼	7	24⅞
	Duplex	28	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	21⅛	14	4¾	2¼	7	....
CH230B—CH430B—CH630B CH240B—CH440B—CH640B CH250B—CH450B—CH650B	Single	27	29¾	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	17¾	17⅛	5⅝	2⅞	9¼	27½
	Duplex	28	43½	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	18¾	17⅛	5⅝	2⅞	9¼	....
CH810B—CH1010B CH815B—CH1015B	Single	33	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	26⅛	14	4¾	2¼	7	24⅞
	Duplex	34	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	27⅛	14	4¾	2¼	7	....
CH820B—CH1020B CH830B—CH1030B CH840B—CH1040B CH850B—CH1050B	Single	33	29¾	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	23¾	17⅛	5⅝	2⅞	9¼	27½
	Duplex	34	43½	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	24¾	17⅛	5⅝	2⅞	9¼	....
CH1510B—CH2010B—CH2510B—CH3010B	Single	45	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	38⅛	14	4¾	2¼	7	24⅞
CH1515B—CH2015B—CH2515B—CH3015B	Duplex	46	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	39⅛	14	4¾	2¼	7	....
CH1520B—CH2020B—CH2520B—CH3020B CH1530B—CH2030B—CH2530B—CH3030B CH1540B—CH2040B—CH2540B—CH3040B CH1550B—CH2050B—CH2550B—CH3050B	Single	45	29¾	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	35¾	17⅛	5⅝	2⅞	9¼	27½
	Duplex	46	43½	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	36¾	17⅛	5⅝	2⅞	9¼	....
CH4010B—CH5010B	Single	57	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	50⅛	14	4¾	2¼	7	24⅞
	Duplex	58	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	51⅛	14	4¾	2¼	7	....
CH4015B—CH5015B	Single	57	29¾	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	50⅛	14½	5⅝	2¼	7	27½
	Duplex	58	43½	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	51⅛	14½	5⅝	2¼	7	....
CH4020B—CH5020B CH4030B—CH5030B CH4040B—CH5040B CH4050B—CH5050B	Single	57	29¾	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	47¾	17⅛	5⅜	2⅞	9¼	27½
	Duplex	58	43½	25¾	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	19⅜	15	7	48¾	17⅛	5⅝	2⅞	9¼	....

CONDENSATION PUMP AND RECEIVER—TYPE CHH, MODEL B

CONSTRUCTION

Single Unit



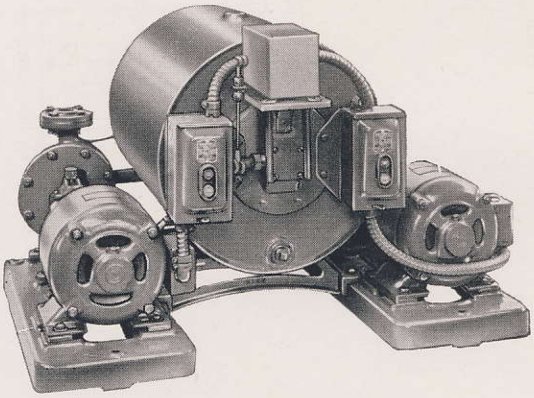
The Type CHH, Model B, Condensation Pump is a complete, compact assembly for automatically returning water of condensation to boilers for gravity systems or steam process equipment.

The bronze-fitted Centrifugal Pump has a non-corrosive shaft. The case is of volute design. The Impeller is of the enclosed type, hydraulically and statically balanced for high efficiency and long life. Ball bearings of liberal size are used to insure maximum length of service with minimum of attention.

The Pump is driven by an electric motor direct connected through a flexible coupling. When direct current, or 60 cycle alternating current is used, the units operate at 3450 r.p.m., 25 or 50 cycle alternating current at 2850 r.p.m.

The Pump and motor are assembled on a rigid cast iron base. The welded copper bearing steel receiver tank is equipped with float switch and push button starting switch with overload protection. The receiver tank is supported by malleable iron saddles bolted to the cast iron base. The Duplex pump is furnished with alternator as standard equipment.

Duplex Unit



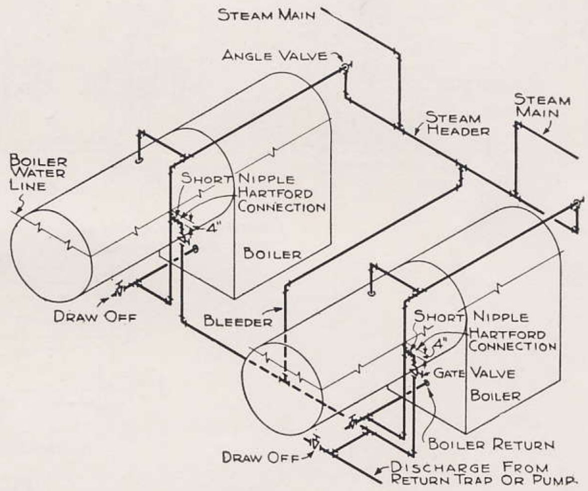


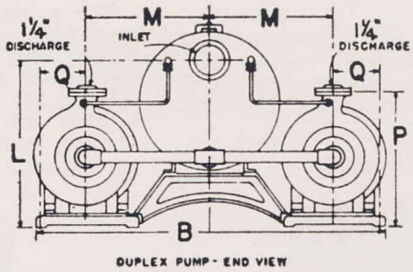
Fig. 1734—When two or more boilers are connected in battery it is difficult to keep their water lines constant due to uneven pressures caused by variations in firing. With the Hartford Connection in use, as shown the water cannot leave either boiler lower than the bottom of the short nipple. It does away with he use of check valves between boilers, being a check valve in itself.

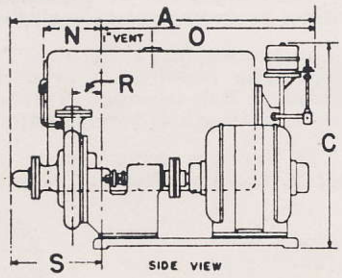
MOTOR HORSEPOWER, CAPACITIES AND SHIPPING WEIGHT

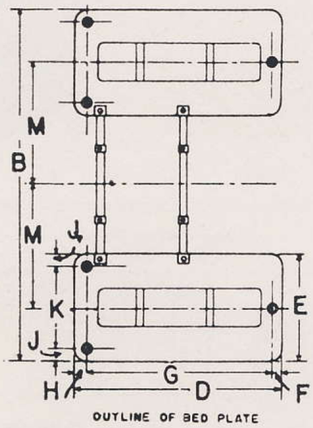
Catalog Numbers and Motor Horsepower						Pump Inlet Tapping Inches	Capacity Sq. Ft. EDR	GPM Rad'n Will Condense	GPM Capac-ity of Pump	Size of Receiver, Ins.		Capacity Re-ceiver Gals.	Approximate Floor Space, Inches		Approx. Shpg. Weights, Lbs.	
		20 Lb.	H.P.	30 Lb.	H.P.					Diam.	Length		Single	Duplex	Single	Duplex
				CHH 230 B	¾	2	2000	1	3	16	18	15¾	27¼x27	38⅛x30½	325	540
				CHH 430 B	¾	2	4000	2	6	16	18	15¾	27¼x27	38⅛x30½	325	540
				CHH 630 B	¾	2	6000	3	9	16	18	15¾	27¼x27	38⅛x30½	325	540
				CHH 830 B	1	3	8000	4	12	16	24	20¾	27¼x33	38⅛x36½	325	570
				CHH1030 B	1	3	10000	5	15	16	24	20¾	27¼x33	38⅛x36½	335	570
		CHH1520 B	¾	CHH1530 B	1	4	15000	7½	22½	16	36	31½	27¼x45	38⅛x48½	350	580
		CHH2020 B	1	CHH2030 B	1½	4	20000	10	30	16	36	31½	27¼x45	38⅛x48½	360	600
		CHH2520 B	1	CHH2530 B	1½	4	25000	12½	37½	16	36	31½	27¼x45	38⅛x48½	370	600
		CHH3020 B	1	CHH3030 B	1½	4	30000	15	45	16	36	31½	27¼x45	38⅛x48½	370	600
		CHH4020 B	1½	CHH4030 B	2	4	40000	20	60	16	48	41½	29¾x57	43½x60½	390	700
		CHH5020 B	2	CHH5030 B	3	4	50000	25	75	16	48	41½	29¾x57	43½x60½	400	720
40 Lb.	H.P.	50 Lb.	H.P.	70 Lb.	H.P.											
CHH 240 B	1	CHH 250 B	1½	CHH 270 B	2	2	2000	1	3	16	18	15¾	29¾x27	43½x30½	370	580
CHH 440 B	1	CHH 450 B	1½	CHH 470 B	2	2	4000	2	6	16	18	15¾	29¾x27	43½x30½	370	580
CHH 640 B	1	CHH 650 B	1½	CHH 670 B	2	2	6000	3	9	16	18	15¾	29¾x27	43½x30½	370	580
CHH 840 B	1	CHH 850 B	1½	CHH 870 B	2	3	8000	4	12	16	24	20¾	29¾x33	43½x36½	380	590
CHH1040 B	1½	CHH1050 B	1½	CHH1070 B	2	3	10000	5	15	16	24	20¾	29¾x33	43½x36½	380	590
CHH1540 B	1½	CHH1550 B	2	CHH1570 B	3	4	15000	7½	22½	16	36	31½	29¾x45	43½x48½	400	640
CHH2040 B	1½	CHH2050 B	2	CHH2070 B	3	4	20000	10	30	16	36	31½	29¾x45	43½x48½	400	700
CHH2540 B	2	CHH2550 B	3	CHH2570 B	5	4	25000	12½	37½	16	36	31½	29¾x45	43½x48½	420	730
CHH3040 B	2	CHH3050 B	3	CHH3070 B	5	4	30000	15	45	16	36	31½	29¾x45	43½x48½	420	730
CHH4040 B	3	CHH4050 B	3	CHH4070 B	5	4	40000	20	60	16	48	41½	29¾x57	43½x60½	450	760
CHH5040 B	3	CHH5050 B	5	....	....	4	50000	25	75	16	48	41½	29¾x57	43½x60½	450	760

CONDENSATION PUMP AND RECEIVER—TYPE CHH, MODEL B—(Cont.)

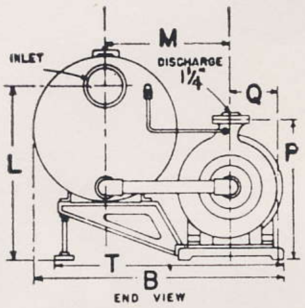
DUPLEX UNIT

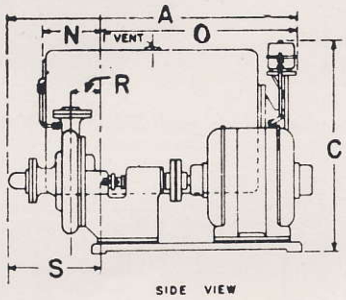






SINGLE UNIT





½ BASE BOLTS MUST EXTEND 3½ ABOVE CONCRETE FOUNDATION

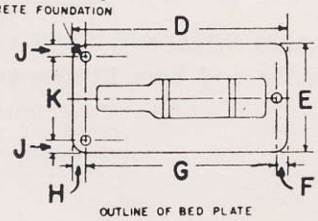


Fig. 3244

DIMENSIONS

Catalogue Number	Unit	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T
		Dimensions in Inches																		
CHH230B—CHH430B—CHH630B CHH240B—CHH440B—CHH640B CHH250B—CHH450B—CHH650B	Single	27	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	20⅛	14	4¾	2¼	7	24⅞
	Duplex	28	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	21⅛	14	4¾	2¼	7	....
CHH270B—CHH470B—CHH670B	Single	27	29¾	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	20⅛	14½	5⅝	2¼	7	27½
	Duplex	28	43½	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	21⅛	14½	5⅝	2¼	7	....
CHH830B—CHH1030B CHH840B—CHH1040B CHH850B—CHH1050B	Single	33	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	26⅛	14	4¾	2¼	7	24⅞
	Duplex	34	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	27⅛	14	4¾	2¼	7	....
CHH870B—CHH1070B	Single	33	29¾	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	26⅛	14½	5⅝	2¼	7	27½
	Duplex	34	43½	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	27⅛	14½	5⅝	2¼	7	....
CHH1520B—CHH2020B—CHH2520B—CHH3020B CHH1530B—CHH2030B—CHH2530B—CHH3030B CHH1540B—CHH2040B—CHH2540B CHH1550B	Single	45	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	38⅛	14	4¾	2¼	7	24⅞
	Duplex	46	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	39⅛	14	4¾	2¼	7	....
CHH3040B CHH2050B—CHH2550B—CHH3050B CHH1570B—CHH2070B—CHH2570B—CHH3070B	Single	45	29¾	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	38⅛	14½	5⅝	2¼	7	27½
	Duplex	46	43½	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	39⅛	14½	5⅝	2¼	7	....
CHH4020B	Single	57	27¼	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	50⅛	14	4¾	2¼	7	24⅞
	Duplex	58	38⅛	24 1/16	26	11⅝	13/16	24⅛	1 1/16	1 1/16	9½	17¾	13¼	4¾	51⅛	14	4¾	2¼	7	....
CHH5020B CHH4030B—CHH5030B CHH4040B—CHH5040B CHH4050B—CHH5050B CHH4070B	Single	57	29¾	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	50⅛	14½	5⅝	2¼	7	27½
	Duplex	58	43½	25½	29⅜	13½	1	27⅛	1¼	1 3/16	11⅛	18⅛	15	4¾	51⅛	14½	5⅝	2¼	7	....

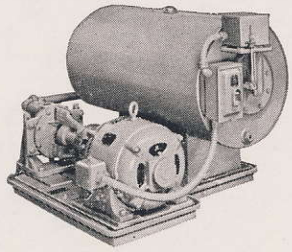
CONDENSATION PUMP AND RECEIVER TYPE CH, MODEL A
70 and 100 Lbs. Discharge Pressure

This Pump is a complete, compact assembly for automatically returning water of condensation to boilers for gravity systems or steam process equipment.

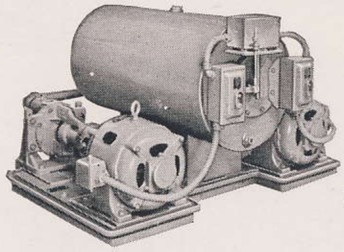
The bronze fitted Turbine Pump has a non-corrosive shaft. The impeller is properly balanced and of high efficiency. Ball bearings of liberal size are used to insure maximum length of service with the minimum of attention.

The Pump is driven by an electric motor direct connected through a flexible coupling. When direct current, or 60 cycle alternating current is used, the units operate at 1750 rpm, 25 or 50 cycle alternating current at 1450 rpm.

The pump, motor and receiver tank with saddles are all assembled on a rigid, extended, cast iron base. The welded copper bearing steel receiver tank is equipped with float switch and with thermal units providing overload protection for motor if 3-phase current. All wiring is completed so that unit is ready for operation when received. The Duplex pump is furnished with alternator as standard equipment.



Single Unit



Duplex Unit

Motor Horse Power—Capacities and Shipping Weight

Pump Catalog Numbers and Motor Horse Power				Pump Inlet Tapping Inches	Capacity Sq. Ft. EDR	GPM Rad'n Will Condense	GPM Capacity of Pump	Size of Receiver Inches		Capacity Receiver Gals.	Approx. Floor Space Inches		Approx. Shipping Weight Lbs.	
70 Lb.	H.P.	100 Lb.	H.P.					Diam.	Length		Single	Duplex	Single	Duplex
CH270A	¾	CH2100A	¾	2	2,000	1	3	16	18	15¾	31x44	48x44	650	1100
CH470A	¾	CH4100A	1	2	4,000	2	6	16	18	15¾	31x44	48x44	650	1100
CH670A	1	CH6100A	1½	2	6,000	3	9	16	18	15¾	31x44	48x44	650	1100
CH870A	1½	CH8100A	2	3	8,000	4	12	16	24	20¾	31x47	48x47	660	1120
CH1070A	2	CH10100A	2	3	10,000	5	15	16	24	20¾	31x47	48x47	660	1120

CONDENSATION PUMP AND RECEIVER TYPE CH, MODEL A
For 1000 sq. ft. Capacity and Low Discharge Pressures

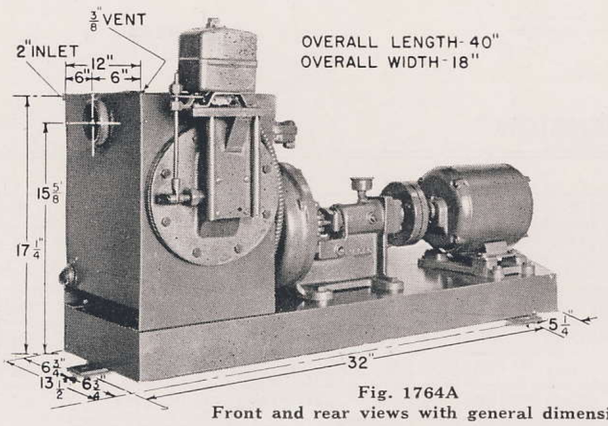


Fig. 1764A

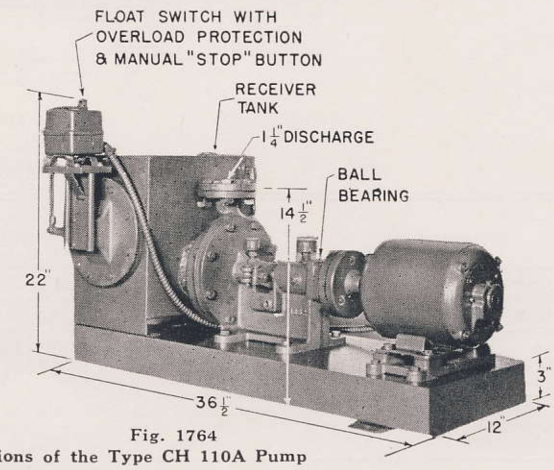


Fig. 1764

Front and rear views with general dimensions of the Type CH 110A Pump

This Pump is a complete, compact assembly for automatically returning water of condensation to boilers for gravity systems or steam process equipment.

The bronze-fitted Centrifugal Pump has a non-corrosive shaft. The case is of a volute design. The Impeller is of the enclosed type, hydraulically and dynamically balanced for high efficiency and long life. Ball bearings of liberal size are used to insure maximum length of service with minimum of attention.

The Pump is driven by an electric motor direct connected through a flexible coupling. When direct current, or 60 cycle alternating current is used, the units operate at 1750 rpm.

The pump, motor and receiver tank are all assembled on a rigid channel iron base. The welded, copper bearing steel receiver tank is equipped with float switch and is also provided with thermal units affording overload protection of motor.

These pumps are not available in duplex units on one base with common receiver tank.

Catalog Number	Motor Horse Power	Discharge Pressure Lb.	Capacities		Approx. Shipping Weights
			Sq. Ft. EDR	GPM Pump Capacity	
CH110A	¼	10	1000	1½	250
CH115A	⅓	15	1000	1½	270
CH120A	½	20	1000	1½	285

Available on D. C. or 50 and 60 cycle A. C. only.

DUNHAM CONDENSATION PUMP WITH MAKE-UP WATER VALVE

There are many installations, particularly on small high pressure boilers, where the maintaining of water line in the boiler within narrow limits is important.

This can best be accomplished by having the Pump controlled by a Boiler Water Level Controller installed at the boiler water line. When the boiler needs water, the pump supplies it from the receiver. It is, therefore, necessary that the receiver be equipped with a reliable float controlled water make-up valve, assuring a supply of water at all times within the receiver. This make-up water valve is connected to hot water tank or to city water as a source of supply.

This arrangement can be applied to any Dunham Type CH or Type CHH Condensation Pump and Receiver, by omitting the regular control by float switch and equipping the receiver with make-up water valve. Installation is made as illustrated.

Wiring to motor (or motors in case of a duplex pump) is made in accordance with wiring diagram, with the Boiler Water Level Controller switch as a pilot circuit connected to an automatic starter (or starters) which carries the main power circuit to the motor. At extra cost an automatic starter for each motor will be furnished and mounted on receiver and wired to motor for the convenience in making installation.

The prefix "AW" to any Condensation Pump selected identifies it as of this construction.

In ordering specify the AWCH or AWCHH assembly of the size, type and discharge pressure desired equipped with make-up water valve, and give the characteristics of electric current. If other items are to be furnished, but at extra cost, such as the automatic starter for motor, the Boiler Water Level Controller, and an alarm bell and transformer, they should be mentioned.

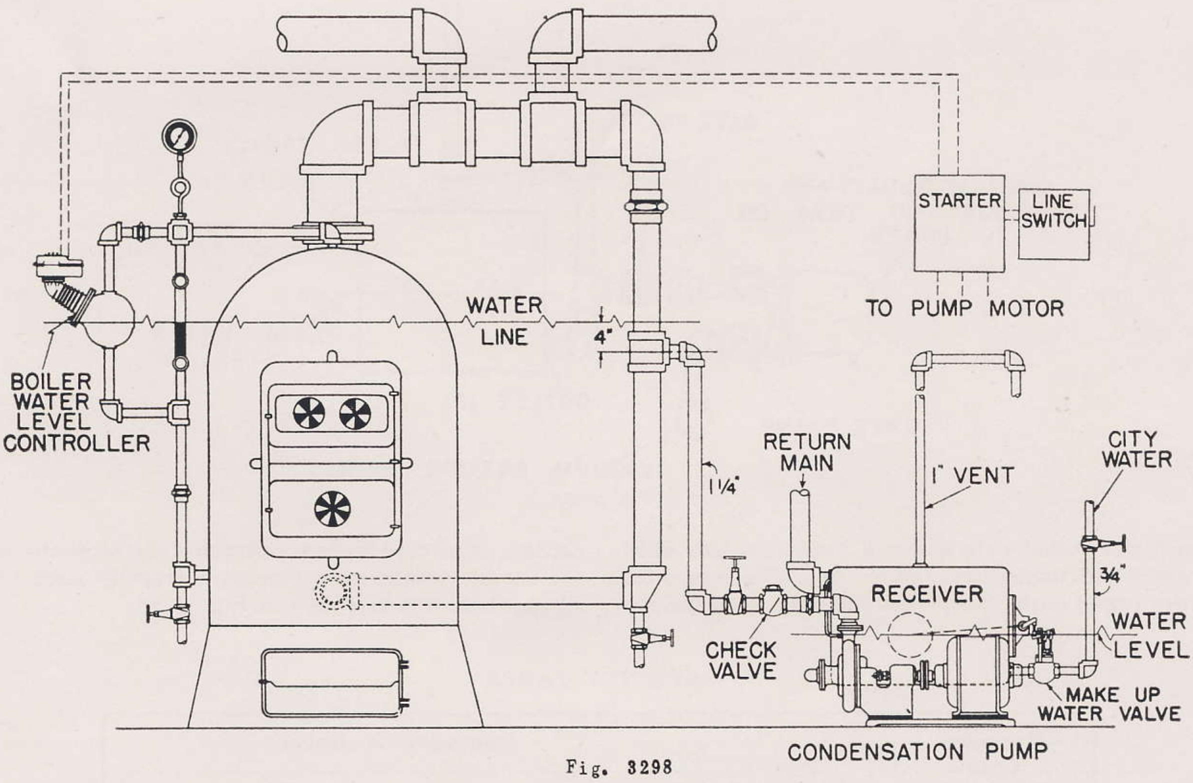


Fig. 3298

Should the installation include a battery of two or more boilers in service at the same time, it will be important that some method be used that will guarantee that the boiler demanding water be the one to receive it.

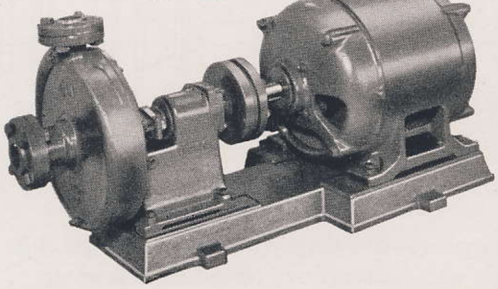
The piping layout shown as Fig. 1734 on Page 28 will not do. For two boilers a simple solution is to install a duplex pump then connect the pump on one side to one boiler only and the pump on the other side to the other boiler only. Then wire the boiler water level controller on a boiler to the control of its respective pump.

For two or more boilers being served by one pump it will be necessary that a more expensive installation be made, such as installing electrically controlled valves in the return line to each boiler, so again when a boiler needs water and its controller starts the pump this particular boiler will be the one to receive water. Full details can be furnished upon request.

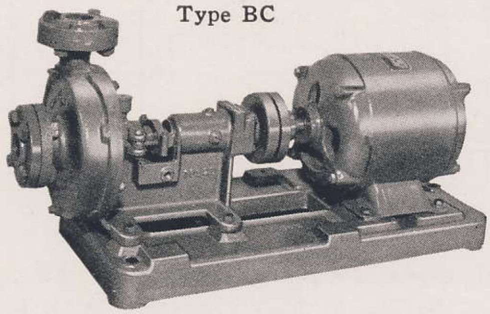
DUNHAM CENTRIFUGAL PUMPS

TYPES BC, LC AND LD

Type LD



Type BC



Single impeller, side suction, centrifugal pumps for moderate capacities and heads up to 125 feet are applicable because of their compactness, simplicity of construction, and ease of maintenance.

These Dunham enclosed impeller centrifugal pumps have efficiencies higher than normal for such sizes. The designs contemplate the efficient handling of liquids even at elevated temperatures and fill the demand for efficient and well constructed pumps within the range of their designed capacity and head.

The impeller of the pump receives the liquid at a low velocity and imparts to it a high velocity due to the centrifugal force created in the liquid itself. This velocity is then converted into pressure in the casing and sufficient velocity is retained to cause flow through the discharge pipe if the total head against which the pump discharges is less than the head developed by the pump.

The head which a centrifugal pump will work against is determined by the impeller diameter and its R.P.M. Since direct connected centrifugal pumps are driven by motors of a fixed speed it is important that the total head against which pump is to be operated be fully determined.

CONSTRUCTION

CASING. The pump case is of the volute type of best quality gray cast iron of ample strength for the working pressure. The case is bolted to the bearing head to which it is held in proper alignment by male and female shoulder rings and by cap screws. Suction and discharge connections are flanged, and discharge is directly over center line of shaft so that pump cannot become air bound.

PUMP HEAD. This carries the two heavy duty ball bearings and the full bronze bushing in perfect alignment providing proper support for the shaft and fixing the position of the impeller within the case. Drip pocket beneath the packing box is tapped for drain connection.

IMPELLER. The impeller is of the enclosed type, of close gray iron, or of bronze for a bronze fitted pump, and is both dynamically and hydraulically balanced to insure quiet operation. The design produces efficient performance with liquid at high temperatures. The impeller is pressed on the shaft and held rigidly by key and retaining nut or screw.

PACKING BOX. The packing box is deep and equipped with lantern ring and water seal. It is packed with high quality metallic packing and provided with gland which with minimum pressure will keep the packing tight and prevent undue leakage.

SHAFT. The shaft is of ample size to transmit the necessary power and revolve truly around its center in operation. It is machined all over and then ground to a high degree of accuracy.

COUPLING. Flexible coupling between pump and motor is of Hardy Disc type, finished all over and properly attached to shafts by keys and set screws. No projecting bolts or nuts means safety to the operator; and the ease by which proper alignment can be obtained by lining up faces of the coupling is a further advantage.

BED PLATE. Pump and motor are rigidly fastened to the cast iron bed plate of ample strength to maintain alignment and permit easy installation.

TESTING. Prior to shipment all pumps are given a running test to prove their ability to develop the desired head and capacity and to check the ability of the motor to operate at proper speed without overload.

GUARANTEE. The C. A. Dunham Company guarantee their pumps to be free of any mechanical defect or fault, and will within one year of shipment replace free of charge any part returned to them and found to be defective due to material or workmanship. This guarantee does not apply where pumps have been used to handle corrosive substances or have failed through abuse, nor does it include any damages, charges for labor and freight or other expense in making the change. The best grade of heavy duty electric motors are furnished as ordered with these pumps and a guarantee is furnished by the manufacturer of the motor.

In writing for a recommendation for application of a pump give all information possible, even furnishing a sketch illustrating elevations, pipe sizes and lengths, fittings, suction head or suction lift, pressures to be obtained, together with information of liquid to be pumped and its temperature. If pump is to be used for cooling tower, give the refrigeration load, the proposed design of condenser, and number and type of spray heads if these are to be used. If pump is to be used to circulate water through hot water generator, give size and make of generator and other pertinent information. Friction head must be accurately calculated as frequently this is higher than might be expected, and often some change in pipe sizes or in distribution through coils of condenser can be suggested that will reduce materially the friction head and permit a reduced size of motor. If pump circulates liquid under a hydrostatic head, state its pressure.

(Continued on page 33)

Fig. 1382A—Sectional View Type LD Centrifugal Pump

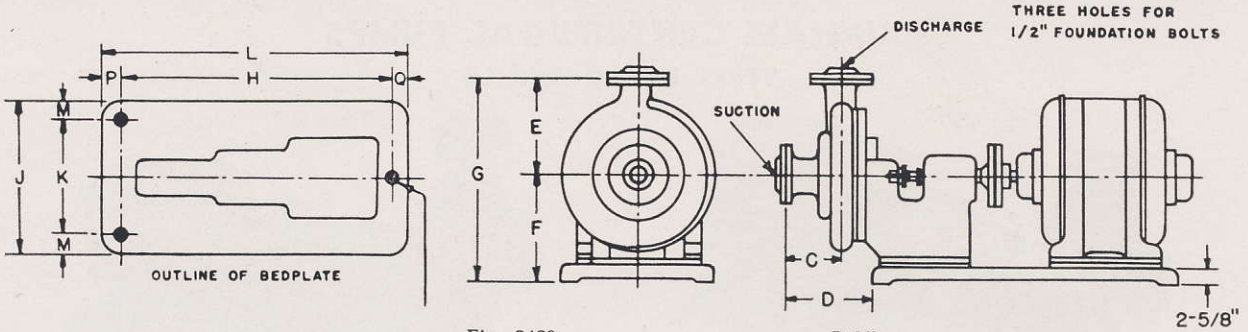


Fig. 3429

This style of base used with BC, LC and LD Pumps employing motors through 5 h. p.

NOTE: Standard companion flanges for pump suction and discharge are furnished with pump.

Pump Type	Pipe Size Inches		DIMENSIONS IN INCHES											
	Discharge	Suction	C	D	E	F	G	H	J	K	L	M	P	Q
BC	3/4	1	2 3/8	3 5/8	6 3/8	7 5/8	14	24 1/8	11 5/8	9 1/2	26	1 1/16	1 1/16	13/16
	1	1 1/4	2 3/8	3 5/8	6 3/8	7 5/8	14	24 1/8	11 5/8	9 1/2	26	1 1/16	1 1/16	13/16
	1 1/4	1 1/2	2 3/8	3 5/8	6 3/8	7 5/8	14	24 1/8	11 5/8	9 1/2	26	1 1/16	1 1/16	13/16
LC or LD	1	1 1/4	4 3/32	5 3/4	7 3/4	9 3/8	17 1/8	27 1/8	13 1/2	11 1/8	29 3/8	1 3/16	1 1/4	1
	1 1/4	1 1/2	4 3/32	5 3/4	7 3/4	9 3/8	17 1/8	27 1/8	13 1/2	11 1/8	29 3/8	1 3/16	1 1/4	1
	1 1/2	2	4 1/16	5 3/4	8	9 3/8	17 3/8	27 1/8	13 1/2	11 1/8	29 3/8	1 3/16	1 1/4	1
	2	2 1/2	3 15/16	5 3/4	8 3/4	9 3/8	18 1/8	27 1/8	13 1/2	11 1/8	29 3/8	1 3/16	1 1/4	1
	2 1/2	3	3 7/8	5 3/4	9 1/4	9 3/8	18 5/8	27 1/8	13 1/2	11 1/8	29 3/8	1 3/16	1 1/4	1

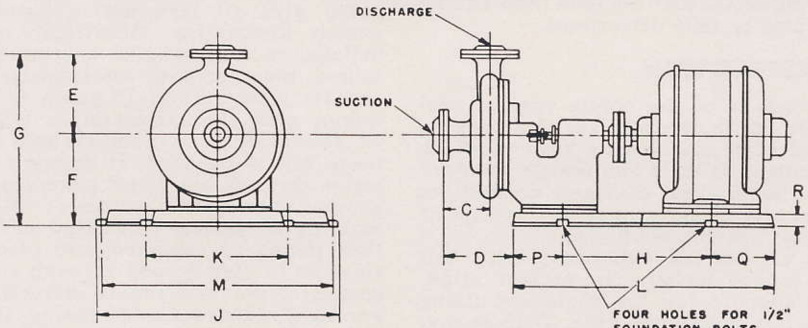


Fig. 3430

This style of base used with LD Pump employing larger motors than 5 h. p.

NOTE: Standard companion flanges for pump suction and discharge are furnished with pump.

Pipe Size Inches		Motor H.P.	DIMENSIONS IN INCHES												
Discharge	Suction		C	D	E	F	G	H	J	K	L	M	P	Q	R
1	1 1/4	7 1/2	4 3/32	4 7/8	7 3/4	9 1/4	17	18 1/2	18 1/4	9 3/4	31 3/4	16 1/2	5 3/8	7 7/8	2 1/2
		10–15	4 3/32	4 7/8	7 3/4	9 1/2	17 1/4	22	19	13	39 3/4	22	7 1/2	10 1/4	2 3/4
1 1/4	1 1/2	7 1/2	4 3/32	4 7/8	7 3/4	9 1/4	17	18 1/2	18 1/4	9 3/4	31 3/4	16 1/2	5 3/8	7 7/8	2 1/2
		10–15	4 3/32	4 7/8	7 3/4	9 1/2	17 1/4	22	19	13	39 3/4	22	7 1/2	10 1/4	2 3/4
1 1/2	2	7 1/2	4 1/16	4 7/8	8	9 1/4	17 1/4	18 1/2	18 1/4	9 3/4	31 3/4	16 1/2	5 3/8	7 7/8	2 1/2
		10–15	4 1/16	4 7/8	8	9 1/2	17 1/2	22	19	13	39 3/4	22	7 1/2	10 1/4	2 3/4
2	2 1/2	7 1/2	3 15/16	4 7/8	8 3/4	9 1/4	18	18 1/2	18 1/4	9 3/4	31 3/4	16 1/2	5 3/8	7 7/8	2 1/2
		10–15	3 15/16	4 7/8	8 3/4	9 1/2	18 1/4	22	19	13	39 3/4	22	7 1/2	10 1/4	2 3/4
2 1/2	3	7 1/2	3 7/8	4 7/8	9 1/4	9 1/4	18 1/2	18 1/2	18 1/4	9 3/4	31 3/4	16 1/2	5 3/8	7 7/8	2 1/2
		10–15	3 7/8	4 7/8	9 1/4	9 1/2	18 3/4	22	19	13	39 3/4	22	7 1/2	10 1/4	2 3/4

PERFORMANCE TABLE ON DUNHAM BC, LC AND LD ENCLOSED IMPELLER PUMPS

Hd. Ft.	10 Feet				15 Feet				20 Feet				25 Feet				30 Feet				35 Feet				Hd. Ft.
Hd. Lbs. Sq.In	4.33				6.5				8.66				10.82				13				15.1				Hd. Lbs. Sq.In
Gal. per Minute	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Gal. per Minute
5	¾″ BC	.22	1150	1800	¾″ BC	.22	1150	1800	¾″ BC	.24	1150	1800	¾″ BC	.25	1450	1800	¾″ BC	.30	1450	1800	¾″ BC	.35	1700	1800	5
10	¾″ BC	.22	1150	1800	¾″ BC	.22	1150	1800	¾″ BC	.24	1150	1800	¾″ BC	.26	1450	1800	¾″ BC	.30	1450	1800	¾″ BC	.39	1700	1800	10
15	¾″ BC	.22	1150	1800	¾″ BC	.22	1150	1800	¾″ BC	.24	1150	1800	¾″ BC	.28	1450	1800	¾″ BC	.38	1450	1800	¾″ BC	.42	1700	1800	15
20	1″ BC	.22	1150	1800	1″ BC	.24	1150	1800	1″ BC	.28	1150	1800	1″ BC	.30	1450	1800	1″ BC	.41	1450	1800	1″ BC	.49	1700	1800	20
25	1″ BC	.23	1150	1800	1″ BC	.25	1150	1800	1″ BC	.30	1150	1800	1″ BC	.37	1450	1800	1″ BC	.43	1450	1800	1″ BC	.55	1700	1800	25
30	1″ BC	.26	1150	1800	1″ BC	.30	1150	1800	1″ BC	.37	1150	1800	1″ BC	.42	1450	1800	1″ BC	.48	1450	1800	1″ BC	.63	1700	1800	30
40	1¼″ BC	.30	1150	1800	1¼″ BC	.37	1150	1800	1¼″ BC	.40	1450	1800	1¼″ BC	.47	1450	1800	1¼″ BC	.50	1450	1800	1¼″ BC	.80	1700	1800	40
50	1¼″ BC	.43	1150	1800	1¼″ BC	.48	1150	1800	1¼″ BC	.55	1450	1800	1¼″ BC	.60	1450	1800	1¼″ BC	.71	1450	1800	1¼″ BC	.84	1700	1800	50
60	1¼″ BC	.57	1150	1800	1¼″ BC	.55	1150	1800	1¼″ BC	.58	1450	1800	1¼″ BC	.67	1450	1800	1¼″ BC	.80	1450	1800	1¼″ BC	1.2	1700	1800	60
70	1¼″ BC	.61	1150	1800	1¼″ BC	.66	1150	1800	1¼″ BC	.68	1450	1800	1¼″ BC	.78	1450	1800	1¼″ BC	.95	1450	1800	1¼″ BC	1.3	1700	1800	70
80	1¼″ LC	.72	900	1800	1¼″ LC	.82	900	1800	1¼″ LC	.95	1150	1800	1¼″ LC	1.1	1150	1800	1¼″ LC	1.3	1150	1800	1¼″ LC	1.5	1150	1800	80
90	1½″ LC	.82	900	1800	1½″ LC	.94	900	1800	1½″ LC	1.1	1150	1800	1½″ LC	1.2	1150	1800	1½″ LC	1.4	1150	1800	1½″ LC	1.6	1150	1800	90
100	1½″ LC	.96	900	1800	1½″ LC	1.1	900	1800	1½″ LC	1.2	1150	1800	1½″ LC	1.3	1150	1800	1½″ LC	1.6	1150	1800	1½″ LC	1.7	1150	1800	100
110	1½″ LC	1.0	900	1800	1½″ LC	1.2	900	1800	1½″ LC	1.4	1150	1800	1½″ LC	1.4	1150	1800	1½″ LC	1.7	1150	1800	1½″ LC	1.9	1150	1800	110
120	1½″ LC	1.1	900	1800	1½″ LC	1.3	900	1800	1½″ LC	1.5	1150	1800	1½″ LC	1.5	1150	1800	1½″ LC	1.9	1150	1800	1½″ LC	2.0	1150	1800	120
130	2″ LC	1.1	900	1800	2″ LC	1.4	900	1800	2″ LC	1.6	1150	1800	2″ LC	1.7	1150	1800	2″ LC	2.0	1150	1800	2″ LC	2.2	1150	1800	130
140	2″ LC	1.1	900	1800	2″ LC	1.5	900	1800	2″ LC	1.7	1150	1800	2″ LC	1.8	1150	1800	2″ LC	2.2	1150	1800	2″ LC	2.4	1150	1800	140
150	2″ LC	1.2	900	1800	2″ LC	1.6	900	1800	2″ LC	1.8	1150	1800	2″ LC	2.0	1150	1800	2″ LC	2.4	1150	1800	2″ LC	2.6	1150	1800	150
160	2″ LC	1.3	900	1800	2″ LC	1.7	900	1800	2″ LC	2.0	1150	1800	2″ LC	2.1	1150	1800	2″ LC	2.5	1150	1800	2″ LC	2.8	1150	1800	160
170	2″ LC	1.4	900	1800	2″ LC	1.8	900	1800	2″ LC	2.2	1150	1800	2″ LC	2.2	1150	1800	2″ LC	2.7	1150	1800	2″ LC	3.0	1150	1800	170
180	2″ LC	1.5	900	1800	2″ LC	2.0	900	1800	2″ LC	2.3	1150	1800	2″ LC	2.4	1150	1800	2″ LC	2.9	1150	1800	2″ LC	3.1	1150	1800	180
190	2″ LC	1.6	900	1800	2″ LC	2.1	900	1800	2″ LC	2.4	1150	1800	2″ LC	2.5	1150	1800	2″ LC	3.1	1150	1800	2″ LC	3.3	1150	1800	190
200	2½″ LD	1.6	900	1800	2½″ LD	2.2	900	1800	2½″ LD	2.5	1150	1800	2½″ LD	2.6	1150	1800	2½″ LD	3.2	1150	1800	2½″ LD	3.5	1150	1800	200
210	2½″ LD	1.7	900	1800	2½″ LD	2.3	900	1800	2½″ LD	2.6	1150	1800	2½″ LD	2.7	1150	1800	2½″ LD	3.3	1150	1800	2½″ LD	3.6	1150	1800	210
220	2½″ LD	1.7	900	1800	2½″ LD	2.4	900	1800	2½″ LD	2.8	1150	1800	2½″ LD	2.9	1150	1800	2½″ LD	3.5	1150	1800	2½″ LD	3.8	1150	1800	220
230	2½″ LD	1.9	900	1800	2½″ LD	2.5	900	1800	2½″ LD	2.9	1150	1800	2½″ LD	3.0	1150	1800	2½″ LD	3.7	1150	1800	2½″ LD	4.0	1150	1800	230
240	2½″ LD	2.0	900	1800	2½″ LD	2.6	900	1800	2½″ LD	3.0	1150	1800	2½″ LD	3.1	1150	1800	2½″ LD	3.9	1150	1800	2½″ LD	4.1	1150	1800	240
250	2½″ LD	2.1	900	1800	2½″ LD	2.7	900	1800	2½″ LD	3.1	1150	1800	2½″ LD	3.2	1150	1800	2½″ LD	4.0	1150	1800	2½″ LD	4.3	1150	1800	250
260	2½″ LD	2.2	900	1800	2½″ LD	2.8	900	1800	2½″ LD	3.3	1150	1800	2½″ LD	3.4	1150	1800	2½″ LD	4.2	1150	1800	2½″ LD	4.5	1150	1800	260
270	2½″ LD	2.3	900	1800	2½″ LD	2.9	900	1800	2½″ LD	3.4	1150	1800	2½″ LD	3.5	1150	1800	2½″ LD	4.3	1150	1800	2½″ LD	4.6	1150	1800	270
280	2½″ LD	2.4	900	1800	2½″ LD	3.0	900	1800	2½″ LD	3.5	1150	1800	2½″ LD	3.6	1150	1800	2½″ LD	4.5	1150	1800	2½″ LD	4.8	1150	1800	280
290	2½″ LD	2.6	900	1800	2½″ LD	3.1	900	1800	2½″ LD	3.6	1150	1800	2½″ LD	3.7	1150	1800	2½″ LD	4.6	1150	1800	2½″ LD	5.0	1150	1800	290
300	2½″ LD	2.8	900	1800	2½″ LD	3.2	900	1800	2½″ LD	3.7	1150	1800	2½″ LD	3.9	1150	1800	2½″ LD	4.8	1150	1800	2½″ LD	5.1	1150	1800	300
310	2½″ LD	2.9	900	1800	2½″ LD	3.3	900	1800	2½″ LD	3.9	1150	1800	2½″ LD	4.0	1150	1800	2½″ LD	5.0	1150	1800	2½″ LD	5.2	1150	1800	310
320	2½″ LD	3.1	900	1800	2½″ LD	3.5	900	1800	2½″ LD	4.0	1150	1800	2½″ LD	4.1	1150	1800	2½″ LD	5.1	1150	1800	2½″ LD	5.5	1150	1800	320

Size and Type of Pump	¾″ BC	1″ BC	1¼″ BC	1″ LC 1″ LD	1¼″ LC 1¼″ LD	1½″ LC 1½″ LD	2″ LC 2″ LD	2½″ LD
Size of Discharge	¾″	1″	1¼″	1″	1¼″	1½″	2″	2½″
Size of Suction	1″	1¼″	1½″	1¼″	1½″	2″	2½″	3″
Weight without Motor	105	110	120	155	160	165	170	180

Brake Horse Power shown are for clear cold water. For pumping brine multiply B.H.P. by 1.2.

Where there is question as to correct head, we advise the addition of 10% leeway in the selection of motor.

Pipe sizes should be increased from connections at pump, particularly of discharge pipe.

PERFORMANCE TABLE ON DUNHAM BC, LC AND LD ENCLOSED IMPELLER PUMPS

Hd. Ft.	40 Feet				45 Feet				50 Feet				55 Feet				60 Feet				65 Feet				Hd. Ft.
Hd. Lbs. Sq. In	17.3				19.5				21.65				23.8				26				28.1				Hd. Lbs. Sq. In
Gal. per Minute	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Gal. per Minute
5	¾" BC	.40	1700	1800	¾" BC	.45	1700	1800	1" LC	.76	1450	1800	1" LD	.80	1450	1800	1" LD	.90	1450	1800	1" LD	1.2	1450	1800	5
10	¾" BC	.42	1700	1800	¾" BC	.50	1700	1800	1" LC	.81	1450	1800	1" LD	.90	1450	1800	1" LD	1.0	1450	1800	1" LD	1.3	1450	1800	10
15	¾" BC	.48	1700	1800	¾" BC	.52	1700	1800	1" LC	.90	1450	1800	1" LD	1.0	1450	1800	1" LD	1.1	1450	1800	1" LD	1.3	1450	1800	15
20	1" BC	.53	1700	1800	1" BC	.55	1700	1800	1" LC	1.0	1450	1800	1" LD	1.1	1450	1800	1" LD	1.3	1450	1800	1" LD	1.4	1450	1800	20
25	1" BC	.58	1700	1800	1" LC	.80	1150	1800	1" LC	1.1	1450	1800	1" LD	1.2	1450	1800	1" LD	1.3	1450	1800	1" LD	1.4	1450	1800	25
30	1" BC	.65	1700	1800	1" LC	.90	1150	1800	1" LC	1.2	1450	1800	1" LD	1.3	1450	1800	1" LD	1.4	1450	1800	1" LD	1.5	1450	1800	30
40	1¼" BC	.74	1700	1800	1¼" LC	1.1	1150	1800	1¼" LC	1.3	1450	1800	1¼" LD	1.4	1450	1800	1¼" LD	1.5	1450	1800	1¼" LD	1.7	1450	1800	40
50	1¼" LC	1.2	1150	1800	1¼" LC	1.3	1150	1800	1¼" LC	1.5	1450	1800	1¼" LD	1.5	1450	1800	1¼" LD	1.7	1450	1800	1¼" LD	1.8	1450	1800	50
60	1¼" LC	1.3	1150	1800	1¼" LC	1.4	1150	1800	1¼" LC	1.7	1450	1800	1¼" LD	1.7	1450	1800	1¼" LD	1.8	1450	1800	1¼" LD	2.0	1450	1800	60
70	1¼" LC	1.4	1150	1800	1¼" LC	1.5	1150	1800	1¼" LC	1.8	1450	1800	1¼" LD	1.9	1450	1800	1¼" LD	2.0	1450	1800	1¼" LD	2.3	1450	1800	70
80	1¼" LC	1.6	1150	1800	1¼" LC	1.7	1150	1800	1¼" LC	1.9	1450	1800	1¼" LD	2.1	1450	1800	1¼" LD	2.3	1450	1800	1¼" LD	2.5	1450	1800	80
90	1½" LC	1.8	1150	1800	1½" LC	1.9	1150	1800	1½" LC	2.2	1450	1800	1½" LD	2.3	1450	1800	1½" LD	2.4	1450	1800	1½" LD	2.6	1450	1800	90
100	1½" LC	1.9	1150	1800	1½" LC	2.0	1150	1800	1½" LC	2.3	1450	1800	1½" LD	2.5	1450	1800	1½" LD	2.6	1450	1800	1½" LD	2.9	1450	1800	100
110	1½" LC	2.0	1150	1800	1½" LC	2.2	1150	1800	1½" LC	2.4	1450	1800	1½" LD	2.7	1450	1800	1½" LD	2.9	1450	1800	1½" LD	3.1	1450	1800	110
120	1½" LC	2.1	1150	1800	1½" LC	2.4	1150	1800	1½" LC	2.5	1450	1800	1½" LD	2.9	1450	1800	1½" LD	3.2	1450	1800	1½" LD	3.4	1450	1800	120
130	2" LC	2.5	1150	1800	2" LC	2.7	1150	1800	2" LC	2.8	1450	1800	2" LD	3.1	1450	1800	2" LD	3.4	1450	1800	2" LD	3.7	1450	1800	130
140	2" LC	2.7	1150	1800	2" LC	2.9	1150	1800	2" LC	3.1	1450	1800	2" LD	3.3	1450	1800	2" LD	3.6	1450	1800	2" LD	4.0	1450	1800	140
150	2" LC	2.9	1150	1800	2" LC	3.1	1150	1800	2" LC	3.4	1450	1800	2" LD	3.6	1450	1800	2" LD	3.8	1450	1800	2" LD	4.3	1450	1800	150
160	2" LC	3.1	1150	1800	2" LC	3.3	1150	1800	2" LC	3.5	1450	1800	2" LD	3.8	1450	1800	2" LD	4.0	1450	1800	2" LD	4.6	1450	1800	160
170	2" LC	3.3	1150	1800	2" LC	3.5	1150	1800	2" LC	3.7	1450	1800	2" LD	4.0	1450	1800	2" LD	4.3	1450	1800	2" LD	5.0	1450	1800	170
180	2" LC	3.5	1150	1800	2" LC	3.7	1150	1800	2" LC	3.9	1450	1800	2" LD	4.2	1450	1800	2" LD	4.6	1450	1800	2" LD	5.2	1450	1800	180
190	2½" LD	3.7	1150	1800	2½" LD	3.9	1150	1800	2½" LD	4.1	1450	1800	2½" LD	4.4	1450	1800	2½" LD	4.8	1450	1800	2½" LD	5.4	1450	1800	190
200	2½" LD	3.9	1150	1800	2½" LD	4.1	1150	1800	2½" LD	4.3	1450	1800	2½" LD	4.6	1450	1800	2½" LD	5.0	1450	1800	2½" LD	5.5	1450	1800	200
210	2½" LD	4.0	1150	1800	2½" LD	4.3	1150	1800	2½" LD	4.5	1450	1800	2½" LD	4.8	1450	1800	2½" LD	5.2	1450	1800	2½" LD	5.6	1450	1800	210
220	2½" LD	4.2	1150	1800	2½" LD	4.5	1150	1800	2½" LD	4.8	1450	1800	2½' LD	5.1	1450	1800	2½" LD	5.4	1450	1800	2½" LD	5.8	1450	1800	220
230	2½" LD	4.5	1150	1800	2½" LD	4.7	1150	1800	2½" LD	5.1	1450	1800	2½" LD	5.4	1450	1800	2½" LD	5.6	1450	1800	2½" LD	6.0	1450	1800	230
240	2½" LD	4.7	1150	1800	2½" LD	5.0	1150	1800	2½" LD	5.4	1450	1800	2½" LD	5.6	1450	1800	2½" LD	5.8	1450	1800	2½" LD	6.3	1450	1800	240
250	2½" LD	4.8	1150	1800	2½" LD	5.1	1150	1800	2½" LD	5.5	1450	1800	2½" LD	5.9	1450	1800	2½" LD	6.1	1450	1800	2½" LD	6.5	1450	1800	250
260	2½" LD	5.0	1150	1800	2½" LD	5.2	1150	1800	2½" LD	5.7	1450	1800	2½" LD	6.1	1450	1800	2½" LD	6.3	1450	1800	2½" LD	6.8	1450	1800	260
270	2½" LD	5.2	1150	1800	2½" LD	5.4	1150	1800	2½" LD	6.0	1450	1800	2½" LD	6.3	1450	1800	2½" LD	6.6	1450	1800	2½" LD	7.1	1450	1800	270
280	2½" LD	5.4	1150	1800	2½" LD	5.7	1150	1800	2½" LD	6.1	1450	1800	2½" LD	6.4	1450	1800	2½" LD	6.8	1450	1800	2½" LD	7.3	1450	1800	280
290	2½" LD	5.6	1150	1800	2½" LD	5.9	1150	1800	2½" LD	6.3	1450	1800	2½" LD	6.6	1450	1800	2½" LD	7.0	1450	1800	2½" LD	7.5	1450	1800	290
300	2½" LD	5.8	1150	1800	2½" LD	6.1	1150	1800	2½" LD	6.5	1450	1800	2½" LD	6.8	1450	1800	2½" LD	7.3	1450	1800	2½" LD	7.7	1450	1800	300
310	2½" LD	6.0	1150	1800	2½" LD	6.3	1150	1800	2½" LD	6.7	1450	1800	2½" LD	7.1	1450	1800	2½" LD	7.5	1450	1800	2½" LD	7.9	1450	1800	310
320	2½" LD	6.3	1150	1800	2½" LD	6.5	1150	1800	2½" LD	6.9	1450	1800	2½" LD	7.3	1450	1800	2½" LD	7.7	1450	1800	2½" LD	8.1	1450	1800	320

Special Performance of Type BC Pump with High Speed Motor

5	¾" BC	.35	2880	3600	¾" BC	.42	2880	3600	¾" BC	.46	2880	3600	¾" BC	.55	2880	3600	¾" BC	.62	2880	3600	¾" BC	.70	2880	3600	5
10	¾" BC	.38	2880	3600	¾" BC	.44	2880	3600	¾" BC	.48	2880	3600	¾" BC	.58	2880	3600	¾" BC	.64	2880	3600	¾" BC	.72	2880	3600	10
15	¾" BC	.44	2880	3600	¾" BC	.46	2880	3600	¾" BC	.53	2880	3600	¾" BC	.63	2880	3600	¾" BC	.70	2880	3600	¾" BC	.78	2880	3600	15
20	1" BC	.48	2880	3600	1" BC	.50	2880	3600	1" BC	.59	2880	3600	1" BC	.67	2880	3600	1" BC	.75	2880	3600	1" BC	.86	2880	3600	20
25	1" BC	.52	2880	3600	1" BC	.58	2880	3600	1" BC	.65	2880	3600	1" BC	.77	2880	3600	1" BC	.86	2880	3600	1" BC	1.0	2880	3600	25
30	1" BC	.58	2880	3600	1" BC	.65	2880	3600	1" BC	.75	2880	3600	1" BC	.85	2880	3600	1" BC	.98	2880	3600	1" BC	1.1	2880	3600	30
40	1¼" BC	.72	2880	3600	1¼" BC	.79	2880	3600	1¼" BC	.95	2880	3600	1¼" BC	1.2	2880	3600	1¼" BC	1.3	2880	3600	1¼" BC	1.4	2880	3600	40
50	1¼" BC	.86	2880	3600	1¼" BC	1.0	2880	3600	1¼" BC	1.2	2880	3600	1¼" BC	1.3	2880	3600	1¼" BC	1.5	2880	3600	1¼" BC	1.7	2880	3600	50

PERFORMANCE TABLE ON DUNHAM BC AND LD ENCLOSED IMPELLER PUMPS

Hd. Ft.	70 Feet				75 Feet				80 Feet				85 Feet				90 Feet				95 Feet				Hd. Ft.
Hd. Lbs. Sq. In	30.3				32.5				34.65				36.8				39				41.1				Hd. Lbs. Sq. In
Gal. per Minute	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Gal. per Minute
5	1" LD	1.2	1450	1800	1" LD	1.3	1450	1800	1" LD	1.4	1450	1800	1" LD	1.5	1700	1800	1" LD	1.6	1700	1800	1" LD	1.7	1700	1800	5
10	1" LD	1.3	1450	1800	1" LD	1.4	1450	1800	1" LD	1.5	1450	1800	1" LD	1.6	1700	1800	1" LD	1.7	1700	1800	1" LD	1.8	1700	1800	10
15	1" LD	1.4	1450	1800	1" LD	1.5	1450	1800	1" LD	1.6	1450	1800	1" LD	1.7	1700	1800	1" LD	1.8	1700	1800	1" LD	1.9	1700	1800	15
20	1" LD	1.4	1450	1800	1" LD	1.5	1450	1800	1" LD	1.7	1450	1800	1" LD	1.8	1700	1800	1" LD	1.9	1700	1800	1" LD	2.0	1700	1800	20
25	1" LD	1.5	1450	1800	1" LD	1.6	1450	1800	1" LD	1.8	1450	1800	1" LD	1.9	1700	1800	1" LD	2.0	1700	1800	1" LD	2.1	1700	1800	25
30	1" LD	1.5	1450	1800	1" LD	1.7	1450	1800	1" LD	1.9	1450	1800	1" LD	2.0	1700	1800	1" LD	2.1	1700	1800	1" LD	2.3	1700	1800	30
40	1¼" LD	1.7	1450	1800	1¼" LD	1.9	1450	1800	1¼" LD	2.1	1450	1800	1¼" LD	2.2	1700	1800	1¼" LD	2.3	1700	1800	1¼" LD	2.5	1700	1800	40
50	1¼" LD	1.9	1450	1800	1¼" LD	2.1	1450	1800	1¼" LD	2.2	1450	1800	1¼" LD	2.4	1700	1800	1¼" LD	2.5	1700	1800	1¼" LD	2.7	1700	1800	50
60	1¼" LD	2.2	1450	1800	1¼" LD	2.3	1450	1800	1¼" LD	2.4	1450	1800	1¼" LD	2.6	1700	1800	1¼" LD	2.6	1700	1800	1¼" LD	3.0	1700	1800	60
70	1¼" LD	2.3	1450	1800	1¼" LD	2.5	1450	1800	1¼" LD	2.6	1450	1800	1¼" LD	2.8	1700	1800	1¼" LD	3.0	1700	1800	1¼" LD	3.3	1700	1800	70
80	1¼" LD	2.6	1450	1800	1¼" LD	2.7	1450	1800	1¼" LD	2.9	1450	1800	1¼" LD	3.2	1700	1800	1¼" LD	3.4	1700	1800	1¼" LD	3.6	1700	1800	80
90	1½" LD	2.9	1450	1800	1½" LD	3.0	1450	1800	1½" LD	3.4	1450	1800	1½" LD	3.5	1700	1800	1½" LD	3.7	1700	1800	1½" LD	4.0	1700	1800	90
100	1½" LD	3.1	1450	1800	1½" LD	3.3	1450	1800	1½" LD	3.7	1450	1800	1½" LD	3.9	1700	1800	1½" LD	4.1	1700	1800	1½" LD	4.5	1700	1800	100
110	1½" LD	3.4	1450	1800	1½" LD	3.6	1450	1800	1½" LD	3.9	1450	1800	1½" LD	4.2	1700	1800	1½" LD	4.3	1700	1800	1½" LD	4.9	1700	1800	110
120	1½" LD	3.7	1450	1800	1½" LD	3.9	1450	1800	1½" LD	4.2	1450	1800	1½" LD	4.5	1700	1800	1½" LD	4.7	1700	1800	1½" LD	5.1	1700	1800	120
130	2" LD	3.8	1450	1800	2" LD	4.2	1450	1800	2" LD	4.4	1450	1800	2" LD	4.7	1700	1800	2" LD	5.2	1700	1800	2" LD	5.6	1700	1800	130
140	2" LD	4.1	1450	1800	2" LD	4.4	1450	1800	2" LD	4.6	1450	1800	2" LD	4.9	1700	1800	2" LD	5.5	1700	1800	2" LD	5.8	1700	1800	140
150	2" LD	4.4	1450	1800	2" LD	4.6	1450	1800	2" LD	4.9	1450	1800	2" LD	5.2	1700	1800	2" LD	5.8	1700	1800	2" LD	6.2	1700	1800	150
160	2" LD	4.7	1450	1800	2" LD	4.8	1450	1800	2" LD	5.4	1450	1800	2" LD	5.9	1700	1800	2" LD	6.2	1700	1800	2" LD	6.6	1700	1800	160
170	2" LD	5.0	1450	1800	2" LD	5.1	1450	1800	2" LD	5.8	1450	1800	2" LD	6.2	1700	1800	2" LD	6.6	1700	1800	2" LD	7.1	1700	1800	170
180	2" LD	5.2	1450	1800	2" LD	5.4	1450	1800	2" LD	6.2	1450	1800	2" LD	6.6	1700	1800	2" LD	7.0	1700	1800	2" LD	7.5	1700	1800	180
190	2½" LD	5.4	1450	1800	2½" LD	5.7	1450	1800	2½" LD	6.3	1450	1800	2½" LD	6.7	1700	1800	2½" LD	7.2	1700	1800	2½" LD	7.7	1700	1800	190
200	2½" LD	5.6	1450	1800	2½" LD	5.9	1450	1800	2½" LD	6.7	1450	1800	2½" LD	7.1	1700	1800	2½" LD	7.4	1700	1800	2½" LD	7.9	1700	1800	200
210	2½" LD	5.8	1450	1800	2½" LD	6.2	1450	1800	2½" LD	7.1	1450	1800	2½" LD	7.3	1700	1800	2½" LD	7.6	1700	1800	2½" LD	8.3	1700	1800	210
220	2½" LD	6.0	1450	1800	2½" LD	6.6	1450	1800	2½" LD	7.3	1450	1800	2½" LD	7.5	1700	1800	2½" LD	7.8	1700	1800	2½" LD	8.7	1700	1800	220
230	2½" LD	6.2	1450	1800	2½" LD	7.0	1450	1800	2½" LD	7.4	1450	1800	2½" LD	7.7	1700	1800	2½" LD	8.2	1700	1800	2½" LD	8.8	1700	1800	230
240	2½" LD	6.5	1450	1800	2½" LD	7.2	1450	1800	2½" LD	7.7	1450	1800	2½" LD	8.0	1700	1800	2½" LD	8.6	1700	1800	2½" LD	9.0	1700	1800	240
250	2½" LD	6.8	1450	1800	2½" LD	7.4	1450	1800	2½" LD	8.0	1450	1800	2½" LD	8.4	1700	1800	2½" LD	9.0	1700	1800	2½' LD	9.4	1700	1800	250
260	2½" LD	7.0	1450	1800	2½" LD	7.6	1450	1800	2½" LD	8.3	1450	1800	2½" LD	8.7	1700	1800	2½" LD	9.3	1700	1800	2½" LD	9.8	1700	1800	260
270	2½" LD	7.4	1450	1800	2½" LD	7.9	1450	1800	2½" LD	8.6	1450	1800	2½" LD	9.1	1700	1800	2½" LD	9.7	1700	1800	2½" LD	10.2	1700	1800	270

Special Performance of Type BC Pump with High Speed Motor

5	¾" BC	.75	2880	3600	¾" BC	.82	2880	3600	¾" BC	.92	2880	3600	¾" BC	.98	2880	3600	¾" BC	1.0	2880	3600	¾" BC	1.1	2880	3600	5
10	¾" BC	.78	2880	3600	¾" BC	.87	2880	3600	¾" BC	.95	2880	3600	¾" BC	1.0	2880	3600	¾" BC	1.1	2880	3600	¾" BC	1.2	2880	3600	10
15	¾" BC	.87	2880	3600	¾" BC	.94	2880	3600	¾" BC	1.1	2880	3600	¾" BC	1.2	2880	3600	¾" BC	1.2	2880	3600	¾" BC	1.3	2880	3600	15
20	1" BC	.96	2880	3600	1" BC	1.1	2880	3600	1" BC	1.2	2880	3600	1" BC	1.3	2880	3600	1" BC	1.3	2880	3600	1" BC	1.4	2880	3600	20
25	1" BC	1.1	2880	3600	1" BC	1.3	2880	3600	1" BC	1.4	2880	3600	1" BC	1.5	2880	3600	1" BC	1.5	2880	3600	1" BC	1.6	2880	3600	25
30	1" BC	1.2	2880	3600	1" BC	1.4	2880	3600	1" BC	1.5	2880	3600	1" BC	1.6	2880	3600	1" BC	1.7	2880	3600	1" BC	1.8	2880	3600	30
40	1¼" BC	1.5	2880	3600	1¼" BC	1.7	2880	3600	1¼" BC	1.8	2880	3600	1¼" BC	1.9	2880	3600	1¼" BC	2.0	2880	3600	1¼" BC	2.2	2880	3600	40
50	1¼" BC	1.8	2880	3600	1¼" BC	2.0	2880	3600	1¼" BC	2.2	2880	3600	1¼" BC	2.3	2880	3600	1¼" BC	2.5	2880	3600	1¼" BC	2.6	2880	3600	50

PERFORMANCE TABLE ON DUNHAM BC AND LD ENCLOSED IMPELLER PUMPS

Hd. Ft.	100 Feet				105 Feet				110 Feet				115 Feet				120 Feet				125 Feet				Hd. Ft.
Hd. Lbs. Sq. In	43.3				45.6				47.6				50				52				54.3				Hd. Lbs. Sq. In
Gal. per Minute	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Gal. per Minute
5	1″ LD	1.8	1700	1800	1″ LD	2.0	1700	1800	1″ LD	2.2	1700	1800													5
10	1″ LD	2.0	1700	1800	1″ LD	2.1	1700	1800	1″ LD	2.3	1700	1800													10
15	1″ LD	2.1	1700	1800	1″ LD	2.2	1700	1800	1″ LD	2.4	1700	1800													15
20	1″ LD	2.2	1700	1800	1″ LD	2.4	1700	1800	1″ LD	2.5	1700	1800													20
25	1″ LD	2.3	1700	1800	1″ LD	2.5	1700	1800	1″ LD	2.6	1700	1800													25
30	1″ LD	2.5	1700	1800	1″ LD	2.7	1700	1800	1″ LD	2.8	1700	1800													30
40	1¼″ LD	2.6	1700	1800	1¼″ LD	2.9	1700	1800	1¼″ LD	3.0	1700	1800													40
50	1¼″ LD	2.9	1700	1800	1¼″ LD	3.2	1700	1800	1¼″ LD	3.5	1700	1800													50
60	1¼″ LD	3.2	1700	1800	1¼″ LD	3.5	1700	1800	1¼″ LD	3.8	1700	1800													60
70	1¼″ LD	3.7	1700	1800	1¼″ LD	3.9	1700	1800	1¼″ LD	4.1	1700	1800													70
80	1¼″ LD	4.0	1700	1800	1¼″ LD	4.5	1700	1800	1¼″ LD	4.7	1700	1800													80
90	1½″ LD	4.4	1700	1800	1½″ LD	4.8	1700	1800	1½″ LD	5.0	1700	1800													90
100	1½″ LD	4.7	1700	1800	1½″ LD	5.2	1700	1800	1½″ LD	5.4	1700	1800													100
110	1½″ LD	5.1	1700	1800	1½″ LD	5.6	1700	1800	1½″ LD	5.9	1700	1800													110
120	1½″ LD	5.5	1700	1800	1½″ LD	6.0	1700	1800	1½″ LD	6.3	1700	1800													120
130	2″ LD	5.9	1700	1800	2″ LD	6.2	1700	1800	2″ LD	6.7	1700	1800													130
140	2″ LD	6.3	1700	1800	2″ LD	6.7	1700	1800	2″ LD	7.1	1700	1800													140
150	2″ LD	6.8	1700	1800	2″ LD	7.4	1700	1800	2″ LD	7.6	1700	1800													150
160	2″ LD	7.4	1700	1800	2″ LD	7.7	1700	1800	2″ LD	8.1	1700	1800													160
170	2″ LD	7.7	1700	1800	2″ LD	8.0	1700	1800	2″ LD	8.5	1700	1800													170
180	2″ LD	8.0	1700	1800	2″ LD	8.5	1700	1800	2″ LD	9.0	1700	1800													180
190	2½″ LD	8.2	1700	1800	2½″ LD	8.8	1700	1800	2½″ LD	9.3	1700	1800													190
200	2½″ LD	8.6	1700	1800	2½″ LD	9.4	1700	1800	2½″ LD	9.8	1700	1800													200
210	2½″ LD	9.1	1700	1800	2½″ LD	9.9	1700	1800	2½″ LD	10.3	1700	1800													210
220	2½″ LD	9.5	1700	1800	2½″ LD	10.2	1700	1800	2½″ LD	10.8	1700	1800													220

Special Performance of Type BC Pump with High Speed Motor

Gal. per Minute	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Pump Recommended	B. H. P.	Minimum Motor Speed	Maximum Motor Speed	Gal. per Minute
5	¾″ BC	1.2	2880	3600	¾″ BC	1.2	2880	3600	¾″ BC	1.3	2880	3600	¾″ BC	1.4	2880	3600	¾″ BC	1.4	2800	3600	¾″ BC	1.5	2880	3600	5
10	¾″ BC	1.3	2880	3600	¾″ BC	1.4	2880	3600	¾″ BC	1.4	2880	3600	¾″ BC	1.5	2880	3600	¾″ BC	1.5	2880	3600	¾″ BC	1.7	2880	3600	10
15	¾ BC	1.4	2880	3600	¾″ BC	1.5	2880	3600	¾″ BC	1.6	2880	3600	¾″ BC	1.7	2880	3600	¾″ BC	1.7	2880	3600	¾″ BC	1.9	2880	3600	15
20	1″ BC	1.5	2880	3600	1″ BC	1.6	2880	3600	1″ BC	1.7	2880	3600	1″ BC	1.8	2880	3600	1″ BC	1.9	2880	3600	1″ BC	2.0	2880	3600	20
25	1″ BC	1.7	2880	3600	1″ BC	1.8	2880	3600	1″ BC	1.9	2880	3600	1″ BC	2.0	2880	3600	1″ BC	2.1	2880	3600	1″ BC	2.2	2880	3600	25
30	1″ BC	1.9	2880	3600	1″ BC	2.0	2880	3600	1″ BC	2.1	2880	3600	1″ BC	2.2	2880	3600	1″ BC	2.3	2880	3600	1″ BC	2.4	2880	3600	30
40	1¼″ BC	2.3	2880	3600	1¼″ BC	2.4	2880	3600	1¼″ BC	2.5	2880	3600	1¼″ BC	2.6	2880	3600	1¼″ BC	2.7	2880	3600	1¼″ BC	2.8	2880	3600	40
50	1¼″ BC	2.7	2880	3600	1¼″ BC	2.9	2880	3600	1¼″ BC	3.0	2880	3600	1¼″ BC	3.1	2880	3600	1¼″ BC	3.2	2880	3600	1¼″ BC	3.3	2880	3600	50

Size and Type of Pump	¾″ BC	1″ BC	1¼″ BC	1″ LD	1¼″ LD	1½″ LD	2″ LD	2½″ LD
Size of Discharge.............	¾″	1″	1¼″	1″	1¼″	1½″	2″	2½″
Size of Suction...............	1″	1¼″	1½″	1¼″	1½″	2″	2½″	3″
Weight without Motor........	105	110	120	155	160	165	170	180

Brake Horse Power shown are for clear cold water. For Pumping Brine multiply B H.P. by 1.2.

Where there is question as to exact head, we advise the addition of 10% power leeway in the selection of motor.

Pipe sizes should be increased from connections at pump, particularly of discharge pipe.

(Continued from page 27)

In using a motor-driven centrifugal pump for boosting the circulation in hot water heating systems, the most positive method is to circulate all of the water through the pump. This, however, may entail an expenditure of power that is appreciable.

In one-story buildings, such as in greenhouses where distribution takes place from one large main, the rate of circulation can be increased without a large power load by circulating a small amount of the water through a small pump and discharging this into the center of the large main as illustrated in Fig. 1381.

For instance, if the distributing main is 4″ or 6″ pipe, experience has proved a ¾″ or 1″ discharge pump driven by a ½ H. P. motor will accomplish the purpose. On 8″ and 10″ main the 1½″ discharge pump with 1 H. P. motor will suffice.

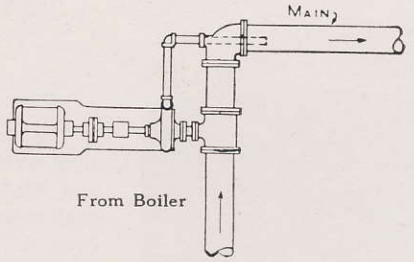


Fig. 1381

Friction of Water in Pipes

Loss of head in feet due to friction, per 100 feet of new, smooth, Wrought Iron Pipe. Multiply the friction loss in feet by 0.433 to give equivalent loss of pressure in pounds. Velocity in feet per second.

Gals. per Min.	½ Inch Pipe		¾ Inch Pipe		1 Inch Pipe		1¼ Inch Pipe		1½ Inch Pipe		2 Inch Pipe		2½ Inch Pipe		3 Inch Pipe		4 Inch Pipe		5 Inch Pipe		6 Inch Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
1	1.05	1.50																				
2	2.10	5.30	1.20	1.40																		
3	3.16	11.30	1.80	2.90	1.12	0.90																
4	4.21	19.20	2.41	5.00	1.40	1.52	0.86	0.40	0.63	0.19												
5	5.26	29.00	3.01	7.50	1.86	2.32	1.07	0 60	0.79	0.28	0.51	0.09	0.33	0.05								
10	10.52	105.00	6.02	27.10	3.72	8.40	2.14	2.18	1.57	1.02	1.02	0.36	0.65	0.12	0.45	0.05						
15	......	......	9.02	57.00	6.13	18.90	3.92	4.65	2.72	2.25	1.53	0.81	0.98	0.25	0.68	0.11						
20	......	......	12.03	97.00	7 44	30.10	4.29	7.90	3.15	3.70	2.04	1.29	1.31	0.43	0.91	0.18						
25	......	......	......	......	9.30	45.50	5.36	11.90	4.56	5.60	2.55	1.96	1.63	0.66	1.13	0.27						
30	......	......	......	......	11.15	64.00	6.43	16.90	4.72	7.80	3.06	2.73	1.96	0.92	1.36	0.38						
35	......	......	......	......	13.02	85.00	7.51	22.30	5.51	10.30	3.57	3.66	2.29	1.23	1.59	0.51						
40	......	......	......	......	14.88	109.00	8.58	28.50	6.30	13.30	4.08	4.68	2.62	1.57	1.82	0.65	1.02	0.16				
45	......	......	......	......	......	......	9.68	35.20	7.08	16.60	4.60	5.80	2.95	1.97	2.02	0.80	1.17	0.20				
50	......	......	......	......	......	......	10.72	43.20	7.87	20.20	5.11	7.10	3.30	2.38	2.27	0.98	1.28	0.24				
70	......	......	......	......	......	......	15.01	81.00	11.02	37.60	7.15	13.20	4.60	4.42	3.18	1.83	1.79	0.45	1,14	0.15		
75	......	......	......	......	......	......	......	......	11.80	42.70	7.66	14.90	4.93	5.07	3.41	2.11	1.92	0.52	1.22	0 17		
100	......	......	......	......	......	......	......	......	15.74	73.00	10.21	25.60	6.54	8.60	4.54	3.52	2.55	0.88	1.63	0 29	1.14	0.10
120	......	......	......	......	......	......	......	......	......	......	12.25	36.00	7.84	12.00	5.45	4.97	3.06	1.22	1.96	0 41	1.42	0.18
125	......	......	......	......	......	......	......	......	......	......	12.75	38.90	8.16	13.01	5.68	5.40	3.19	1.33	2.04	0.46	1.48	0.20
150	......	......	......	......	......	......	......	......	......	......	15.30	54.00	9.80	18.72	6.80	7.72	3.84	1.82	2.45	0.63	1.71	0.23
175	......	......	......	......	......	......	......	......	......	......	......	......	11.43	23.70	7.92	9.75	4.45	2.40	2.86	0.84	2.00	0.34
200	......	......	......	......	......	......	......	......	......	......	......	......	13.07	30.90	9.08	12.80	5.11	3.12	3.27	1.06	2.28	0.44
225	......	......	......	......	......	......	......	......	......	......	......	......	......	......	10.42	16.00	6.32	4.72	3.67	1.33	2.57	0.53
250	......	......	......	......	......	......	......	......	......	......	......	......	......	......	11.28	19.70	6.40	4.80	4.08	1.60	2.80	0.66
270	......	......	......	......	......	......	......	......	......	......	......	......	......	......	12.45	22.70	6.90	5.50	4.42	1.86	3.03	0.81
275	......	......	......	......	......	......	......	......	......	......	......	......	......	......	12.70	23.60	7.03	5.71	4.50	1.94	3.06	0.82
300	......	......	......	......	......	......	......	......	......	......	......	......	......	......	13.62	27.10	7.66	6.70	4.90	2.25	3.40	0.92

By using pipe sizes in which the velocity is low the friction head is low as indicated in this table. This emphasizes the advisability of increasing the pipe sizes from connections at pump.

Example: The distance from the water level up to the pump suction is five feet. The discharge elevation, which is the distance from the pump to the highest point in the discharge line, is fifteen feet, making the total elevation twenty feet. To this, add the friction loss in the pipe as taken from the table. Assuming that a centrifugal pump is to be used with a hundred feet of 2½″ discharge pipe. There is a friction of 8.6 feet per hundred feet of run when discharging 100 gal. per minute.

The actual working head of the pump at this capacity is the total elevation head of 20 feet plus the friction head, 8.6 feet, or a total of 28.6 feet, or, converting it to pounds, it would be 12.4 lbs.

Friction of Water in 90° Elbows and the Equivalent Number of Feet Straight Pipe

Size of Elbow, inches	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12	14	15	16	20
Friction Equiv. Ft. Straight Pipe	5	6	6	8	8	8	11	15	16	18	18	24	30	40	54	55	55	70

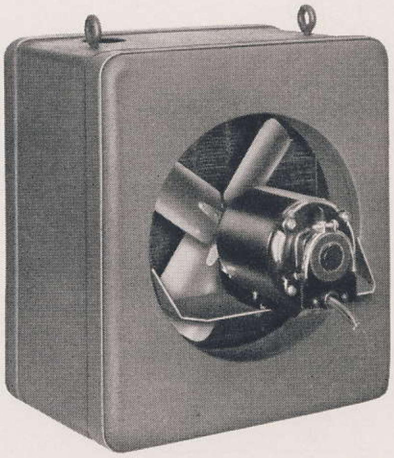
Information to be Supplied with Order

1. Capacity GPM.
2. Liquid pumped.
3. Specific gravity of liquid.
4. Liquid *(lifted) (flows under static head) to pump suction:
   a. From *(open) (closed) receiver.
   b. If closed, the pressure or vacuum__________.
   c. Distance water level to center pump suction tapping__________ft.
5. Suction pipe size and length.
6. Discharge pipe size and length.
7. Pump discharges into *(open) (closed) receiver:
   a. Height from center pump suction to surface of water in receiver.
   b. Distance from pump to receiver.
   c. Pressure in receiver *(steady) (varies from ______lb. sq. in. minimum to ______lb. sq. in. maximum).
8. Temperature of liquid pumped.
9. Drive desired:
   *(Motor___direct connected):
   a. Phase__________.
   b. Cycle__________.
   c. Voltage__________.
   *(Turbine driven):
   a. Initial steam pressure__________.
   b. Degree of superheat__________.
   c. Back pressure__________.

*State which condition applies.

TYPE V UNIT HEATERS

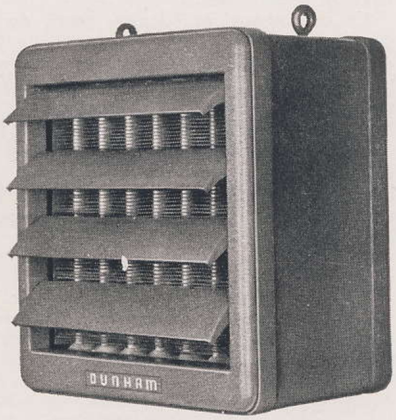
(Non-Ferrous Coil)



Rear View

The Dunham Type V Model G for operation with steam pressures of 2 lbs. or more and Model GM Unit Heaters for operation with steam pressures of 30 lbs. or more have been designed to give better heat distribution by supplying a sufficient volume of air at reasonably low outlet temperatures to reduce stratification to a minimum.

The casing assembly is finished in a rich gray, is neat and attractive in appearance. It is constructed of steel and designed for maximum rigidity and freedom from vibration.



Front View

The louvres are assembled (in a form) to permit individual adjustment as desired to direct the flow of the heated air. The fan shroud is a one piece tunnel which directs the air flow against the heating element and reduces noise and resistance. The motor, with fan mounted directly on its shaft, is attached to a heavy steel subbase through a resilient mounting. This construction insulates motor hum and vibration and prevents these noises from carrying through the building by way of the piping.

THE PROPELLER FAN consists of four or six blades riveted to a steel spider bolted to a cast hub. After assembly the complete fans are accurately balanced.

HEATING ELEMENT. The heating element consists entirely of non-ferrous materials. ½" round copper tubes are silver soldered to bronze headers with fins mechanically attached to the tubes by an expanding process whereby the tubes are expanded to the fins to provide tight contact between fin and tube. No gaskets or bolts of any kind are used in this assembly.

Supply and return tappings are located at opposite corners to equalize steam travel through the element.

These elements withstand hydrostatic pressures of 400 lbs. per square inch and are suitable for working pressures up to 150 lbs. per square inch.

HANGING. The Heaters are provided with eye-bolts at the top of the casing to which hangars may be attached. These eye-bolts are ⅜" in diameter threaded 16 threads per inch, and where desired can be replaced by rods for hanging.

MOTORS. All motors are totally enclosed unit heater type with resilient mounting except explosion proof which have solid mounting. All bearings are waste packed sleeve bearing or grease packed ball bearing. Switches are not included in standard equipment.

All Dunham Unit Heaters are tested and rated in accordance with the code adopted by the American Society of Heating and Ventilating Engineers. They are guaranteed to develop their listed capacities and ratings when circulating air with free inlet and discharge and under the conditions of steam pressure and entering air temperatures specified.

CAPACITY TABLE. TYPE V MODEL G

Unit No. and EDR	Motor Data 60 Cycle and D.C.		*Rating With 2 Lb. Steam and 60° Entering Air					Decibel Rating	Approx. Shipg. Wgt. in Lbs.
	H.P.	R.P.M.	Btu per Hr.	cfm @ 70°	FT° F.	COND.	Outlet Velocity		
V100G	1/50	1600	24,000	402	115	25.0	874	49.5	70
V150G	1/50	1600	36,000	572	118	37.5	1267	51.5	75
V225G	1/20	1140	54,000	889	116	56.3	1399	50.0	90
V300G	1/12	1140	72,000	1229	114	75.0	1506	52.0	145
V400G	1/12	1140	96,000	1609	115	100.0	1510	56.0	175
V525G	1/8	1140	126,000	1904	121	131.3	1354	59.0	185
V675G	1/6	1140	162,000	2666	116	168.8	1430	60.0	210
V900G	1/3	1140	216,000	3841	112	225.0	1637	67.5	280
V1200G	1/2	1140	288,000	5417	109	300.0	1842	71.0	330
V1500G	3/4	1140	360,000	6912	108	375.0	1771	74.0	390

*For capacities at other steam pressures and entering air temperatures, apply proper conversion factor for "blow-thru" units. All motors are constant speed only. Ratings apply only to free inlet and discharge.

EDR denotes equivalent direct radiation. (Btu divided by 240.)

COND. denotes steam condensed in lbs. per hour.

FT denotes final temperature of the discharged air. For determining final temperature of the air at other than rated conditions, use the following formula:

$$FT = \frac{Btu \times (460 + t)}{cfm \times 564} + t,$$

where Btu is the final corrected value, t is the entering air temperature, and cfm is standard air capacity at 70°.

cfm at 70° denotes cubic feet of air per minute measured at 70°, with entering air at 60°. For determining cfm at final temperature (FT), use the following formula:

$$cfm\ @\ FT = cfm\ @\ 70° \left(\frac{FT + 460}{530}\right)$$

Outlet velocity refers to velocity in feet per minute of the heated air leaving the unit.

CAPACITY TABLE. TYPE V MODEL GM

Unit No.	Motor Data 60 Cycle and D.C.		*Rating With 30 Lbs. Steam, 60° Entering Air						Decibel Rating	Approx. Shipg. Wgt. Lbs.
	H.P.	R.P.M.	EDR	Btu per Hr.	cfm @ 70°	FT	COND.	Outlet Velocity		
V100GM	1/50	1600	104	24,960	410	116.1	26.0	877	49.5	65
V150GM	1/50	1600	156	37,440	585	119.0	39.0	1266	51.1	70
V225GM	1/20	1140	231	55,440	904	116.5	57.8	1387	50.0	85
V300GM	1/12	1140	309	74,160	1247	114.8	77.3	1484	52.0	135
V400GM	1/12	1140	414	99,360	1635	116.0	103.5	1500	56.0	163
V525GM	1/8	1140	545	130,800	1929	122.5	136.3	1342	59.0	175
V675GM	1/6	1140	699	167,760	2698	117.3	174.8	1396	60.0	195
V900GM	1/3	1140	929	222,960	3899	112.7	232.3	1600	67.5	263
V1200GM	1/2	1140	1241	297,840	5425	110.6	310.3	1775	71.0	305
V1500GM	3/4	1140	1548	371,520	6931	109.4	387.0	1708	74.0	370

*For capacities at other steam pressures and entering air temperatures, apply proper conversion factor. All motors are constant speed only. Ratings apply only to free inlet and discharge.

EDR denotes equivalent direct radiation. (Btu divided by 240.)

FT denotes final temperature of the discharged air. For determining final temperature of the air at other than rated conditions, use the following formula:

$$FT = \frac{Btu \times (460 + t)}{cfm \times 564} + t,$$

where Btu is the final corrected value, t is the entering air temperature, and cfm is standard air capacity at 70°.

cfm @ 70° denotes cubic feet of air per minute measured at 70°, with entering air at 60°.

Outlet velocity refers to velocity in feet per minute of the heated air leaving the unit.

COND. denotes pounds of steam condensed per hour.

TABLE A—*CONVERSION FACTORS FOR TYPE V MODEL GM UNIT HEATERS

Entering Air Temp.	Steam Pressure—Lbs. per Sq. In. Gage										
	30	40	50	60	70	80	90	100	125	150	200
35	1.154	1.22	1.270	1.312	1.358	1.397	1.430	1.465	1.536	1.599	1.702
40	1.120	1.185	1.237	1.281	1.324	1.362	1.397	1.43	1.505	1.562	1.668
45	1.090	1.153	1.207	1.250	1.291	1.330	1.363	1.395	1.468	1.530	1.633
50	1.060	1.123	1.176	1.218	1.259	1.298	1.311	1.364	1.435	1.497	1.600
55	1.030	1.091	1.143	1.185	1.228	1.265	1.298	1.333	1.402	1.464	1.568
60	1.000	1.062	1.112	1.152	1.193	1.231	1.265	1.295	1.368	1.430	1.534
65	0.971	1.032	1.082	1.123	1.167	1.202	1.235	1.267	1.336	1.399	1.500
70	0.940	1.002	1.051	1.094	1.133	1.171	1.205	1.234	1.310	1.364	1.467
75	0.911	0.972	1.022	1.065	1.103	1.141	1.172	1.204	1.275	1.332	1.435
80	0.884	0.944	0.994	1.035	1.074	1.111	1.145	1.175	1.244	1.303	1.402
85	0.857	0.916	0.963	1.006	1.045	1.082	1.113	1.146	1.215	1.273	1.372
90	0.828	0.888	0.938	0.976	1.015	1.052	1.085	1.117	1.183	1.243	1.341
100	0.775	0.831	0.882	0.920	0.960	0.998	1.029	1.058	1.126	1.183	1.280

*To obtain Btu capacity at conditions other than those in capacity table, multiply basic rating (30 lb. steam, 60° enter. air) by proper factor from above table

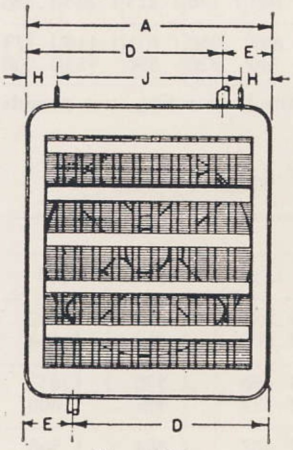


Fig. 1595A

Dimensions "M" varies slightly with motors of various characteristics.

When duct work is to be attached to units, an extended steel strip will be added at the back, drilled and tapped for 1/4" stove bolts on 6" centers on all sides.

When so ordered, louvres may be omitted and a collar for duct connections substituted.

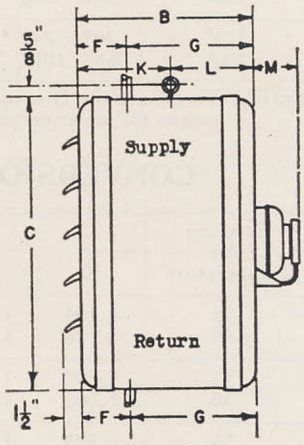


Fig. 1595A

Unit No.	Dimensions in Inches—See Fig. 1595A.												Element Tappings	
	A	B	C	D	E	F	G	H	J	K	L	M	Supply	Return
V100G —V100GM	14⅝	10⅛	13	11⅛	3½	3½	6⅝	2¼	10⅛	5⅞	4¼	2¾	1¼	1¼
V150G —V150GM	14⅝	10⅛	13	11⅛	3½	3½	6⅝	2¼	10⅛	5⅞	4¼	2¾	1¼	1¼
V225G —V225GM	16½	13⅝	16½	12	4½	3½	10⅛	3¼	10	6¾	6⅞	6	1¼	1¼
V300G —V300GM	18⅛	13⅝	16⅞	14⅛	4	3½	10⅛	2¼	13⅝	6¾	6⅞	6	1½	1½
V400G —V400GM	18⅛	13⅝	20½	14⅛	4	3½	10⅛	2¼	13⅝	6¾	6⅞	6	1½	1½
V525G —V525GM	23⅜	14¾	21	17⅝	5¾	3½	11¼	2¼	18⅞	7⅜	7⅜	6	2	2
V675G —V675GM	23⅜	14¾	26¼	17⅝	5¾	3½	11¼	2¼	18⅞	7⅜	7⅜	6	2	2
V900G —V900GM	28⅝	18¼	26¾	22⅜	6¼	3½	14¾	2¼	24⅛	9⅛	9⅛	2	2½	2½
V1200G—V1200GM	28⅝	18¼	32	22⅜	6¼	3½	14¾	2¼	24⅛	9⅛	9⅛	3⅜	2½	2½
V1500G—V1500GM	33¾	18¼	34¾	27½	6¼	3½	14¾	2¼	29¼	9⅛	9⅛	5	2½	2½

CONVERSION TABLE

CONVERSION FACTORS FOR DETERMINING THE CAPACITY OF BLOW-THRU TYPE UNIT HEATERS FOR VARIOUS STEAM PRESSURES AND ENTERING AIR TEMPERATURES
(Based on 2 lbs. Gage Steam Pressure and Entering Air Temperature of 60° F.)

DUNHAM TYPE V, EXCEPT TYPE V, MODEL GM (See below)

Temperatures of Entering Air	STEAM PRESSURE—LBS. PER SQ. IN. GAGE																		
	0	2	5	10	15	20	30	40	50	60	70	75	80	90	100	125	150	175	200
—10°	1.538	1.585	1.640	1.730	1.799	1.861	1.966	2.058	2.134	2.196	2.256	2.283	2.312	2.361	2.409	2.510	2.603	2.685	2.753
0°	1.446	1.495	1.550	1.639	1.708	1.769	1.871	1.959	2.035	2.094	2.157	2.183	2.211	2.258	2.307	2.409	2.496	2.580	2.648
10°	1.369	1.405	1.456	1.545	1.614	1.675	1.775	1.862	1.936	1.997	2.057	2.085	2.112	2.159	2.204	2.305	2.395	2.472	2.542
20°	1.273	1.320	1.370	1.460	1.525	1.584	1.684	1.771	1.845	1.902	1.961	1.990	2.015	2.063	2.108	2.205	2.296	2.372	2.437
30°	1.191	1.237	1.289	1.375	1.441	1.498	1.597	1.683	1.755	1.811	1.872	1.896	1.925	1.968	2.015	2.114	2.198	2.275	2.341
40°	1.110	1.155	1.206	1.290	1.335	1.416	1.509	1.596	1.666	1.725	1.782	1.808	1.836	1.880	1.927	2.022	2.105	2.182	2.245
45°	1.072	1.117	1.168	1.252	1.316	1.373	1.469	1.552	1.623	1.681	1.739	1.765	1.790	1.835	1.879	1.977	2.060	2.134	2.200
50°	1.034	1.078	1.127	1.211	1.275	1.333	1.429	1.511	1.582	1.640	1.696	1.721	1.748	1.792	1.836	1.932	2.015	2.090	2.154
55°	.994	1.038	1.089	1.171	1.234	1.290	1.387	1.470	1.540	1.596	1.652	1.679	1.703	1.748	1.792	1.888	1.971	2.044	2.106
60°	.956	**1.000**	1.050	1.131	1.194	1.251	1.346	1.430	1.498	1.555	1.610	1.635	1.660	1.705	1.749	1.842	1.925	2.000	2.062
65°	.918	.961	1.011	1.093	1.156	1.213	1.307	1.390	1.457	1.512	1.571	1.594	1.620	1.662	1.708	1.800	1.881	1.958	2.018
70°	.881	.926	.974	1.056	1.117	1.174	1.266	1.349	1.416	1.472	1.527	1.552	1.577	1.621	1.663	1.757	1.837	1.912	1.974
75°	.846	.888	.937	1.018	1.079	1.136	1.227	1.308	1.377	1.432	1.488	1.512	1.538	1.579	1.621	1.716	1.795	1.869	1.933
80°	.809	.853	.901	.982	1.043	1.097	1.190	1.270	1.338	1.393	1.447	1.472	1.497	1.541	1.581	1.675	1.755	1.826	1.889
85°	.774	.817	.866	.945	1.006	1.061	1.153	1.232	1.298	1.354	1.407	1.433	1.456	1.500	1.541	1.634	1.712	1.785	1.846
90°	.739	.782	.829	.908	.970	1.024	1.115	1.194	1.262	1.314	1.368	1.392	1.418	1.461	1.502	1.592	1.672	1.743	1.804
100°	.671	.713	.760	.838	.897	.952	1.042	1.119	1.187	1.239	1.293	1.316	1.342	1.383	1.424	1.513	1.592	1.664	1.722
110°	.602	.644	.692	.769	.829	.881	.970	1.047	1.112	1.165	1.219	1.242	1.267	1.307	1.349	1.438	1.514	1.586	1.645
120°	.537	.578	.625	.701	.760	.813	.901	.975	1.040	1.093	1.145	1.170	1.192	1.235	1.274	1.362	1.439	1.507	1.566
130°	.474	.513	.561	.636	.694	.745	.833	.908	.972	1.023	1.075	1.097	1.122	1.163	1.203	1.289	1.365	1.434	1.491
140°	.409	.452	.496	.572	.629	.680	.766	.841	.904	.954	1.006	1.029	1.053	1.092	1.132	1.218	1.293	1.361	1.418
150°	.347	.390	.436	.508	.565	.617	.701	.776	.838	.887	.939	.962	.984	1.024	1.063	1.148	1.223	1.288	1.346
175°	.203	.242	.286	.357	.413	.462	.545	.617	.678	.726	.775	.798	.820	.859	.897	.980	1.051	1.118	1.173
200°	.0643	.1018	.1216	.215	.268	.316	.397	.468	.526	.573	.622	.643	.665	.706	.740	.820	.890	.954	1.008

NOTE: To obtain the Btu capacity for conditions other than those in the Capacity Tables, multiply the basic rating (two pounds steam, 60° entering air) by the proper constant from the above table.

*CONVERSION FACTORS FOR TYPE V MODEL GM UNIT HEATERS

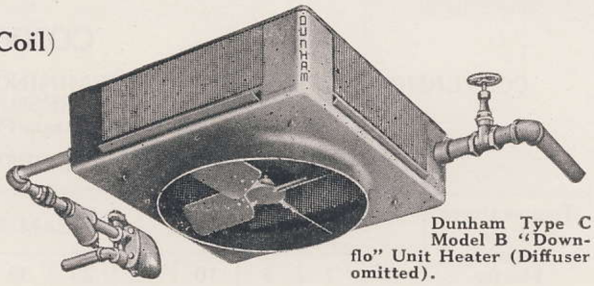
Entering Air Temperature	STEAM PRESSURE—LBS. PER SQ. IN. GAGE										
	30	40	50	60	70	80	90	100	125	150	200
35	1.154	1.22	1.270	1.312	1.358	1.397	1.430	1.465	1.536	1.599	1.702
40	1.120	1.185	1.237	1.281	1.324	1.362	1.397	1.43	1.505	1.562	1.668
45	1.090	1.153	1.207	1.250	1.291	1.330	1.363	1.395	1.468	1.530	1.633
50	1.060	1.123	1.176	1.218	1.259	1.298	1.311	1.364	1.435	1.497	1.600
55	1.030	1.091	1.143	1.185	1.228	1.265	1.298	1.333	1.402	1.464	1.568
60	1.000	1.062	1.112	1.152	1.193	1.231	1.265	1.295	1.368	1.430	1.534
65	0.971	1.032	1.082	1.123	1.167	1.202	1.235	1.267	1.336	1.399	1.500
70	0.940	1.002	1.051	1.094	1.133	1.171	1.205	1.234	1.310	1.364	1.467
75	0.911	0.972	1.022	1.065	1.103	1.141	1.172	1.204	1.275	1.332	1.435
80	0.884	0.944	0.994	1.035	1.074	1.111	1.145	1.175	1.244	1.303	1.402
85	0.857	0.916	0.963	1.006	1.045	1.082	1.113	1.146	1.215	1.273	1.372
90	0.828	0.888	0.938	0.976	1.015	1.052	1.085	1.117	1.183	1.243	1.341
100	0.775	0.831	0.882	0.920	0.960	0.998	1.029	1.058	1.126	1.183	1.280

*To obtain Btu capacity at conditions other than those in capacity table, multiply basic rating (30 lb. steam, 60° entering air) by proper factor from above table.
For capacity at 2 lb. steam, 60° entering air, divide basic rating by 1.346.

TYPE C "DOWNFLO" UNIT HEATERS—(Non-Ferrous Coil)

The Dunham Type C Model B "Downflo" Unit Heater for operation on steam pressures from 2 lbs. gage to 150 lbs. gage discharges its air stream vertically downward. Type C Model BM for operation with steam pressures of 30 lbs. or more. The outlet temperatures are relatively low.

Adjustment of air volume and temperature is provided by means of adjustable dampers. Adjustment is readily made and retained in place. Variation in the relative air volumes circulated from various sides is possible with the heater's construction.



Dunham Type C Model B "Downflo" Unit Heater (Diffuser omitted).

MOTOR MOUNTING—The motor, with fan mounted directly on shaft, is attached to spider members that grip the special resilient mounting, which, in turn, is mounted on the conical air guide. The entire motor mounting with air guide is removable. The resilient mounting insulates the motor hum or vibration from the remainder of the assembly so that vibrations are isolated at their source and are not carried through the building by way of the piping.

HEATING ELEMENT—The heating element withstands hydrostatic pressures of 400 bs. per square inch and is suitable for working pressures up to 150 lbs. per square inch. It consists entirely of nonferrous materials, using ½" round copper tubes silver soldered to bronze headers. The fins are mechanically attached to the tubes by an expanding process whereby the tubes are expanded to provide tight contact between fin and tube. No gasket or bolts of any kind are used in this assembly. For convenience in making piping connections the supply header is arranged for either top or side connections. One plug of proper size is supplied with each unit.

CASING ASSEMBLY—The streamlined casing is constructed of steel with rounded corners. The casing sides are electric welded to the top assuring rigidity and freedom from vibration. The motor and fan assembly may be removed for inspection or service without removing the heater from its hanger or disconnecting the heating pipes.

MOTORS—The Motors (used on the "Downflo" heaters) are ball bearing, grease packed, with resilient mounting. All motors are constant speed and operate at 1140 r.p.m. where used with 60 cycle or DC current. Wiring diagrams are furnished with each unit for convenience in making electrical connections. Switches are not included in standard equipment.

STEAM TRAVEL—The heater is constructed to equalize the distance of steam travel, and the steam flow into each of the tubes.

TYPE OF DIFFUSERS

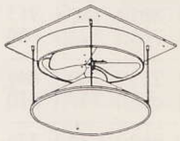


Fig. 3238—Cone Assembly

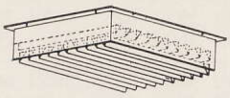


Fig. 3237—Double Louver Assembly (Adjustable)

All sizes of units are available in one of three types of adjustable diffusers as illustrated in Figs. 3237, 3238 and 3239. Anemostats with fixed cones can be supplied on special order in either 3 cone or 4 cone type.

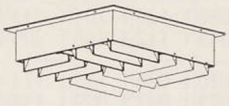


Fig. 3239—Four-Way Louver Assembly (Adjustable).

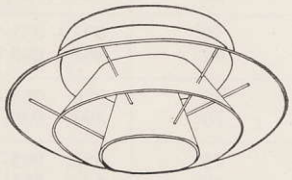


Fig. 3300—Type C With Anemostat.

CAPACITY TABLE—TYPE C—MODEL B

Unit No. and EDR	Motor Data 60 Cycle and DC		*Rating—2 Lb. Steam, 60° Entering Air						Mounting Height in Feet		Floor Spread Circle Diam. in Feet		Decibel Rating	Approx. Shipg. Wt. in Lbs.
	HP	RPM	BTU per Hour	cfm at 70°	cfm at FT.	FT. °F.	Cond.	Outlet Veloc.	Max.	Min.	Max.	Min.		
C325B	1/12	1140	78,000	1284	1395	116	81.0	1146	15	10	18	14	65.0	200
C640B	1/6	1140	153,600	2671	2888	113	160.0	1324	19	14	31	22	67.0	300
C810B	1/4	1140	194,400	3258	3535	115	202.5	1620	27	21	54	38	69.0	315
C1040B	1/2	1140	249,600	4182	4538	115	260.0	1358	20	15	34	25	72.0	400
C1530B	3/4	1140	367,200	6509	7025	112	382.5	2103	40	30	70	55	77.0	525
C2000B	1	1140	480,000	8043	8727	115	500.0	2195	43	34	75	60	79.0	575

CAPACITY TABLE—TYPE C—MODEL BM

Unit No.	Motor Data 60 Cycle and DC		*Rating with 30 Lbs. Steam, 60° Entering Air							Mounting Height in Feet		Floor Spread Circle Diam. in Feet		Decibel Rating	Approx. Shipg. Wt. Lbs.
	HP	RPM	EDR	BTU per Hr.	CFM at 70°	CFM at FT.	FT. °F.	Cond.	Outlet Veloc.	Max.	Min.	Max.	Min.		
C325BM	1/12	1140	330	79,200	1352	1464	114.0	82.5	1203	16	11	18	14	65.0	175
C640BM	1/6	1140	680	163,200	2701	2934	115.7	170.0	1345	20	14	31	22	67.0	290
C810BM	1/4	1140	859	206,160	3282	3579	117.9	214.8	1641	28	21	54	38	69.0	305
C1040BM	1/2	1140	1103	264,720	4212	4594	118.0	275.8	1375	21	15	34	25	72.0	385
C1530BM	3/4	1140	1622	389,280	6597	7150	114.4	405.5	2140	41	30	70	55	77.0	510
C2000BM	1	1140	2120	508,800	8104	8836	117.9	530.0	2222	44	34	75	60	79.0	555

*For capacity at other steam pressures and entering air temperatures, apply proper conversion factor. All motors are constant speed only. Ratings apply to free inlet and discharge.

EDR denotes equivalent direct radiation. (Btu divided by 240.)

cfm at 70° denotes cubic feet of air per minute measured at 70°, with entering air at 60°.

cfm at FT denotes total cfm delivered by the unit.

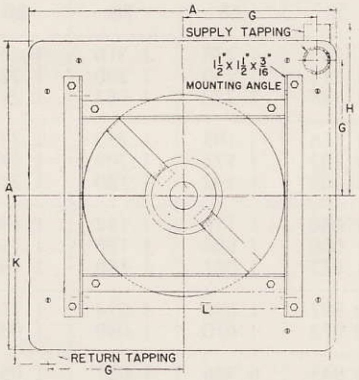
FT denotes final temperature of the discharged air. For determining final temperature of the air at other than rated conditions, use the following formula:

$$FT = \frac{(460+t)}{\dfrac{cfm \times 575}{Btu} - 1} + t,$$

where Btu is the final corrected value, it is the entering air temperature, and cfm is the delivered air quantity (cfm at FT).

COND. denotes pounds of steam condensed per hour.

Outlet velocity refers to velocity in feet per minute of the heated air leaving the unit.



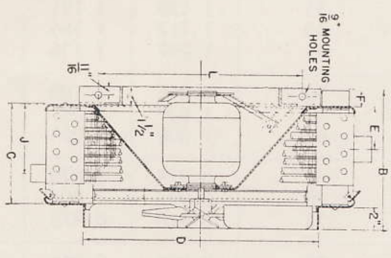


Fig. 3295—Type C Model B and BM Unit Heater

Unit No.	DIMENSIONS IN INCHES											Element Tappings	
	A	B	C	D	E	F	G	H	J	K	L	Supply	Return
C 325B-C 325BM	26⅜	12	8½	15⅛	3⅝	1¼	11½	14½	6	14¼	19½	1½	¾
C 640B-C 640BM	36	13½	10	20⅛	4⅜	1⅜	16$\frac{5}{16}$	19⅜	7½	19⅛	23¾	2	1
C 810B-C 810BM	36	13½	10	20⅛	4⅜	1⅜	16$\frac{5}{16}$	19⅜	7½	19⅛	23¾	2	1
C1040B-C1040BM	36	18	14½	24⅞	6⅝	1⅞	16⅛	19⅞	11⅞	19¼	23¾	2½	1¼
C1530B-C1530BM	46½	18	14½	24⅞	6⅝	1⅞	21⅜	25⅛	11⅞	24½	32¾	2½	1¼
C2000B-C2000BM	46½	18	14½	27	6⅝	1⅞	21⅜	25⅛	11⅞	24½	32¾	2½	1¼

CONVERSION TABLE

CONVERSION FACTORS FOR DETERMINING THE CAPACITY OF DRAW-THRU TYPE UNIT HEATERS FOR VARIOUS STEAM PRESSURES AND ENTERING AIR TEMPERATURES

(Based on 2 lbs. Gauge Steam Pressure and Entering Air Temperature of 60° F.)

DUNHAM TYPES R, C, AND TEMPERATORS, EXCEPT TYPE C, MODEL BM (See below)

Temperatures of Air Entering Heater	STEAM PRESSURE—LBS. PER SQ. IN. GAGE																		
	0	2	5	10	15	20	30	40	50	60	70	75	80	90	100	125	150	175	200
—10°	1.483	1.520	1.565	1.637	1.688	1.728	1.803	1.864	1.927	1.973	2.018	2.043	2.064	2.102	2.150	2.213	2.277	2.336	2.389
0°	1.405	1.442	1.485	1.558	1.610	1.649	1.725	1.787	1.850	1.897	1.943	1.970	1.988	2.028	2.071	2.137	2.200	2.259	2.311
10°	1.329	1.363	1.410	1.480	1.533	1.572	1.648	1.710	1.773	1.820	1.869	1.895	1.914	1.951	1.994	2.061	2.125	2.183	2.237
20°	1.253	1.290	1.334	1.403	1.458	1.498	1.572	1.637	1.700	1.748	1.795	1.822	1.841	1.878	1.919	1.985	2.050	2.108	2.163
30°	1.178	1.215	1.260	1.328	1.382	1.421	1.497	1.563	1.628	1.673	1.722	1.750	1.770	1.804	1.845	1.911	1.978	2.037	2.090
40°	1.105	1.141	1.187	1.253	1.310	1.350	1.423	1.491	1.554	1.601	1.651	1.680	1.698	1.732	1.770	1.840	1.906	1.967	2.018
45°	1.070	1.105	1.150	1.219	1.274	1.313	1.387	1.455	1.520	1.565	1.617	1.645	1.663	1.697	1.735	1.805	1.870	1.931	1.981
50°	1.032	1.069	1.114	1.182	1.239	1.278	1.352	1.420	1.483	1.531	1.582	1.609	1.629	1.661	1.700	1.770	1.835	1.895	1.947
55°	.997	1.035	1.080	1.148	1.204	1.243	1.318	1.385	1.450	1.500	1.548	1.573	1.595	1.625	1.665	1.734	1.801	1.860	1.913
60°	.962	**1.000**	1.045	1.112	1.168	1.208	1.281	1.350	1.416	1.463	1.512	1.540	1.560	1.590	1.630	1.700	1.768	1.824	1.880
65°	.926	.965	1.010	1.078	1.133	1.172	1.247	1.318	1.382	1.430	1.478	1.505	1.525	1.557	1.595	1.663	1.733	1.790	1.845
70°	.892	.930	.975	1.042	1.099	1.138	1.212	1.282	1.347	1.394	1.443	1.471	1.491	1.523	1.560	1.629	1.698	1.757	1.810
75°	.858	.895	.940	1.008	1.063	1.104	1.179	1.249	1.312	1.360	1.410	1.438	1.458	1.490	1.527	1.593	1.662	1.723	1.775
80°	.822	.861	.906	.973	1.028	1.070	1.145	1.215	1.278	1.325	1.377	1.402	1.422	1.457	1.492	1.560	1.630	1.690	1.742
85°	.788	.825	.872	.938	.993	1.035	1.112	1.181	1.245	1.293	1.343	1.369	1.389	1.421	1.460	1.528	1.599	1.656	1.709
90°	.754	.792	.838	.903	.960	1.002	1.078	1.148	1.211	1.260	1.310	1.333	1.354	1.387	1.425	1.493	1.564	1.622	1.675
100°	.688	.728	.771	.838	.895	.936	1.010	1.081	1.145	1.194	1.243	1.268	1.288	1.321	1.359	1.428	1.497	1.555	1.609
110°	.621	.662	.706	.772	.828	.870	.945	1.017	1.080	1.130	1.178	1.203	1.223	1.253	1.292	1.360	1.430	1.488	1.542
120°	.556	.598	.641	.708	.763	.807	.882	.952	1.015	1.065	1.113	1.138	1.158	1.189	1.227	1.297	1.364	1.423	1.477
130°	.493	.531	.577	.643	.700	.742	.820	.890	.952	1.000	1.050	1.072	1.094	1.123	1.162	1.232	1.300	1.359	1.410
140°	.430	.469	.513	.580	.635	.680	.758	.828	.890	.939	.987	1.011	1.032	1.061	1.100	1.169	1.237	1.295	1.348
150°	.368	.407	.452	.518	.572	.620	.698	.767	.828	.878	.925	.950	.970	1.000	1.038	1.105	1.175	1.232	1.287
175°	.218	.255	.302	.368	.422	.468	.547	.615	.676	.725	.772	.798	.818	.848	.885	.955	1.022	1.082	1.132
200°	.070	.108	.155	.223	.276	.322	.403	.470	.528	.578	.625	.650	.670	.698	.738	.808	.873	.932	.982

NOTE: To obtain the Btu capacity for conditions other than those in the Capacity Tables, multiply the basic rating (two pounds steam, 60° entering air) by the proper constant from the above table.

*CONVERSION FACTORS FOR TYPE C MODEL BM UNIT HEATERS

Entering Air Temperature	STEAM PRESSURE—LBS. PER SQ. IN. GAGE										
	30	40	50	60	70	80	90	100	125	150	200
35	1.139	1.191	1.24	1.278	1.316	1.353	1.380	1.410	1.463	1.515	1.620
40	1.112	1.165	1.213	1.250	1.290	1.325	1.353	1.382	1.437	1.487	1.572
45	1.082	1.136	1.188	1.222	1.283	1.299	1.325	1.354	1.410	1.459	1.546
50	1.058	1.109	1.158	1.195	1.255	1.271	1.297	1.327	1.382	1.432	1.519
55	1.029	1.081	1.132	1.171	1.209	1.245	1.268	1.300	1.353	1.405	1.494
60	1.000	1.053	1.105	1.142	1.180	1.218	1.241	1.271	1.327	1.380	1.468
65	0.973	1.029	1.080	1.116	1.152	1.190	1.215	1.245	1.298	1.352	1.440
70	0.947	1.001	1.050	1.088	1.128	1.164	1.190	1.218	1.270	1.324	1.413
75	0.920	0.975	1.023	1.061	1.100	1.137	1.163	1.191	1.243	1.297	1.385
80	0.894	0.946	0.997	1.034	1.074	1.110	1.137	1.165	1.218	1.271	1.360
85	0.870	0.923	0.972	1.010	1.049	1.083	1.110	1.139	1.192	1.248	1.332
90	0.841	0.896	0.945	0.986	1.021	1.057	1.082	1.112	1.165	1.221	1.308
100	0.788	0.844	0.894	0.932	0.971	1.005	1.032	1.060	1.113	1.168	1.255

*To obtain Btu capacity at conditions other than those in capacity table, multiplying basic rating (30 lb. steam, 60° entering air) by proper factor from above table.

For capacity at 2 lb. steam, 60° entering air, divide basic rating by 1.281.

DUNHAM UNIT HEATERS

TYPE R

(NON-FERROUS COIL)

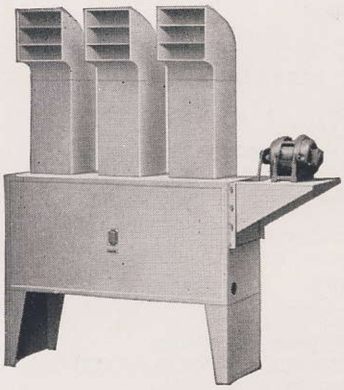


Fig. 3423—Floor Type with elongated nozzles; without damper.

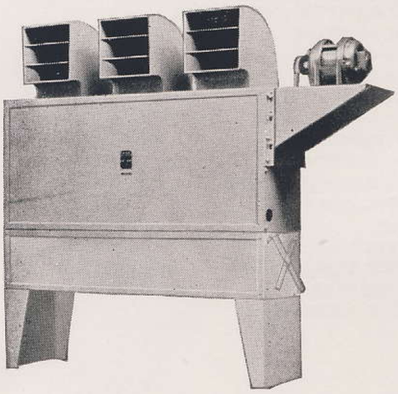
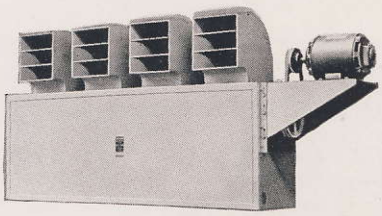
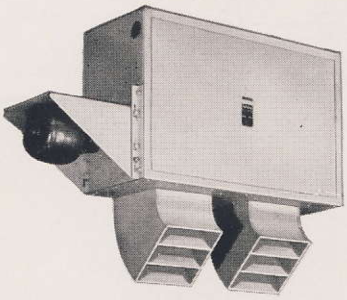


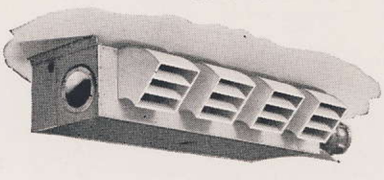
Fig. 3474—Floor Type with Mixing Damper.



Wall Type, Fig. 1445A



Inverted Wall Type, Fig. 1442A



Ceiling Type, Fig. 1446A

Dunham Type R Unit Heaters are essentially industrial type units, primarily designed for heating large spaces. These units are available in various types of mounting for floor, wall, ceiling, inverted, suspended and platform installations. They can be obtained with various appurtenances to satisfy practically every requirement such as mixing dampers, by-pass dampers and filter sections for heating and ventilating or for heating only.

All units have belt driven centrifugal type fans using constant speed 1750 rpm motors. These blower fans are double width, double inlet type with forward pitched blades.

All essential parts of the Type R units are easily accessible. The complete heating element and complete fan and shaft assembly can be removed through either end of the heater casing. If necessary, the entire heater casing can be dismantled.

Self aligning, dust proof ball bearings support the fan shaft at each end to assure trouble free operation. These bearings are assembled in heavy cast iron end bells to dampen vibration.

The Type R heating element is a replaceable tube type made up of seamless drawn copper tubes, wound with copper fin in the form of a helix and metallically attached. These tubes are securely fastened into one piece semi-steel cast headers by means of brass clamping nuts. This construction makes it possible to remove and replace any one or number of tubes in the event of damage. Elements with non-freeze type of tubes are also available, on special order.

These elements withstand hydrostatic pressures up to 300 lbs. per sq. inch and are suitable for operation on steam pressures up to 150 lbs. per sq. inch.

Type R units are manufactured in various sizes as listed in the following capacity tables.

CAPACITY TABLES

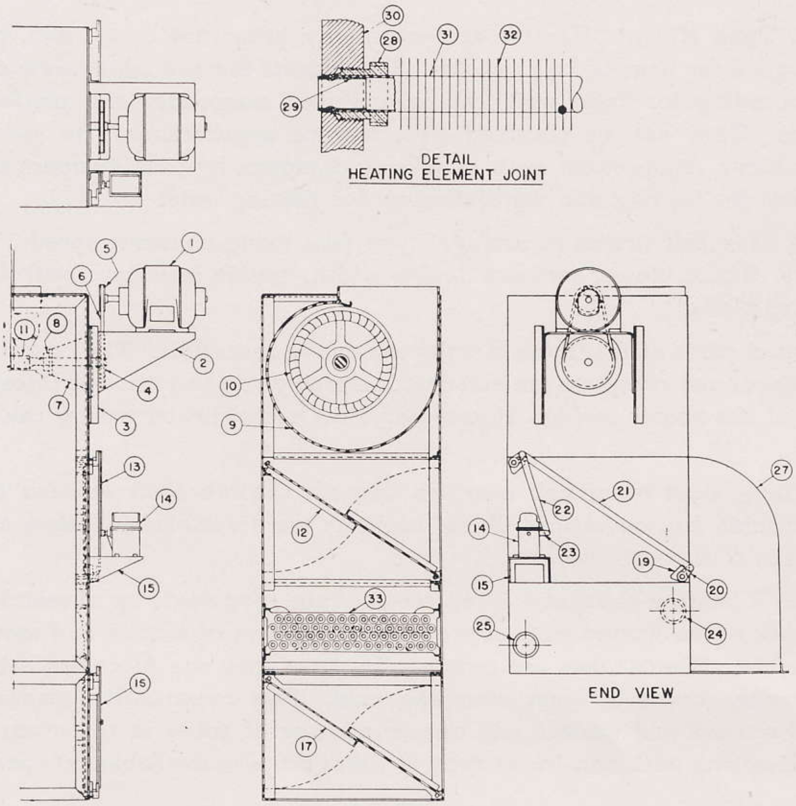
Type R (Non-Ferrous Coil) for Operation with Steam Pressures from 0 Lbs. to 150 Lbs. Gage.

Unit Size	No. of Fans or Outlets	Rows of Tubes	Rated Capacity—Standard Conditions 2 Lb. Steam, 60° Ent. Air			Final Temp.	Fan RPM	Motor HP	Supply and Return Tappings
			Btu	EDR	*cfm				
R1848	2	4	216,000	900	3,800	117.1	900	1½	2½"
R1866	3	3	280,000	1167	5,700	108.6	900	1½	2½"
R1884	4	3	350,000	1458	7,150	108.4	850	2	2½"
R1884	4	4	430,000	1792	7,450	118.0	950	2	2½"
R3066	2	4	535,000	2229	9,100	119.2	575	2	3"
R3084	3	3	665,000	2771	13,300	109.5	625	3	3"
R3084	3	4	800,000	3333	14,100	117.0	700	5	3"

Type R (Non-Ferrous Coil) for Operation with Steam Pressures from 30 Lbs. to 150 Lbs. Gage.

Unit Size	No. of Fans or Outlets	Rows of Tubes	Rated Capacity—30 Lb. Steam, 60° Ent. Air			Final Temp.	Fan RPM	Motor HP	Supply and Return Tappings
			Btu	EDR	*cfm				
R1848	2	2⅔	216,000	900	4,050	113.2	900	1½	2½"
R1866	3	2⅓	280,000	1167	6,000	105.9	900	1½	2½"
R1884	4	2⅓	350,000	1458	7,450	106.8	850	2	2½"
R1884	4	2⅔	430,000	1792	8,150	112.5	950	2	2½"
R3066	2	2⅔	535,000	2229	9,450	116.1	575	2	3"
R3084	3	2⅓	665,000	2771	13,600	108.3	625	3	3"
R3084	3	2⅔	800,000	3333	15,100	112.8	700	5	3"

*Cfm at final temperature—free delivery, no external resistance. For capacity operating against a specific external resistance, write to C. A. Dunham Co., 450 E. Ohio St., Chicago 11, Ill.
Non-freeze tubes reduce Btu capacity approximately 10%.



PARTS LIST

1—UNIT MOTOR
2—MOTOR BRACKET
3—MOTOR BRACKET MOUNTING ANGLES
4—FAN PULLEY
5—MOTOR PULLEY
6—V BELT
7—BEARING HOUSING
8—SELF ALIGNING BALL BEARING
9—FAN HOUSING
10—FAN
11—SHAFT
12—BY-PASS DAMPER (OPTIONAL)
13—DAMPER LINKAGE (MOTOR OPERATED)
14—DAMPER MOTOR
15—DAMPER MOTOR BRACKET
16—DAMPER LINKAGE (MANUAL OPERATED)
17—MIXING DAMPER (OPTIONAL)
19—DAMPER BEARING
20—DAMPER CRANK
21—DAMPER LINKING BAR
22—DAMPER MOTOR BAR
23—DAMPER MOTOR ARM
24—SUPPLY TAPPING
25—RETURN TAPPING
27—BY-PASS DUCT (OPTIONAL)
28—CLAMPING UNIT
29—FERRULE
30—RADIATOR HEADER
31—RADIATOR TUBE
32—RADIATOR FINS
33—RADIATOR ASSEMBLY

Fig. 3471—Typical Construction Details Type "R" Unit Heaters.

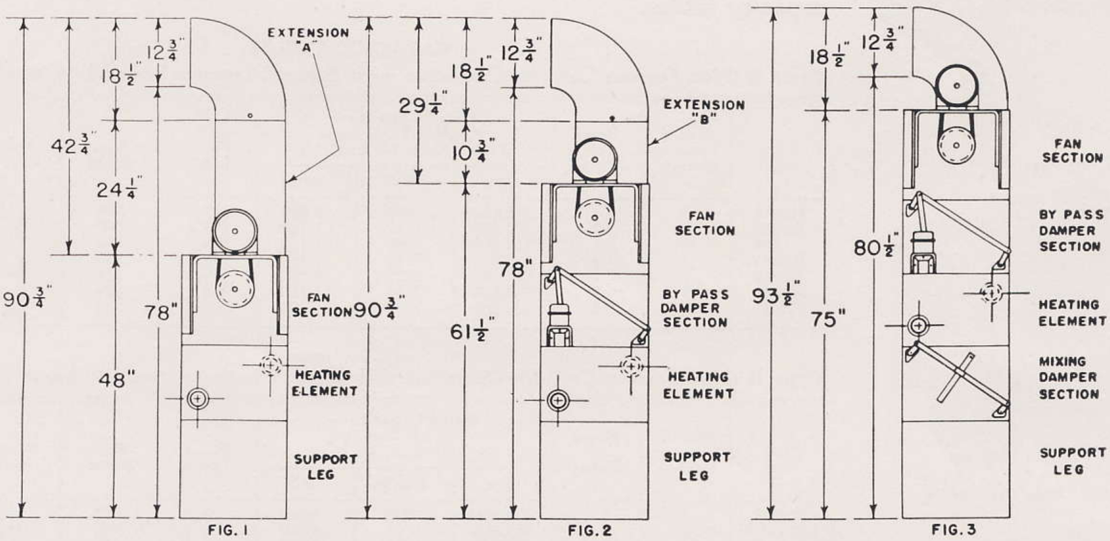


Fig. 3464—Height Dimensions 18 Series. Floor Mounted Type "R" Unit Heaters with Standard Discharge Nozzles and Extensions.

Note:
Holes for duct connection at fresh air inlet drilled and tapped for 5/16"x18 screws.
If filter section is requested add 29" to the overall height of unit.

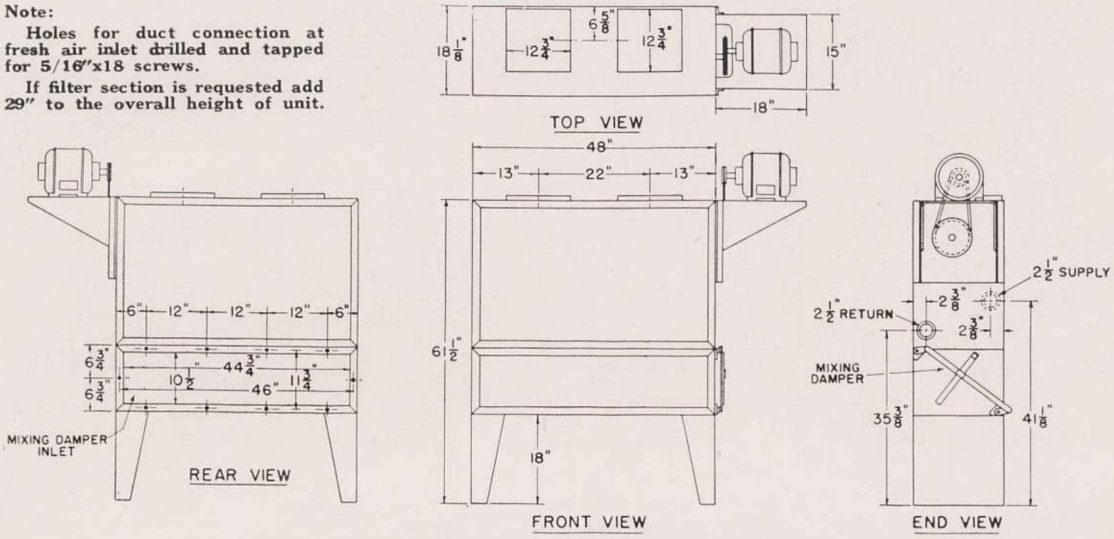


Fig. 3470—No. 1848 Type "R" Unit Heater. Floor Mounting. Mixing Damper.

Note:
Holes for duct connection at fresh air inlet drilled and tapped for 5/16"x18 screws.
If filter section is requested add 28½" to the overall height of unit.

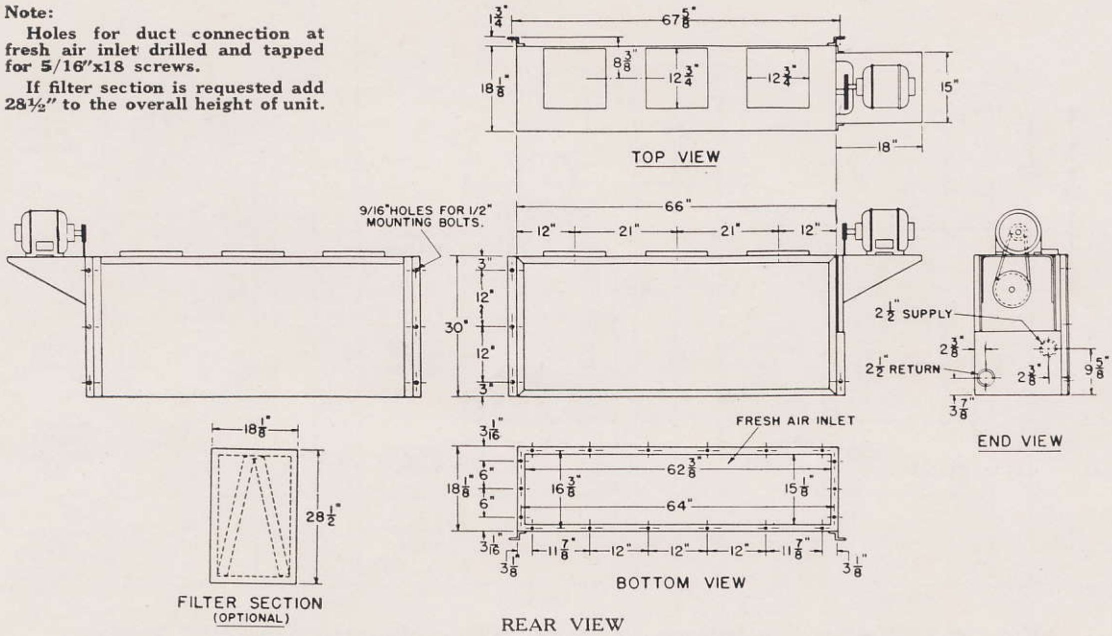


Fig. 3472—No. 1866 Type "R" Unit Heater. Wall Mounting.

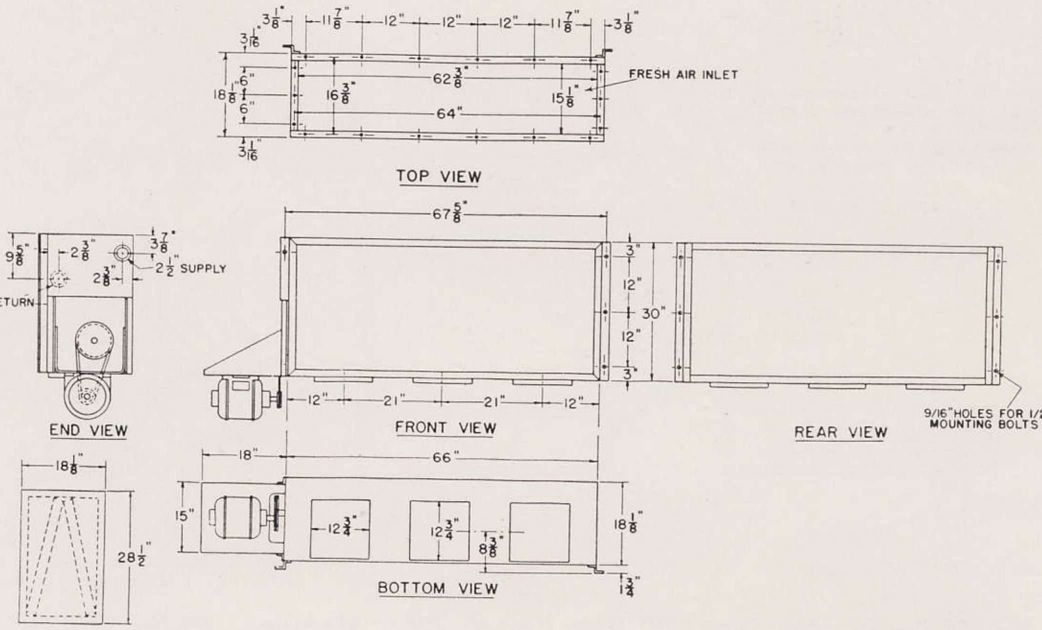


Fig. 3469—No. 1866 Type "R" Unit Heater. Inverted Wall Mounting.

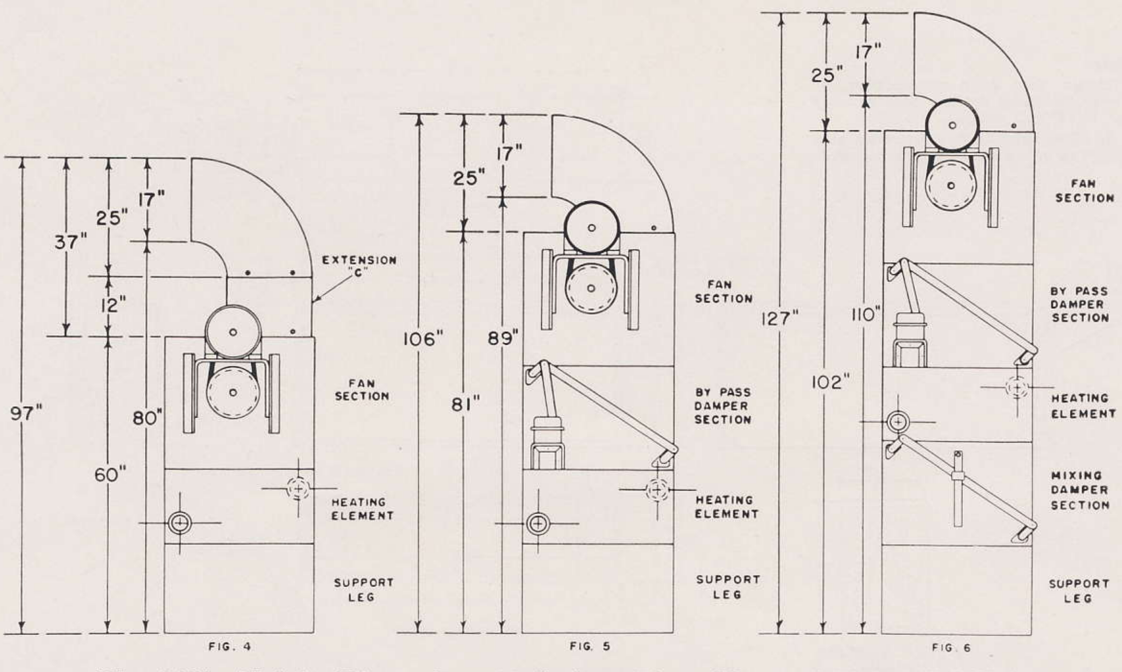


Fig. 3465—Height Dimensions 30 Series. Floor Mounted Type "R" Unit Heaters with Standard Discharge Nozzles and Extensions.

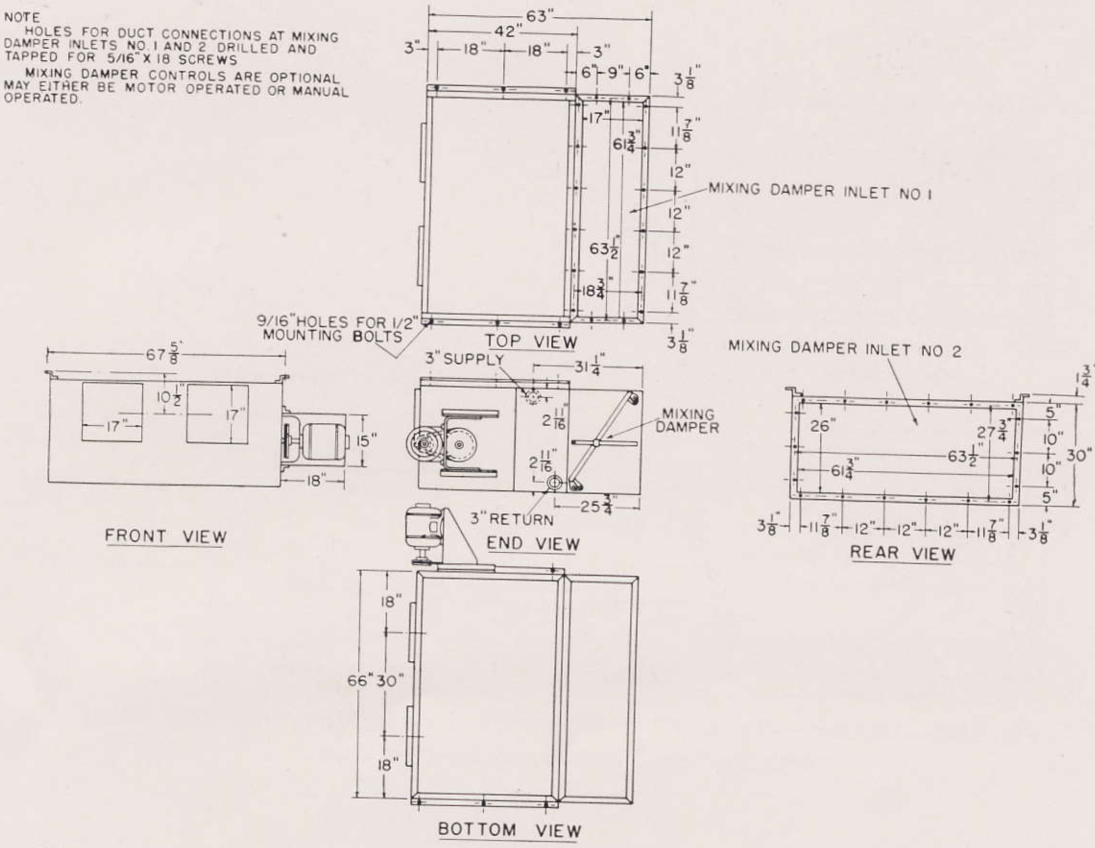


Fig. 3468—No. 3066 Type "R" Unit Heater. Ceiling Mounting, Mixing Damper.

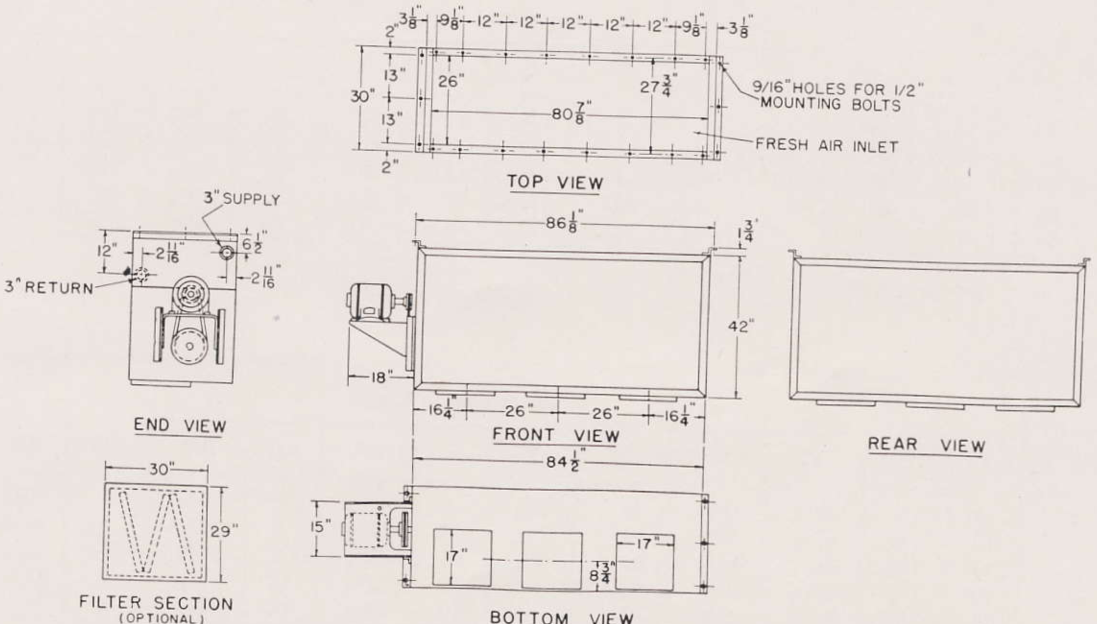


Fig. 3467—No. 3084 Type "R" Unit Heater. Inverted Suspended Mounting.

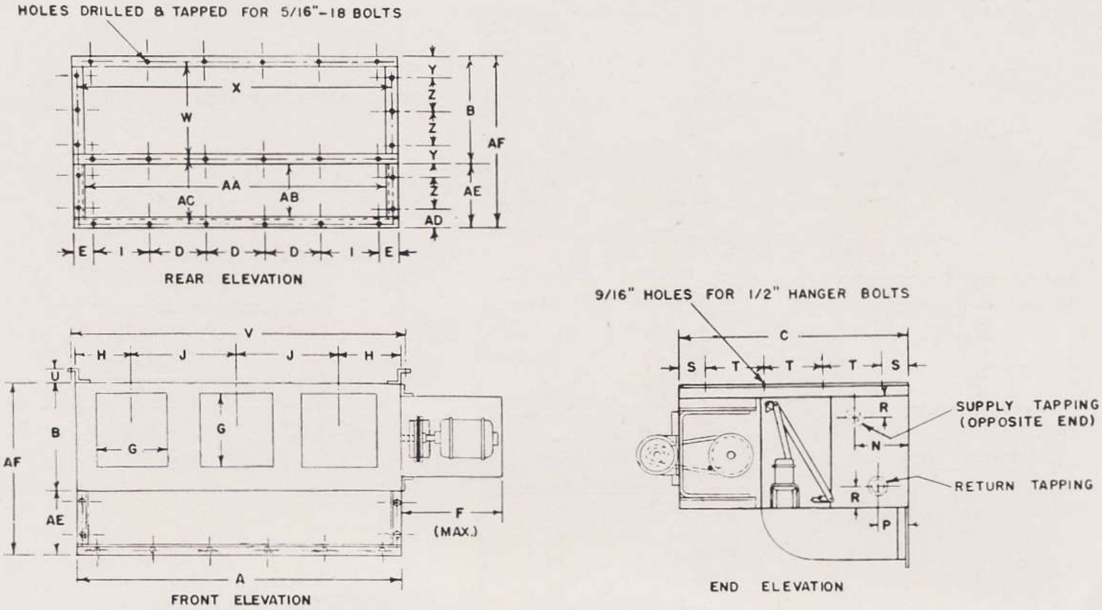
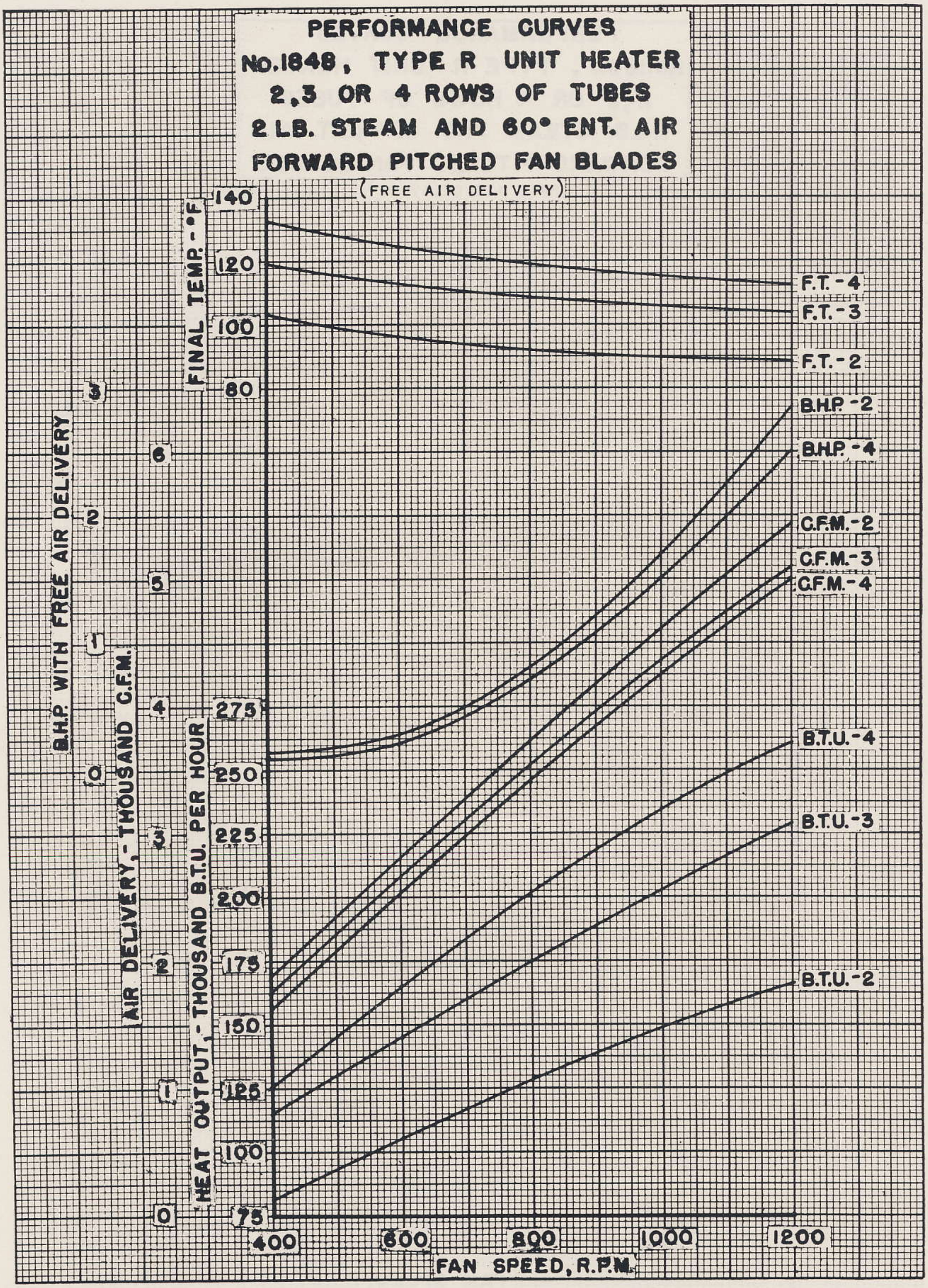
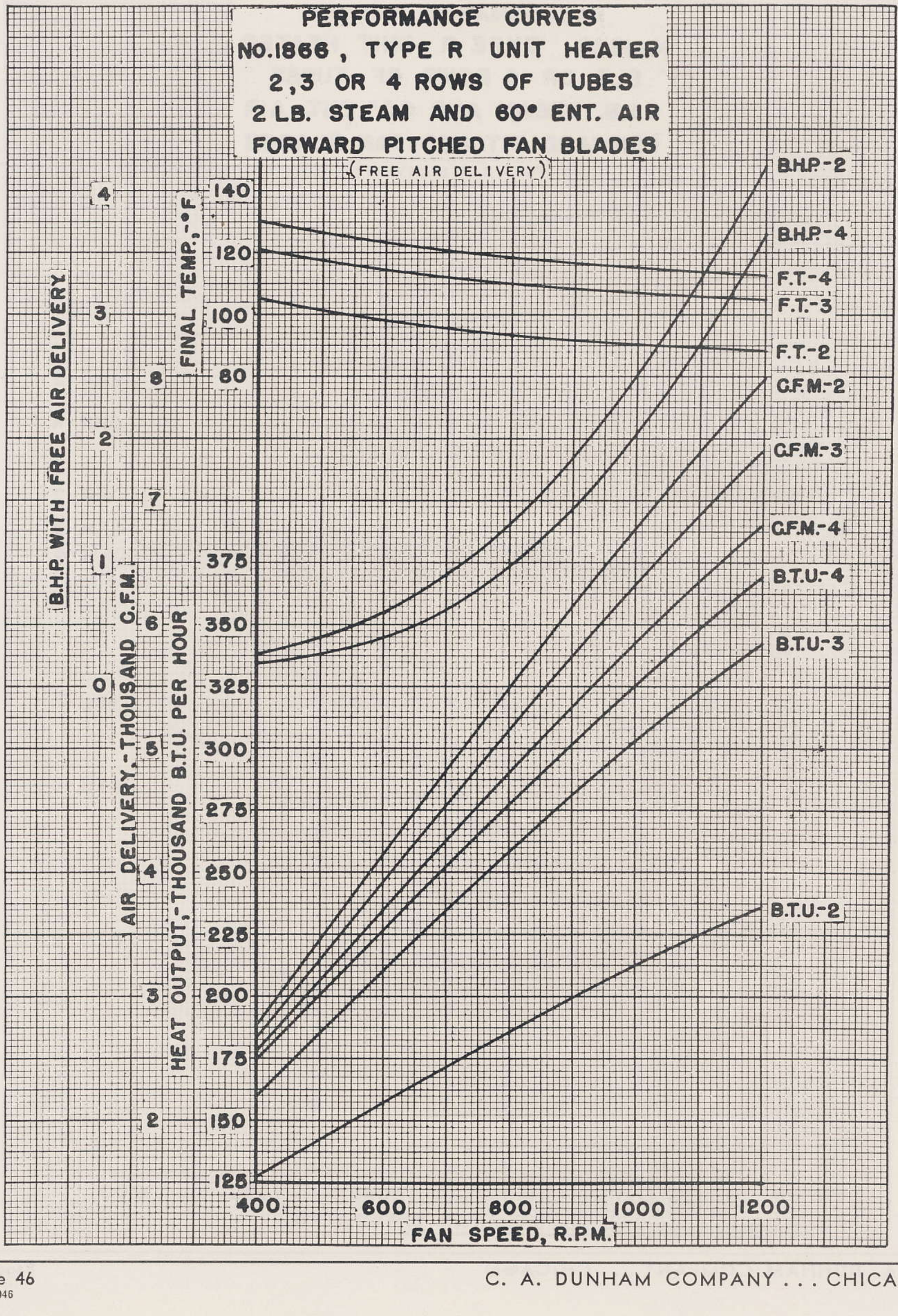


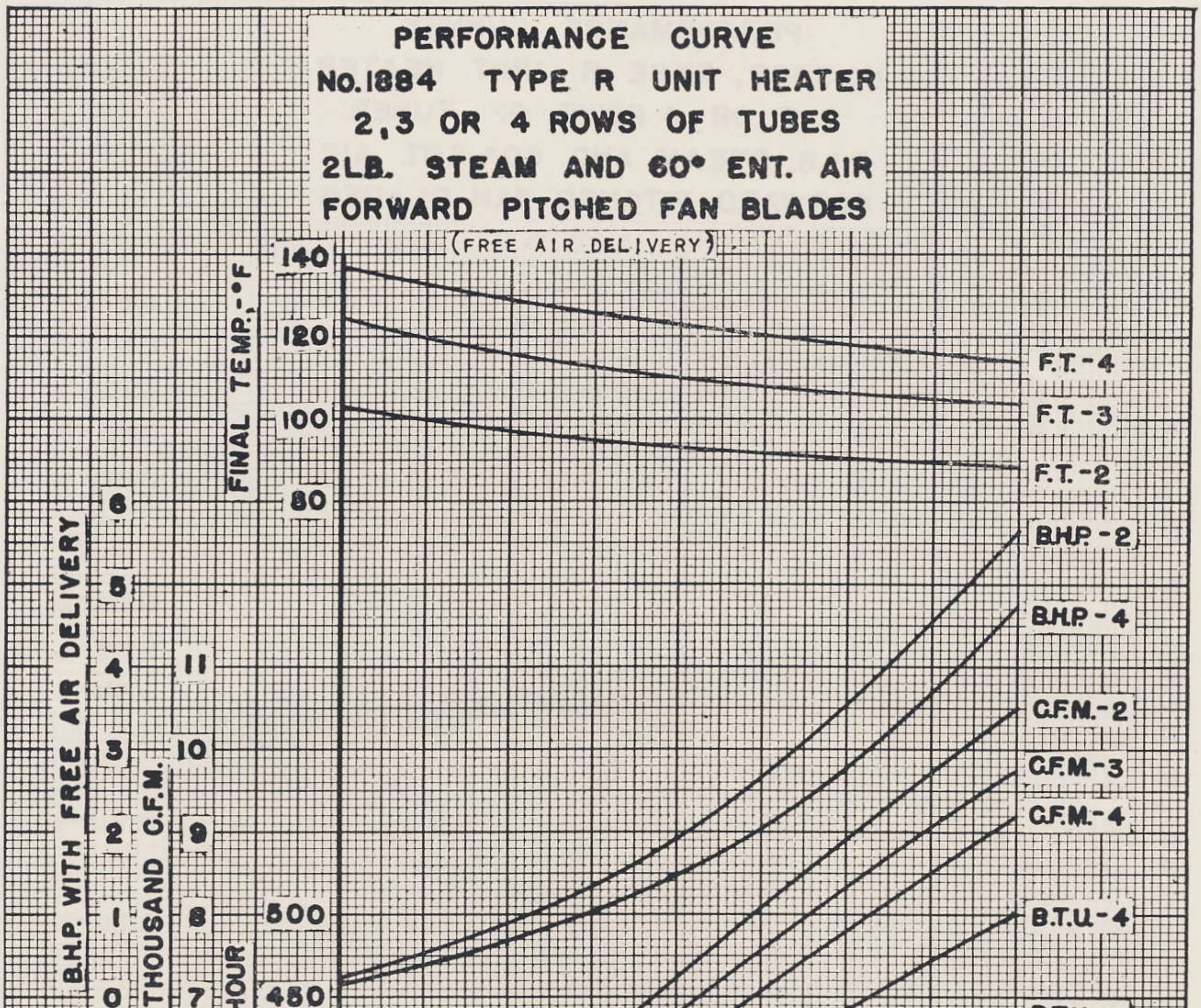
Fig. 3466—Dunham—Type "R" Unit Heaters. Ceiling Mounting—Belt Drive with By-Pass Damper and By-Pass Duct.

Unit No.	No. of Outlets	Dimensions in Inches													
		A	B	C	D	E	F	G	H	I	J	N	P	R	S
1848	2	43	18⅛	43½	12	6	25	12¾	13	12	22	9⅝	3⅞	2⅜	2¼
1866	3	66	18⅛	43½	12	3⅛	25	12¾	12	11⅞	21	9⅝	3⅞	2⅜	2¼
1884	4	84½	18⅛	43½	12	3⅛	25	12¾	12¼	9⅛	20	9⅝	3⅞	2⅜	2¼
3066	2	66	30	63	12	3⅛	25	17	18	11⅞	30	10¼	4¾	2 11/16	3
3084	3	84½	30	63	12	3⅛	25	17	16¼	9⅛	26	10¼	4¾	2 11/16	3

Unit No.	No. of Outlets	Dimensions in Inches												
		T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1848	2	13	1¾	49⅝	16⅜	46	3 1/16	6	44⅜	9	10¾	3	10½	28⅝
1866	3	13	1¾	67⅝	16⅜	64	3 1/16	6	62⅜	9	10¾	3	10½	28⅝
1884	4	13	1¾	86⅛	16⅜	82½	3 1/16	6	80⅞	9	10¾	3	10½	28⅝
3066	2	19	1¾	67⅝	27¾	63½	5	10	62⅜	15	17	4	16½	46½
3084	3	19	1¾	86⅛	27¾	82	5	10	80⅞	15	17	4	16½	46½


PERFORMANCE CURVES
No.1848, TYPE R UNIT HEATER
2,3 OR 4 ROWS OF TUBES
2 LB. STEAM AND 60° ENT. AIR
FORWARD PITCHED FAN BLADES
(FREE AIR DELIVERY)
FINAL TEMP. - °F
HEAT OUTPUT, - THOUSAND B.T.U. PER HOUR
AIR DELIVERY, - THOUSAND C.F.M.
B.H.P. WITH FREE AIR DELIVERY
FAN SPEED, R.P.M.
F.T. - 4
F.T. - 3
F.T. - 2
B.H.P. - 2
B.H.P. - 4
C.F.M. - 2
C.F.M. - 3
C.F.M. - 4
B.T.U. - 4
B.T.U. - 3
B.T.U. - 2
140
120
100
80
275
250
225
200
175
150
125
100
75
400
600
800
1000
1200


PERFORMANCE CURVES
No.1866, TYPE R UNIT HEATER
2,3 OR 4 ROWS OF TUBES
2 LB. STEAM AND 60° ENT. AIR
FORWARD PITCHED FAN BLADES
(FREE AIR DELIVERY)
B.H.P. WITH FREE AIR DELIVERY
AIR DELIVERY,-THOUSAND C.F.M.
HEAT OUTPUT,-THOUSAND B.T.U. PER HOUR
FINAL TEMP.,-°F
4
3
2
1
0
8
7
6
5
4
3
2
140
120
100
80
375
350
325
300
275
250
225
200
175
150
125
400
600
800
1000
1200
FAN SPEED, R.P.M.
B.H.P.-2
B.H.P.-4
F.T.-4
F.T.-3
F.T.-2
C.F.M.-2
C.F.M.-3
C.F.M.-4
B.T.U.-4
B.T.U.-3
B.T.U.-2


PERFORMANCE CURVE
No.1884 TYPE R UNIT HEATER
2,3 OR 4 ROWS OF TUBES
2LB. STEAM AND 60° ENT. AIR
FORWARD PITCHED FAN BLADES
(FREE AIR DELIVERY)
FINAL TEMP.,-°F
B.H.P. WITH FREE AIR DELIVERY
AIR DELIVERY,-THOUSAND C.F.M.
HEAT OUTPUT,-THOUSAND B.T.U. PER HOUR
F.T.-4
F.T.-3
F.T.-2
B.H.P.-2
B.H.P.-4
C.F.M.-2
C.F.M.-3
C.F.M.-4
B.T.U.-4
B.T.U.-3
B.T.U.-2
FAN SPEED, R.P.M.
400
600
800
1000
1200
140
120
100
80
500
450
400
350
300
250
200
150
100
0
1
2
3
4
5
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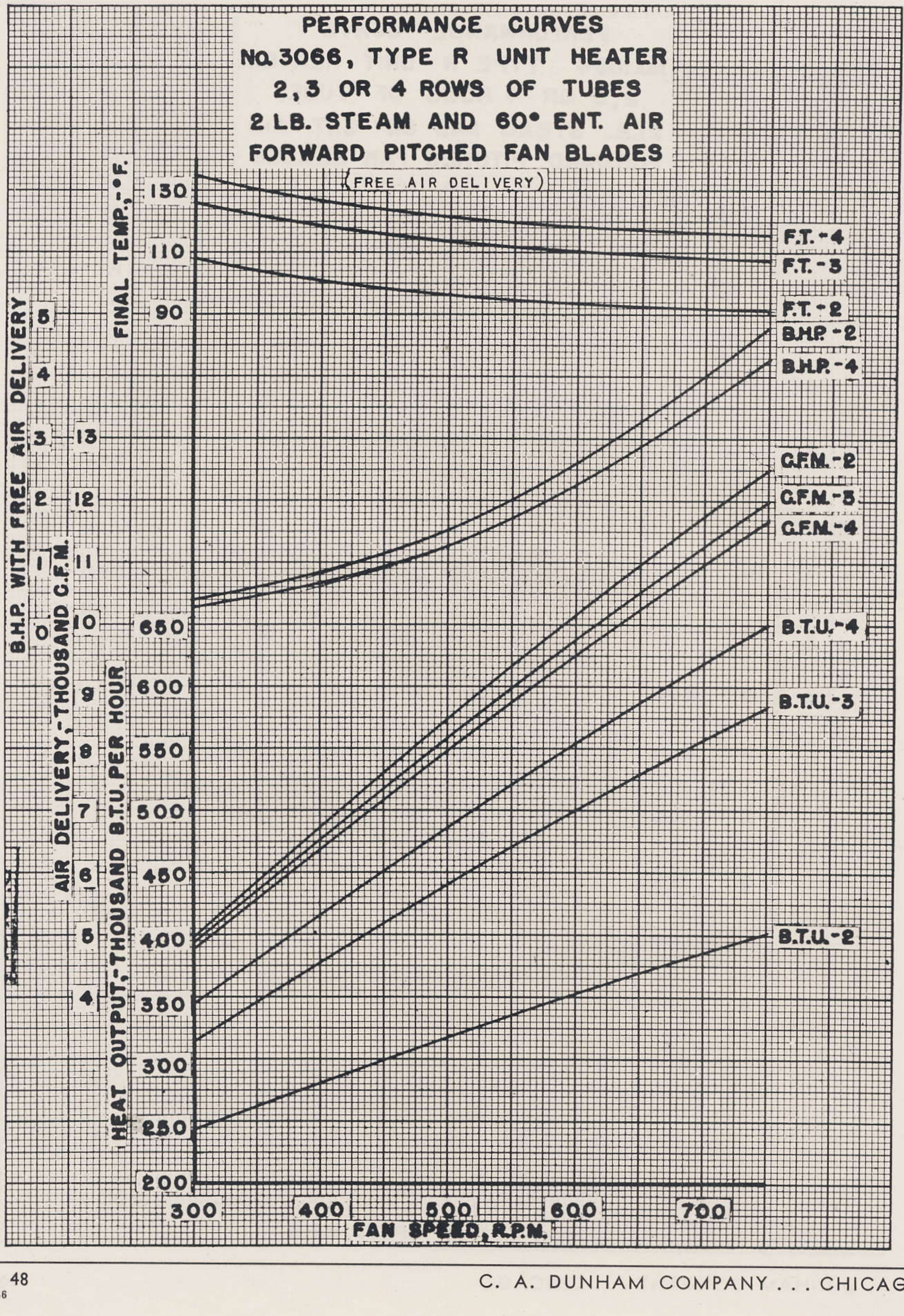
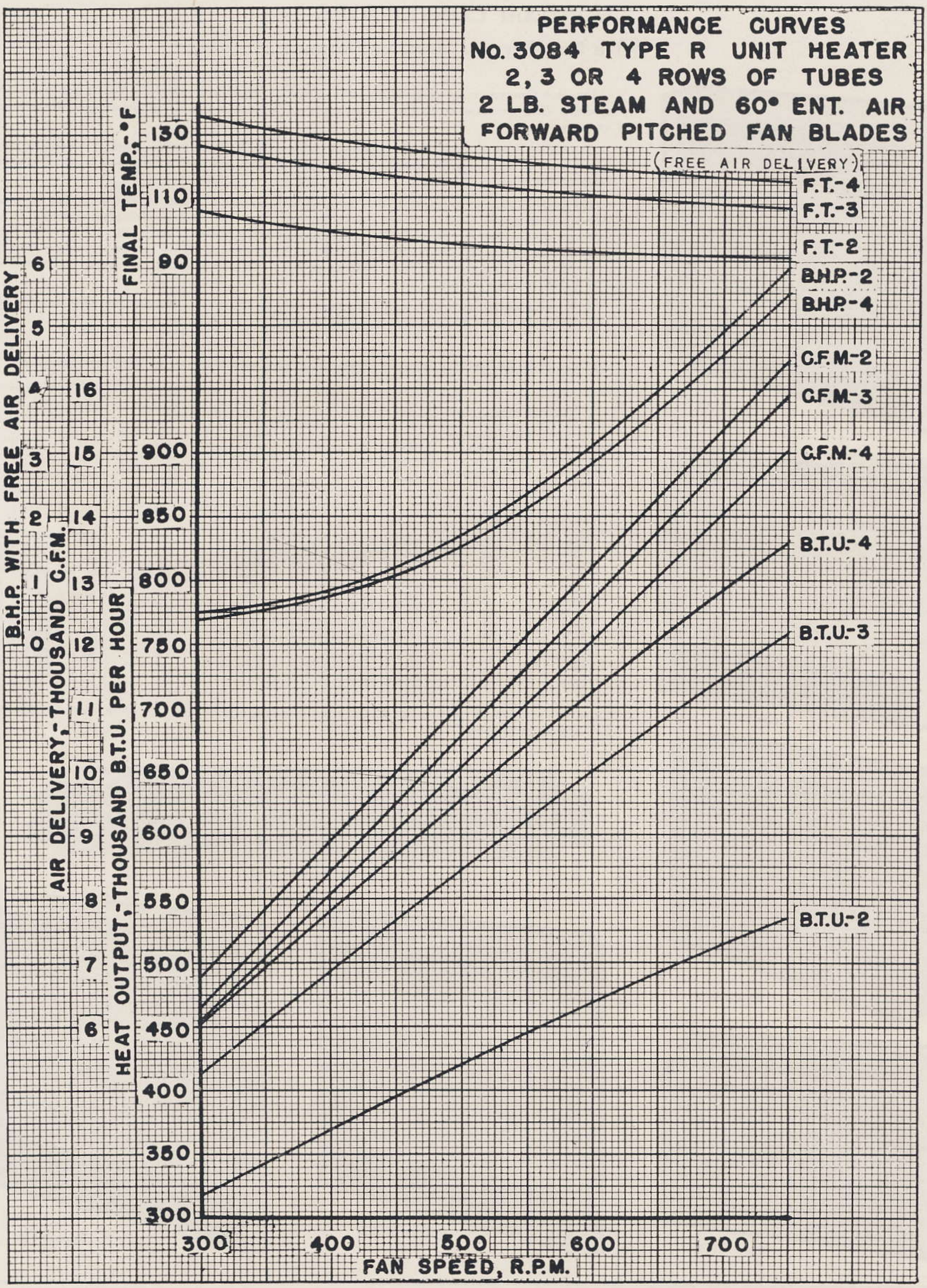
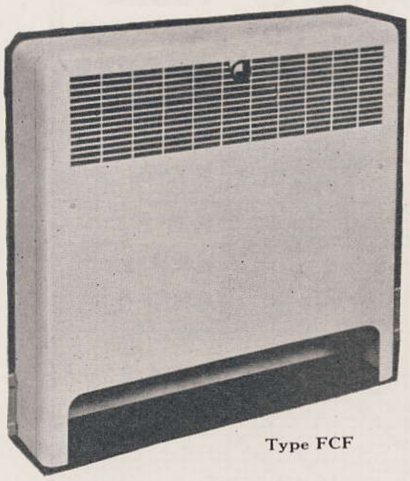
7
8
9
10
11


PERFORMANCE CURVES
NO. 3066, TYPE R UNIT HEATER
2, 3 OR 4 ROWS OF TUBES
2 LB. STEAM AND 60° ENT. AIR
FORWARD PITCHED FAN BLADES
(FREE AIR DELIVERY)
B.H.P. WITH FREE AIR DELIVERY
0
1
2
3
4
5
AIR DELIVERY - THOUSAND C.F.M.
4
5
6
7
8
9
10
11
12
13
FINAL TEMP., -°F.
90
110
130
HEAT OUTPUT, - THOUSAND B.T.U. PER HOUR
200
250
300
350
400
450
500
550
600
650
F.T. - 4
F.T. - 3
F.T. - 2
B.H.P. - 2
B.H.P. - 4
C.F.M. - 2
C.F.M. - 3
C.F.M. - 4
B.T.U. - 4
B.T.U. - 3
B.T.U. - 2
300
400
500
600
700
FAN SPEED, R.P.M.


PERFORMANCE CURVES
No. 3084 TYPE R UNIT HEATER
2, 3 OR 4 ROWS OF TUBES
2 LB. STEAM AND 60° ENT. AIR
FORWARD PITCHED FAN BLADES
(FREE AIR DELIVERY)
F.T.-4
F.T.-3
F.T.-2
B.H.P.-2
B.H.P.-4
C.F.M.-2
C.F.M.-3
C.F.M.-4
B.T.U.-4
B.T.U.-3
B.T.U.-2
B.H.P. WITH FREE AIR DELIVERY
0
1
2
3
4
5
6
AIR DELIVERY,-THOUSAND C.F.M.
6
7
8
9
10
11
12
13
14
15
16
HEAT OUTPUT,-THOUSAND B.T.U. PER HOUR
300
350
400
450
500
550
600
650
700
750
800
850
900
FINAL TEMP.,-°F
90
110
130
300
400
500
600
700
FAN SPEED, R.P.M.

DUNHAM CONVECTORS

With Non-Ferrous Heating Element



Type FCF

Dunham Convectors are designed for use on steam or vapor, and gravity or forced hot water heating systems. They are manufactured in cabinet types and sizes shown in the accompanying illustrations and capacity table.

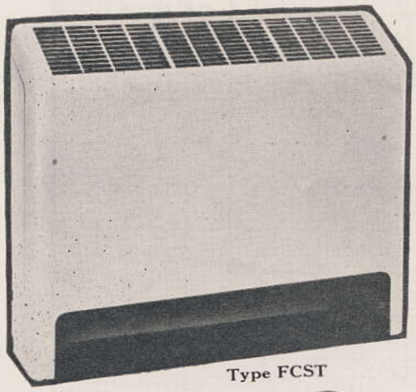
Casings are constructed of No. 18 gage steel with removable fronts having rounded corners for pleasing appearance. The outlet grille consists of horizontal openings punched in the casing front. Dampers can be furnished when so ordered.

The heating element is constructed of non-corrosive materials, copper or aluminum fins on seamless drawn, round copper tubes brazed to bronze headers. The tubes are expanded after assembly to assure intimate contact between fin and tube for permanent heat transfer. Heavy side plates protect the fins from damage. The elements are tested at a hydrostatic pressure of 400 lbs. per sq. in. and are suitable for operation on 150 lb. steam or water working pressure. Either end or top and bottom tapped headers (¾″ I.P.S.) can be supplied.

EDR capacities of stock sizes with 1 lb. steam, 65° entering air are shown in the table on other side of this sheet. These are CMC (Convector Manufacturers Certified) ratings.

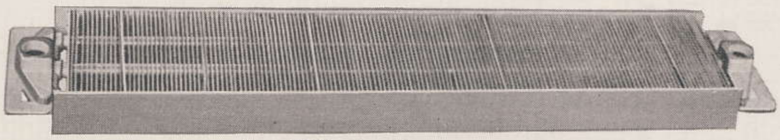
CAPACITIES OF DUNHAM CONVECTORS WITH STEAM AT 1 LB. AND 65° ENTERING AIR

Ordering Height "H"		20″	24″	32″	Ordering Height "H"		20″	24″	32″
Actual Cabinet Ht. Non-Recessed Types	Floor Mounted Types	20″	24″	32″	Actual Cabinet Ht. Non-Recessed Types	Floor Mounted Types	20″	24″	32″
	Wall Mounted Types	16″	20″	28″		Wall Mounted Types	16″	20″	28″
Catalog Number	Cabinet Length, Inches				Catalog Number	Cabinet Length, Inches			
T1804	18	12.0	13.0	14.0	T4006	40	39.5	45.5	48.5
T2004	20	13.5	15.0	16.5	T4806	48	47.0	53.0	57.5
T2404	24	16.5	18.0	20.0	T5606	56	54.0	60.0	65.0
T2804	28	19.5	21.5	23.5	T6406	64	60.0	65.0	71.0
T3204	32	22.5	25.0	27.0	T3208	32	40.5	44.0	47.0
T4004	40	28.0	30.5	33.5	T4008	40	51.0	56.5	60.0
T4804	48	33.5	37.0	40.0	T4808	48	61.5	68.5	72.5
T5604	56	37.5	42.0	46.0	T5608	56	72.0	79.5	84.0
T6404	64	41.5	46.5	50.5	T6408	64	80.5	88.0	94.0
T2006	20	19.5	22.0	23.0	T40010	40	55.5	61.0	66.0
T2406	24	23.5	27.5	28.5	T48010	48	68.0	74.5	80.5
T2806	28	27.0	31.5	34.0	T56010	56	81.0	87.5	94.0
T3206	32	31.5	36.0	39.0	T64010	64	92.5	96.0	108.0

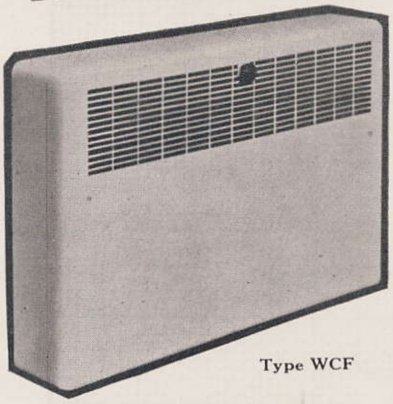


Type FCST

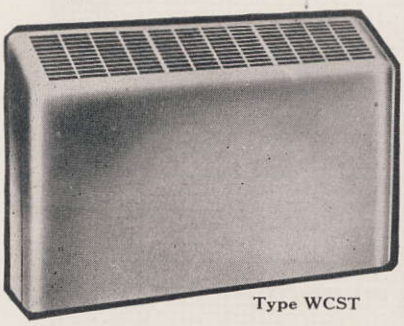
Capacities with Hot Water Systems depend upon a number of conditions. See Data Sheet File No. 6A-2-3 for Capacity information.



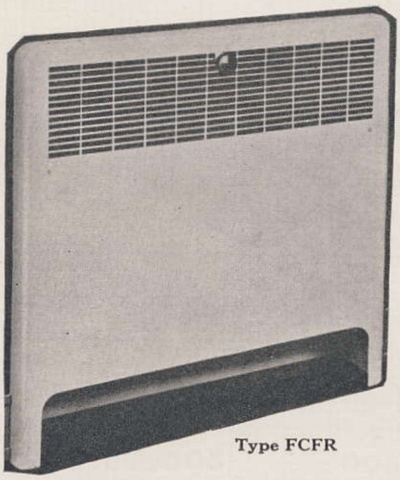
Type T Heating Element



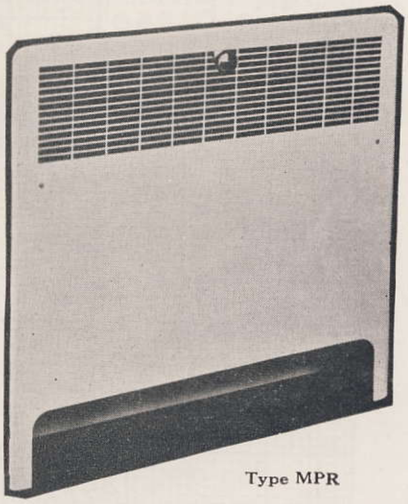
Type WCF



Type WCST



Type FCFR



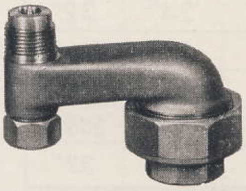
Type MPR

DUNHAM ADJUSTABLE REGULATING FITTINGS

The Dunham Adjustable Regulating Fitting is a device which makes it possible to accurately apportion the supply of steam to every radiator. These fittings are made entirely of brass, accurately machined and in ¾″ size only.

These fittings simplify the problem of applying orifice regulation to a concealed radiator which is complicated due to the steam supply being located in the bottom of the element. For satisfactory operation the orifice or port through which steam enters must be higher than the radiator tube, so water cannot accumulate above the port and cause noise. When applied to Dunham Convectors, the parts are properly located as shown by Fig. 1470B.

For Use With Dunham Convectors



Type 197—Adjustable Regulating Fitting with Female Union Inlet.

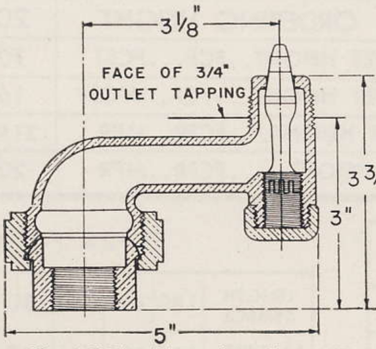
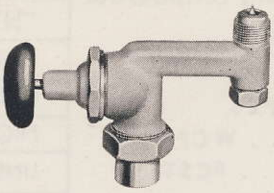


Fig. 1607A—Dimensions Type 197



Type 297—Combination Valve and Adjustable Regulating Fitting. For use with Concealed Radiators.

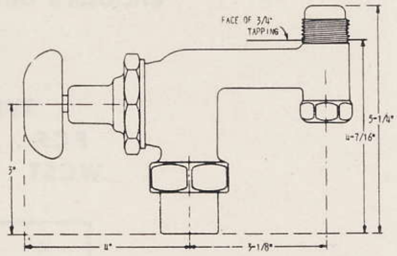


Fig. 1510—Dimensions Type 297

Type 298—Vertical Fitting

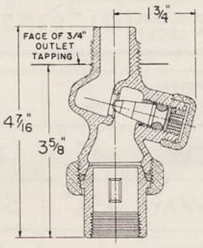
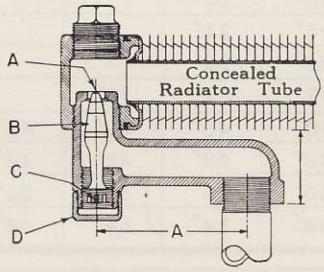


Fig. 1935—Dimensions for Vertical Type Fitting



Section through Adjustable Regulating Fitting and Concealed Radiation

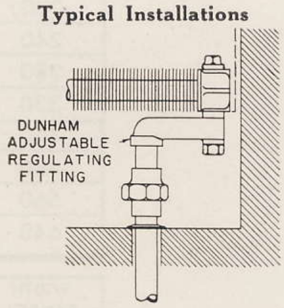
A. Port through which steam enters radiator is higher than radiator tube. Water cannot accumulate above port and cause noise.

B. Adjustable screw can be removed from fitting for cleaning.

C. Screw is easily adjusted for radiator of any size and stack height. Remove cap and adjust with screwdriver.

D. Ground joint cap makes joint absolutely tight.

Typical Installations



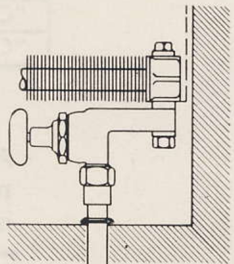
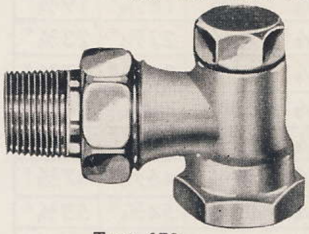


Fig. 1470B

For other makes of concealed radiators than Dunham, the Adjustable Regulating Fitting can be applied by use of the Type 196 Adapter in connection with one of the standard fittings as shown by Fig. 1674.

When ordering Type 196 Adapter Fittings give: (1) Make of Radiation, (2) Size of radiator supply tapping, (3) Amount of radiation in square feet and (4) Distance from face of inlet to bottom of radiator tube.

For Use With Direct Cast Iron Radiators



Type 178 Adjustable Regulating Fitting

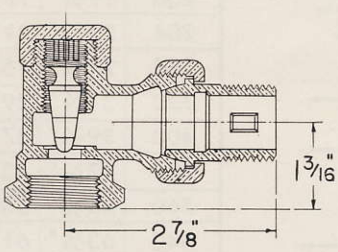


Fig. 1934—Type 178

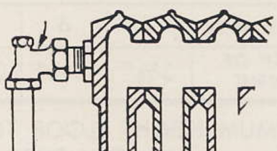


Fig. 3234—Typical Installation

Dunham Adapter Fitting, Type 196

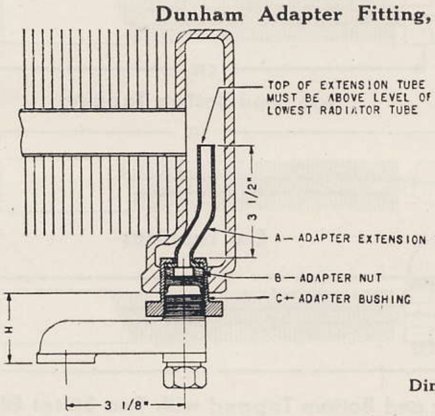


Fig. 1674. Sectional view of Adapter Fitting installed with Adjustable Regulating Fitting on a concealed radiator having an offset tapping 3¼″ below lowest radiator tube.

Dimension "H" in Inches (Approx.)

Radiator Tapping	Adapter Cat. No.	Types 197 and 198
1	AF1	3¾
1¼	AF1¼	3¾
1½	AF1½	3¾

CONVECTORS

DUNHAM INSTALLATION INSTRUCTIONS FOR CABINET CONVECTORS...

Each convector catalog number is a combination of two dimension symbols. The Length Symbol includes the first three digits, viz: 180, 200, 240, etc. The Width Symbol includes the remaining digit or digits, viz: 4, 6, 8, 10. The tables are keyed to these symbols, making it easy to determine any pertinent dimension required for installation fitting. Cabinet heights are as shown for the particular style of enclosure being considered.

"H" ORDERING HEIGHT	20"	24"	32"
CABINET HEIGHT..FCF...FCST	20"	24"	32"
CABINET HEIGHT..WCF..WCST	16"	20"	28"
FRONT HEIGHT...FCFR..MPR	21½"	25½"	33½"
LINER HEIGHT.....FCFR..MPR	20"	24"	32"

TYPES
FCF . . . WCF
WCST . . . FCST

LENGTH SYMBOL	4" Width	6" Width	8" Width	10" Width
	"CL" CABINET			
180	18"			
200	20"	20"		
240	24"	24"		
280	28"	28"		
320	32"	32"	32"	
400	40"	40"	40"	40"
480	48"	48"	48"	48"
560	56"	56"	56"	56"
640	64"	64"	64"	64"

WIDTH SYMBOL	4	6	8	10
"CW"	4"	6"	8"	10½"
"CTW"	2"	3"	4"	5¼"

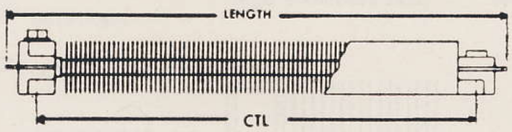
TYPES, FCFR, MPR

LENGTH SYMBOL	180	200	240	280	320	400	480	560	640
LL LINER LENGTH	18"	20"	24"	28"	32"	40"	48"	56"	64"
FL CABINET LENGTH	21"	23"	27"	31"	35"	43"	51"	59"	67"

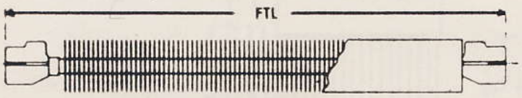
WIDTH SYMBO	4	6	8		10	
CW	4"	6"	8"		10½"	
LWM	3¾"	5¾"	7¾"		10¼"	
FW	....	2"	2"	4"	2"	4"
LW	......	4"	6"	4"	8½"	6½"
CTW	2"	3"	4"		5¼"	

DUNHAM HEATING ELEMENTS

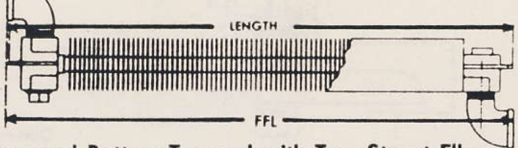
All tappings are on center-line of element width. Heating elements are held in proper pitch alignment by brackets welded to each end of the enclosure. Pitch is variable from 5/16" to 5/8".



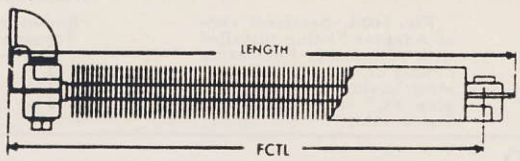
Top and Bottom Tappings



End Tappings



Top and Bottom Tapped with Two Street Ells



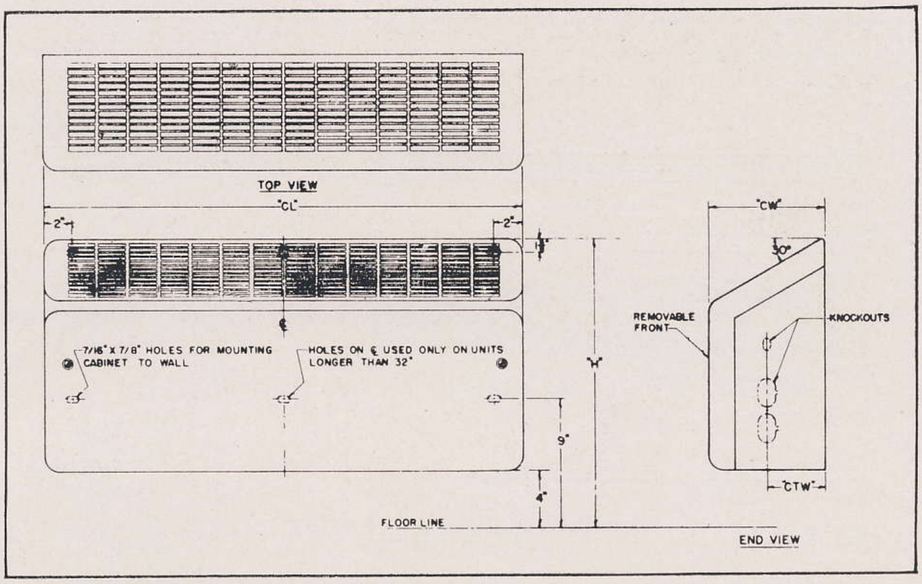
Top and Bottom Tapped with One Street Ell

LENGTH SMYBOL	OVERALL LENGTH	CTL	FTL	FCTL	FFL
180	17¾"	15⅛"	17¾"	16 7/16"	17¾"
200	19¾"	17⅛"	19¾"	18 7/16"	19¾"
204	23¾"	21⅛"	23¾"	22 7/16"	23¾"
280	27¾"	25⅛"	27¾"	26 7/16"	27¾"
320	31¾"	29⅛"	31¾"	30 7/16"	31¾"
400	39¾"	37⅛"	39¾"	38 7/16"	39¾"
480	47¾"	45⅛"	47¾"	46 7/16"	47¾"
560	55¾"	53⅛"	55¾"	54 7/16"	55¾"
640	63¾"	61⅛"	63¾"	62 7/16"	63¾"

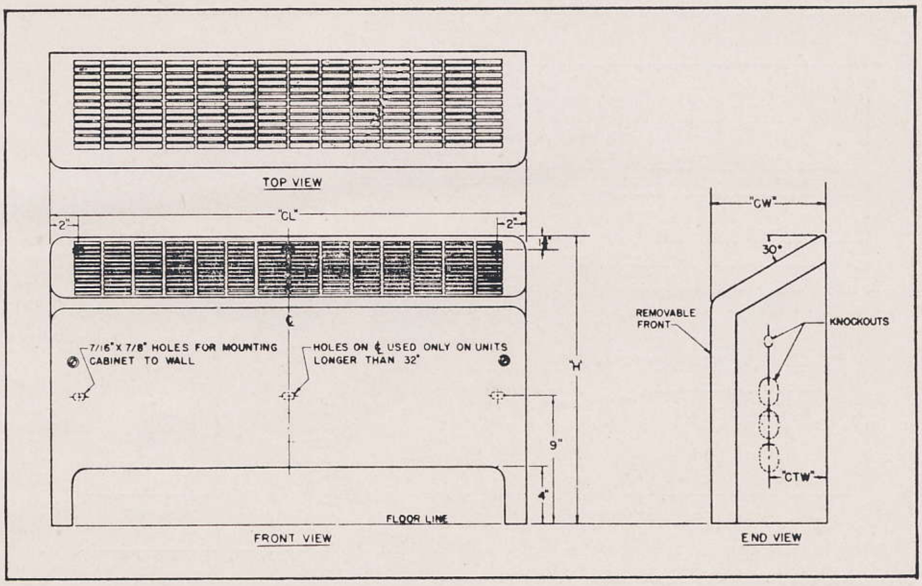
WIDTH SYMBOL	4	6	8	10
WIDTH OF ELEMENT	3⅝"	5⅝"	7⅝"	10¼"

MINIMUM HEIGHT FLOOR TO TAPPING AT LOW END

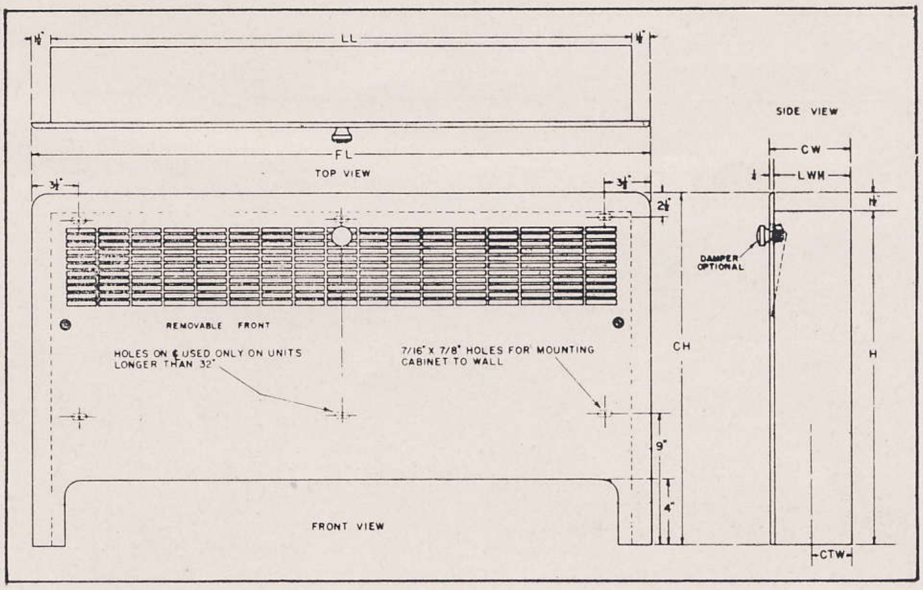
BOTTOM TAPPING 5½" TO FACE
END TAPPING 6½" TO CENTER
STREET ELL 4 3/16" TO CENTER



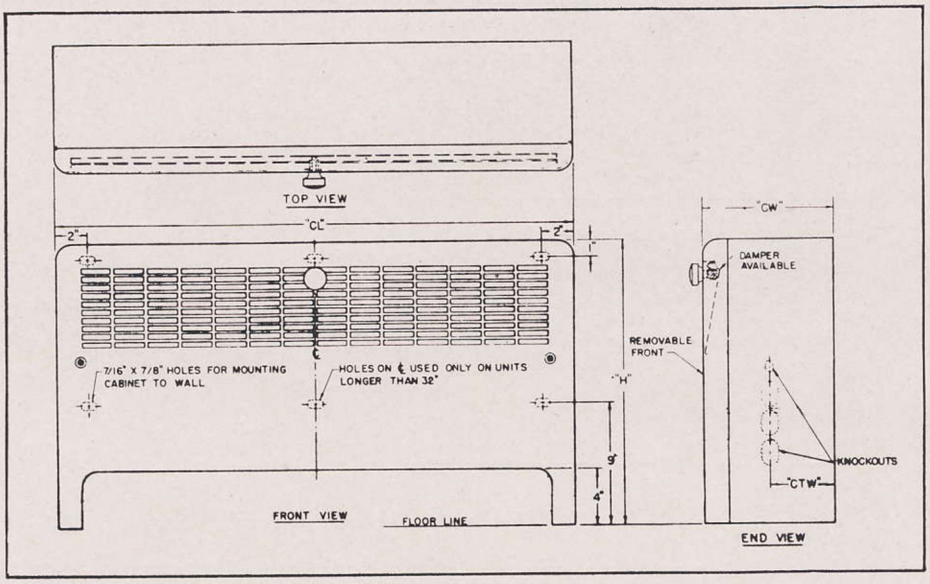
WCST



FCST

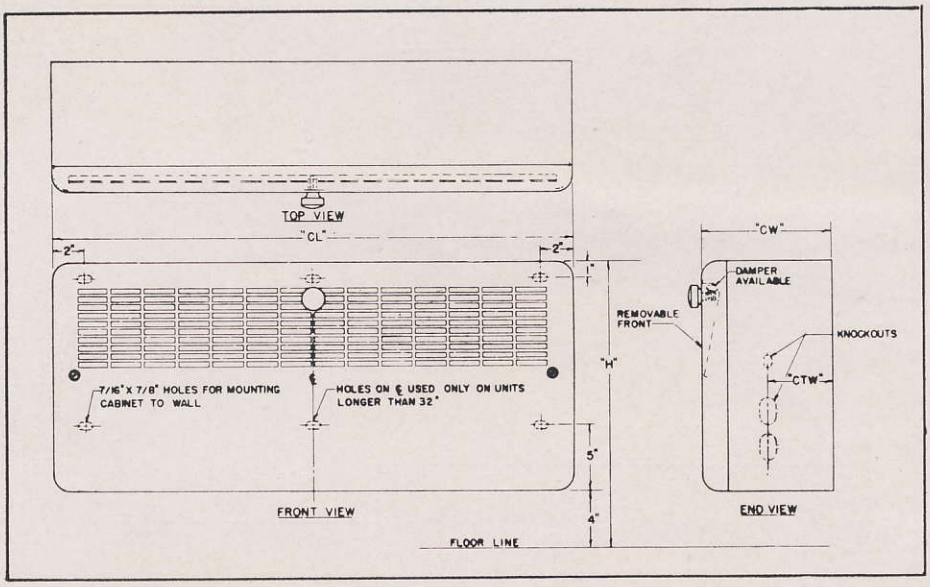


MPR



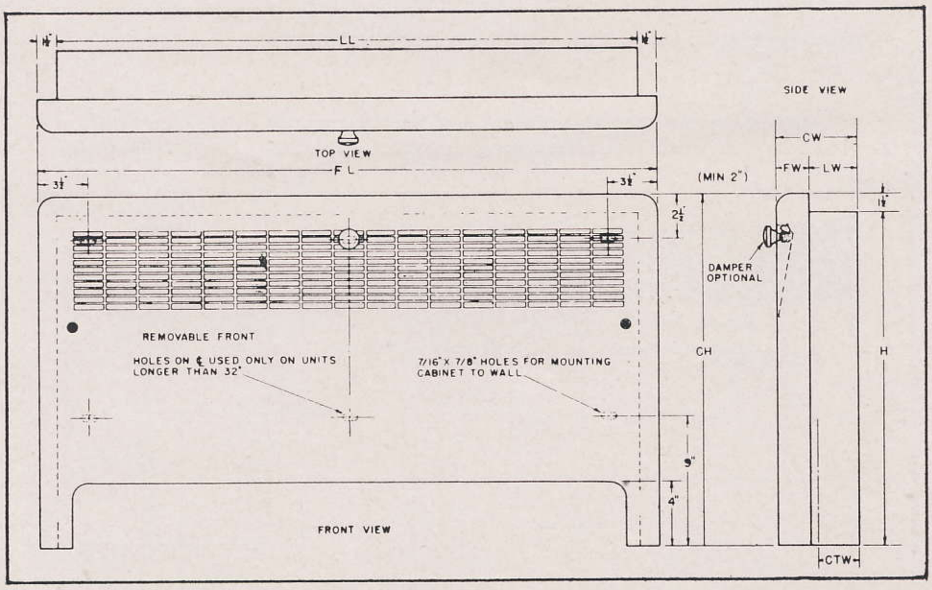
TOP VIEW
"CL"
2"
2"
1"
"CW"
DAMPER AVAILABLE
REMOVABLE FRONT
7/16" X 7/8" HOLES FOR MOUNTING CABINET TO WALL
HOLES ON ℄ USED ONLY ON UNITS LONGER THAN 32"
"H"
9"
4"
KNOCKOUTS
"CTW"
FRONT VIEW
FLOOR LINE
END VIEW

FCF



TOP VIEW
"CL"
2"
2"
1"
"CW"
DAMPER AVAILABLE
REMOVABLE FRONT
KNOCKOUTS
"H"
"CTW"
7/16" X 7/8" HOLES FOR MOUNTING CABINET TO WALL
HOLES ON ℄ USED ONLY ON UNITS LONGER THAN 32"
5"
4"
FRONT VIEW
END VIEW
FLOOR LINE

WCF



LL
SIDE VIEW
TOP VIEW
CW
FW
LW
F L
(MIN 2")
DAMPER OPTIONAL
REMOVABLE FRONT
HOLES ON ℄ USED ONLY ON UNITS LONGER THAN 32"
7/16" X 7/8" HOLES FOR MOUNTING CABINET TO WALL
CH
H
9"
4"
FRONT VIEW
CTW

FCFR

TYPE M UNIT HEATERS

(NON-FERROUS COIL)

The Dunham Type M unit is a compact cabinet type heating unit, quiet in operation and soundly constructed. The heating element is constructed of non-ferrous materials consisting of copper fins on copper tubes, silver soldered to bronze headers. Casings are made of steel and have removable front for access to working parts.

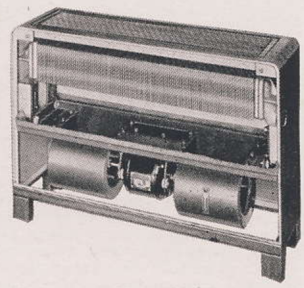


Fig. 1727—Type M (Sectional)

APPLICATIONS—Vestibules and lobbies of large buildings, general offices, display rooms, retail stores, churches, restaurants, hospital wards, basement rooms, waiting rooms, etc.

The Type M unit provides from three to five times the ordinary radiator capacity in the same space. It can be mounted on the wall—upright or inverted—flat against the ceiling or on the floor. Available in two sizes equivalent to 250 and 350 EDR.

MOTORS—All motors three speed, 1140 r.p.m., resilient mounted, for operation on single phase, 60 cycle, 115 volt current.

ENGINEERING DATA

Unit No.	Fan Speed	Motor		Unit EDR	With Steam at 2 lb. Ga. and Air at 60°F.				Shipping Weight	Tappings, Ins.	
		HP	RPM		Btu.	Cond.	F. T.	CFM		Supply	Ret'n
250	High Normal Low	1/12	1140 870 570	300 250 185	72,000 60,000 44,300	74.5 62.1 45.9	130.7 134.9 144.5	938 739 500	240 lb.	1¼	1¼
350	High Normal Low	1/4	1140 870 570	423 350 258	101,500 84,000 62,000	105.0 87.0 64.1	133.6 138.0 144.6	1270 994 675	290 lb.	1½	1½

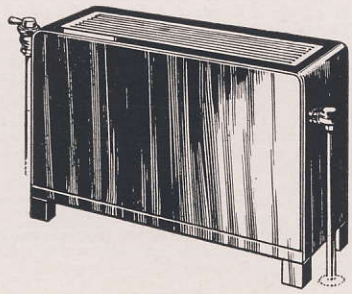


Fig. 1728—Floor Mounting

Btu—Total heat in discharged air above room temperature. Cond.—Steam condensed in pounds per hour. F.T.—Temperature of air discharged in degrees F. EDR—Equivalent Direct Radiation (ASH&VE definition one square foot is 240 Btu at 2 lbs. steam and 60° entering air). CFM—Cubic feet of air per minute handled by the fan expressed in CFM measured at 70° F. under standard conditions.

Floor mounted units are furnished with legs. All wall mounted or ceiling mounted units are furnished with a hanger frame for fastening to stud walls.

POSITION—Dunham Type M Unit Heaters can be installed in any position, discharging their air directly upwards, directly downwards, or horizontally. Units must be ordered for the position in which they are to be set, so that proper mounting can be provided.

After the frame has been installed, the unit can then be attached to the frame by means of bolts thru the back panel, engaging holes provided for that purpose.

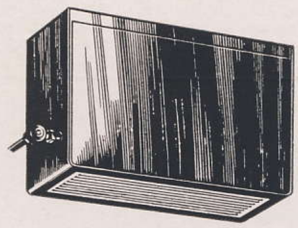


Fig. 1729—Inverted Wall Mounting

The recess in the back of the heater completely hides the hanger frame, so that after installation, no means of hanging are visible.

PIPING—The illustrations indicate the simplicity of piping. The supply end should always be provided with a valve, and the return end with a trap on vacuum return line or vapor systems.

On two pipe gravity systems, an air vent should be provided on the return connection. Location of supply and return connections as shown cannot be reversed.

All Dunham Unit Heaters are tested and rated in accordance with the Standard Code for testing and rating Unit Heaters adopted by the ASHVE and IUHA in 1930.

When the unit is to be mounted behind a wall, handling its air through grilles in the face of the wall, the standard upright or inverted wall mounting is used, as desired. The necessary duct work or elbows, must be built on the job. When the unit is installed in a position where it is exposed on all sides, a special panel is provided for the rear, matching the removable front panel.

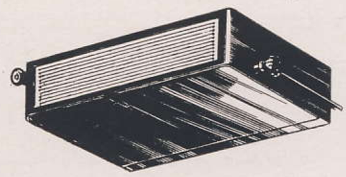
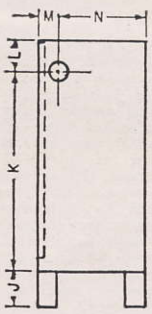


Fig. 1730—Ceiling Mounting

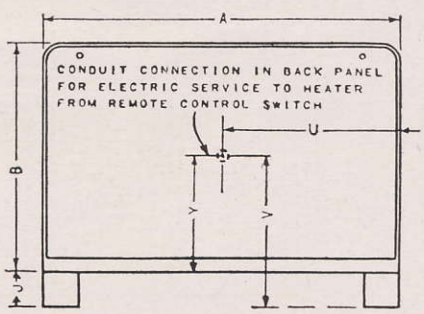
Unit No.	Dimensions in Inches						
	A	B	C	D	E	F	G
250	33	25	12⅜	1½	10½	9	9⅜
350	40 3/16	27¼	14 5/16	1½	13¼	10 11/16	11 5/16

Unit No.	Dimensions in Inches						
	H	J	K	L	M	N	P
250	⅝	3⅝	22 7/16	2 9/16	1⅞	10½	19 5/16
350	⅝	4⅝	24⅜	2⅞	2⅛	12 3/16	21½

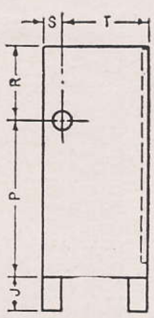
Unit No.	Dimensions in Inches							
	R	S	T	U	V	W	X	Y
250	5 11/16	1⅞	10½	16½	16⅜	27½	9¼	12¾
350	5¾	2⅛	12 3/16	20 3/16	19½	34¾	11	14⅞



LEFT SIDE

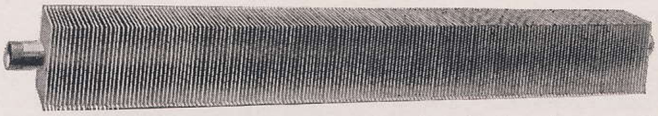


FRONT OF UNIT
Fig. 1720



RIGHT SIDE

DUNHAM TYPE OTS HEATING ELEMENT



The Type OTS element is an extended surface heating element made entirely of steel. Its construction and design is entirely different than used in the ordinary radiator. The unit is long and narrow, suitable for many installations where standard type radiators are not desirable. It is light in weight and has unusual heating capacity.

Each element is made up of 1¼" welded steel pipe, with No. 22 gage heavy fins, mechanically attached, eliminating the use of a solder bond without sacrifice of heat transfer. Fig. 3400 shows section of fin and pipe assembly. The fin design is unique in that each fin, when pressed on the pipe, interlocks with the preceding fin. The result is an exceedingly tight and permanent mechanical joint. This construction assures greater contact area between fin and tube than is obtained with commonly used methods. A greater heating capacity throughout the life of the element is assured. The complete unit is painted with heat-resisting zinc chromate black enamel.

The single pipe feature of the OTS element permits high, safe working pressures. It can withstand sudden shock without injury.

OTS elements are manufactured in standard lengths from 18" to 72" as given in Table A. Longer lengths up to 12' can be supplied on order by welding two standard lengths together. Standard units are threaded at each end with standard pipe threads unless otherwise ordered. Units for welding to piping systems can be supplied with chamfered ends on special order. No end fittings are furnished.

CAPACITIES

Capacities are given in Table A. These capacities are based on standard conditions of 1 lb. steam with 65° entering air. For capacities at other than standard conditions, apply proper conversion factor from Tables B or C. Capacities are based on actual tests verified by reliable and authentic outside source.

COVERS

Covers for OTS elements are available for all lengths of units. The cover is constructed of No. 18 gage metal and extends the entire fin length of the unit, see Fig. 3402. The covers reduce the rated capacity of the unit by approximately 3%.

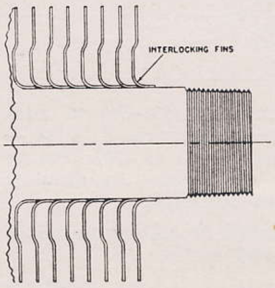


Fig. 3400
Showing interlocking of fins.

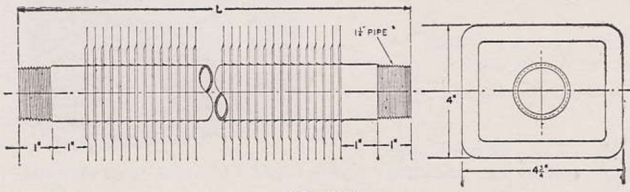


Fig. 3403

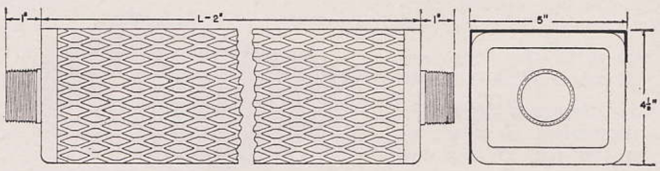


Fig. 3402

TABLE A—CAPACITY RATINGS
1¼" OTS Heating Element (without cover)

Element Number	Length (Inches)	1 Lb. Steam 65° Entering Air Btu/Hr	"Rated" EDR	Approx.** Net Wgt. Pounds
OTS-418	18	1880	7.8	11.0
OTS-424	24	2525	10.5	14.9
OTS-430	30	3170	13.2	18.8
OTS-436	36	3815	15.9	22.6
OTS-442	42	4460	18.6	26.5
OTS-448	48	5105	21.3	30.4
OTS-454	54	5750	24.0	34.3
OTS-460	60	6395	26.6	38.2
OTS-466	66	7040	29.3	42.1
OTS-472	72	7685	32.0	46.0

*Deduct 3% from above capacities if cover is used.

To determine capacity at conditions other than given in above tables, multiply capacity at 1 lb. steam, 65° entering air by proper conversion factor taken from table B or C.

**Average weight without cover, approx. 7⅔ lbs. per foot of length

HANGERS

Hangers for wall and suspended types of element mountings, are illustrated in Fig. 3404 and 3405.

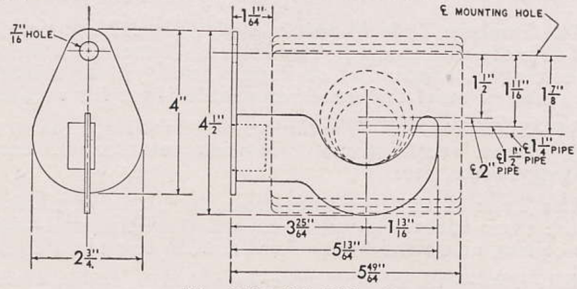


Fig. 3404 (Wall Type)

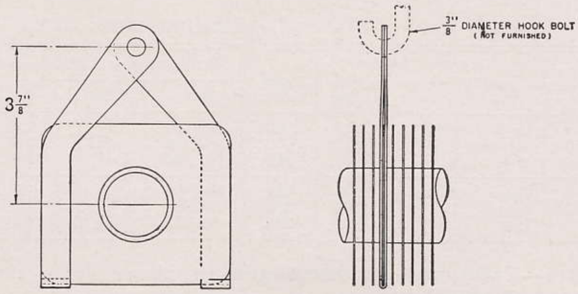


Fig. 3405 (Suspended Type)

TABLE B—CONVERSION FACTORS FOR STEAM

Steam Pressure Lbs/Sq. In.	Entering Air Temperatures—Degrees F. 80	75	70	65	60	55	50
1	.85	.90	.95	1.00	1.05	1.10	1.15
2	.89	.93	.98	1.03	1.08	1.14	1.19
5	.97	1.02	1.06	1.12	1.18	1.23	1.28
15	1.20	1.26	1.31	1.36	1.42	1.48	1.54
25	1.39	1.45	1.50	1.56	1.62	1.68	1.74
50	1.75	1.81	1.87	1.92	2.00	2.06	2.12
80	2.07	2.14	2.20	2.27	2.33	2.40	2.47
100	2.25	2.32	2.39	2.45	2.52	2.59	2.66
125	2.45	2.52	2.59	2.66	2.73	2.80	2.87

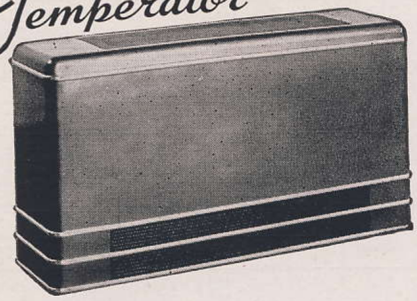
TABLE C—CONVERSION FACTORS FOR HOT WATER

Water Tempera-ture, Deg. F.	Entering Air Temperatures—Degrees F. 80	75	70	65	60	55	50
150	.32	.35	.39	.43	.47	.51	.55
160	.39	.43	.47	.51	.55	.59	.63
180	.55	.59	.63	.67	.72	.76	.81
200	.72	.76	.81	.85	.90	.95	1.00
215	.85	.90	.95	1.00	1.05	1.10	1.15
230	1.00	1.05	1.10	1.15	1.21	1.26	1.32
250	1.21	1.26	1.32	1.37	1.43	1.49	1.54
300	1.78	1.84	1.91	1.97	2.03	2.09	2.16

DUNHAM AIR CONDITIONING UNIT

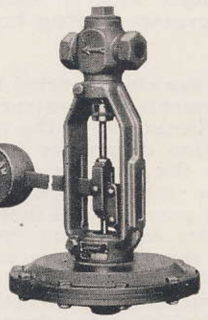
This single unit, when correctly installed, offers complete air conditioning, including warming and humidification for the heating season and cooling and dehumidification for the summer, with filtering, ventilation and circulation of air the year 'round. These combined services are rendered with a minimum requirement of space and a high functional effiiciency which guarantees genuine satisfaction and genuine economy. For details of construction, etc., of the modernized 1946 model, write the company at Chicago.

Temperator



DUNHAM PRESSURE REDUCING VALVES

TYPE 340—SINGLE SEATED VALVE



Type 340

This weight loaded type valve is single seated and is particularly recommended for "dead end" service, such as where the valve in the low pressure line may be closed off without shutting off the high pressure steam supply. Their construction embodies refinements which make them very responsive and accurate. They are adaptable to reduction of steam or air pressures and render excellent service where the pressures or the demand may fluctuate or the service is intermittent.

APPLICATION. This valve may be used for the reduction and regulation of steam or air service. It is available in small sizes and corresponding small capacities. It is suitable for "dead end" application where equipment has cycle and other special control. It serves to regulate steam pressure on fixtures singly or in groups as well as for heating loads within its capacity limits.

CONSTRUCTION. The body, diaphragm casing and yoke are close grained cast iron steel mixture. Standardization of construction permits interchange in diaphragms to meet reduced pressure requirements covering a wide variety of operating conditions. Seats and valves are of special hard steam metal alloy which resists the erosive and cutting action of steam service. The valves are ground in under steam pressure and tested steam tight under the pressure and temperature of the operating condition. The stuffing nut, gland and valve stem are of bronze. The diaphragm is special rubber composition reinforced with special weave heavy weight fabric. The weight lever is hinged to the yoke by a link and pivoted to the valve stem yoke. The pins are finished to properly fit the holes. The stuffing box is extra deep and provided with a bronze gland. The construction provides a valve which is accurate, responsive, reliable and which operates satisfactorily with minimum attention.

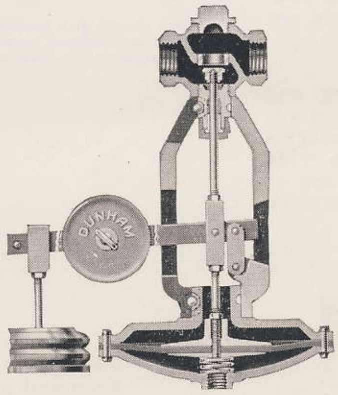


Fig. 3460
Sectional View, Type 340

OPERATION. The delivery pressure governs the operation of the valve by its action upon the valve diaphragm through the balance pipe which is connected into the main or fixture using the low pressure steam. Normally the weight on the lever holds the valve open but as the pressure builds up in the diaphragm chamber the valve is moved toward its closed position. The position and amount of weights on the lever determine the pressure which will be maintained in the low pressure main. In operation the valve adjusts itself to a working position which permits the flow of sufficient steam to maintain the desired low pressure.

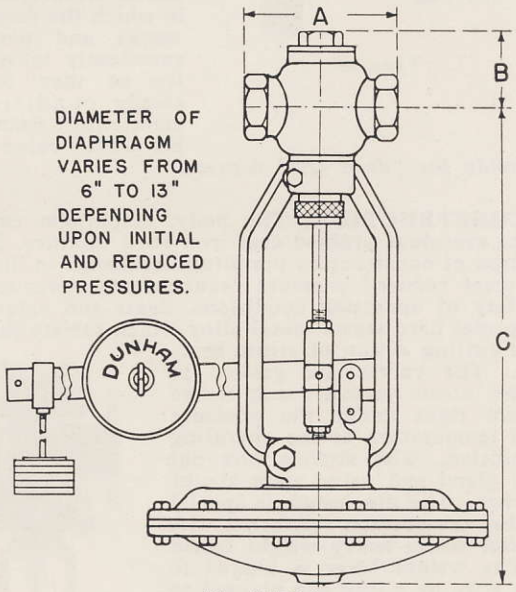


Fig. 1576 A
Type 340 Straight Pattern

Size Inches	Catalog No.	Connection	Shipping Weight Lb.	Code	Dimensions in Inches			
					A	B	C	D*
¾	RSS¾	Screwed	105	Apparent	5	2½	16⅞	....
1	RSS1	Screwed	105	Appeach	5	2½	16⅞	....
1¼	RSS1¼	Screwed	107	Appeal	5	2½	16⅞	....
1½	RSS1½	Screwed	110	Appetite	5¾	3	17¼	....
2	RSF2	Flanged	118	Appease	5¾	3	17¼	6
2½	RSF2½	Flanged	156	Append	9	5	20⅜	7
3	RSF3	Flanged	161	Appendix	10¼	5⅜	20¾	7½

*Outside diameter of flange.

SIZING PRESSURE REDUCING VALVES

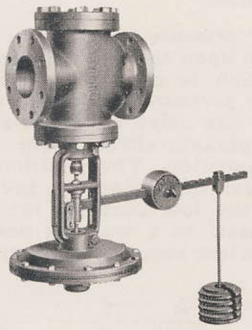
The proper size of reducing valve must be selected to insure proper service. If a valve is too large, it may be difficult to hold the desired pressure on the controlled main or fixture. Under some conditions the pressures will tend to build up on the reduced side. Under other conditions the valve will work so close to its seat that it will have short life or be noisy in operation. If the valve is too small the steam flow through it will be insufficient to enable the reduced pressure to be as high as desired. The accompanying charts are provided to aid in selecting the proper size of valve. At times the supply pipe may necessarily be larger than the valve. The supply pipe to the valve should be one which will carry the proper weight of steam with velocities in it from 6000 to 8000 ft. per minute.

To use the charts: First determine the ratio of the reduced pressure to the supply or initial pressure. If the ratio is less than 0.58 use the chart in Fig. 1699. If the ratio is greater than 0.58 use the chart in Fig. 1700.

VALVES & MISC.

DUNHAM PRESSURE REDUCING VALVES

Double Seated Valve



Type 300

This reducing valve automatically lowers steam or air from a higher initial pressure to a lower delivery pressure. The lower delivery pressure may be from 80 pounds down.

This line of reducing valves offers a construction embodying refinements of detail which enable them to dependably provide steady reduced pressures with greater than usual accuracy for this type of valve. They are adaptable to service which is intermittent or in which the demand fluctuates and perform as excellently in such service as they do where steady conditions are maintained. Being a double seated valve it is not suitable for "dead end" service.

CONSTRUCTION. The body, diaphragm casing and yoke are close grained cast iron steel mixture. Standardization of construction permits interchange in diaphragms to meet reduced pressure requirements covering a wide variety of operating conditions. Seats and valves are of a special hard steam metal alloy which resists the erosive and cutting action of steam service. The valves are ground in under steam pressure and tested steam tight under the pressure and temperature of the operating condition. The stuffing box nut and gland and valve stem are of bronze. The diaphragm is special rubber composition reinforced with special weave heavy weight fabric.

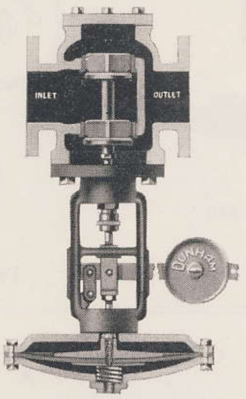


Fig. 989A
Sect. View, Type 300

The weight lever is hinged to the yoke by a link and pivoted to the valve stem yoke. The valve stem is guided at the valve stem yoke. This construction eliminates side thrust on the stuffing box.

The elimination of side thrust on the stuffing box enables it to remain steam tight with a minimum tightening of the stuffing box nut. This, together with the extra depth of stuffing box, insures tightness over long periods of time with minimum friction and increased accuracy of operation.

The stuffing boxes are provided with an extra long bronze gland, which further decreases stuffing box wear and friction.

The weight mechanism pivots are closely fitted to their holes. Theoretically these refinements of construction do not improve operation under pulsating flow, the supposition being that because the action of gravity is always downward the force exerted on the stem by the weight mechanism is constantly in the same direction. As a matter of fact, under fluctuating pressure and flow conditions, the momentum of the parts enters into the effect and with ordinary construction short time intervals may obtain during which the force of the weight is not exerted on the stem. These refinements in construction materially reduce the tendency of the valves to vibrate under pulsating flow.

Yokes are supported from the valve bonnet by split clamping ring connection and screw. The body of the screw engages an annular ring on the bonnet to serve as a positive lock against vertical movement. The yoke may be turned at any angle with the pipe line so the valve may be fitted to close places.

Orders should give catalog number or type number and size as well as both the initial and reduced pressures under which each valve is to function together with the amount of radiation the valve is to supply or pounds of steam per hour.

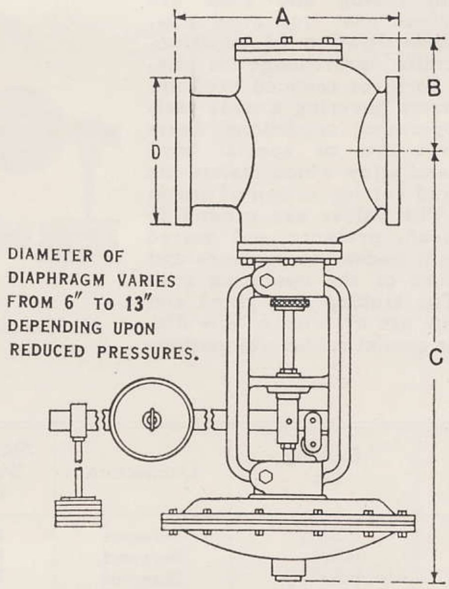


Fig. 1724
Straight Pattern Type 300

Size Inches	Catalog No.	Connection	Shipping Weight Lb.	Code	Dimensions in Inches			
					A	B	C	D
1½	RDF1½	Flanged	135	Antidote	7¾	4¼	19⅝	5
2	RDF2	Flanged	139	Antipathy	8⅜	4 7/16	19 13/16	6
2½	RDF2½	Flanged	147	Antipode	9	5	20⅜	7
3	RDF3	Flanged	159	Antler	10¼	5⅜	20¾	7½
4	RDF4	Flanged	216	Aorta	12	6¾	21⅝	9
5	RDF5	Flanged	232	Ape	13	7½	22⅜	10
6	RDF6	Flanged	275	Apostle	14¾	8 7/16	23 5/16	11
8	RDF8	Flanged	389	Apparel	19	10 7/16	25 3/16	13½
10	RDF10	Flanged	505	Apparency	19½	12 3/16	26 15/16	16

SIZING PRESSURE REDUCING VALVES

TYPES 340 AND 300

The proper size of pressure reducing valve must be selected to insure proper service. If a valve is too large, it may not be able to hold the reduced pressure on the controlled main or fixture down to the desired level. Under some conditions the pressures will tend to build up on the reduced side. Or in holding the desired reduced pressure, the inner valve may have to work so close to its seat that operation may be noisy and wear excessive.

Sizing Chart for use where the Final Pressure is Less Than 58% of the Initial Pressure (Absolute). See other side for pressures greater than 58%.

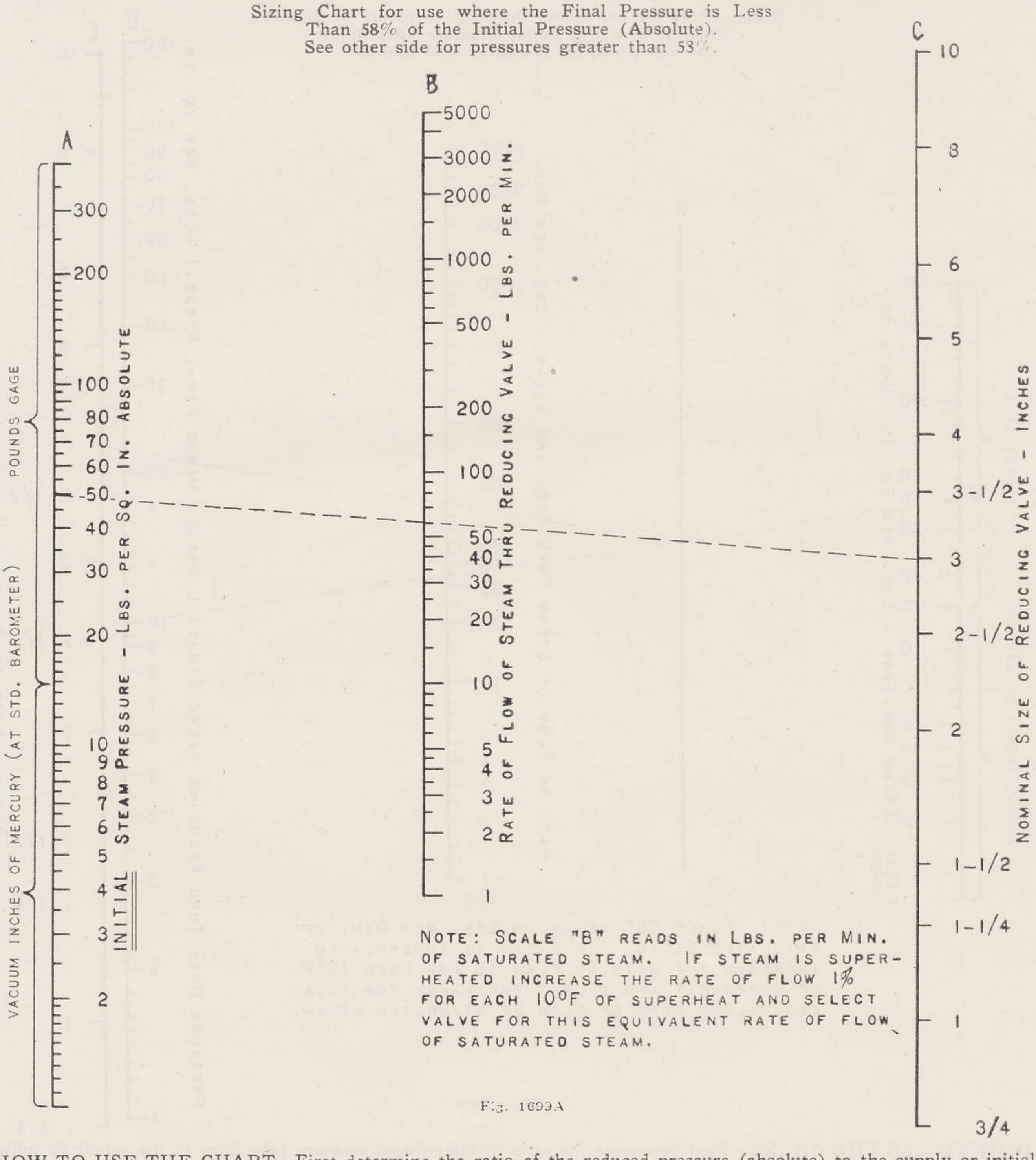


Fig. 1699A

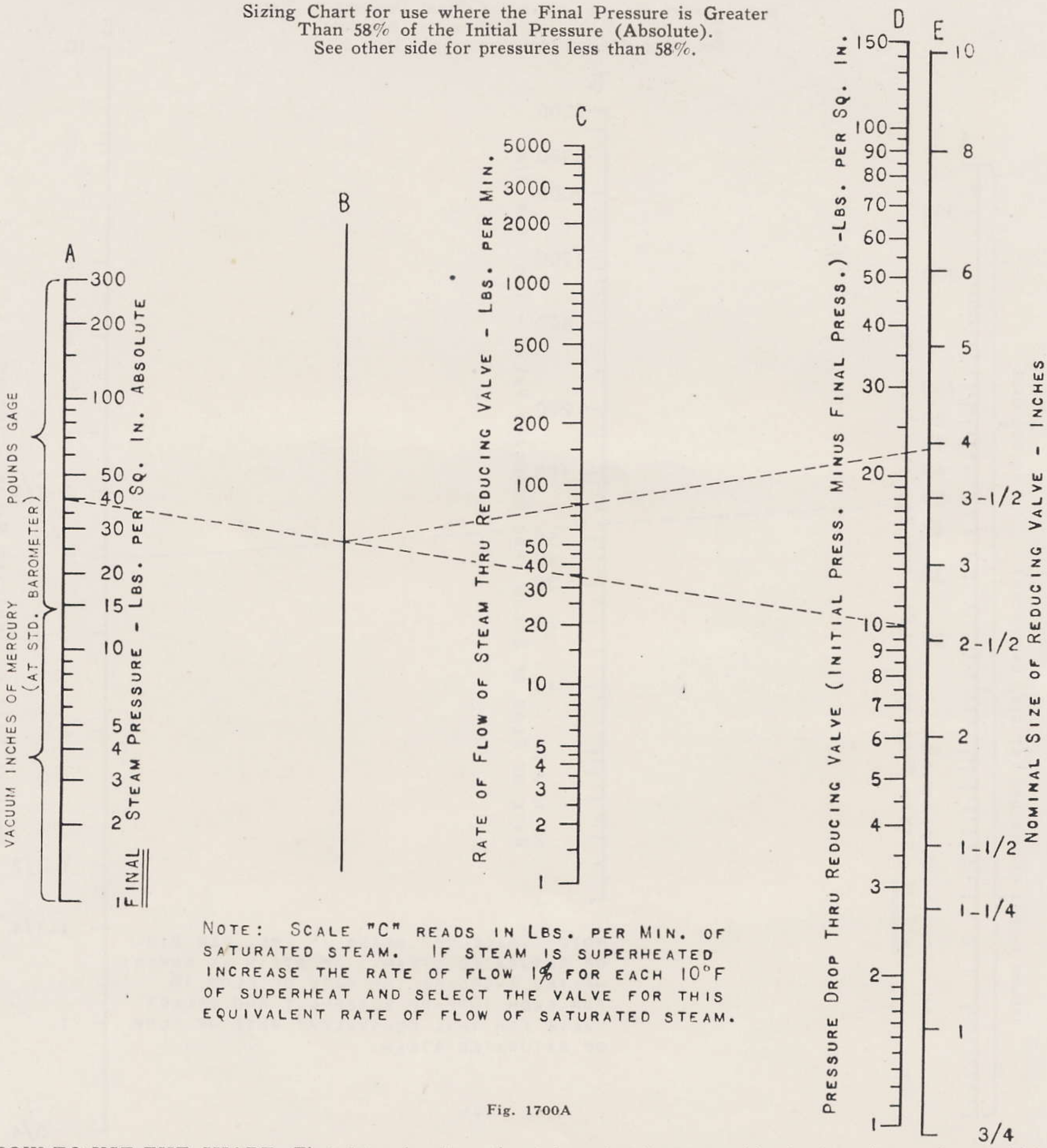
HOW TO USE THE CHART—First determine the ratio of the reduced pressure (absolute) to the supply or initial pressure. If the ratio is less than .58, use this chart. From the point on "A" which corresponds to the initial steam pressure (absolute) draw a straight line to the point on "B" which corresponds to the quantity of steam required per minute. The point where the continuation of this line intersects "C" indicates the size of pressure reducing valve required.

SIZING PRESSURE REDUCING VALVES

TYPES 340 AND 300

If a pressure reducing valve which is too small for the service is selected, the steam flow through it will be insufficient to enable the reduced pressure to be as high as desired. The accompanying charts are provided to aid in selecting the proper size of valve. At times the supply pipe may necessarily be larger than the valve. The supply pipe to the valve should be one which will carry the proper weight of steam with velocities in it from 6000 to 8000 ft. per minute.

Sizing Chart for use where the Final Pressure is Greater Than 58% of the Initial Pressure (Absolute). See other side for pressures less than 58%.



NOTE: SCALE "C" READS IN LBS. PER MIN. OF SATURATED STEAM. IF STEAM IS SUPERHEATED INCREASE THE RATE OF FLOW 1% FOR EACH 10°F OF SUPERHEAT AND SELECT THE VALVE FOR THIS EQUIVALENT RATE OF FLOW OF SATURATED STEAM.

Fig. 1700A

HOW TO USE THE CHART—First determine the ratio of the reduced pressure (absolute) to the supply or initial pressure. If the ratio is greater than .58, use this chart. From the point on "A" which corresponds to the final steam pressure (absolute) draw a straight line to the point on "D" which corresponds to the pressure drop through the valve. From the point of intersection of this line with "B" draw another line to the point on "C" which corresponds to the quantity of steam required per minute. The point where the continuation of this line crosses "E" indicates the size of pressure reducing valve required.

DUNHAM AIR ELIMINATOR

The Dunham Air Eliminator is made in two sizes of capacities given below. They are used to vent air from the return piping of gravity steam heating systems operating on from 6 ounces to a maximum of 10 ounces steam pressure. They are always open to atmosphere except when boiler pressure is such that the water of condensation will not return to the boiler by gravity. The water then accumulates in the Air Eliminator stand pipe raising the float in the Eliminator closing the vent valve, thus preventing water from escaping.

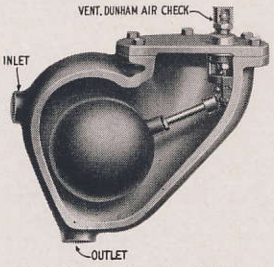
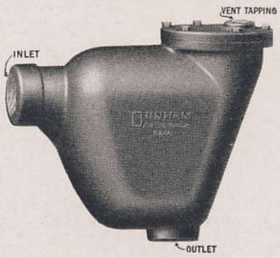


Fig. 1788—Sectional View Type 220 Air Eliminator



Type 221 Air Eliminator

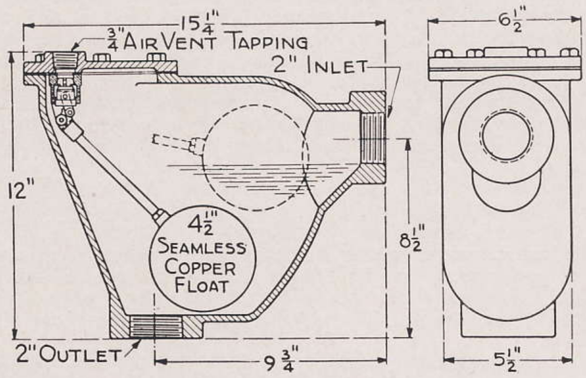


Fig. 961B Dimensions Type 221

Fig. 1802

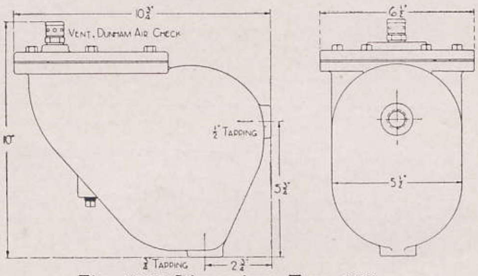


Fig. 1802 Dimensions Type 220

Type No.	Cat. No.	Net Weight Lb.	Capy. Sq. Ft. EDR	Tappings—Inches		
				Bottom	Side	Air Vent Top
220	AE20	21¾	2000	¾	½	⅜
221	AE60	33	6000	2	2	¾

The Type 220 Air Eliminator includes the Dunham Air Check Type 222 to be placed in the ⅜" vent tapping.
Specify Catalog number or Type number on order.

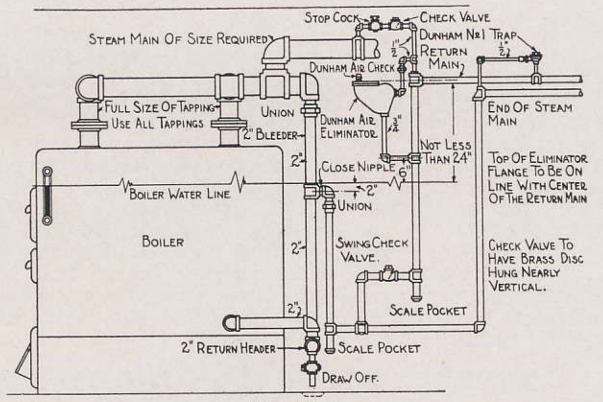


Fig. 937C

Method of installing Eliminator Type 220B on installations using boiler with two or more supply tappings

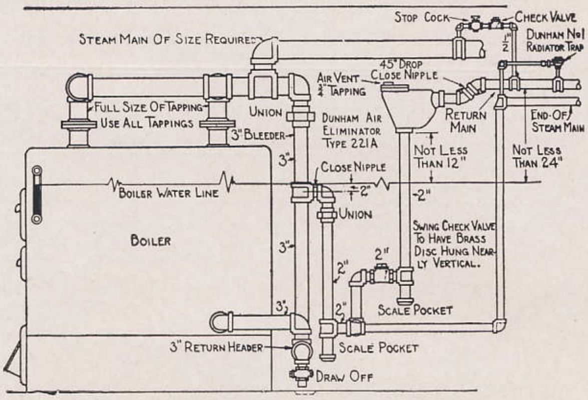


Fig. 938A—Method of installing the Type 221 Air Eliminator

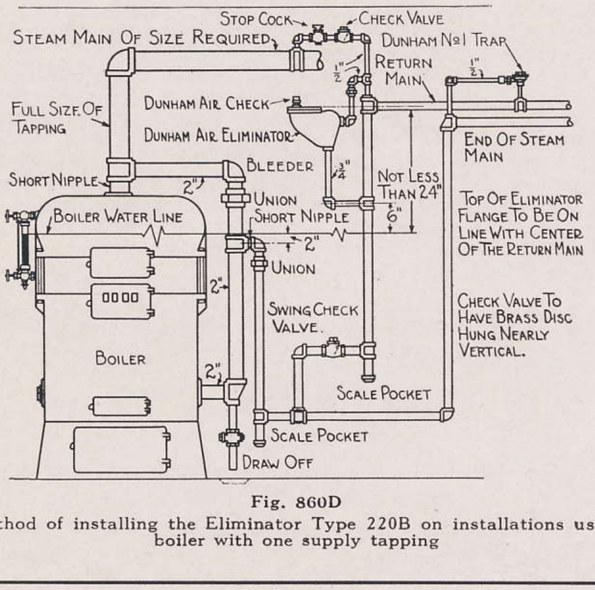


Fig. 860D

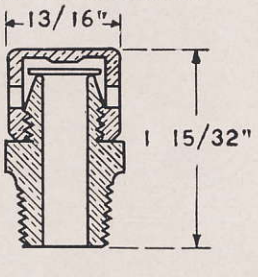
Method of installing the Eliminator Type 220B on installations using boiler with one supply tapping

Dunham Air Check Type 222

The Dunham Air Check is used to vent the Accumulator Tank on Differential installations and is also applied to the Type 220 Dunham Air Eliminator. It releases air at the slightest pressure but prevents its re-entrance into the system.

Pipe Thread .... ⅜"
Cat. No. .... AC⅜

Fig 918A →
Section and Dimensions Dunham Air Check



NOTE—Type 221 Air Eliminator has been discontinued

DUNHAM VACUUM RETURN LINE HEATING SYSTEM

(See also pages 15 to 19)

This is a two-pipe steam heating system employing atmospheric pressure or higher in steam supply piping and radiation and a partial vacuum in the return piping to insure positive circulation. It provides control of the heat output only within a narrow range of atmospheric steam pressures and temperatures which is insufficient for adequate temperature regulation. It is recommended for installations in which temperature regulation is not a primary consideration.

In its physical parts, a Dunham Vacuum Return Line System consists principally of a boiler or other source of steam which may be either a central station, or exhaust steam, a system of steam supply piping dripped through Dunham Float and Thermostatic Traps (page 10), Dunham Radiator Valves (pages 7 and 8) with regulating plates, on cast iron exposed radiators and Dunham Adjustable Regulating Fittings (page 51) on concealed radiators, Dunham Radiator Traps (page 9) and a system of return piping to the Vacuum Return Line Heating Pump (page 62) from which air is vented and condensate returned to the boiler or receiver. For pipe sizing tables see pages 13 and 14.

DUNHAM RETURN HEATING SYSTEM

This is a two-pipe steam system operating at pressures up to 15 lb. and utilizing a Dunham Return Trap or Dunham Condensation Pump to provide positive return of condensate to boiler.

This system is adaptable for apartment buildings, small hotels, and medium-sized commercial or industrial buildings, schools and churches. It affords provision for retaining self-induced vacuums under conditions of a declining fire, prolong the periods in which heat is supplied and thus tend to minimize the defect of "On" and "Off" Heating.

The Dunham Return Heating System consists principally of a steam boiler, a system of properly dripped steam supply piping. Dunham Radiator Valves (pages 7 and 8) with Regulating Fittings (page 51) on concealed radiators, Dunham Radiator Traps (page 9), a system of return piping leading to a Dunham Air Eliminator (page 61) and a Dunham Return Trap (page 12) or Condensation Pump (page20) from which the air is vented and condensate is returned to the boiler. For pipe sizing tables see pages 13 and 14.

DUNHAM VAPOR HEATING SYSTEM

This is economical in operation because of the low pressure used, usually less than 8 ounces. In extremely mild weather or at any time on a declining fire, a self-induced vacuum of as much as ten to twenty inches is established. The piping and control equipment are so arranged that, even under this self-induced vacuum, circulation may be maintained for some time after reducing or cutting off the heat supply. When required, pressures above eight ounces can be carried.

In its physical part the vapor system consists of a boiler which may be coal, oil, or gas-fired and temperature control equipment a system of properly dripped steam piping to the radiators, with regulating plates of cast-iron radiators or Dunham Adjustable Regulating Fittings (page 51) on concealed radiators, and Dunham Radiator Traps (page 9), a system of return piping to the boiler in which are installed a Dunham Return Trap (page 12) and Dunham Air Eliminator (page 61) with Dunham Air Check (page 61). For pipe sizing tables see pages 13 and 14.

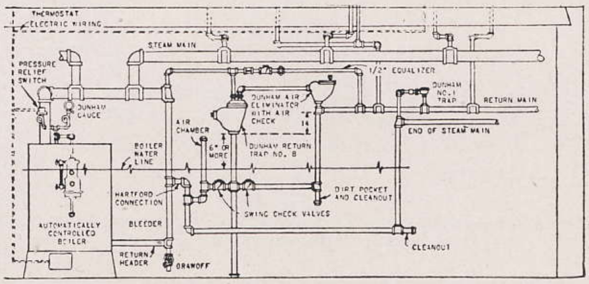


Fig. 1584
Typical installation of Dunham Vapor System with Low Limit Control.

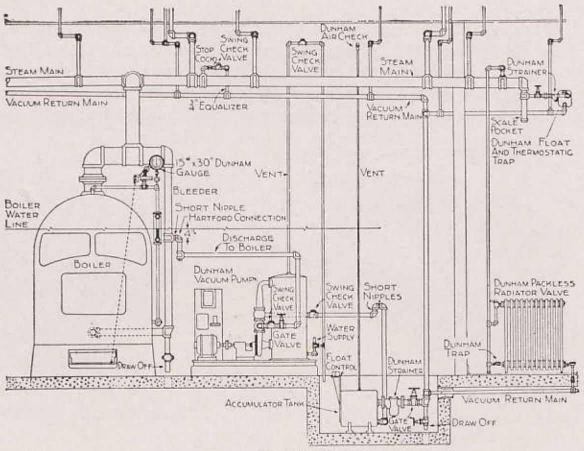


Fig. 889B
Typical boiler room arrangement for a Dunham Vacuum Return Line Heating System with radiation in basement and Accumulator Tank set into pit. Steam supply is from a low pressure boiler. Where the supply is from high pressure boiler or central station service, a pressure reducing valve is required in the steam main to the system.

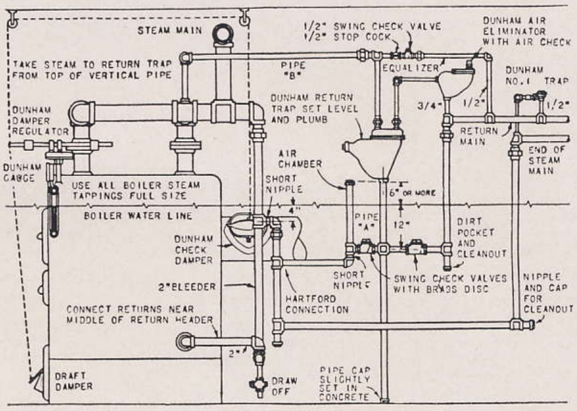


Fig. 1585
Typical boiler connections for Dunham Return Traps Nos. 8A and 9A

Size of Trap	Size of Pipes		Minimum Height Bottom of Trap to Bottom of Return Main
	"A"	"B"	
No. 8A	1¼″	¾″	14″
No. 9A	1½″	1¼″	13″

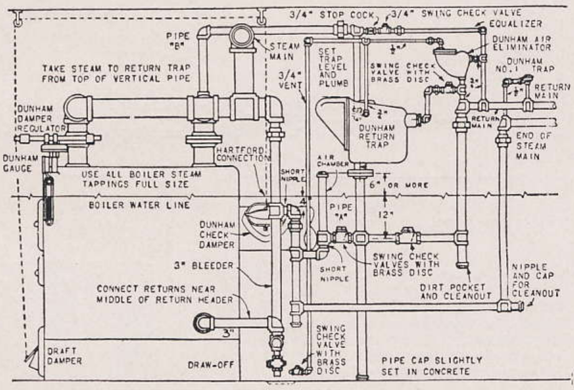


Fig. 963B
Typical boiler connections for Dunham Return Trap No. 10A

Size of Trap	Size of Pipes		Minimum Height Bottom of Trap to Bottom of Return Main
	"A"	"B"	
No. 10A	2″	1¼″	20″

ENGINEERING DATA

A heating system should be capable of delivering a quantity of heat sufficient to replace that transmitted through the structure to the atmosphere and the surroundings under a stated extreme temperature difference, with allowances for exposure to winds, air leakage and heat losses in piping and ducts. When the service is to be interrupted at night or periodically for one or more days, extra capacity must be provided for the heat that will be absorbed by the building and furnishings until normal room temperature and rate of heat transmission are reached.

The science of heating is the art of supplying heat to a building at the rate at which heat is being given off by that building. Any building regardless of size, shape, or construction, unless the temperature within it is the same as outdoors, gives off heat just as a stove or a radiator in proportion to its size gives off heat to the room wherein it stands. The amount of heat so lost from the building varies with the outdoor temperature, the velocity of the winds, the shape and size of the building, the character of its construction as well as the materials of its structure, and its position with relation to other buildings or naturally protected or exposed spots.

The rule for heat required in Btu per hour is:

$$H = t\ (W \times U_W + G \times U_G)\ L \times E$$

where:

H = Total heat in Btu.

t = Temperature difference between base temperature and room temperature.

W = Net exposed wall in square feet. (Gross exposed wall less glass area.)

U = Co-efficient of heat transmission, see table "D."

G = Glass area in square feet including entire window opening. Figure outside doors as glass, see Table "J," page 446.

L = Air leakage through building walls including windows, see Table "C."

E = Exposure and Wind allowance, see Table "B."

In addition to the heat losses through the exterior walls and windows they also occur through any partition, floor, roof or ceiling where there is a difference in temperature between the room and other side. Compute Btu per hour using Rule 2. This loss is added to the other heat losses computed in Rule 1.

Designing Heating Systems

There are several important factors to consider when designing a steam heating system:

1. The radiation must be ample to heat the building to the specified temperature in severe weather.

2. The boiler must be of proper size for this load with a tight chimney of proper size, so as to obtain required draft.

3. The piping, mains, risers and spring pieces must be of proper size, and properly planned.

4. The heating appliances must be properly selected and installed for the service they are to perform.

CALCULATING RADIATION—The first step in the design of a heating system is to calculate the amount of radiation required. The most exact method for doing this is that which is properly called the Btu method to distinguish it from the rule of thumb methods. The Btu method, as recommended, is based upon the rate of heat transfer or heat movement through materials of the several kinds used in building construction. These coefficients, known as "U" factors, have been carefully determined for most of the building materials and are defined as the amount of heat transmitted per square foot of surface, per hour, per degree difference in temperature (Fahrenheit), stated in British thermal units (Btu). With this factor known, there are two more or less variables: the first is the temperature range for which heat must be provided; the second the amount of air leakage or "infiltration" to be allowed for in the structure.

The inside or room temperatures usually specified are shown in Table "A." These are the temperatures at the breathing line 5 ft. above the floor and not less than 3 ft. from the outside walls.

The temperature of an unheated attic will vary with the character of the roof construction and whether it contains windows, ventilators or vertical wall surface which would tend to reduce its temperature. Under average conditions it may be assumed as 35 degrees F. above the base outside temperature. It may be determined more accurately by equating the heat loss through the roof with the heat gain to attic through the floor.

A temperature of 35 degrees F. may be assumed in unheated cellars, vestibules and rooms kept closed.

THE OUTSIDE TEMPERATURE will vary with the location of the building, the altitude, latitude and local prevailing winds. The lowest temperature on record in any locality is frequently much lower than commonly exists, or than is maintained for more than a few hours at a time. The minimum and average outside temperatures and also prevailing wind direction and velocity may be obtained from Weather Bureau Reports.

THE BASE TEMPERATURE must not be confused with the lowest temperature on record. It is obtained by taking an average of the lowest temperature known in the locality and the lowest mean temperature for the months of the heating season. The base temperature is usually 10 to 20 degrees above the record minimum temperature. The base temperature to be used in the calculation of radiation should never be selected more than 20 degrees above the lowest temperature on record.

THE WIND EXPOSURE is dependent upon prevailing wind direction in each locality. The coldest exposure varies with the location. In many localities North and West are the coldest exposures but this is by no means universal. Depending upon the location, prevailing winds come from each cardinal point of the compass. This indicates how important it is to know not only the average and lowest temperatures of a place but also the prevailing wind directions in winter (Dec., Jan., Feb.). Every heating plan should therefore show the "points of the compass" which should be considered when locating radiators and designing the steam piping. For northern climates, where wind direction is mostly north and west during most severe weather, we recommend that the following allowance percentages be added to straight heat losses through the materials. In other climates and wherever wind directions are different, changes must be made to suit local conditions.

Table "A" Inside Temperatures Usually Specified

Schools		Theatres	
Class Rooms	70-72° F.	Seating Space	68-72° F.
Assembly Rooms	68-72° F.	Lounge Rooms	68-72° F.
Gymnasiums	55-65° F.	Toilets	68° F.
Toilets and Baths	70° F.	Hotels	
Wardrobe and Locker Rooms	65-68° F.	Bedrooms and Baths	70° F.
Kitchens	66° F.	Dining Rooms	70° F.
Dining and Lunch Rooms	65-70° F.	Kitchens and Laundries	66° F.
Playrooms	60-65° F.	Ball Rooms	65-68° F.
Natatoriums	75° F.	Toilet, Service Rooms	68° F.
Hospitals		Homes	70-72° F.
Private Rooms	70-72° F.	Stores	65-68° F.
Private Rooms (surgical)	70-80° F.	Public Buildings	68-72° F
Operating Rooms	70-95° F.	Warm Air Baths	120° F.
Wards	68° F.	Steam Baths	110° F.
Kitchens and Laundries	66° F.	Factories, Machine Shops	60-65° F.
Toilets	68° F.	Foundries and Boiler Shops	50-60° F.
Bathrooms	70-80° F.	Paint Shops	80° F.

Table "B"—Exposure Factor "E" (See example 1 Page 67)

North	35	percent	1.35 Factor E
Northeast	25	percent	1.25 Factor E
East	15	percent	1.15 Factor E
Southeast	7.5	percent	1.07 Factor E
South	0.		1.00 Factor E
Southwest	12.5	percent	1.12 Factor E
West	25	percent	1.25 Factor E
Northwest	30	percent	1.30 Factor E

Air Leakage. In all buildings there is air leakage through the walls, the windows, doors, and other openings. The amount of leakage is not dependent upon and seldom has any relation to the volume of any room but rather upon the construction and character of the walls, the size and type of windows, the size of doors, and other openings, and the tightness of windows and doors and that produced by fans, if used. In tall buildings the air pressure will force the air in at the lower levels and out at the upper. No definite rule can be given for determining the leakage, and the allowance made for this heat loss must be largely a matter of judgment and experience. The following table gives factors which have been used extensively.

Table "C" Air Leakage Factor or "Infiltration" "L" Through Building Walls Including Windows. (Rule 1)

Good construction, moderately tight windows	1.5
Loose construction	1.6 or 1.7
Casement or French windows or doors opening outside	1.6
Factory Buildings, large amount of glass, using steel window frames	1.7 or 1.8
Corridors and Vestibules	2.0 or 2.5
Corner rooms in Residences and in Apartment Buildings of first class and tight construction	1.4

ENGINEERING DATA (Cont'd)

Temperature Records Compiled From Weather Bureau Records

City	Average Temp. Oct. 1st—May 1st	Suggested Base Design Temp.	Average Wind Velocity Dec., Jan., Feb., Miles per Hr.	Direction of Prevailing Wind Dec., Jan., Feb.,
Albany	35.1	0	7.9	S
Atlanta, Ga.	51.4	+10	11.8	NW
Baltimore, Md.	43.6	+10	7.2	NW
Birmingham, Ala.	53.9	+15	8.6	N
Boston, Mass.	37.6	0	11.7	W
Buffalo, N. Y.	34.7	0	17.7	W
Chicago, Ill.	36.4	0	17.0	SW
Cleveland, Ohio	36.9	0	14.5	SW
Denver, Colo.	39.3	−10	7.4	S
Detroit, Mich.	35.4	0	13.1	SW
Duluth, Minn.	25.1	−25	11.1	SW
El Paso, Texas	53.0	+20	10.5	NW
Indianapolis, Ind.	40.2	0	11.8	S
Little Rock, Ark.	51.6	+ 5	9.9	NW
Los Angeles, Calif.	58.6	+35	....	NE
Louisville, Ky.	45.2	+ 5	9.3	SW
Memphis, Tenn.	50.9	+10	9.6	NW
Milwaukee, Wis.	33.0	− 5	11.7	W
Minneapolis, Minn.	29.6	−15	11.5	NW
New Haven, Conn.	38.0	0	9.3	N
New Orleans, La.	61.5	+25	9.6	N
New York, N. Y.	40.3	0	13.3	NW
Oklahoma City, Okla.	48.0	+ 5	12.0	N
Philadelphia, Pa.	41.9	0	11.0	NW
Pittsburgh, Pa.	40.8	0	13.7	NW
Portland, Ore.	45.9	+15	6.5	S
Providence, R. I.	37.6	0	14.6	NW
Richmond, Va.	47.4	+10	7.4	S
St. Louis, Mo.	43.3	0	11.8	NW
Salt Lake City, Utah	40.0	0	4.9	SE
San Antonio, Texas	60.7	+20	8.2	N
San Francisco, Calif.	54.3	+35	....	N
Seattle, Wash.	45.3	+20	9.1	SE

RULE 2. $H = U (T_s - T_r)$

where:
H = Heat in Btu.
T = Temperature difference.
W = Wall, Ceiling, Roof or Floor Area in square feet.
U = Co-Efficient of heat transmission, see table "D."

HEAT TRANSMISSION, FACTOR "U" Heat flow is from a higher to a lower temperature at a definite rate, depending upon the difference in temperature and the character and thickness of the material through which it passes. The values given in table "D" are for average construction, and are the number of Btu transmitted per degree difference in temperature per hour per sq. ft. of surface.

Table "D"—Factor "U" for Masonry Walls

Thickness Inches	A	B	C	D	E	F	G	H	I
8	0.38	0.36	0.28	0.60	0.53	0.63	......	0.31	0.24
12	0.29	0.28	0.24	0.46	0.40	0.51	0.43	0.26	0.23
16	0.25	0.24	0.21	0.39	0.34	0.43	0.36	0.23	0.18
20	0.22	0.21	0.19	0.33	0.29	0.38	0.32	0.20	0.13
24	0.19	0.18	0.16	0.29	0.26	0.35	0.29	......	......
28	0.17	0.16	0.15	0.27	0.24	0.31	0.27	......	......
32	0.15	0.14	0.13	0.25	0.22	0.28	0.24	......	......
36	0.14	0.13	0.12	0.23	0.20	0.26	0.23	......	......

A. Brick, plain, no interior finish.
B. Brick, plastered one side on brick.
C. Brick furring, lath and plaster one side.
D. Concrete plastered one side on concrete.
E. Concrete furred, 2-inch terra cotta or wood, and plaster one side.
F. Limestane.
G. Limestone furred, 2-inch terra cotta or wood, and plaster one side.
H. Hollow terra cotta tile, stucco or plaster outside, plaster inside.
I. 4" brick, hollow tile, plaster inside.

Frame Walls

Clapboard, 7/16 inch; on wood shingles, paper, sheathing, 3/4 inch; studding, lath and plaster 0.25
Clapboard, 7/16 inch; sheathing, 3/4 inch; studding, lath and plaster (no paper) 0.30
Clapboard, 7/16 inch; paper, studding, lath and plaster (no sheathing) 0.32
Stucco, sheathing, studding, lath and plaster 0.30
Brick veneer, paper, sheathing, studding, lath and plaster 0.27

Glass

Single window .... 1.00 Single glazed skylight .. 1.16
Double window ...... .60 Double glazed skylight 0.62

Partitions

Ordinary stud partition, lath and plaster, on side 0.60
Ordinary stud partition, lath and plaster, both sides ... 0.34
Hollow terra cotta tile, 2 inches thick, plaster both sides on tile 0.47
Hollow terra cotta tile, 4 inches thick, plaster both sides on tile 0.40
Channel irons, wire lath and plaster, both sides 0.34
Channel irons, metal lath and plaster, both sides, asbestos filling 0.21

Floors

Earth Below. Assume Ground Temperature to be 50°F.

Earth or ground floor surface 0.23
Concrete, cement, or tile on ground 0.31
Single wood or plank flooring with sleepers on ground 0.13

Cold Room Below

Single, 3/4 inch wood floor on joist, no plaster below ... 0.30
Single, 3/4 inch wood floor on joist, lath and plaster below 0.20
Double wood floor on joist, lath and plaster below 0.15
Hollow tile, cinder concrete fill, wood sleepers, wood flooring, metal lath and plaster below 0.15
Reinforced concrete, cinder concrete fill, wood sleepers and floor metal lath and plaster below 0.15

Ceilings

Cold Room Above

Joist, no plaster, single 3/4 inch wood floor above 0.40
Joist, lath and plaster ceiling, no flooring above 0.50
Joist, lath and plaster ceiling, single wood floor above .. 0.26
Joist, single wood ceiling, single wood floor above 0.30
Joist, steel ceiling, single wood floor above 0.35
Hollow tile, reinforced concrete no plaster or floor 0.40
Hollow tile, or reinforced concrete plaster ceiling, wood sleepers and floor above 0.18

Roofs

Sheathing, studding and wood shingles 0.32
1 inch boards and tar paper 0.44
1 inch T. & G. wood sheathing, tar paper, tar and gravel roofing 0.30
2 inch wood sheathing, tar paper, tar and gravel roofing 0.26
Tin roofing on T. & G. tight wood sheathing 0.30
Reinforced concrete, tar, pitch and felt layers, asphalt finish 0.38
Reinforced concrete, tar felt asphalt and gravel roofing, air space suspended metal lath and plaster ceiling 0.22
Slate roof on tight T. & G. wood sheathing 0.40

Proportioning Radiation

The radiation should be proportioned and distributed in units so as to obtain a balanced system which will heat the rooms substantially alike with resultant economy.

In stair wells the stratification of air makes it advisable to increase the amount of radiation at the lower level and to

ENGINEERING DATA (Cont'd)

decrease the amount at the higher level. Since cold air seeks the lowest level, it is considered good practice to add 10% for each step down for lower level rooms. To illustrate: in a living room two steps lower than the remainder of the first floor, the radiation should be increased 20%.

Allowances for heat supplied by persons, lights, machinery and industrial equipment should be made after careful consideration of all local conditions. Where audiences are involved the heating system should have sufficient capacity to bring the building up to temperature before the audience arrives. In no case should the actual heating installation be reduced below that required to maintain at least 40°F. in the building.

Output of Radiators

To obtain the amount of radiation in equivalent square feet divide the total heat requirements "H," given in Btu, by the heat emission value of the type or kind of radiation to be used. A value of 240 Btu is considered standard for Concealed Radiators and Direct Tubular Type Radiators located in rooms heated to 70°F. steam at 215.3°F.

Table "E" gives the heat emission values of several types of radiation at different altitudes. In the last column the effect of the altitude is reduced to a percentage taking the value of any type of radiation at sea level as 100%. The table is based on a 68 to 70 degree room temperature, and the use of steam at low heating pressure, with the radiation along outside walls, near floors, or under windows.

Table "E"

Approximate Btu Heat Value per Square Foot of EDR at Several Altitudes 70 Degrees Room Temperature.

Altitude	Concealed Radiators and Tubular Direct Radiators	Single Column Radiation 38"	Two-Column Radiation 38"	Three-Column Radiation 38"	Four-Column Radiation 38"	Window Radiation	Wall Type Radiation	Pipe Coils	Per Cent
Sea level to 1,000 ft.	240	270	250	232	218	278	285	300	100
1,000 to 3,000 ft.	230	260	238	223	209	266	274	288	96
3,000 to 5,000 ft.	223	252	231	217	203	260	266	280	93
5,000 to 7,000 ft.	216	245	225	211	198	252	258	272	90
7,000 to 10,000 ft.	209	234	215	202	189	240	247	260	87

For other radiator heights and room temperatures use Rule 3, and table "G" to obtain the Btu heat value.

Table "F"—Boiling Point of Water at Various Altitudes

Altitude Above Sea Level Feet	Boiling Point Deg. Fahr.	Altitude Above Sea Level Feet	Boiling Point Deg. Fahr.
Sea Level	212	6,000	200
1,000	210	7,000	198
2,000	208	8,000	196
3,000	206	9,000	194
4,000	204	10,000	192
5,000	202	15,000	184

RULE 3. $H = U_r (T_s - T_r)$

To find the approximate total Btu transmitted per sq. ft. per hour (H) multiply the (U_r) values in Table "G" by the temperature difference.

U = coefficient of heat emission in Btu per square foot per hour, per degree difference between radiator and room temperature.

T_s = Temperature of steam in the radiator.

T_r = Room temperature.

Effect of Painting a Raditor

Paint influences the heat output of a radiator.

1. Heat transmission depends upon the character of the last coat applied. Results are influenced, primarily by the character of the paint. All finely ground materials give a fairly uniform high value while the coarser paints give a relatively low value.

2. Tests indicate that if radiators are given a coat of flake metal paint, their ability to emit heat will be about 10% less than if the surface coat is of pigment paint. The pigment paint gave slightly better results than the bare iron surface.

High Ceiling

The heat losses determined by RULE 1 must be increased to make allowance for high ceilings, or intermittent or interrupted heating, and for any unusual condition which may cause additional heat losses not already included in the equation.

In making allowance for high ceiling add 2% of the calculated heat losses for each foot in height over 12 feet up to 24 feet; for ceilings 25 feet high and over add 25%.

Intermittent Heating

The allowance to be made on account of intermittent or interrupted heating depends upon the length of time from the end of one heating to the beginning of the next.

The following factors for intermittent heating are commonly used:

For building heated during the day only and not during night, add.................................15%

For building not heated daily but intermittently..25 to 50%

Example on Calculating Radiation

Assume a room 20 x 30 feet with a 15-foot ceiling, the 30 foot side is exposed facing west, and is a 12-inch brick wall, furred, lathed and plastered; base outside temperature is zero; inside temperature desired 70 degrees; glass surface amounts to 110 square feet. The net exposed wall surface is 340 square feet. The "U" factor for this wall is 0.24 for the glass 1.00. The temperature difference is 70 degrees.

There is a cold attic above room, the ceiling is lath and plaster, no flooring above, assume attic temperature 35 degrees. Temperature difference 70 — 35 = 35. "U" factor for ceiling is 0.50. Ceiling 600 square feet.

$H = T(W \times Uw + G \times Ug)\, L \times E$ ....(Rule 1)
$= 70\,(340 \times 0.24 + 110 \times 1.00)\, 1.5 \times 1.25 = 25147$ Btu
High Ceiling—3 feet above 12 add $3 \times 2\% = 1509$ Btu
Cold Ceiling ....35 $(600 \times 0.50) = 10500$ Btu

Total heat losses...........................37156 Btu
Radiation required..........37156 ÷ 240 = 155 sq. ft.

The above method and the coefficients it employs have been applied for a number of years with very satisfactory result for the types of construction noted. For other methods and coefficients, the reader is referred to the A.S.H. & V.E. Guide.

Table "G"

Co-efficient of Heat Emission "Ur" (Rule 3) for direct radiators in Btu per sq. ft. per degree temperature difference.

Type of Radiator	Misc. Rad's.	Height of Radiator in Inches			
		22	26	32	38
1 Column		1.95	1.90	1.85	1.80
2 Column		1.80	1.75	1.70	1.65
3 Column		1.70	1.65	1.60	1.55
4 Column		1.60	1.55	1.50	1.45
Window Radiator	1.85				
Wall Radiator	1.90				
Pipe Coil	2.00				

THE DEGREE DAY METHOD OF COMPARING HEATING RESULTS

It is oftentimes of value to be able to compare the cost of heating a building for one heating season with another season by comparing the fuel used during the two periods. To make this comparison more accurate, the difference in outside temperature must be taken into consideration. Comparison between different buildings may be made by reducing the fuel consumption to a unit basis in terms of fuel or steam per sq. ft. of radiation, or per cubic foot of heated building space, taking into account the hours of occupancy as well as the difference in outside temperatures.

A unit commonly used for taking into account time and temperature differences is the Degree-day based on the difperference between 65° F. and the outside temperature.

The generally accepted definition for the Degree-day is: "A unit, based upon temperature difference and time, used in specifying the nominal heating load in winter. For any one day there exists as many Degree-days as there are degrees Fahr. difference in temperature between the mean temperature for the day and 65° F."*

An extended study by the American Gas Association, and later substantiated by the National District Heating Association, determined that the heat required by a building depends upon the difference between existing outdoor and an indoor temperature of 65° F. thus establishing a consumption rate on 24 hour basis. The Association's study of actual conditions established, that with a mean daily outside temperature of 65° F. for a 24 hour period, the average inside daytime temperature would be about 70° F. and that the only time the room temperature would be below this temperature would be at night.

The temperature limit of a heating season was fixed at 65° F. mean daily temperature; that is, whenever the average outside temperature for 24 hours falls below 65° F., heating of the building is necessary.

The amount of heat required by a building varies with the outside temperature when other variables are eliminated. 65° F. as used for determining the Degree-day becomes in effect the mean 24 hour inside temperature. Studies by the N.D.H.A. have established that some buildings (such as hotels, hospitals, etc.) having continuous 24 hour occupancy require Degree-day base temperatures exceeding 65° F.

The U. S. Weather Bureau maintains records which show the boundaries of each heating season, mean daily temperatures, etc., and from this data the total number of Degree-days for any period of time may be determined. For instance, if the mean temperature was 32° F. on February 5th (or any date that desired), then there were (65° — 32°) × 1 day = 33 Degree-days on that date. By totaling the daily Degree-days the heat requirement may be obtained for any given period or heating season.

* See A.S.H.V.E. Guide.

NOTE: A careful operating engineer will keep daily records thus establishing a fuel consumption rate for his particular building and will compare each week or each month's consumption as these periods are completed to determine if most economical operation is being obtained. To make this comparison a record of the number of Degree-days for each month and the quantity of fuel burned or steam used must be kept. From this data, the quantity of fuel or steam consumed per Degree-day may be obtained for each month, which affords a direct comparison of operation.

Example. Comparing two months' operation in the same building. The first month's mean temperature was 25° F and the coal consumption was 25,000 lb. The second month's mean temperature was 30° F and the coal consumption was 24,000 lb. The comparison is calculated as follows:

First Month: (65°—25°) × 31 days = 1040 Degree Days.

$$\frac{25{,}000 \text{ lb.}}{1240 \text{ D. D.}} = \mathbf{20.16} \text{ lb. coal per D. D.}$$

Second Month: (65°—30°) × 31 days = 1085 Degree Days.

$$\frac{24{,}000 \text{ lb.}}{1085 \text{ D. D.}} = \mathbf{22.1} \text{ lb. coal per D. D.}$$

It is apparent that operation during the second month was not so economical as the first month. The difference in economy may be calculated as follows:

$$\frac{(22.1 - 20.16)100}{20.16} = 9.6\%$$

The operating engineer must now determine the reason for the increase in consumption for the second month. Was it due to overheating and open windows or faulty combustion, etc., and take steps to correct the cause.

Comparison between *different* buildings either in the same locality or in localities with the same "design base" temperature is similarly made except that the difference in load (sq. ft. of radiation) must be taken into consideration by a comparison of rates per 1000 sq. ft. of radiation per Degree Day. Thus assuming 2400 sq. ft. of EDR for the above example, the second month would have a rate of:

$$\left(\frac{24000}{1085}\right) \times \frac{1000}{2400} = 9.2 \text{ lb. coal per M sq. ft. per D. D.}$$

Comparison between *different* buildings in different localities with *different* design base tempratures requires correction to place the rates on a comparative basis. Assume Bldg. No. 1 has a design base temperature of 0° F and Bldg. No. 2, —10° F. Both are heated to 70° F. The design basis degree days is 65 D. D. for Bldg. No. 1 and 75 D. D. for Bldg. No. 2.

Example. Bldg. No. 1 uses 46.1 lb. steam per M sq. ft. EDR per D. D.
Bldg. No. 2 uses 40.0 lb. steam per M sq. ft. EDR per D. D.
To compare No. 2 with No. 1:

$$(40.0)\left(\frac{75}{65}\right) = 46.1 \text{ lb. steam per M sq. ft. EDR per D. D.}$$

In this case, the corrected rate for Bldg. No. 2 becomes equal to that for Bldg. No. 1.

Normal Degree Days for Cities in the United States

State	City	Degree-Days
Ala.	Birmingham	2618
Ark.	Little Rock	3005
Cal.	San Francisco	3143
	Los Angeles	1390
Colo.	Denver	5863
Conn.	New Haven	5879
D. C.	Washington	4598
Ga.	Atlanta	3002
Ill.	Chicago	6287
Ind.	Indianapolis	5487
Iowa	Des Moines	6391
Ky.	Louisville	4791
La.	New Orleans	1208
Md.	Baltimore	4522
Mass.	Boston	5943
Mich.	Detroit	6580
Minn.	Duluth	9766
	Minneapolis	7989
Mo.	Kansas City	4984
	St. Louis	4610
Neb.	Omaha	6102
N. J.	Atlantic City	5049
N. Y.	Albany	6658
	Buffalo	6935
	New York	5306
Ohio	Cincinnati	5013
	Cleveland	6171
Okla.	Oklahoma City	3698
Ore.	Portland	4379
Pa.	Philadelphia	4749
	Pittsburgh	5466
S. C.	Charleston	1870
Tenn.	Memphis	3078
Texas	Houston	1360
Utah	Salt Lake City	5637
Va.	Richmond	3944
Wash.	Seattle	4864
	Spokane	6305
Wis.	Milwaukee	7086

HEATING POWER OF BRASS AND IRON PIPE

(Lying horizontal in water storage tank)

To bring out reliable working information the Institute of Thermal Research of the American Radiator Company prepared a comparative chart which is reproduced here. It is plotted from numerous tests made with brass and iron pipings, lying in horizontal position in a tank of water. To allow for bad water and the consequent fouling and pitting of pipes, only half of the acutal condensing power is shown on the chart.

Example 1. It is required to condense 500 pounds of steam per hour in a pipe-coil immersed in the water of a storage tank. How many square feet of pipe should the coil contain?

Temperature of steam in pipe....................................220°
Initial temperature of water.. 40°
Terminal temperature of water..................................160°
Mean temperature of water...100°
Temperature difference steam and water......................120°

Observe that the line for IRON pipe intersects the vertical line of 120 degrees temperature difference at the horizontal line representing 22.4 pounds. The intersection of the line for BRASS pipe shows 34.5 pounds.

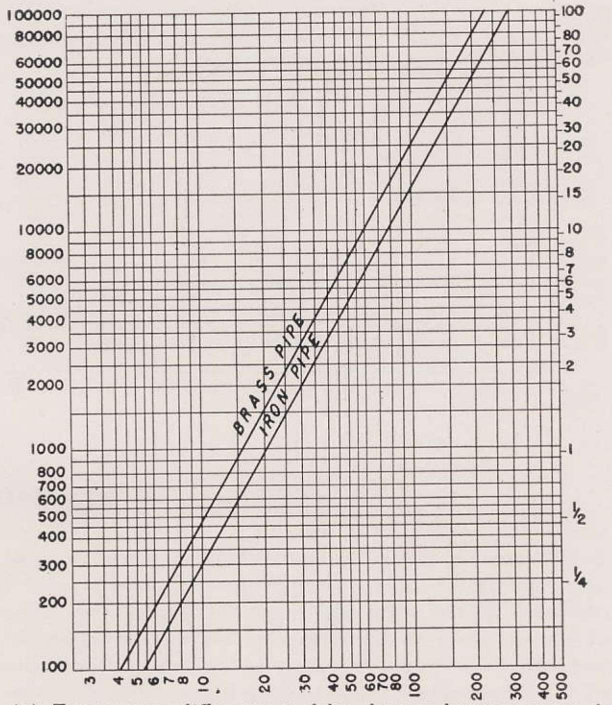
The quantity of pipe required in square feet is determined by dividing the 500 pounds of steam which must be condensed per hour by the quantity of steam one square foot of pipe will condense. Thus:

For iron pipe....500 ÷ 22.4 = 22.2 sq. ft. would be required.
For brass pipe..500 ÷ 34.5 = 14.5 sq. ft. would be required.

Example 2. Suppose a tank containing 300 U. S. gallons of cold water at 60 degrees F. is to be heated by low pretssure steam (at 5 pounds pressure) to a temperature of 140 degrees, in 2 hours; how many sq. ft. of brass pipe will be required, and how much steam will be condensed per hour?

300 U. S. gallons weight 300 × 8.33................2500 pounds
Total temperature rise desired...........................80 degrees
Temperature rise per hour.................................40 degrees
Heat required per hour = 2500 × 40................100,000 Btu.
Temperature of steam at 5 pounds' pressure (approx.) ....227 degrees
Mean temperature of water...............................100 degrees
Mean temperature difference between steam and water..127 degrees

Where the line for BRASS pipe intersects the vertical for 127 degrees, read the transmission per sq. ft., 36,500 Btu., and the condensing power, 38 pounds of steam per sq. ft. per hour. The total sq. ft. of BRASS pipe required will then be 100,000 ÷ 36,500 = 2.74 sq. ft. The condensation per hour would be 2.74 × 38 = 104.1 pounds.



(c) Temperature difference in fahr. degrees between steam in coil and steam or average temperature of water in tank.
Fig. 3417

For use with Low Pressure Steam up to 10 lbs. gage. A factor of safety of 50% is included to allow for bad water and consequent fouling and pitting of pipes. Chart plotted with coil lying horizontal in tank.

HEAT LOSSES FROM PIPING

The following Tables 1-2-3-4 are reprinted from Chapter 43, A.S.H.V.E. Guide 1943.

Table 1. Heat Losses from Horizontal Bare Steel Pipes. Expressed in Btu per hour per linear foot per degree Fahrenheit difference in temperature between the pipe and surrounding still air at 70° F.

Nominal Pipe Size (Inches)	HOT WATER				STEAM		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb.)	297.7 F (50 Lb.)	337.9 F (100 Lb.)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
½	0.455	0.495	0.546	0.584	0.612	0.706	0.760
¾	0.555	0.605	0.666	0.715	0.748	0.866	0.933
1	0.684	0.743	0.819	0.877	0.919	1.065	1.147
1¼	0.847	0.919	1.014	1.086	1.138	1.324	1.425
1½	0.958	1.041	1.148	1.230	1.288	1.492	1.633
2	1.180	1.281	1.412	1.512	1.578	1.840	1.987
2½	1.400	1.532	1.683	1.796	1.883	2.190	2.363
3	1.680	1.825	2.010	2.153	2.260	2.630	2.840
3½	1.900	2.064	2.221	2.433	2.552	2.974	3.215
4	2.118	2.302	2.534	2.717	2.850	3.320	3.590
5	2.580	2.804	3.084	3.303	3.470	4.050	4.385
6	3.036	3.294	3.626	3.886	4.074	4.765	5.160
8	3.880	4.215	4.638	4.960	5.210	6.100	6.610
10	4.760	5.180	5.680	6.090	6.410	7.490	8.115
12	5.590	6.070	6.670	7.145	7.500	8.800	9.530

Note:—For data on piping insulation, refer to current issue of the A.S.H.V.E. GUIDE.

Table 2. Heat Loss from Horizontal Bare Bright Copper Pipe. Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70° F.

Nominal Pipe Size (Inches)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb.)	297.7 F (50 Lb.)	337.9 F. (100 Lb)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
½	0.180	0.210	0.218	0.229	0.299	0.338	0.355
¾	0.236	0.275	0.291	0.307	0.357	0.408	0.418
1	0.290	0.338	0.354	0.373	0.440	0.492	0.523
1¼	0.340	0.400	0.418	0.443	0.510	0.571	0.598
1½	0.390	0.463	0.473	0.507	0.598	0.671	0.710
2	0.490	0.525	0.600	0.628	0.719	0.813	0.851
2½	0.580	0.675	0.709	0.750	0.840	0.953	1.008
3	0.680	0.788	0.848	0.871	0.987	1.107	1.165
3½	0.760	0.888	0.946	1.000	1.114	1.235	1.307
4	0.940	1.000	1.045	1.107	1.210	1.361	1.456
4½	....	....	....	....	1.335	1.495	1.488
5	1.020	1.200	1.255	1.320	1.465	1.670	1.755
6	1.160	1.375	1.410	1.500	1.685	1.890	1.942
8	1.460	1.725	1.820	1.890	2.100	2.373	2.510

Note:—For data on piping insulation, refer to current issue of the A.S.H.V.E GUIDE.

HEAT LOSSES FROM PIPING (Continued)

Table 3. Heat Loss from Bright Copper Pipe Given One Thin Coat of Clear Lacquer.
Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70° F.

Nominal Pipe Size (Inches)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb.)	297.7 F (50Lb.)	337.9 F (100Lb.)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
½	0.240	0.265	0.282	0.307	0.401	0.461	0.478
¾	0.320	0.356	0.373	0.414	0.477	0.571	0.578
1	0.390	0.437	0.463	0.507	0.598	0.681	0.710
1¼	0.470	0.537	0.554	0.614	0.700	0.812	0.840
1½	0.540	0.612	0.645	0.714	0.830	0.966	0.990
2	0.690	0.762	0.818	0.892	1.005	1.164	1.201
2½	0.840	0.937	0.991	1.085	1.178	1.361	1.420
3	0.960	1.025	1.135	1.270	1.400	1.625	1.700
3½	1.100	1.250	1.318	1.442	1.580	1.845	1.905
4	1.241	1.400	1.480	1.556	1.750	2.040	2.130
4½	....	....	....	....	1.910	2.240	2.350
5	1.480	1.685	1.790	1.965	2.130	2.415	2.610
6	1.700	1.936	2.052	2.272	2.450	2.810	2.990
8	2.200	2.500	2.630	2.854	3.120	3.425	3.730

Note:—For data on piping insulation, refer to current issue of the A.S.H.V.E. GUIDE.

Table 4. Heat Loss from Horizontal Tarnished Copper Pipe.
Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70° F.

Nominal Pipe Size (Inches)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb.)	297.7 F (50Lb.)	337.9 F (100Lb.)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
½	0.250	0.287	0.300	0.321	0.433	0.500	0.530
¾	0.340	0.381	0.409	0.429	0.533	0.543	0.654
1	0.440	0.475	0.509	0.536	0.636	0.746	0.803
1¼	0.500	0.559	0.618	0.622	0.764	0.878	0.934
1½	0.580	0.656	0.710	0.750	0.904	1.053	1.120
2	0.730	0.825	0.890	0.957	1.101	1.273	1.364
2½	0.880	1.000	1.091	1.143	1.305	1.490	1.605
3	1.040	1.175	1.272	1.343	1.560	1.800	1.940
3½	1.180	1.350	1.454	1.535	1.750	2.020	2.170
4	1.460	1.500	1.635	1.715	1.941	2.240	2.430
4½	....	....	....	....	2.131	2.465	2.650
5	1.600	1.812	1.980	2.071	2.387	2.770	2.990
6	1.840	2.125	2.270	2.430	2.740	3.210	3.440
8	2.400	2.685	2.910	3.110	3.310	4.050	4.370

Note:—For data on piping insulation, refer to current issue of the A.S.H.V.E. GUIDE.

EQUATION OF PIPES

It is frequently desired to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the squares of their diameters; thus, one 4-inch pipe will deliver the same volume as four 2-inch pipes. With the same head, however, the velocity is less in the smaller pipe, and the volume delivered varies about as the square root of the fifth power (i.e., as the 2.5 power). The following table has been calculated on this basis. The figure opposite the intersection of any two sizes is the number of the smaller-sized pipes required to equal one of the larger. Thus, one 4-inch pipe is equal to 5.7 2-inch pipes.

Diameter Inches	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1														
3	15.6	2.8	1													
4	32	5.7	2.1	1												
5	55.9	9.9	3.6	1.7	1											
6	88.2	15.6	5.7	2.8	1.6	1										
7	130	22.9	8.3	4.1	2.3	1.5	1									
8	181	32	11.7	5.7	3.2	2.1	1.4	1								
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1							
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1						
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3						
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1					
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2					
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1				
15	871	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2				
16	....	181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1			
17	....	211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2			
18	....	243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1		
19	....	278	101	49.1	28.1	17.8	12.1	8.7	6.5	5	3.2	2.1	1.5	1.1		
20	....	316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	
22	....	401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	
24	....	499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26	....	609	221	108	61.7	39.1	26.6	19	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28	....	733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3	2.3	1.5
30	....	871	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36	....	....	499	243	130	88.2	60	43	32	24.6	15.6	10.6	7.6	5.7	4.3	2.8
42	....	....	733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4.1
48	....	....	....	499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5.7
54	....	....	....	670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60	....	....	....	871	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

CAPACITIES OF COPPER TUBING — STEAM HEATING SYSTEMS

Capacities of copper tubing when used on Steam Heating System may be taken to equal those of standard steel pipe of same nominal sizes. While it is true that internal areas of copper tubing are generally less than those of steel pipe of same nominal sizes, the smoother inside surface and the freedom from fouling due to absence of rust and corrosion compensate for the slightly smaller areas.

Some authorities advise that satisfactory results may be obtained when using copper tubing by increasing the capacities given for steel pipe by the following percentage for relative nominal diameters and when used with solder or compression type fittings.

1", 1¼", 1½" sizes increase 5% to 10%
2", 3", 3½", 4" sizes increase 15%
2½" size increase 24%

The above data taken from Copper Tube Hand Book issued by the Copper & Brass Research Ass'n. The relative areas of standard steel pipe and copper tubing are given in following table when considering Type M hard copper tube.

COMPARATIVE INTERNAL DIAMETERS AND AREAS
STEEL PIPE AND COPPER TUBE

Nominal Size	Internal Dia. Ins.		Internal Area Sq. Ins.	
	Steel Pipe	Copper Tube	Steel Pipe	Copper Tube
⅛	.270	.200	.057	.031
¼	.364	.325	.104	.083
⅜	.493	.450	.191	1.59
½	.622	.569	.304	.254
⅝	....	.690	....	.374
¾	.824	.811	.533	.516
1	1.048	1.055	.861	.874
1¼	1.380	1.291	1.496	1.309
1½	1.610	1.527	2.036	1.831
2	2.067	2.009	3.356	3.170
2½	2.468	2.495	4.780	4.890
3	3.067	2.981	7.383	6.980
3½	3.548	3.459	9.887	9.397
4	4.026	3.935	12.730	12.161
5	5.045	4.907	19.986	18.911
6	6.065	5.881	28.890	27.163
8	7.981	7.785	50.027	47.600
10	10.018	9.701	78.823	73.913
12	12.000	11.617	113.098	105.992

NOTE: Internal diameters and areas for Types K and L tubing will be slightly less than those for M tubing.

COPPER TUBE WATER CAPACITY DATA

The following tables are taken from "Copper Tube Hand Book" issued by the Copper & Brass Research Association. Where steel pipe sizes have been determined the copper tube size suitable for same requirements may be selected from table following:

The following table gives sizes of short branches to fixture connections for various initial water pressures:

SIZES OF COPPER TUBE WATER SUPPLY FOR SHORT BRANCHES TO PLUMBING FIXTURES

FIXTURE	PRESSURES		
	High Over 60 Lbs.	Medium 30 to 60 Lbs.	Low Under 30 Lbs.
To Baths	½ In.	¾ In.	¾ In.
Lavatories	⅜	½	½
Tank Closets	⅜	⅜	½
Valve Closets	1	1	1¼
Pantry Sinks	½	½	½
Kitchen Sinks	½	½	¾
Slop Sinks	½	¾	¾
Showers	½	½	¾
Urinals (Flush Tank)	½	¾	¾
Urinals (Flush Valve)	¾	¾	¾
Drinking Fountains	⅜	⅜	½

When determining the size of mains to supply the various fixtures the total rate will be less than the rate on table above times the number of fixtures as not all fixtures would be in use at same time. The following rules are recommended to determine main sizes—estimate total requirements for all fixtures and divide by the value indicated for various types of buildings.

For residences, apartments, schools, office buildings, divide by 4.

For Clubs and Hotels, divide by 3.

For gymnasiums, hospitals, public comfort stations, divide by 2.

For public baths, launderies and factories allow full amount shown for each fixture.

The Rate of Flow of water to various plumbing fixtures is given in following table:

U. S. G. P. M. USED BY VARIOUS FIXTURES

FIXTURES	RATE OF FLOW (gallons per minute)
Each Bath	8-10
Lavatory	5-8
Tank closet	3-5
Flush valve closet	30-40
Shower	5-8
Sink	8-10
Laundry tub	8-10
Garden hose	5-10

For the approximate capacity of copper tubes for water mains with allowances made for fittings are given in table following:

APPROXIMATE CAPACITY OF COPPER TUBE IN U. S. GALLONS PER MINUTE

Tube Size	⅜"		½"		⅝"		¾"		1"	
Pressure Drop Lbs. P.S.I.	S	L	S	L	S	L	S	L	S	L
5	3	0.7	6	2	10	3	14	5	35	11
10	4	1.0	10	3	17	5	25	7	50	17
20	6	2.0	14	4	24	7	35	11	70	25
30	8	2.5	16	5	30	9	45	14	90	30
40	9	2.7	18	6	36	11	55	17	100	35
50	10	3.0	20	7	42	13	65	20	110	40
Tube Size	1¼"		1½"		2"		2½"		3"	
Pressure Drop Lbs. P.S.I.	S	L	S	L	S	L	S	L	S	L
5	70	20	100	35	200	75	400	150	700	200
10	100	30	150	50	325	110	600	225	1000	300
20	150	45	215	75	500	165	900	300	1500	500
30	180	60	275	95	600	200	1100	350	1800	600
40	220	70	310	115	700	250	1300	450	2200	700
50	240	80	350	130	800	280	1500	500	2500	800

NOTES: Columns marked S give deliveries through short lines, such as branches 15-ft. or shorter. Columns marked L give deliveries through lines approximately 100-ft. long.

Maximum pressure drop of 20 pounds per 100 ft. run is recommended to reduce noise to a practical minimum.

A 10-pound drop in 100 ft. for residence installations is recommended.

STEEL PIPE AND COPPER TUBE SIZES FOR RELATIVE CAPACITIES FOR HOT AND COLD WATER SERVICE

Iron Pipe Nominal Diameter	CORRESPONDING SUITABLE SIZES FOR COPPER TUBE	
	Hot Water	Cold Water
½ inch	⅜ inch	⅜ inch
¾ inch	½ inch	½ inch
1 inch	¾ inch	¾ inch
1¼ inch	1 inch	1 inch
1½ inch	1 inch	1¼ inch
2 inch	1¼ inch	1½ inch
2½ inch	1½ inch	2 inch
3 inch	2 inch	2½ inch

TABLE GIVING FULL AREA IN SQUARE FEET OF TWO-PANE WINDOWS, INCLUDING THE SASH, ALLOWING 4 INCHES TO THE WIDTH AND 6 INCHES TO THE HEIGHT. FRAME AND SASH OF WOOD.

Width of Glass	Width of Opening	Height of Glass in Each Pane in Inches														
		16″	18″	20″	22″	24″	26″	28″	30″	32″	34″	36″	38″	40″	42″	44″
		Height of Window Opening in Feet and Inches														
		3′-2″	3′-6″	3′-10″	4′-2″	4′-6″	4′-10″	5′-2″	5′-6″	5′-10″	6′-2″	6′-6″	6′-10″	7′-2″	7′-6″	7′-10″
16″	1′-8″	5.3	5.8	6.4	7.0	7.5	8.1	8.6	9.2	9.7	10.3	10.8	11.4	11.9	12.5	13.0
18″	1′-10″	5.8	6.4	7.0	7.6	8.3	8.9	9.5	10.1	10.7	11.3	11.9	12.5	13.1	13.7	14.3
20″	2′-0″	6.3	7.0	7.7	8.3	9.0	9.7	10.3	11.0	11.7	12.3	13.0	13.7	14.3	15.0	15.6
22″	2′-2″	6.9	7.6	8.3	9.0	9.7	10.5	11.2	11.9	12.6	13.4	14.1	14.8	15.5	16.2	17.1
24″	2′-4″	7.4	8.2	8.9	9.7	10.5	11.3	12.1	12.8	13.6	14.4	15.2	15.9	16.7	17.5	18.3
26″	2′-6″	7.9	8.8	9.6	10.5	11.3	12.1	12.9	13.8	14.6	15.4	16.3	17.1	17.9	18.8	19.6
28″	2′-8″	8.2	9.3	10.2	11.1	12.0	12.9	13.8	14.7	15.6	16.5	17.3	18.2	19.1	20.0	20.9
30″	2′-10″	9.0	9.9	10.9	11.8	12.8	13.7	14.6	15.6	16.5	17.5	18.4	19.4	20.3	21.2	22.2
32″	3′-0″	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5
34″	3′-2″	10.0	11.1	12.1	13.2	14.3	15.3	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.8	24.8
36″	3′-4″	10.6	11.7	12.8	13.9	15.0	16.1	17.2	18.3	19.5	20.6	21.7	22.8	23.9	25.0	26.1
38″	3′-6″	11.1	12.3	13.4	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	24.0	25.1	26.2	27.4
40″	3′-8″	11.6	12.8	14.1	15.3	16.5	17.7	19.0	20.2	21.4	22.6	23.8	25.1	26.3	27.5	28.7
42″	3′-10″	12.1	13.4	14.7	16.0	17.3	18.5	19.8	21.1	22.4	23.6	24.9	26.2	27.5	28.8	30.0
44″	4′-0″	12.7	14.0	15.3	16.7	18.0	19.3	20.7	22.0	23.4	24.7	26.0	27.4	28.6	30.0	31.3

Example: A window containing two lights each measuring 26″x28″ would have an area, including sash, of 12.9 square feet, which should be used as exposed glass area in the calculation of the radiation.

TABLE OF CRACK LENGTH IN FEET FOR TWO-PANE WINDOWS INCLUDING THE SASH, ALLOWING 4 INCHES TO WIDTH AND 6 INCHES TO HEIGHT-FRAME AND SASH OF WOOD.

Width of Glass	Width of Opening	Height of Glass in Each Pane in Inches														
		16″	18″	20″	22″	24″	26″	28″	30″	32	34″	36″	38″	40″	42″	44″
		Height of Window Opening in Feet and Inches														
		3′-2″	3′-6″	3′-10″	4′-2″	4′-6″	4′-10″	5′-2″	5′-6″	5′-10″	6′-2″	6′-6″	6′-10″	7′-2″	7′-6″	7′-10″
16″	1′-8″	11.3	12.0	12.6	13.3	14.0	14.6	15.3	16.0	16.6	17.3	18.0	18.6	19.3	20.0	20.6
18″	1′-10″	11.8	12.5	13.1	13.8	14.5	15.1	15.8	16.5	17.1	17.8	18.5	19.1	19.8	20.5	21.1
20″	2′-0″	12.3	13.0	13.6	14.3	15.0	15.6	16.3	17.0	17.6	18.3	19.0	19.6	20.3	21.0	21.6
22′	2′-2″	12.8	13.5	14.1	14.8	15.5	16.1	16.8	17.5	18.1	18.8	19.5	20.1	20.8	21.5	22.1
24″	2′-4″	13.3	14.0	14.6	15.3	16.0	16.6	17.3	18.0	18.6	19.3	20.0	20.6	21.3	22.0	22.6
26″	2′-6″	13.8	14.5	15.1	15.8	16.5	17.1	17.8	18.5	19.1	19.8	20.5	21.1	21.8	22.5	23.1
28″	2′-8″	14.3	15.0	15.6	16.3	17.0	17.6	18.3	19.0	19.6	20.3	21.0	21.6	22.3	23.0	23.6
30″	2′-10″	14.8	15.5	16.1	16.8	17.5	18.1	18.8	19.5	20.1	20.8	21.5	22.1	22.8	23.5	24.1
32″	3′-0″	15.3	16.0	16.6	17.3	18.0	18.6	19.3	20.0	20.6	21.3	22.0	22.6	23.3	24.0	24.6
34″	3′-2″	15.8	16.5	17.1	17.8	18.5	19.1	19.8	20.5	21.1	21.8	22.5	23.1	23.8	24.5	25.1
36″	3′-4″	16.3	17.0	17.6	18.3	19.0	19.6	20.3	21.0	21.6	22.3	23.0	23.6	24.3	25.0	25.6
38″	3′-6″	16.8	17.5	18.1	18.8	19.5	20.1	20.8	21.5	22.1	22.8	23.5	24.1	24.8	25.5	26.1
40″	3′-8″	17.3	18.0	18.6	19.3	20.0	20.6	21.3	22.0	22.6	23.3	24.0	24.6	25.3	26.0	26.6
42″	3′-10″	17.8	18.5	19.1	19.8	20.5	21.1	21.8	22.5	23.1	23.8	24.5	25.1	25.8	26.5	27.1
44″	4′-0″	18.3	19.0	19.6	20.3	21.0	21.6	22.3	23.0	23.6	24.3	25.0	25.6	26.3	27.0	27.6

Example: A window containing two lights 26″x28″ would have a total crack length of 17.8 feet which should be used to determine the air infiltration by the "Crack Method."

SQUARE FEET GROSS WALL SURFACE, FLOOR AREA OR CEILING

Ht. of Ceiling or Width of Room in Feet	Length of Exposed Wall or Length of Room in Feet										Ht. of Ceiling or Width of Room in Feet
	5′	6′	8′	10′	12′	14′	16′	18′	20′	24′	
8′	40	48	64	80	96	112	128	144	160	192	8′
8½′	43	51	68	85	102	119	136	153	170	204	8½′
9′	45	54	72	90	108	126	144	162	180	216	9′
9½′	48	57	76	95	114	133	152	171	190	228	9½′
10′	50	60	80	100	120	140	160	180	200	240	10′
10½′	53	63	84	105	126	147	168	189	210	252	10½′
11′	55	66	88	110	132	154	176	198	220	264	11′
11½′	58	69	92	115	138	161	184	207	230	276	11½′
12′	60	72	96	120	144	168	192	216	240	288	12′
13′	65	78	104	130	156	181	208	234	260	312	13′
14′	70	84	112	140	168	196	224	252	280	336	14′
15′	75	90	120	150	180	210	240	270	300	360	15′
16′	80	96	128	160	192	224	256	288	320	384	16′
17′	85	102	136	170	204	238	272	306	340	408	17′
18′	90	108	144	180	216	252	288	324	360	432	18′
19′	95	114	152	190	228	266	304	342	380	456	19′
20′	100	120	160	200	240	280	320	360	400	480	20′
21′	105	126	168	210	252	294	336	378	420	504	21′
22′	110	132	176	220	264	308	352	396	440	528	22′
23′	115	138	184	230	276	322	368	414	460	552	23′
24′	120	144	192	240	288	336	384	432	480	576	24′
25′	125	150	200	250	300	350	400	450	500	600	25′

CUBICAL CONTENTS OF ROOMS

Floor Dimensions	Having Ceilings of the Following Heights							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
5 x 8	320	340	360	380	400	420	440	480
5 x 10	400	425	450	475	500	525	550	600
6 x 8	384	408	432	456	480	504	528	576
6 x 10	480	510	540	570	600	630	660	720
7 x 8	448	476	504	532	560	588	616	672
7 x 10	560	595	630	665	700	735	770	840
8 x 10	640	680	720	760	800	840	880	960
8 x 12	768	816	864	912	960	1008	1056	1152
8 x 14	896	952	1008	1064	1120	1176	1232	1344
9 x 10	720	765	810	855	900	945	990	1080
9 x 12	864	918	972	1026	1080	1134	1188	1296
9 x 14	1008	1071	1134	1197	1260	1323	1386	1512
10 x 12	960	1020	1080	1140	1200	1260	1320	1440
10 x 14	1120	1190	1260	1330	1400	1470	1540	1680
10 x 16	1280	1360	1440	1520	1600	1680	1760	1920
10 x 18	1440	1530	1620	1710	1800	1890	1980	2160
12 x 14	1344	1428	1512	1596	1680	1764	1848	2016
12 x 18	1728	1836	1944	2052	2160	2268	2376	2592
14 x 16	1792	1904	2016	2128	2240	2352	2464	2688
14 x 20	2240	2380	2520	2660	2800	2940	3080	3360
16 x 20	2560	2720	2880	3040	3200	3360	3520	3840
16 x 24	3072	3264	3456	3648	3840	4032	4224	4608
18 x 22	3168	3366	3564	3762	3960	4158	4356	4752
18 x 30	4320	4590	4860	5130	5400	5670	5940	6480
20 x 24	3840	4080	4320	4560	4800	5040	5280	5760
20 x 30	4800	5100	5400	5700	6000	6300	6600	7200

Piping Design

The function of the supply piping of a two-pipe steam heating system is to deliver the steam to the radiation. The function of the return piping is to conduct the air as well as the water of condensation from each radiator. Steam is prevented from entering returns by the Traps. The flow in a two-pipe system should always be positive and in one direction, except in the steam spring pieces and runouts to radiators. This eliminates noise caused by water hammer which is often prevalent in piping where steam and condensate flow in opposite directions. A very important point to watch in design and installation is that no connection be shown or made between any steam carrying pipe and a return pipe unless a trap is properly interposed. All piping must be well graded in proper direction and entirely free from sags or pockets. All pipes cut on a job must be carefully reamed to remove cutting burr entirely before they are installed.

RADIATOR CONNECTIONS—Typical methods of making radiator connections are shown on page 9.

RUNOUTS AND SPRINGPIECES—The term "runout" means the horizontal connection from riser to radiator. The term "springpiece" means the horizontal connection from main to riser. Steam supply springpieces and runouts usually grade back to main and riser respectively, pitching in a direction opposite to the steam flow. They must be given a good grade, not less than ½" per foot, and be entirely free from sags or pockets. To reduce the steam velocity in them they are always made one size larger, and sometimes two sizes larger than the riser or radiator connection which they supply. The proper installation of runouts and springpieces is essential for good circulation.

STEAM MEMORANDA

Steam: Since a pound of steam at atmospheric pressure (14.7 pounds per square inch) occupies a space of more than 26 cubic feet, and a pound of water occupies only about 28 cubic inches, it follows that if a vessel, such as a steam boiler containing water and steam, is closed so that the steam is confined and each pound is not allowed to expand to this 26 cubic feet, a pressure above that of the atmosphere will be produced. The water will now boil at a higher temperature corresponding to the higher pressure.

On the other hand, if a vessel containing steam at atmospheric pressure is closed, and the fire checked, the temperature of the steam will be lowered, and each pound will tend to occupy less than 26 cubic feet. This it cannot do because, owing to the elastic quality of steam, it completely fills the available space at a lesser density, and a partial vacuum is the result. This partial vacuum permits the water to boil at a lower temperature than 212 degrees.

For every pressure of the steam there is a definite temperature at which the water will boil. (See Table below.)

Steam, Volume of: If water at 39.2 degrees Fahrenheit is evaporated into steam at atmospheric pressure, the volume of steam will be 1,646 times as great as the volume of water from which it was evaporated.

Properties of Saturated Steam

Vacuum Inches of Mercury	Absolute Pressure Lbs. per Sq. Inch	Boiling Point, or Steam Temp.	Volume of 1 Lb. of Steam Cu. Ft.	Heat of the Liquid Btu	Latent Heat of Evap. Btu	Total Heat of Steam Btu
29	.452	76.62	706.	44.66	1048.6	1093.2
28	.944	99.93	351.5	67.90	1035.6	1103.6
27	1.435	114.22	236.8	82.15	1027.7	1109.8
26	1.926	124.77	179.5	92.67	1021.7	1114.4
25	2.417	133.22	145.0	101.10	1017.0	1118.1
24	2.908	140.31	121.9	108.18	1012.9	1121.1
23	3.399	146.45	105.4	114.31	1009.4	1123.8
22	3.890	151.87	92.9	119.73	1006.3	1126.0
21	4.382	156.75	83.1	124.61	1003.5	1128.1
20	4.873	161.19	75.2	129.05	1001.0	1130.0
19	5.364	165.24	68.7	133.10	998.6	1131.7
18	5.855	169.00	63.3	136.86	996.4	1133.3
17	6.346	172.51	58.7	140.38	994.3	1134.7
16	6.837	175.80	54.7	143.67	992.4	1136.1
15	7.329	178.91	51.3	146.79	990.6	1137.4
14	7.82	181.82	48.30	149.71	988.8	1138.5
13	8.31	184.61	45.61	152.50	987.1	1139.6
12	8.80	187.21	43.27	155.11	985.6	1140.7
11	9.29	189.75	41.12	157.66	984.0	1141.7
10	9.78	192.19	39.16	160.10	982.6	1142.7
9	10.28	194.50	37.41	162.42	981.2	1143.6
8	10.77	196.73	35.81	164.65	979.9	1144.5
7	11.26	198.87	34.35	166.81	978.5	1145.3
6	11.75	200.96	32.99	168.90	977.2	1146.2
5	12.24	202.92	31.77	170.87	976.0	1146.9
4	12.73	204.85	30.62	172.81	974.8	1147.6
3	13.22	206.70	29.56	174.67	973.7	1148.4
2	13.71	208.50	28.58	176.48	972.5	1149.1
1	14.20	210.25	27.67	178.24	971.4	1149.7
Pounds Gauge						
0	14.70	212.0	26.79	180.00	970.4	1150.4
1	15.70	215.3	25.20	183.3	968.2	1151.6
2	16.70	218.5	23.78	186.6	966.2	1152.8
4	18.70	224.4	21.40	192.5	962.4	1154.9
6	20.70	229.8	19.45	198.0	958.8	1156.8
8	22.70	234.8	17.85	203.0	955.5	1158.6
10	24.70	239.4	16.49	207.7	952.5	1160.2
15	29.70	249.8	13.87	218.2	945.5	1163.7
25	39.70	266.8	10.57	235.6	933.6	1169.2
50	64.70	297.7	6.68	267.2	911.2	1178.4
75	89.70	320.1	4.91	290.3	894.2	1184.4
100	114.70	337.9	3.891	308.8	880.0	1188.8
125	139.70	352.9	3.225	324.4	867.8	1192.2

Interpolated from Marks and Davis Temperature Tables. For more complete tables see the current issue of A.S.H.V.E. GUIDE.

Flow of Steam in Pipes

(Also See Friction of Water Chart Page 77)

P = Loss in pressure in lb.
d = Actual inside diameter of pipe in inches
L = Length of pipe in feet including allowance for elbows and valves (see table, page 81)
D = Weight of 1 cu. ft. steam
W = lb. of Steam per Min.

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

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

Press Loss in Oz.	Col. 1: $87.0\sqrt{\frac{P}{100}}$	Pipe Size	Col. 2: $\sqrt{\frac{d^5}{1+\frac{3.6}{d}}}$	Steam Press by Gauge	Col. 3: $\sqrt{D}$	Length of Pipe in Feet	Col. 4: $\sqrt{\frac{100}{L}}$
1	2.175	1	0.536	0.0	0.193	20	2.240
2	3.076	1¼	1.178	0.3	0.195	40	1.580
3	3.767	1½	1.828	1.3	0.201	60	1.290
4	4.350	2	3.710	2.3	0.207	80	1.120
5	4.863	2½	6.109	5.3	0.223	100	1.000
6	5.328	3	11.183	10.3	0.248	120	0.912
7	5.755	3½	16.705	15.3	0.270	140	0.841
8	6.152	4	23.631	20.3	0.290	160	0.793
10	6.878	5	43.719	30.3	0.326	180	0.741
12	7.534	6	71.762	40.3	0.358	200	0.710
14	8.138	8	149.382	50.3	0.388	250	0.632
16	8.700	10	272.592	60.3	0.415	300	0.578
20	9.727	12	437.503	75.3	0.452	350	0.538
24	10.655	14	566.693	100.3	0.507	400	0.500
28	11.509	16	816.872	125.3	0.557	450	0.477
32	12.304	....	....	150.3	0.603	500	0.447
40	13.756	....	....	175.3	0.645	600	0.407
48	15.069	....	....	200.3	0.685	700	0.378
80	19.454	....	....	....	....	800	0.354
160	27.512	....	....	....	....	900	0.333
320	38.908	....	....	....	....	1000	0.316
480	47.652	....	....	....	....	1500	0.258

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

Example. 1 oz. drop, 2 in. pipe, 1.3 lb pressure and 100 ft. long = 2.175 × 3.710 × 0.201 × 1 = 1.6219 lb per min. then 1.6219 × 60 − 20 per cent = 77.85 lb of steam per hr.

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

From A. S. H. & V. E. Guide.

STEAM CONSUMPTION OF PROCESS EQUIPMENT

The following data on steam consumption of laundry, kitchen and hospital equipment was selected from data compiled by the National District Heating Association and published in their "Proceedings" of 1942.

Sources of data on steam requirements of other process steam equipment were varied. They are listed in the "Proceedings," N.D.H.A. '42.

KITCHEN EQUIPMENT

	Operating Pressure Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
Steam Jacket Kettles			
40 Gal. Cap. American Aluminum Co.	8	55	......
Full Jacket Cast Iron Kettle at Various Steam Pressures	2	62	24
	5	133	36
	10	174	97
	15	228	116
Half Jacket, Cast Iron Kettle at Various Steam Pressures	2	38	16
	15	43	24
Candy Kettles			
Per sq. ft. of Jacket	30	60	......
Per sq. ft. of Jacket	75	100	......
Dish Warmers			
Size 5′6″ x 9″ x 5′4″, Htg. Surface, 25.02 sq. ft. Htg. Element, Inside Temp. 149°F.	2	16	15
Steam Tables			
Size 3′3″ x 1′9″ x 5″ Deep, Htg. Surface 0.99 Sq. Ft.	2	31	14
Same Table at 5 lbs. Press.	5	32	20.5
Size 9′0″ x 22″ x 8″, 3.33 sq. ft. Copper Element	8	70	......
Size 6′9″ x 28″	....	......	24
Size 9′0″ x 28″	....	......	32
Compartment Cookers			
Three Compartment	....	......	75
Bain Marie			
Size 9′0″ x 18″	....	......	41
Coffee and Hot Water Urns			
Test on 8 Gal Urn, 1.66 Sq. Ft. Brass Element at Various Pressures	5	46	10
	10	85	40
	15	120	75
3.32 Sq. Ft. Brass Element at Various Pressures	2	43	13
	5	75	25
	10	144	57
	15	150	75
	25	200	139

APPROXIMATE UNIT STEAM CONSUMPTION OF KITCHEN APPLIANCES

Appliance	Lb. Steam per Hour
Stock and Vegetable Kettles (per 5 gal.)	20.0
Coffee Urns (per gal.)	3.4
Water Urn (per gal.)	5.0
Steam Tables (per sq. ft.)	1.7
Plate and Cup Warmers (per 20 cu. ft.)	35.0
Vegetable Steamers (per compt.)	40.0
Soup Warmer, 30″ x 30″ x 28″	100.0
Clam, Lobster, and Potato Steamers (per compt.)	40.0
Egg Boilers (3 compts.)	18.0
Oyster Pots	18.0
Bain Marie (per sq. ft.)	3.4
Food Warming Ovens (per 20 cu. ft.)	35.0
Silver Burnisher and Washer	69.0
Dish Washer (per tray)	60.0

Note: Above figures represent average operating conditions after warm-up period and do not include hot water. Pressures will vary from 7 to 20 lb. gauge.

HOSPITAL EQUIPMENT

	Cap. Bottles / Size	Depth of Water	Operating Pressure Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
Sterilizers (Non-Pressure Type)					
For Bottles or Pasteurization Start with water at 70°. Then Maintained at Boiling for Period of 20 Min.	36	3″	40	36	36
	54	3″	40	51	51
	72	3″	40	69	69
For Instruments and Utensils	Size				
Start with Water at 70°, Then Boil Vigorously for 20 Minutes	8″x 9″x18″	3½″	40	27	27
	9″x20″x10″	3½″	40	30	30
	10″x12″x22″	4″	40	39	39
	12″x16″x24″	4″	40	60	60
	10″x12″x36″	4″	40	66	66
	16″x15″x20″	10″	40	92	92
	20″x20″x24″	10″	40	144	144
Sterilizers (Pressure Type)	Size				
For Surgical Supplies. Sterilizing, Period, 30 Minutes at Temperature of 240°-250° F.	12″x20″		40	22	22
	14″x22″		40	28	28
	16″x24″		40	38	38
	16″x36″		40	54	54
	20″x28″		40	60	60
	20″x36″		40	78	78
	20″x48″		40	98	98
	20″x60″		40	124	124
	10″x20″		35-60	9.5	9.5
	24″x48″		35-60	50.0	50.0
For Instruments. Sterilizing Period, 20 Minutes at 240°-250°F.	12″x20″		40	48	48
	14″x22″		40	60	60
	16″x24″		40	72	72
Sterilizers (Pressure Type) (Autoclave)	Size				
Sterilizing Period, 30 Minutes at 240°-250°.	15½″x24″		40	24	24
	17½″x26″		40	32	32
	21½″x30″		40	40	40
	24″x36″		35-60	42	42
Water Sterilizers	Cap., Gals.				
Start With Water at 70° and Maintain at Temperature of 240°-250° for 15 Minutes	6		40	76	76
	10		40	120	120
	15		40	180	180
	25		40	300	300
	50		40	600	600
Unit Requirements for Water Sterilizer = 2.5 lb. steam per Gal. Sterilized			35-60	......	......
Mattress Disinfector					
Size 30″x42″x84″			35-60	......	42
Size 60″x66″x108″			35-60	......	318
Blanket Warmer					
Size 18″x24″x72″			35-60	......	4

TANNERY EQUIPMENT

	Operating Pressure Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
Lime Vat (Cap. 800 Gal. per Vat) Per Set of 3 Vats	......	697	......
Paddle Vat (Cap. 1000 Gal.)	......	448	......
Revolving Drums	......	531	......
Iron Plate on Press. 9″ Coil Plate is 2′6″x2′6″ at 150°	......	100	......

STEAM CONSUMPTION OF PROCESS EQUIPMENT (Continued)

CLOTHING MANUFACTURING EQUIPMENT

Cloth Sponging	Operating Pressure of Equipment Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
1 Sponging Machine			
1 Refinishing Roll			
1 Semi-decating unit			
1 Manifold			
1 Wetting-out tank for cold water shrinking			
1 Drier			
Total Load	90-100	......	1,000
1 Under Press	65	......	20
1 Steam Iron (Standard)	....	......	15
Hosiery Dyeing			
24 Hosiery Drying Forms—Total per Table of 24 Forms	40	......	60
Mfg. of Men's Clothing			
16 Presses (With Central Elec. Vac.)			
3 Shoulder Presses			
2 Collar Presses			
4 Edge Presses			
5 Body Presses			
2 Back Presses			
16 Operated by Five Men	65	......	122
8 Under Presses, Central Electric Vacuum	65	......	103
120 Lineal Ft., 2", Insulated Main	65	......	37
Avg. Unit Use per Press	65	......	7.6
Avg. Unit Use per Under Press	65	......	12.9

LAUNDRY EQUIPMENT

	Operating Pressure Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
Tumbler (Drying Machine)			
Size 40"x94"	80-100	......	360
Size 30"x36"	80-100	......	225
Mangle (Flat Work Ironer)			
Size 8 roll	80-100	......	480
Size 6 roll	80-100	......	415
Large Shirt Body Press	80-100	......	190
Cuff and Neck Band Press	80-100	......	15
Standard Press	80-100	......	105
Feather cleaning and sterilizing (Cap. 15 pillows per hour)	80-100	......	175
1 Mangle, Amer. Laundry			
5 Presses			
1 Sleever			
1 Sock Drier			
1 Dry Tumbler			
Total Group Use	90	......	......
Line Loss Only	90	......	......
Washers, 3'0" Diameter	60	......	......
Washers, 6'0" Diameter	170	......	......
50 Gal. Starch Kettle	60	......	......

CLEANING AND PRESSING EQUIPMENT

Clothes Presses	Operating Pressure Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
U. S. Hoff-Man (Electric Vacuum)	18	......	25
U. S. Hoff-Man (Electric Vacuum)	30	......	25
Large Press. (Steam Vacuum)	65	......	30
Large Press. (Elec. Vacuum)	65	......	20

	Operating Pressure of Equipment Pounds Gauge	Pounds Steam Per Hour Max.	Pounds Steam Per Hour In Use
Individual use per Steam-Electric Iron	35	......	8.4
Individual use per Press	42	......	12.2
Individual use per Sleever	45	......	5

FUEL DATA (Coal)

In the tables which follow have been reproduced from Kent's Mechanical Engineers Handbook "Power" Eleventh Edition

COAL DATA — Classification of Coal

Class	Type of Coal	Volatile, Percent of Combustible	Oxygen in Combustible Percent	Moisture in Air-dry, Ash-free Coal, Percent	B.T.U. per Pound of Combustible	B.T.U. per Pound of Air-dry, Ash-free Coal
I	Anthracite	Under 10	1 to 4	Under 1.8	14,800 to 15,400	14,600 to 15,400
II	Semi-anthracite	10 to 15	1 to 5	Under 1.8	15,400 to 15,500	15,200 to 15,500
III	Semi-bituminous	15 to 30	1 to 6	Under 1.8	15,400 to 16,050	15,300 to 16,000
IV*	Cannel	45 to 60	5 to 8	Under 1.8	15,700 to 16,200*	15,500 to 16,050*
V	Bituminous, high grade	30 to 45	5 to 14	1 to 4	14,900 to 15,600	14,350 to 14,400
VI	Bituminous, medium grade	32 to 50	6 to 14	2.5 to 6.5	13,800 to 15,100	11,300 to 14,400
VII	Bituminous, low grade	32 to 50	7 to 14	5 to 12	12,400 to 14,600	11,300 to 13,400
VIII	Sub-bituminous lignite	27 to 60	10 to 33	7 to 26	9,600 to 13,250	7,400 to 11,650

*Eastern cannel. The Utah cannel coal has a much lower heating value.

SCREEN SIZES OF ANTHRACITE

Size	Passes Through	Retained On	Approx. Weight Per Cu. Ft.
Broken	$4\frac{7}{16}$"	$3\frac{7}{16}$"	52 —55
Egg	$3\frac{7}{16}$"	$2\frac{8}{16}$"	53 —58
Stove	$2\frac{8}{16}$"	$1\frac{9}{16}$"	....
Chestnut	$1\frac{9}{16}$"	$\frac{11}{16}$"	52.5—56.5
Pea	$\frac{12}{16}$"	$\frac{8}{16}$"	53.5—54.5
No. 1 Buckwheat	$\frac{9}{16}$"	$\frac{5}{16}$"	50.5
No. 2 Buckwheat (Rice)	$\frac{5}{16}$"	$\frac{3}{16}$"	....
No. 3 Buckwheat (Barley)	$\frac{3}{16}$"	$\frac{3}{32}$"	....

PROPORTIONS OF SOFT AND HARD COAL TO BE USED FOR HAND FIRING

	Soft Coal	Hard Coal
No. 1 Buckwheat—Forced Draft	30%	70%
No. 1 Buckwheat—Natural Draft	40%	60%
No. 2 Buckwheat—Forced Draft	40%	60%
No. 2 Buckwheat—Natural Draft	50%	50%
No. 3 Buckwheat—Forced Draft	50%	50%
No. 3 Buckwheat—Natural Draft	65%	35%

MIXTURES OF HARD AND SOFT COAL for hand-fired boilers as shown in this table are given in Tech. Paper 220, U. S. Bureau of Mines. The coking qualities of the soft coal prevent draft and grate losses of the fine anthracite, while the higher fixed carbon of the anthracite increases the heating value of the mixture.

ANALYSES OF REPRESENTATIVE COALS

Class No.	1	2	3	4a	4b	5	6
Kind	Anthracite Culm	Semi-anthracite	Semi-bituminous	Bituminous, Coking	Bituminous, Non Coking	Sub bituminous	Lignite
Location	Penna.	Ark.	W. Va.	Pa.	Ohio	Wyo.	Tex.
Moisture	2.08	1.28	0.65	0.97	7.55	8.68	9.88
Volatile combustible	7.27	12.82	18.80	29.09	34.03	41.31	35.17
Fixed carbon	74.32	73.69	75.92	60.85	52.57	46.49	43.65
Ash	16.33	12.21	4.63	9.09	5.85	3.52	10.30
Loss on air-drying	3.40	1.10	1.10	4.20	Undet.	11.30	23.50
ULTIMATE ANALYSIS OF COAL DRIED AT 221° F.							
Hydrogen	2.63	3.63	4.54	4.57	5.06	5.31	4.47
Carbon	76.86	78.32	86.47	77.10	75.82	73.31	64.84
Oxygen	2.27	2.25	2.68	6.67	10.47	15.72	16.52
Nitrogen	0.82	1.41	1.08	1.58	1.50	1.21	1.30
Sulphur	0.78	2.03	0.57	0.90	0.82	0.60	1.44
Ash	16.64	12.36	4.66	9.18	6.33	3.85	11.43
RESULTS CALCULATED TO AN ASH- AND MOISTURE-FREE BASIS							
Volatile combustible	8.91	14.82	19.85	32.34	39.30	47.05	45.31
Fixed carbon	91.09	85.18	80.15	67.66	60.70	52.95	54.69
ULTIMATE ANALYSIS							
Hydrogen	3.16	4.14	4.76	5.03	5.41	5.50	5.05
Carbon	92.20	89.36	90.70	84.89	80.93	76.35	73.21
Oxygen	2.72	2.57	2.81	7.34	11.18	16.28	18.65
Nitrogen	0.98	1.61	1.13	1.74	1.61	1.25	1.47
Sulphur	0.94	2.32	0.60	1.00	0.87	0.62	1.62
CALORIFIC VALUE IN B. T. U. PER LB., BY DULONG'S FORMULA							
Air-dried coal	12,472	13,406	15,190	13,951	12,510	11,620	10,288
Combustible	15,286	15,496	16,037	15,511	14,446	13,235	12,889

APPROXIMATE HEATING VALUES OF COALS

Percent Volatile Matter in Coal Dry and Free from Ash	Heating Value, B.T.U. per lb. of Combustible	Equivalent Water Evaporated Lb., From and at 212° F. per lb. of Combustible
0	14,580	15.09
3	14,940	15.47
6	15,210	15.75
10	15,480	16.03
13	15,660	16.21
20	15,840	16.40
28	15,660	16.21
32	15,480	16.03
37	15,120	15.65
40	14,760	15.28
43	14,220	14.72
45	13,860	14.35
47	13,320	13.79
49	12,420	12.86

WEIGHT OF BITUMINOUS AND SEMI-BITUMINOUS COAL

Coal from	Size†	Pounds per Cubic Foot
Alabama	D.	45.5
Alabama	R.M.	51-54
Arkansas	R.M.	49.5-59.5
Colorado	Lump	50.5-52.5
Colorado	D.	49.5
Georgia	60-10-30	54
Illinois	D. Lump	49.5
Illinois	R.M.	54.5-55.5
Illinois	Lump	44-48.5
Iowa	60-25-15	46.5
Kansas	95- 5- 0	55.5
Kentucky	95- 5- 0	43.0-54.5
Kentucky	Lump	45-47.5
Montana	90- 5- 5	52
Ohio	90- 5- 5	49
Ohio	70-15-15	47.5
Ohio	60-30-10	46.5
Ohio	40-20-20	50.0
Oklahoma	40-20-20	50.0
Oklahoma	35-45-20	48.5
Pennsylvania	90- 5- 5	47-49.5
Pennsylvania	70-20-10	50.5
Pennsylvania	60-25-10	50.5
Pennsylvania	20-30-50	52
Pennsylvania	10-15-75	52
Pennsylvania	0-10-90	49.5-53.5
Pennsylvania	0- 0-100	52
Pennsylvania	Lump	46.5
Utah	90- 0- 5	44.5
West Virginia‡	75-15-10	55.5
West Virginia‡	60-30-10	47.0
West Virginia‡	20-10-70	55.0
West Virginia‡	5-10-85	55.5
West Virginia‡	4- 2-94	54
West Virginia‡	3- 5-92	57.5
West Virginia‡	0- 5-95	56.5

†D—Domestic; R.M.—Run-of-Mine; the figures represent the respective percentages of lump, nut and slack.
‡Semi-bituminous.

AVERAGE LOSS OF BOILER EFFICIENCY DUE TO ASH IN COAL

Percentage of Ash	10	20	30	40	50
Anthracite coal	12	23	45	70	100
Bituminous coal	10	20	40	75	100
Western coal	5	18	32	98	....

ANALYSES AND ASH FUSION TEMPERATURES OF VARIOUS COALS
COAL IN AS RECEIVED CONDITION

Sample No.	Grade*	State	County	Bed	Moisture %	Fixed Carbon %	Volatile Matter %	Ash %	Sulphur %	Heating Value B.T.U. Per Lb.	Ash Fusion Temperatures, Deg. F. Initial	Softening	Fluid
1	SB	Pa.	Somerset	B	1.7	75.4	15.9	7.0	0.8	14,280	2550	2930	a
2	SB	Md.	Allegheny	Big Vein	1.0	72.1	19.1	7.8	0.9	14,260	2840	2930	a
3	SB	Pa.	Clearfield	B	1.5	65.9	24.2	8.4	1.9	14,120	2450	2520	2580
4	SB	Pa.	Somerset	C Prime	1.6	72.8	15.7	9.9	2.0	13,770	2180	2440	2580
5	SB	Pa.	Cambria	Miller or B	1.2	72.3	21.2	5.3	1.2	14,670	2520	2650	2710
6	B	Ohio	Meigs	8-A	5.2	45.0	37.6	12.2	2.4	11,820	2020	2190	2390
7	B	Ill.	Williamson	No. 6	9.6	44.4	33.4	12.6	3.6	11,260	1960	2070	2290
8	B	Pa.	Westmoreland	Pittsburgh	1.3	55.4	32.3	11.0	1.5	13,390	2460	2600	2700
9†	B	Pa.	Westmoreland	Pittsburgh	1.3	57.0	33.5	8.2	1.6	13,890	2460	2570	2700
10	SB	W. Va.	New River Coal		1.6	70.5	20.7	7.2	1.0	14,240	2440	2580	2630
11	SB	W. Va.	Pocahontas Coal		1.8	71.3	20.9	6.0	0.6	14,480	2160	2300	2440
12	B	Ohio	Jefferson	Pittsburgh No. 8	2.2	53.3	35.6	8.9	2.2	13,280	2090	2210	2330
13	SB	W. Va.	Raleigh	Beckley	1.5	73.8	17.6	7.1	0.8	14,310	2630	2800	2850
14	SB	Pa.	Mercer	Brookville	1.5	70.2	17.7	10.6	1.4	13,640	2390	2640	2830
15	B	Ill.	Williamson	No. 6	5.6	50.4	33.4	10.6	2.0	12,130	2110	2280	2460
16	B	Pa.	Westmoreland	Pittsburgh	1.9	54.8	32.5	10.8	1.8	13,200	2360	2520	2640
17	B	Pa.	Allegheny	Pittsburgh	2.4	54.0	34.2	9.4	1.4	13,280	2100	2270	2430
18	B	Pa.	Westmoreland	Pittsburgh	1.4	58.2	33.8	6.6	0.8	14,080	2580	2730	2840
19	SB	Pa.	Somerset	Miller or B	1.3	72.8	16.7	9.2	1.9	13,940	2390	2470	2560
20†	SB	Pa.	Somerset	Miller or B	1.3	74.1	16.7	7.9	1.4	14,200	2500	2630	2720
21	B	Ill.	Mixture from 7 mines		12.5	38.3	33.0	16.2	3.2	10,190	1930	1990	2170

*SB—Semi-bituminous; B—Bituminous. †Washed coal, same as next preceding sample. a—Did not attain temperature of fluidity.

ANALYSES AND HEATING VALUES OF GAS COKE

Kind of Coal	COAL						COKE						
	Moisture	Ash	Volatile	Fixed Carbon	Sulphur	B.T.U. per Pound	Condition*	Moisture	Ash	Volatile	Fixed Carbon	Sulphur	B.T.U. per Pound
Pittsburgh:													
As received	1.92	6.41	32.82	58.85	1.12	14,026	A	8.54	11.46	0.97	79.03	0.84	11,552
Dry	....	6.54	33.46	60.00	1.14	14,301	B	....	12.53	1.06	86.41	0.92	12,631
Alabama:													
As received	2.71	4.29	29.13	63.87	0.50	13,990	A	....	....	....	....	....	....
Dry	....	4.41	29.94	65.65	0.51	14,380	B	....	11.40	1.59	81.01	0.52	12,883
Colorado:													
As received	7.17	14.55	32.36	45.92	1.00	10,953	A	21.31	19.93	1.40	57.28	0.68	8,417
Dry	....	15.67	34.86	49.47	1.08	11,799	B	....	25.35	1.78	72.87	0.87	10,706
Kentucky:													
As received	2.46	6.25	31.18	60.11	0.43	13,885	A	12.43	10.09	0.92	76.56	0.36	11,210
Dry	....	6.41	31.97	61.62	0.44	14,234	B	....	11.52	1.05	87.43	0.41	12,802

*Condition—A—3 days after quench; B—from retorts.

COKE DATA

ANALYSES OF CLAIRTON BY-PRODUCT COKE

Sample No.	Moisture	Volatile Matter	Fixed Carbon	Ash	B.T.U. per Lb.	
					As Fired	Ash and Moisture Free
1	3.6	2.1	80.0	14.3	11,770	14,330
2	2.3	2.3	81.1	14.3	11,890	14,260
3	0.8	1.1	80.5	17.6	11,720	14,370

ANALYSES OF WET- AND DRY-QUENCHED COKE

Analysis	Original Coal	Wet-Quenched Coke		Dry-Quenched Coke	
		Moisture Free	As Received	Moisture Free	As Received
B.T.U. per lb.	14,300	13,039	11,463	13,088	13,023
Volatile matter, percent	36.47	1.71	1.49	1.16	1.15
Fixed Carbon, percent	58.97	91.29	79.51	91.48	91.03
Ash, percent (calculated on ash and moisture free basis)	4.56	7.00	6.10	7.36	7.32
Moisture, percent	....	....	12.90	....	0.50
Sulphur, percent (separately determined)	0.75	0.75	0.75	0.68	....

WOOD FUEL DATA

HEATING VALUE OF WOODS
(Based on U. S. Dept. of Agriculture Bull. No. 753)

	Weight per cord, lb.		Heating Value, B.T.U. per lb.		Equivalent lb. of Coal of 13,500 B.T.U. per lb.	
	Green	Air-dry	Green	Air-dry	Green	Air-dry
Ash, white	4300	3800	4628	5395	0.343	0.400
Beech	5000	3900	3940	5359	.292	.397
Birch, yellow	5100	4000	3804	5225	.282	.387
Chestnut	4900	2700	2633	5778	.195	.428
Cottonwood	4200	2500	3024	6000	.224	.444
Elm, white	4400	3100	3591	5710	.266	.423
Hickory	5700	4600	4053	5391	.300	.399
Maple, sugar	5000	3900	4080	5590	.302	.414
Maple, red	4700	3200	3745	5969	.277	.442
Oak, red	5800	3900	3379	5564	.250	.412
Oak, white	5600	4300	3972	5558	.294	.412
Pine, yellow	3100	2300	7097	9174	.526	.680
Pine, white	3300	2200	4226	5864	.313	.434
Walnut, black	5100	4000	4078	4650	.302	.344
Willow	4600	2300	2370	5870	.176	.435

A cord of Wood is a pile 4'x4'x8' = 128 cu. ft. comprising approximately 56% Solid wood and 44% Interstitial spaces.

NATURAL GAS DATA

ANALYSES OF NATURAL GAS COLLECTED IN 31 CITIES IN THE U. S.
(Tech. Paper 158, U. S. Bureau of Mines)

Town	Paraffin Hydrocarbons C_nH_{2n+2}	Methane, CH_4	Ethane, C_2H_6	Carbon Dioxide CO_2	Nitrogen N_2	Calculated Gross Heating Value B.T.U. per Cu. Ft. (760 mm. Pressure)		Calculated Specific Gravity (Air—1)
						0° C.	60° F.	
Fayette, Alabama	97.6	97.6	0.0	0.3	2.10	1039	983	0.57
Alma, Arkansas	99.2	99.2	0.0	0.20	0.6	1057	1000	.56
Little Rock, Arkansas	96.7	96.7	0.0	1.00	2.3	1030	974	.57
Los Angeles, California	93.5	77.5	16.0	6.50	0.0	1123	1062	.70
Olney, Illinois	97.1	37.5	59.6	0.0	1.7*	1591	1505	.86
Palestine, Illinois	95.6	95.6	0.0	0.5	3.9	1018	963	.58
Geneva, Indiana	98.8	75.4	23.4	0.0	1.2	1238	1171	.68
Coffeyville, Kansas	98.0	98.0	0.0	1.2	0.8	1044	988	.57
Pittsburgh, Kansas	93.0	90.5	2.5	0.4	6.6	1010	955	.60
Ashland, Kentucky	79.0	75.0	24.0	.0	1.0	1245	1178	.68
Lexington, Kentucky	99.0	76.4	22.6	.0	1.0	1234	1167	.67
Kansas City, Missouri	90.8	84.1	6.7	.8	8.4	1025	965	.63
Elmira, New York	99.0	84.0	15.0	.0	1.0	1174	1111	.63
Bolivar, New York	97.4	59.8	37.6	.4	2.2	1336	1264	.75
Buffalo, New York	99.6	88.1	11.5	.0	0.4	1152	1090	.61
Pavilion, New York	98.7	91.9	6.8	.0	1.3	1105	1045	.59
Wellsville, New York	98.0	78.1	19.9	.0	2.0	1212	1137	.65
Ashtabula, Ohio	98.7	82.2	16.5	.0	1.3	1182	1118	.65
Lima, Ohio	96.3	83.5	12.8	.0	3.7	1127	1066	.63
Piqua, Ohio	90.9	78.3	12.6	.2	8.9	1068	1010	.66
Sandusky, Ohio	96.0	83.5	12.5	.2	3.8	1122	1061	.63
Utica, Ohio	93.9	74.8	19.1	.3	5.8	1152	1090	.68
Guthrie, Oklahoma	91.9	73.5	18.4	.0	8.1	1125	1064	.68
Sapulpa, Oklahoma	98.8	93.1	5.7	.4	0.8	1098	1039	.59
Altoona, Pennsylvania	99.0	90.0	9.0	.2	0.8	1126	1065	.60
Oil City, Pennsylvania	97.7	64.3	33.4	.0	3.3	1306	1235	.74
St. Marys, Pennsylvania	99.2	88.0	11.2	.0	0.8	1146	1084	.61
Sharon, Pennsylvania	99.3	32.3	67.0	.0	.7	1591	1505	.89
Charleston, West Virginia	99.3	76.8	22.5	.0	.7	1236	1169	.67
Clarksburg, West Virginia	99.3	66.6	32.7	.0	.7	1318	1247	.72
Fairmont, West Virginia	99.0	82.0	17.0	.1	.9	1189	1125	.64

*Contained also 1.2% hydrogen sulphide H_2S.

GAS FUEL DATA

HEAT CONTENT OF MIXTURES OF BLAST-FURNACE AND COKE-OVEN GAS PERCENTAGES BY VOLUME

Blast-Furnace Gas Percent	Coke-Oven Gas Percent	B.T.U. per Cu. Ft.
95	5	119.1
90	10	141.1
85	15	163.1
80	20	185.1
75	25	207.1
70	30	229.1
65	35	251.1
60	40	273.1
55	45	295.1
50	50	317.1
45	55	339.1
40	60	361.1
35	65	383.1
30	70	405.1
25	75	427.1
20	80	449.1
15	85	471.1
10	90	493.1
5	95	515.1

ANALYSES AND CALORIFIC VALUES OF MOISTURE-FREE PEAT

Location		Volatile	Fixed Carbon	Ash	B.T.U. Per Lb.
Connecticut	Min.	16.37	6.08	77.55	1,708
Connecticut	Max.	61.17	31.58	7.25	10,001
Florida	Min.	11.42	38.53	50.05	1,202
Florida	Max.	67.80	30.67	1.53	10,865
Maine	Min.	29.88	12.31	57.81	3,634
Maine	Max.	59.95	31.93	8.12	9,779
Massachusetts	Min.	54.13	30.69	15.18	8,663
Massachusetts	Max.	57.04	34.61	8.35	9,308
Michigan	Min.	42.54	18.03	39.43	5,845
Michigan	Max.	60.77	32.22	7.01	10,026
New Hampshire	Min.	31.00	14.24	54.76	4,046
New Hampshire	Max.	66.74	28.67	4.59	10,280
New York	Min.	26.25	10.46	63.29	3,515
New York	Max.	67.10	28.99	3.91	10,307
North Carolina	....	51.88	28.83	19.29	8,249
North Carolina	....	51.88	28.83	19.29	8,249
Wisconsin	Min.	23.69	5.91	70.40	2,608
Wisconsin	Max.	62.77	27.71	9.52	9,391

FUEL OIL DATA

ANALYSES AND CALORIFIC VALUE OF VARIOUS FUEL OILS

Oil	Chemical Analysis C	H	O	N	S	Specific Gravity	Flash Point deg. F.	Fire Point deg. F.	B.T.U. per lb. as Reported	B.T.U. per lb. by formula
Beaumont, Tex.	84.60	10.90	2.87	....	1.63	0.92	142	181	19,060	19,142
Colinga, Cal.	86.37	11.30	....	1.14	0.60	0.95	162	....	18,720	18,948
Bakersfield, Cal.	85.0	12.0	1.0	0.2	0.8	....	....	....	18,600	....
Penna, crude	84.9	13.7			....	0.89	....	....	19,210	19,350
Penna, light	82.0	14.8	1.4		....	0.83	....	....	17,930	19,809
West Va., crude	84.3	14.1	3.2		....	0.84	....	....	18,400	19,736
Ohio, crude	83.4	14.7	1.6		0.6	0.80	....	....	19,580	20,065
Mexican, crude	82.8	12.19			2.83	0.91	77	120	18,493	19,215
Baku, Russia, heavy	86.6	12.3	1.3	....	....	0.94	....	....	19,440	19,017
			0.43	1.72						
			1.11							

VENTILATION

RECOMMENDED SUPPLY GRILLE HEIGHTS IN INCHES FOR CONVENTIONAL GRILLE CONSTRUCTION, BASED ON 350 FEET PER MIN. AIR VELOCITY THROUGH FREE AREA

Difference Between Room Air and Entering Air, Dry-Bulb Temperature	WIDTH OF CONDITIONED ROOM IN FEET 8 ft.	12 ft.	16 ft.	20 ft.	24 ft.	30 ft.
	GRILLE HEIGHT IN INCHES					
10° F.	4	8	10	12	16	18
12° F.	4	6	8	10	12	16
14° F.	4	4	6	8	10	12
16° F.	3	4	6	8	10	12
18° F.	3	4	6	8	10	12
Recommended Height of Grille Above Floor	8′ 0″	8′ 6″	9′ 0″	9′ 6″	10′ 0″	10′ 0″

AIR CHANGES FOR VENTILATION FOR VARIOUS ESTABLISHMENTS

Assembly Halls	1 to 4 Min.
Bakeries	1 to 3 Min.
Billiard and Pool Rooms	1 to 5 Min.
Bowling Alleys	1 to 5 Min.
Cabins	5 Minutes
Conduits	1 to 5 Min.
Dance Halls	1 to 3 Min.
Foundries	2 to 5 Min.
Garages	3 to 5 Min.
Laboratories	2 to 5 Min.
Laundries	½ to 5 Min.
Lodge Rooms	1 to 5 Min.
Offices	1 to 8 Min.
Restaurants—Dining Rooms	1 to 8 Min.
Restaurants—Kitchens	1 to 2 Min.
Stores	1 to 5 Min.
Ship Holds	10 Minutes
Theatres—Auditoriums	1 to 4 Min.
Theatres—Projecting Booths	1 Minute
Toilets	3 to 5 Min.
Tunnels	1 to 10 Min.

Consult Local and State Laws for applications in different localities.
For Capacities of Fans, Heaters and other air conditioning equipment consult manufacturers' catalogues and engineering data.

FINAL TEMPERATURES AND CONDENSATION RATES

REGULAR SECTION VENTS—STANDARD SPACING, 5-INCH CENTERS OF SECTIONS, STEAM 227°, 5 POUNDS GAUGE

No. of Stacks Deep	Temp. of Entering Air	Velocity Through Heater in Feet per Minute—Measured at 70°: 600 Final Temp. of Air Leaving Heater	600 Cond. Lb. per Sq. Ft. per Hour	1000 F.T.	1000 C.	1200 F.T.	1200 C.	1600 F.T.	1600 C.	2000 F.T.	2000 C.
1	−20	......	......	....	....	....	....	....	....	....	....
	−10	34	1.69	....	....	....	....	....	....	....	....
	0	43	1.65	35	2.24	32	2.46	....	....	....	....
	20	58	1.46	51	1.99	49	2.23	45	2.56	42	2.82
	30	66	1.39	60	1.92	58	2.17	54	2.46	51	2.69
2	−20	63	1.60	49	2.22	44	2.46	37	2.92	31	3.27
	−10	69	1.52	56	2.12	51	2.35	44	2.77	38	3.08
	0	75	1.44	62	1.99	58	2.23	51	2.62	46	2.95
	20	87	1.29	76	1.80	72	2.00	66	2.36	62	2.69
	30	93	1.21	83	1.70	79	1.89	73	2.21	69	2.50
3	−20	91	1.42	75	2.03	69	2.28	59	2.70	52	3.08
	−10	96	1.36	80	1.92	75	2.18	66	2.60	58	2.90
	0	101	1.30	86	1.84	81	2.08	72	2.46	65	2.78
	20	110	1.15	97	1.65	92	1.85	85	2.22	79	2.52
	30	115	1.09	103	1.56	98	1.75	91	2.08	85	2.35
4	−20	114	1.29	96	1.86	90	2.12	78	2.51	70	2.88
	−10	117	1.22	101	1.78	95	2.02	84	2.41	76	2.76
	0	121	1.16	106	1.70	100	1.92	90	2.31	82	2.63
	20	130	1.06	115	1.52	110	1.73	101	2.08	94	2.37
	30	134	1.00	120	1.44	115	1.63	106	1.95	99	2.21
5	−20	132	1.17	114	1.72	107	1.95	94	2.34	86	2.72
	−10	135	1.13	118	1.64	111	1.86	99	2.24	91	2.59
	0	138	1.06	122	1.56	115	1.77	104	2.14	96	2.46
	20	144	.95	130	1.41	124	1.60	114	1.93	107	2.23
	30	148	.91	134	1.33	128	1.51	118	1.80	112	2.10

From "Vento Heaters." Similar data is published by the Manufacturers of Cast Iron Surface and Pipe Coil Heaters.

WATER MEMORANDA

Doubling the diameter of a pipe increases its capacity 4 times. Friction of liquids in pipes increases as the square of the velocity.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. Approximately, we say that every foot elevation is equal to ½ pound pressure per square inch; this allows for ordinary friction.

Weight of One Cubic Foot of Pure Water

At 32 degrees Fahr. (freezing point) .... 62.418 lbs.
At 39.1 degrees Fahr. (maximum density) .... 62.425 lbs.
At 62 degrees Fahr. (standard temperature) .... 62.355 lbs.
At 212 deg. Fahr. (boiling point, under 1 atmosphere) .. 59.76 lbs.
Imperial gallon = 277.274 cubic in. of water at 62°Fahr.. 10. lbs.
U. S. gallon = 231 cubic in. of water at 62°F......... 8.3356 lbs.
Water expands in bulk from 40 degrees to 212 degrees .... = One twenty-third.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic foot of steam (approximately).

Pressure for Different Heads of Water at 62 Degrees Fahr.

1 foot head = 0.43302 lb per sq. in. 1 inch head = 0.5774 ounces per sq. in.

Inches of Water to Ounces Per Square Inch

Head, inches	1	2	3	4	5	6	7	8	9	10	11	12
Pressure, ounces	.577	1.15	1.73	2.31	2.89	3.46	4.04	4.62	5.20	5.77	6.35	6.93

Head of Water at 62 Degrees Fahr. Corresponding to Different Pressures

pound per sq. in. = 2.3095 feet head. 1 ounce per sq. in. = 1.732 of water

Ounces per Square Inch to Inches of Water

Pressure, ounces	1	2	3	4	5	6	7	8
Head, inches	1.73	3.46	5.20	6.93	8.66	10.39	12.12	13.85
Pressure, ounces	9	10	11	12	13	14	15	16
Head, inches	15.59	17.32	19.05	20.78	22.52	24.25	25.98	27.71

Friction of Water in 90° Elbows and the Equivalent Number of Feet Straight Pipe

Size of Elbow, inches	½	¾	1	1¼	1½	2	2½	3	4	5	6
Friction Equiv. Feet Straight Pipe	5	6	6	8	8	8	11	15	16	18	18

Friction of Water in Pipes

See Table on page 77.

NUMBER OF GALLONS IN ROUND TANKS

Diameter, Inches

Depth or Length	18-inch	24-inch	30-inch	36-inch	42-inch	48-inch	54-inch	60-inch	66-inch	72-inch
1 Inch	1.10	1.96	3.06	4.41	5.99	7.83	9.91	12.24	14.81	17.62
1 ft.	13.	23.	37.	53.	72.	94.	119.	147.	178.	211.
1½ ft.	20.	35.	55.	79.	108.	141.	179.	220.	267.	317.
2 ft.	26.	47.	73.	106.	144.	188.	238.	294.	355.	423.
2½ ft.	33.	59.	92.	132.	180.	235.	298.	367.	444.	529.
3 ft.	40.	71.	110.	159.	216.	282.	357.	441.	533.	634.
3½ ft.	46.	82.	129.	185.	252.	329.	417.	514.	622.	740.
4 ft.	53.	94.	147.	211.	288.	376.	476.	587.	711.	846.
4½ ft.	59.	106.	165.	238.	324.	423.	536.	661.	800.	952
5 ft.	66.	118.	183.	264.	360.	470.	597.	734.	889.	1157.
5½ ft.	73.	129.	202.	291.	396.	517.	657.	808.	977.	1263.
6 ft	79.	141.	220.	317.	432.	564.	714.	881.	1056.	1369.
7 ft.	92.	164.	257.	370.	504.	658.	833.	1028.	1244.	1580.
8 ft	106.	188.	294.	423.	576.	752.	952.	1175.	1422.	1792.
9 ft.	119.	212.	330.	476.	648.	846.	1071.	1322.	1599.	2003.
10 ft.	132.	235.	367.	529.	720.	940.	1190.	1469.	1777.	2115.
12 ft.	157.	282.	440.	634.	864.	1128.	1428.	1762.	2133.	2537.
14 ft	185.	329.	514.	740.	1008.	1316.	1666.	2056.	2488.	2960.
16 ft.	211.	376.	587.	846.	1152.	1504.	1904.	2350.	2844.	3383.
18 ft.	238.	423.	661.	952.	1296.	1692.	2142.	2644.	3199.	3806.
20 ft.	264.	470.	734.	1057.	1440.	1880.	2380.	2937.	3554.	4229.

One-inch depth is given to facilitate figuring intermediate depths.

For tanks having a diameter other than those given in the table, multiply the square of the diameter in inches by the length in feet and multiply this product by 0.0408 to obtain tank capacity in U. S. gallons. When both diameter and length are given in inches, the capacity in U. S. gallons equals $0.0034 \times d^2 L$.

Number of U. S. Gallons in Rectangular Tanks—For one foot in depth

Width of Tank	Length of Tank																				
	2 ft.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft.	5 ft. 6 in.	6 ft.	6 ft. 6 in.	7 ft.	7 ft. 6 in.	8 ft.	8 ft. 6 in.	9 ft.	9 ft. 6 in.	10 ft.	10 ft. 6 in.	11 ft.	11 ft. 6 in.	12 ft
2 ft.	30	37	45	52	60	67	75	82	90	97	105	112	120	127	135	142	150	157	165	172	180
2 ft. 6 in.		47	56	65	75	84	94	103	112	122	131	140	150	159	168	178	187	196	206	215	224
3 ft.			67	79	90	101	112	123	135	146	157	168	180	191	203	213	224	236	247	258	269
3 ft. 6 in.				92	105	118	131	144	157	170	183	195	209	223	236	249	262	275	288	301	314
4 ft.					120	135	150	165	180	194	209	224	239	254	269	284	299	314	329	344	359
4 ft. 6 in.						151	168	185	202	219	236	252	269	286	303	320	337	353	370	387	404
5 ft.							187	206	224	243	262	281	299	318	337	355	374	393	411	430	449
5 ft. 6 in.								226	247	267	288	309	329	350	370	391	411	432	453	473	494
6 ft.									269	292	314	337	359	381	404	426	449	471	494	516	539
6 ft. 6 in.										316	340	365	389	413	438	462	486	511	535	559	583
7 ft.											367	393	419	445	471	497	524	550	576	602	628
7 ft. 6 in.												421	449	477	505	533	561	589	617	645	673
8 ft.													479	509	540	569	598	628	658	688	718
8 ft. 6 in.														540	572	604	636	668	699	731	763
9 ft.															606	640	673	707	741	774	808
9 ft. 6 in.																675	711	746	782	817	853
10 ft.																	748	785	823	860	898
10 ft. 6 in.																		825	864	903	943
11 ft.																			905	946	987
11 ft. 6 in.																				989	1032
12 ft.																					1077

PIPING

Dimensions of Standard Weight Wrought Iron and Steel Pipe

(National Tube Works)

Nominal Inside Diam.	Actual Outside Diam.	Actual Inside Diam.	Thick-ness of Metal	Internal Circum-ference	External Circum-ference	Length of Pipe per sq. ft. Inside Surface	Length of Pipe per sq. ft. Outside Surface	Internal Area		External Area		Length of Pipe cont'g 1 cu. ft.	U. S. Gallons per Ft. of Pipe	Weight of Pipe per Lin. Ft.	Weight of Water per Lin. Ft. of Pipe	No. of Threads per Inch	Length of Perf. Thread
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Feet	Feet	Sq. Ins.	Sq. Ft.	Sq. Ins.	Sq. Ft.	Feet	Gals.	Lbs.	Lbs.	No.	Ins.
⅛	.405	.270	.068	.848	1.272	14.151	9.434	.057	.0004	.128	.0009	2500.0	.0029	.24	.024	27	.19
¼	.540	.364	.088	1.144	1.696	10.500	7.075	.104	.0007	.229	.0016	1383.280	.0054	.42	.045	18	.29
⅜	.675	.493	.091	1.552	1.552	2.121	5.658	.191	.0013	.357	.0025	754.322	.0099	.56	.083	18	.30
½	.840	.622	.109	1.957	2.639	6.132	4.547	.304	.0021	.554	.0038	473.840	.0158	.84	.132	14	.39
¾	1.050	.824	.113	2.589	3.299	4.635	3.638	.533	.0037	.866	.0060	270.016	.0277	1.12	.231	14	.40
1	1.315	1.048	.134	3.292	4.131	3.645	2.904	.861	.0060	1.358	.0094	167.246	.0447	1.67	.373	11½	.51
1¼	1.660	1.380	.140	4.335	5.215	2.768	2.301	1.496	.0104	2.164	.0150	96.257	.0777	2.24	.648	11½	.54
1½	1.900	1.610	.145	5.058	5.969	2.372	2.010	2.036	.0141	2.835	.0197	70.727	.1058	2.68	.882	11½	.55
2	2.375	2.067	.154	6.434	7.461	1.848	1.608	3.356	.0233	4.430	.0308	42.908	.1743	3.61	1.453	11½	.58
2½	2.875	2.468	.204	7.753	9.032	1.548	1.329	4.780	.0332	6.492	.0451	30.337	.2483	5.74	2.070	8	.89
3	3.500	3.067	.217	9.635	10.996	1.245	1.091	7.383	.0513	9.621	.0668	19.504	.3835	7.54	3.197	8	.95
3½	4.000	3.548	.226	11.146	12.566	1.077	0.955	9.887	.0687	12.566	.0875	14.567	.5136	9.00	4.291	8	1.00
4	4.500	4.026	.237	12.648	14.137	0.949	.849	12.730	.0884	15.904	.1104	11.312	.6613	10.66	5.512	8	1.05
5	5.563	5.045	.259	15.849	17.475	.757	.687	19.986	.1388	24.301	.1688	7.205	1.038	14.50	8.652	8	1.16
6	6.625	6.065	.280	19.054	20.813	.630	.577	28.890	.2006	34.472	.2394	4.984	1.500	18.76	12.503	8	1.26
8	8.625	7.981	.322	25.076	27.096	.479	.443	50.027	.3474	58.426	.4057	2.876	2.599	28.18	21.664	8	1.46
10	10.75	10.018	.366	31.476	33.772	.381	.355	78.823	.5474	90.763	.6303	1.827	4.095	40.06	34.134	8	1.68
12	12.75	12.000	.375	37.699	40.055	.318	.300	113.098	.7854	127.677	.8867	1.273	5.875	49.00	48.972	8	1.88
13	14	13.25	.375	41.626	43.982	.288	.273	137.887	.9577	153.938	1.0690	1.044	7.163	54.00	59.708	8	2.09
14	15	14.25	.375	44.768	47.124	.268	.255	159.485	1.1075	176.715	1.2272	0.900	8.285	58.00	69.060	8	2.10
15	16	15.25	.375	47.909	50.266	.250	.239	182.665	1.2685	201.062	1.3963	.793	9.489	62.00	79.097	8	2.20
…….	18	17.25	.375	54.193	56.549	.221	.212	239.706	1.6229	254.470	1.7671	.616	12.141	70.00	101.203	…….	…….
…….	20	19.25	.375	60.476	62.832	.198	.191	291.040	2.0211	314.159	2.1817	.495	15.119	78.00	126.026	…….	…….
…….	22	21.25	.375	66.759	69.115	.180	.174	354.657	2.4629	380.134	2.6398	.406	18.424	85.00	153.575	…….	…….
…….	24	23.25	.375	73.042	75.398	.164	.159	424.558	2.9483	452.390	3.1416	.339	22.055	93.00	183.842	…….	…….

Pipe from ⅛ inch to 1 inch inclusive is butt-welded, and proved to 300 lbs. per sq. in. Pipe 1¼ inch and larger is lap-welded, and proved to 500 lbs. per sq. inch

Friction of Water in Pipes. Loss of Head in Feet Due to Friction, per 100 Feet of New, Smooth Wrought Iron Pipe.

Velocity Heads† and Friction Heads†† for Flow of Water in Pipes

Gallons per Min. U. S.	½″ Pipe		¾″ Pipe		1″ Pipe		1¼″ Pipe		1½″ Pipe		2″ Pipe		2½″ Pipe		3″ Pipe		4″ Pipe	
	Vel.† Head	Fric.†† Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head	Vel. Head	Fric. Head
1	0.02	1.50	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……
2	0.07	5.30	0.02	1.40	……	……	……	……	……	……	……	……	……	……	……	……	……	……
3	0.16	11.30	0.05	2 90	0.02	0.90	……	……	……	……	……	……	……	……	……	……	……	……
4	0.26	19.20	0.09	5.00	0.03	1.52	0.01	0.40	……	0.18	……	……	……	……	……	……	……	……
5	0.43	29.00	0.14	7.50	0.05	2.32	0.02	0.60	0.01	0.28	0.01	0.09	……	0.05	……	……	……	……
10	1.72	105.00	0.56	27.10	0.22	8.40	0.07	2.18	0.04	1.02	0.02	0.36	0.01	0.12	……	0.05	……	……
15	……	……	1.26	57.00	0.58	18.90	0.24	4.65	0.12	2.25	0.04	0.81	0.02	0.25	……	0.11	……	……
20	……	……	2.25	97.00	0.86	30.10	0.28	7.90	0.16	3.70	0.06	1.29	0.03	0.43	0.01	0.18	……	……
25	……	……	……	……	1.39	45.50	0.45	11.90	0.32	5.60	0.10	1.96	0.04	0.66	0.02	0.27	……	……
30	……	……	……	……	1.92	64.00	0.65	16.90	0.35	7.80	0.15	2.73	0.06	0.92	0.03	0.38	……	……
35	……	……	……	……	2.65	85.00	0.88	22.30	0.47	10.30	0.20	3.66	0.08	1.23	0.04	0.51	0.01	……
40	……	……	……	……	3.42	109.00	1.15	28.50	0.62	13.30	0.26	4.68	0.11	1.57	0.05	0.65	0.02	0.16
45	……	……	……	……	……	……	1.47	35.20	0.78	16.60	0.33	5.80	0.14	1.97	0.06	0.80	0.02	0.20
50	……	……	……	……	……	……	1.79	43.20	0.96	20.20	0.40	7.10	0.17	2.38	0.08	0.98	0.03	0.24
70	……	……	……	……	……	……	3.50	81.00	1.88	37.60	0.79	13.20	0.33	4.42	0.16	1.83	0.05	0.45
80	……	……	……	……	……	……	4.55	102.95	2.40	48.28	1.04	16.83	0.43	5.61	0.20	2.33	0.06	0.58
90	……	……	……	……	……	……	5.75	127.80	3.09	59.64	1.31	20.87	0.54	6.96	0.26	2.90	0.08	0.71
100	……	……	……	……	……	……	……	……	3.85	72.42	1.62	25.42	0.66	8.52	0.32	3.52	0.10	0.87
125	……	……	……	……	……	……	……	……	……	……	2.36	38.90	1.03	13.01	0.50	5.40	0.16	1.33
150	……	……	……	……	……	……	……	……	……	……	3.64	53.96	1.49	18.72	0.72	7.72	0.23	1.82

† Velocity heads given in feet. †† Friction head for 100 ft. of straight new wrought-iron pipe.

Square Feet of Actual Surface per Lineal Foot of Pipe

On all lengths over one foot, fractions less than tenths are added to or dropped. For equivalent direct radiation multiply actual surface by 1.25.

Lgth. of Pipe	Size of Pipe ¾	1	1¼	1½	2	2½	3	4	5	6	8
1	.275	.346	.434	.494	.622	.753	.916	1.175	1.455	1.739	2.257
2	.5	.7	.9	1.	1.2	1.5	1.8	2.4	2.9	3.5	4.5
3	.8	1.	1.3	1.5	1.9	2.3	2.7	3.5	4.4	5.2	6.8
4	1.1	1.4	1.7	2.	2.5	3.	3.6	4.7	5.8	7.	9.
5	1.4	1.7	2.2	2.4	3.1	3.8	4.6	5.8	7.3	7.7	11.3
6	1.6	2.1	2.6	2.9	3.7	4.5	5.5	7.	8.7	10.5	13.5
7	1.9	2.4	3.	3.4	4.4	5.3	6.4	8.2	10.2	12.1	15.8
8	2.2	2.8	3.5	3.9	5.	6.	7.3	9.4	11.6	13.9	18.
9	2.5	3.1	3.9	4.4	5.6	6.8	8.2	10.6	13.1	15.7	20.3
10	2.7	3.5	4.3	4.9	6.2	7.5	9.1	11.8	14.6	17.4	22.6
11	3.	3.8	4.8	5.4	6.8	8.3	10.	12.9	16.	19.1	24.9
12	3.3	4.1	5.2	5.9	7.5	9.	11.	14.1	17.4	20.9	27.1
13	3.6	4.5	5.6	6.4	8.1	9.8	11.9	15.3	18.9	22.6	29.4
14	3.8	4.8	6.1	6.9	8.7	10.5	12.8	16.5	20.3	24.3	31.6
15	4.1	5.2	6.5	7.4	9.3	11.3	13.7	17.6	21.8	26.1	33.9
16	4.4	5.5	6.9	7.9	10.	12.	14.6	18.8	23.2	27.8	36.1
17	4.7	5.9	7.4	8.4	10.6	12.8	15.5	20.	24.7	29.5	38.4
18	5.	6.2	7.8	8.9	11.2	13.5	16.5	21.2	26.2	31.3	40.6
19	5.2	6.6	8.3	9.4	11.8	14.3	17.4	22.3	27.6	33.1	42.9
20	5.5	6.9	8.7	9.9	12.5	15.	18.3	23.5	29.1	34.8	45.2
21	5.8	7.3	9.1	10.4	13.	15.8	19.2	24.7	30.5	36.5	47.4
22	6.	7.6	9.6	10.9	13.7	16.5	20.2	25.9	32.	38.3	49.7
23	6.3	8.	10.	11.3	14.3	17.3	21.1	27.	33.5	40.	52.
24	6.6	8.3	10.4	11.9	14.9	18.	22.	28.2	34.9	41.7	54.2
25	6.9	8.6	10.9	12.3	15.6	18.8	22.9	29.3	36.3	43.5	56.4

Lgth. of Pipe	Size of Pipe ¾	1	1¼	1½	2	2½	3	4	5	6	8
1	.275	.346	.434	.494	.622	.753	.916	1.175	1.455	1.739	2.257
26	7.1	9.	11.3	12.8	16.2	19.5	23.8	30.5	37.8	45.2	58.6
27	7.4	9.4	11.7	13.3	16.8	20.3	24.7	31.7	39.3	47.	61.
28	7.7	9.7	12.2	13.8	17.4	21.	25.6	32.9	40.7	48.7	63.2
29	8.	10.	12.6	14.3	18.	21.8	26.6	34.1	42.2	50.4	65.5
30	8.3	10.4	13.	14.8	18.7	22.5	27.5	35.3	43.6	52.1	67.7
31	8.5	10.7	13.5	15.3	19.3	23.3	28.4	36.4	45.1	53.9	70.
32	8.8	11.1	13.9	15.8	19.9	24.1	29.3	37.6	46.5	55.6	72.2
33	9.1	11.4	14.3	16.3	20.5	24.8	30.2	38.8	48.	57.4	74.4
34	9.4	11.7	14.7	16.8	21.2	25.6	31.1	40.	49.5	59.1	76.7
35	9.6	12.1	15.2	17.3	21.8	26.3	32.	41.1	50.9	60.8	79.
36	9.9	12.5	15.6	17.8	22.4	27.	33.	42.3	52.4	62.6	81.3
37	10.2	12.8	16.1	18.3	23.	27.8	33.9	43.5	53.8	64.3	83.5
38	10.5	13.2	16.5	18.8	23.7	28.5	34.8	44.6	55.2	66.	85.8
39	10.7	13.5	16.9	19.3	24.3	29.3	35.7	45.8	56.7	67.8	88.
40	11.	13.8	17.4	19.8	24.9	30.1	36.6	47.	58.2	69.5	90.2
41	11.3	14.2	17.8	20.3	25.5	30.8	37.6	48.2	59.6	71.3	92.5
42	11.5	14.5	18.2	20.8	26.1	31.6	38.5	49.4	61.1	73.	94.8
43	11.8	14.9	18.7	21.3	26.8	32.3	39.4	50.6	62.5	74.8	97.
44	12.1	15.2	19.1	21.8	27.4	33.1	40.3	51.7	64.	76.5	99.3
45	12.4	15.6	19.5	22.2	28.	33.8	41.2	52.9	65.5	78.2	101.6
46	12.7	15.9	20.	22.7	28.6	34.6	42.2	54.	67.	80.	103.8
47	12.9	16.3	20.4	23.2	29.2	35.3	43.	55.2	68.4	81.7	106.
48	13.2	16.6	20.8	23.7	29.9	36.1	43.9	56.4	69.8	83.5	108.4
49	13.5	17.	21.3	24.2	30.5	36.8	44.8	57.6	71.2	85.1	110.5
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	58.7	72.7	87.	112.8

For greater lengths of pipe, use multiples from this table.

PIPE FITTINGS AND CONNECTIONS

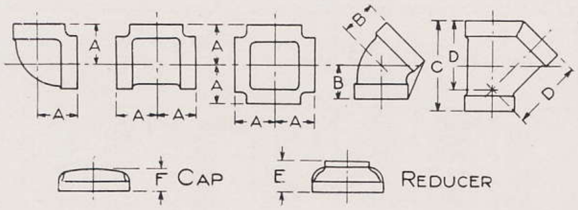


Fig. 935

Size Inches	A	B	C	D	E	F
1/4	13/16	3/4	....	....	....	....
3/8	15/16	13/16	....	....	....	....
1/2	1 1/8	7/8	2 1/2	1 7/8	....	....
3/4	1 5/16	1	3	2 1/4	....	....
1	1 7/16	1 1/8	3 1/2	2 3/4	....	....
1 1/4	1 3/4	1 5/16	4 1/4	3 1/4	2 1/8	....
1 1/2	1 15/16	1 7/16	4 7/8	3 13/16	2 1/4	....
2	2 1/4	1 11/16	5 3/4	4 1/2	2 7/16	....
2 1/2	2 11/16	1 15/16	6 3/4	5 3/16	2 11/16	....
3	3 1/8	2 3/16	7 7/8	6 1/8	2 15/16	....
3 1/2	3 7/16	2 3/8	8 7/8	6 7/8	3 1/8	....
4	3 3/4	2 5/8	9 3/4	7 5/8	3 3/8	2 1/16
4 1/2	4 1/16	2 13/16	10 5/8	8 1/2	3 5/8	2 3/16
5	4 7/16	3 1/16	11 5/8	9 1/4	3 7/8	2 3/8
6	5 1/8	3 7/16	13 7/16	10 3/4	4 3/8	2 5/8
7	5 13/16	3 7/8	15 1/4	12 1/4	4 13/16	2 7/8
8	6 1/2	4 1/4	16 15/16	13 5/8	5 1/4	3 1/8
9	7 3/16	4 11/16	20 11/16	16 3/4	5 11/16	3 3/8
10	7 7/8	5 3/16	20 11/16	16 3/4	6 3/16	3 5/8
12	9 1/4	6	24 1/8	19 5/8	7 1/8	4 1/4

The above dimensions are subject to slight variations (from Crane).

Standard Companion Flanges and Bolts

(For Working Pressure up to 125 Lbs.)

Dimensions

Size Inches	Diam. of Flange Inches	Bolt Circle Inches	No. of Bolts	Size of Bolts, Inches	Length of Bolts
3/4	3 1/2	2 1/2	4	3/8	1 3/8
1	4 1/4	3 1/8	4	1/2	1 1/2
1 1/4	4 5/8	3 1/2	4	1/2	1 1/2
1 1/2	5	3 7/8	4	1/2	1 3/4
2	6	4 3/4	4	5/8	2
2 1/2	7	5 1/2	4	5/8	2 1/4
3	7 1/2	6	4	5/8	2 1/4
3 1/2	8 1/2	7	8	5/8	2 1/2
4	9	7 1/2	8	5/8	2 3/4
5	10	8 1/2	8	3/4	2 3/4
6	11	9 1/2	8	3/4	3
8	13 1/2	11 3/4	8	3/4	3 1/4
10	16	14 1/4	12	7/8	3 1/2
12	19	17	12	7/8	3 1/2
14	21	18 3/4	12	1	4
16	23 1/2	21 1/4	16	1	4 1/4

Bolt holes are in multiples of four so that flanges may be made to face in any quarter and bolt holes straddle the center line.

Bolt holes are drilled 1/8 inch larger than nominal diameter of bolts.

When ordering specify size and diameter of companion flange. Example, a two-inch companion flange would be described 2"x6".

Length of Thread on Pipe That is Screwed Into Fittings to Make a Tight Joint

Dimensions in Inches

Size	A	Size	A
1/8	1/4	3 1/2	1 1/16
1/4	3/8	4	1 1/16
3/8	3/8	4 1/2	1 1/8
1/2	1/2	5	1 3/16
3/4	1/2	6	1 1/4
1	9/16	7	1 1/4
1 1/4	5/8	8	1 5/16
1 1/2	5/8	9	1 3/8
2	11/16	10	1 1/2
2 1/2	15/16	12	1 5/8
3	1		

Dimensions given do not allow for variation in tapping or threading (from Crane).

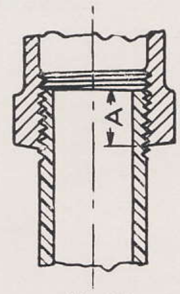


Fig. 936

BRANCH CONNECTIONS

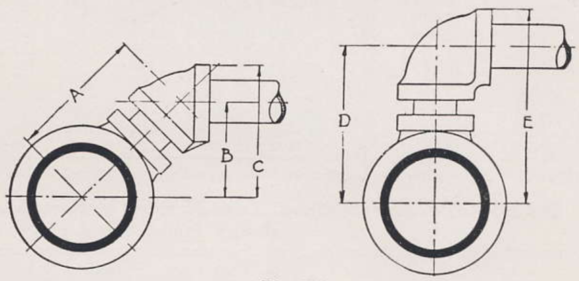


Fig. 896

Minimum Height of Connections Off Pipe Mains

Mains Inches	Branches Inches	A In.	B In.	C In.	D In.	E In.	Branches Inches	Mains Inches
2	1	3 3/8	2 3/8	3 13/32	3 31/32	5	1	2
2	1 1/4	3 11/16	2 5/8	3 7/8	4 7/16	5 11/16	1 1/4	2
2	1 1/2	4	2 27/32	4 7/32	4 13/16	6 3/16	1 1/2	2
2 1/2	1	3 3/4	2 21/32	3 11/16	4 11/32	5 3/8	1	2 1/2
2 1/2	1 1/4	4 1/16	2 7/8	4 1/8	4 13/16	6 1/16	1 1/4	2 1/2
2 1/2	1 1/2	4 3/8	3 3/32	4 15/16	5 3/16	6 9/16	1 1/2	2 1/2
2 1/2	2	4 7/8	3 7/16	5 1/8	5 7/8	7 9/16	2	2 1/2
3	1	4 1/16	2 [illegible]/8	3 29/32	4 21/32	5 11/16	1	3
3	1 1/4	4 3/8	3 3/32	4 11/32	5 1/8	6 3/8	1 1/4	3
3	1 1/2	4 11/16	3 5/16	4 11/16	5 1/2	6 7/8	1 1/2	3
3	2	5 5/16	3 11/16	5 3/8	6 3/16	7 7/8	2	3
3	2 1/2	5 9/16	3 15/16	6	6 13/16	8 7/8	2 1/2	3
3 1/2	1	4 11/32	3 1/16	4 3/32	4 15/16	5 31/32	1	3 1/2
3 1/2	1 1/4	4 21/32	3 5/16	4 9/16	5 13/32	6 21/32	1 1/4	3 1/2
3 1/2	1 1/2	4 31/32	3 17/32	4 9/32	5 25/32	7 5/32	1 1/2	3 1/2
3 1/2	2	5 15/32	3 7/8	5 9/16	6 15/32	8 5/32	2	3 1/2
3 1/2	2 1/2	5 27/32	4 1/8	6 3/16	7 3/32	9 5/32	2 1/2	3 1/2
4	1	4 11/16	3 5/16	4 11/32	5 9/32	6 5/16	1	4
4	1 1/4	5	3 17/32	4 25/32	5 3/4	7	1 1/4	4
4	1 1/2	5 5/16	3 3/4	5 1/8	6 1/8	7 1/2	1 1/2	4
4	2	5 13/16	4 1/8	5 13/16	6 13/16	8 1/2	2	4
4	2 1/2	6 3/16	4 3/8	6 7/16	7 7/16	9 1/2	2 1/2	4
5	1 1/4	5 17/32	3 29/32	5 5/32	6 9/32	7 17/32	1 1/4	5
5	1 1/2	5 27/32	4 1/8	5 1/2	6 21/32	8 1/32	1 1/2	5
5	2	6 11/32	4 1/2	6 3/16	7 11/32	9 1/32	2	5
5	2 1/2	6 23/32	4 3/4	6 13/16	7 31/32	10 1/32	2 1/2	5
6	1 1/4	6 3/16	4 3/8	5 1/8	6 15/16	8 3/16	1 1/4	6
6	1 1/2	6 1/2	4 5/8	6	7 5/16	8 11/16	1 1/2	6
6	2	7	4 31/32	6 21/32	8	9 11/16	2	6
6	2 1/2	7 3/8	5 7/32	7 9/32	8 5/8	10 11/16	2 1/2	6
8	2	8 1/4	5 27/32	7 17/32	9 1/4	10 15/16	2	8
8	2 1/2	8 5/8	6 1/8	8 3/16	9 7/8	11 15/16	2 1/2	8
8	3	9	6 3/8	8 3/4	10 7/16	12 13/16	3	8

The above table prepared by F. Du Bois Ingals, M. E., indicates dimensions of branch connections when made up as close as possible with close nipple between tee on main and branch nipple.

OFFSET CONNECTIONS

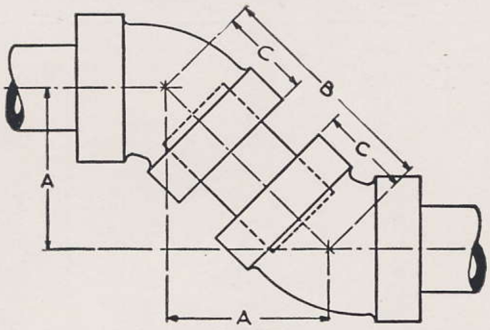


Fig. 897

TABLE—45 DEGREE OFFSETS

Pipe Size	Close Nipple: Length of Nipple	Close Nipple: Offset A	Close Nipple: Center to Center B	Close Nipple: Center to Face C	Short Nipple: Length of Nipple	Short Nipple: Offset A	Short Nipple: Center to Center B	Short Nipple: Center to Face C
½	1⅛	1 5/16	1⅞	⅞	1½	1 9/16	2¼	⅞
¾	1⅜	1 11/16	2⅜	1	2	2 3/16	3	1
1	1½	1⅞	2⅝	1⅛	2	2¼	3⅛	1⅛
1¼	1⅝	2⅛	3	1 5/16	2½	2¾	3⅞	1 5/16
1½	1¾	2⅜	3⅜	1 7/16	2½	2 15/16	4⅛	1 7/16
2	2	2 13/16	4	1 11/16	2½	3 3/16	4½	1 11/16
2½	2½	3 3/16	4½	1 15/16	3	3 9/16	5	1 15/16
3	2⅝	3 9/16	5	2 3/16	3	3 13/16	5⅜	2 3/16
3½	2¾	3 13/16	5⅜	2⅜	4	4 11/16	6⅝	2⅜
4	3	4 5/16	6⅛	2⅝	4	5 1/16	7⅛	2⅝
4½	3	4½	6⅜	2 13/16	4	5 3/16	7⅜	2 13/16
5	3¼	4 15/16	7	3 1/16	4½	5 13/16	8¼	3 1/16
6	3¼	5⅜	7⅝	3 7/16	4½	6¼	8⅞	3 7/16
7	3½	6 3/16	8¾	3⅞	5	7¼	10¼	3⅞
8	3½	6⅝	9⅜	4¼	5	7 11/16	10⅞	4¼

The Offset "A" is equal to the distance "B" divided by 1.414.

ROLLING OFFSETS

It is often necessary to calculate the length of a piece of pipe between two 45-degree fittings where there is both a drop and a spread. In the sketch below, "A" represents the drop, "B" the spread, "X" the center to center distance. Using the formula: $X = 1.414\sqrt{A^2+B^2}$, which means that the center to center distance equals 1.414 times the square root of the sum of the drop squared plus the spread squared.

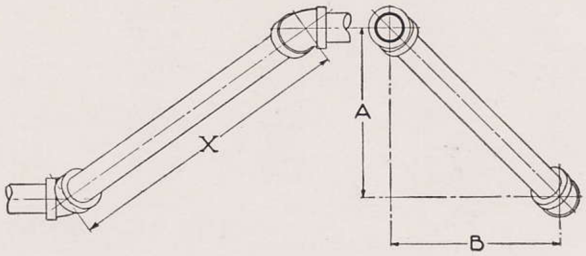


Fig. 1211

Example

$$\begin{aligned} \text{Drop } A &= 12'' \\ \text{Spread } B &= 8'' \\ X &= 1.414\sqrt{(12)^2+(8)^2} \\ &= 1.414\sqrt{208} \\ &= 1.414 \times 14.42'' \\ &= 20.38'' \end{aligned}$$

For rolling offsets using other than 45° ells, the numbers given in the "Table for Offset Calculations," page 250, may be substituted for 1.414 as follows:

For rolling offsets using 5⅝° ells....$X = 10.207\sqrt{A^2+B^2}$
For rolling offsets using 11¼° ells....$X = 5.126\sqrt{A^2+B^2}$
For rolling offsets using 22½° ells....$X = 2.613\sqrt{A^2+B^2}$
For rolling offsets using 30° ells........$X = 2\sqrt{A^2+B^2}$
For rolling offsets using 60° ells........$X = 1.155\sqrt{A^2+B^2}$

Elbows of 22½°, 45° and 60° are usually carried in stock. Others may be obtained on special order.

OFFSET CALCULATIONS

By Warren E. Hill

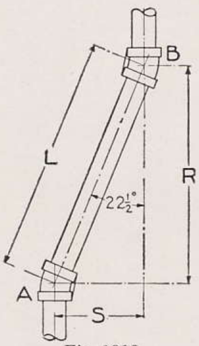


Fig. 1212

Example

Set S = 10″, 22½° angle
Length L = S × Factor
(from table below)
L = 10″ × 2.6131
= 26.131″ approx. 26⅛″

The Right Triangle is the basis of the solution of all offsets. The angle from which a fitting derived its name is the angle shown as 22½ degrees in Fig. 1212 as A and B.

Note that the three sides of the triangle are lettered and that each side may be referred to as part of the offset. "S" stands for the short side or "SET" of the offset," "L" for the long side or "LENGTH" of center to center distance of the fittings, and "R" for the "RUN" side.

In calculating the usual offset, side "S" is known and side "L" is required, thus the figures in the top line of the following table are most frequently used.

To Find Side	When You Know Side	Multiply Side	For 5⅝° Ells By	For 11¼° Ells By	For 22½° Ells By	For 30° Ells By	For 45° Ells By	For 60° Ells By
L	S	S	10.207	5.1258	2.6131	2.00	1.41421	1.1547
S	L	L	.0980	.1951	.3827	.50	.707	.866
R	S	S	10.153	5.0273	2.4142	1.732	1.	.5773
S	R	R	.0985	.1989	.4142	.5773	1.	1.732
L	R	R	1.0048	1.0196	1.0824	1.1547	1.41421	2.00
R	L	L	.9952	.9809	.9239	.866	.7071	.500

WEIGHTS OF BRASS, RED BRASS AND COPPER PIPE

Standard Pipe Sizes—Regular

Standard Pipe Size (I. P. S.)	Diameter, Inches		Thickness, Inches	Pounds per Foot			Feet per Pound		
	Outside	Inside	Wall	67 Brass	85 Red Brass	Copper	67 Brass	85 Red Brass	Copper
⅛	0.405	0.281	0.0620	0.246	0.253	0.259	4.07	3.95	3.86
¼	0.540	0.375	0.0825	0.437	0.450	0.460	2.29	2.22	2.17
⅜	0.675	0.494	0.0905	0.612	0.630	0.643	1.63	1.59	1.56
½	0.840	0.625	0.1075	0.911	0.938	0.957	1.10	1.07	1.04
¾	1.050	0.822	0.1140	1.24	1.27	1.30	0.805	0.787	0.769
1	1.315	1.062	0.1265	1.74	1.79	1.83	0.575	0.559	0.546
1¼	1.660	1.368	0.1460	2.56	2.63	2.69	0.391	0.380	0.372
1½	1.900	1.600	0.1500	3.04	3.13	3.20	0.329	0.319	0.313
2	2.375	2.062	0.1565	4.02	4.14	4.23	0.249	0.242	0.236
2½	2.875	2.500	0.1875	5.83	6.00	6.14	0.172	0.167	0.163
3	3.500	3.062	0.2190	8.31	8.56	8.75	0.120	0.117	0.114
3½	4.000	3.500	0.2500	10.85	11.17	11.41	0.092	0.090	0.088
4	4.500	4.000	.02500	12.29	12.66	12.94	0.081	0.079	0.077
4½	5.000	4.500	0.2500	13.74	14.15	14.46	0.073	0.071	0.069
5	5.563	5.063	0.2500	15.40	15.85	16.21	0.065	0.063	0.062
6	6.625	6.125	0.2500	18.44	18.99	19.41	0.054	0.053	0.052
7	7.625	7.062	0.2815	23.92	24.63	25.17	0.042	0.041	0.040
8	8.625	8.000	0.3125	30.05	30.95	31.63	0.033	0.032	0.032
9	9.625	8.937	0.3440	36.94	38.03	38.83	0.027	0.026	0.026
10	10.750	10.019	0.3655	43.91	45.20	46.22	0.023	0.022	0.022

SIZES AND WEIGHTS OF COPPER TUBES

Nominal Size Inch	Outside Diameter Inch	Inside Diameter Inch			Wall Thickness Inch			Permissible Variation in Gauge ± Inch			Pounds per Foot		
	Type K-L-M	Type K	Type L	Type M	Type K	Type L	Type M	Type K	Type L	Type M	Type K	Type L	Type M
⅛	.250	.186	.200	.200	.032	.025	.025	0.001	0.001	0.001	.085	.068	.068
¼	.375	.311	.315	.325	.032	.030	.025	.001	.001	.001	.134	.126	.106
⅜	.500	.402	.430	.450	.049	.035	.025	.004	.0035	.0025	.269	.198	.144
½	.625	.527	.545	.569	.049	.040	.028	.004	.0035	.0025	.344	.284	.203
⅝	.750	.652	.666		.049	.042		.0045	.004		.418	.362	
¾	.875	.745	.785	.811	.055	.045	.032	.0045	.004	.003	.641	.454	.328
1	1.125	.995	1.025	1.055	.055	.050	.035	.0045	.004	.0035	.839	.653	.464
1¼	1.375	1.245	1.255	1.291	.065	.055	.042	.0045	.0045	.0035	1.04	.882	.681
1½	1.625	1.481	1.505	1.527	.072	.060	.049	.005	.0045	.004	1.36	1.14	.940
2	2.125	1.959	1.985	2.009	.083	.070	.058	.005	.005	.0045	2.06	1.75	1.46
2½	2.625	2.435	2.465	2.495	.095	.080	.065	.005	.005	.0045	2.92	2.48	2.03
3	3.125	2.907	2.945	2.981	.109	.090	.072	.005	.005	.0045	4.00	3.33	2.68
3½	3.625	3.385	3.425	3.459	.120	.100	.083	.005	.005	.005	5.12	4.29	3.58
4	4.125	3.857	3.905	3.935	.134	.110	.095	.006	.005	.005	6.51	5.38	4.66
5	5.125	4.805	4.875	4.907	.160	.125	.109	.006	.005	.005	9.67	7.61	6.66
6	6.125	5.741	5.845	5.881	.192	.140	.122	.007	.006	.006	13.87	10.20	8.91

For underground services and general plumbing purposes with severeconditions—Type K, hard or soft. For general plumbing purposes—Type L, hard or soft. For general plumbing and heating purposes, with sweat fittings only, and with normal water conditions—Type M, hard.

THERMAL EXPANSION OF PIPE IN INCHES PER 100 FT.a

(For superheated steam and other fluids refer to temperature column)

Saturated Steam			Elongation in Inches per 100 Ft. from −20 F up				Saturated Steam		Elongation in Inches per 100 Ft. from −20 F up			
Vacuum Inches of Hg.	Pressure Pounds per Square Inch Gage	Temperature Degrees Fahrenheit	Cast-Iron Pipe	Steel Pipe	Wrought-Iron Pipe	Copper Pipe	Pressure Pounds per Square Inch Gage	Temperature Degrees Fahrenheit	Cast-Iron Pipe	Steel Pipe	Wrought Iron Pipe	Copper Pipe
		−20	0	0	0	0	664.3	500	3.847	4.296	4.477	6.110
		0	0.127	0.145	0.152	0.204	795.3	520	4.020	4.487	4.677	6.352
		20	0.255	0.293	0.306	0.442	945.3	540	4.190	4.670	4.866	6.614
		40	0.390	0.430	0.465	0.655	1115.3	560	4.365	4.860	5.057	6.850
29.39		60	0.518	0.593	0.620	0.888	1308.3	580	4.541	5.051	5.268	7.123
28.89		80	0.649	0.725	0.780	1.100	1525.3	600	4.725	5.247	5.455	7.338
27.99		100	0.787	0.898	0.939	1.338	1768.3	620	4.896	5.437	5.660	7.636
26.48		120	0.926	1.055	1.110	1.570	2041.3	640	5.082	5.627	5.850	7.893
24.04		140	1.051	1.209	1.265	1.794	2346.3	660	5.260	5.831	6.067	8.153
20.27		160	1.200	1.368	1.427	2.008	2705	680	5.442	6.020	6.260	8.400
14.63		180	1.345	1.528	1.597	2.255	3080	700	5.629	6.229	6.481	8.676
6.45		200	1.495	1.691	1.778	2.500		720	5.808	6.425	6.673	8.912
	2.5	220	1.634	1.852	1.936	2.720		740	6.006	6.635	6.899	9.203
	10.3	240	1.780	2.020	2.110	2.960		760	6.200	6.833	7.100	9.460
	20.7	260	1.931	2.183	2.279	3.189		780	6.389	7.046	7.314	9.736
	34.5	280	2.085	2.350	2.465	3.422		800	6.587	7.250	7.508	9.992
	52.3	300	2.233	2.159	2.630	3.665		820	6.779	7.464	7.757	10.272
	74.9	320	2.395	2.690	2.800	3.900		840	6.970	7.662	7.952	10.512
	103.3	340	2.543	2.862	2.988	4.145		860	7.176	7.888	8.195	10.814
	138.3	360	2.700	3.029	3.175	4.380		880	7.375	8.098	8.400	11.175
	180.9	380	2.859	3.211	3.350	4.628		900	7.579	8.313	8.639	11.360
	232.4	400	3.008	3.375	3.521	4.870		920	7.795	8.545	8.867	11.625
	293.7	420	3.182	3.566	3.720	5.118		940	7.989	8.755	9.089	11.911
	366.1	440	3.345	3.740	3.900	5.358		960	8.200	8.975	9.300	12.180
	451.3	460	3.511	3.929	4.096	5.612		980	8.406	9.196	9.547	12.473
	550.3	480	3.683	4.100	4.280	5.855		1000	8.617	9.421	9.776	12.747

aFrom *Piping Handbook*, by Walker and Crocker. This table gives the expansion from −20F. to the temperature in question. To obtain the amount of expansion between any two temperatures take the difference between the figures in the table for those temperatures. For example, if a steel pipe is installed at a temperature of 6 F. and is to operate at 300 F. the expansion would be 2.519 − 0.593 = 1.926 in.

TEMPERATURE CONVERSION TABLES

Note—The numbers in **black face** refer to the temperature in either degrees Centigrade or Fahrenheit which it is desired to convert into the other scale.

(Approximate)
0 to 400

C		F	C		F	C		F	C		F
—17.8	**0**	32	0	**32**	89.6	19.4	**67**	152.6	37.2	**99**	210.2
—17.2	**1**	33.8	.6	**33**	91.4	20.0	**68**	154.4	37.8	**100**	212.0
—16.7	**2**	35.6	1.1	**34**	93.2	20.4	**69**	156.2	37.8	**100**	212
—16.1	**3**	37.4	1.7	**35**	95.0	21.1	**70**	158.0	43.3	**110**	230
—15.5	**4**	39.2	2.2	**36**	96.8	21.7	**71**	159.8	48.9	**120**	248
—15.0	**5**	41.0	2.8	**37**	98.6	22.2	**72**	161.6	54.4	**130**	266
—14.4	**6**	42.8	3.3	**38**	100.4	22.8	**73**	163.4	60	**140**	284
—13.9	**7**	44.6	3.9	**39**	102.2	23.3	**74**	165.2	65.6	**150**	302
—13.3	**8**	46.4	4.4	**40**	104.0	23.9	**75**	167.0	71	**160**	320
—12.8	**9**	48.2	4.9	**41**	105.8	24.4	**76**	168.8	76.7	**170**	338
—12.2	**10**	50.0	5.6	**42**	107.6	25.0	**77**	170.6	82.2	**180**	356
—11.6	**11**	51.8	6.1	**43**	109.4	25.6	**78**	172.4	87	**190**	374
—11.1	**12**	53.6	6.7	**44**	111.2	26.1	**79**	174.2	93.3	**200**	392
—10.6	**13**	55.4	7.2	**45**	113.0	26.6	**80**	176.0	98.9	**210**	410
—10.0	**14**	57.2	7.8	**46**	114.8	27.2	**81**	177.8	100	**212**	413
— 9.4	**15**	59.0	8.3	**47**	116.6	27.8	**82**	179.6	104	**220**	428
— 8.9	**16**	60.8	8.9	**48**	118.4	28.3	**83**	181.4	110	**230**	446
— 8.3	**17**	62.6	9.4	**49**	120.2	28.9	**84**	183.2	115	**240**	464
— 7.8	**18**	64.4	10.0	**50**	122.0	29.4	**85**	185.0	121	**250**	482
— 7.2	**19**	66.2	10.6	**51**	123.8	29.9	**86**	186.8	127	**260**	500
— 6.7	**20**	68.0	11.1	**52**	125.6	30.4	**87**	188.6	132	**270**	518
— 6.1	**21**	69.8	11.7	**53**	127.4	31.0	**88**	190.4	138	**280**	536
— 5.5	**22**	71.6	12.2	**54**	129.2	31.6	**89**	192.2	143	**290**	554
— 5.0	**23**	73.4	12.8	**55**	131.0	32.2	**90**	194.0	149	**300**	572
— 4.4	**24**	75.2	13.3	**56**	132.8	32.6	**91**	195.8	154	**310**	590
— 3.9	**25**	77.0	13.7	**57**	134.6	33.3	**92**	197.6	160	**320**	608
— 3.3	**26**	78.8	14.4	**58**	136.4	33.8	**93**	199.4	165	**330**	626
— 2.8	**27**	80.6	15.0	**59**	138.2	34.4	**94**	201.2	171	**340**	644
— 2.2	**28**	82.4	15.6	**60**	140.0	35.0	**95**	203.0	177	**350**	662
— 1.7	**29**	84.2	16.7	**62**	143.6	35.5	**96**	204.8	182	**360**	680
— 1.1	**30**	86.0	16.1	**61**	141.8	36.1	**97**	206.6	188	**370**	698
— .6	**31**	87.8	17.2	**63**	145.4	36.6	**98**	208.4	193	**380**	716
			17.8	**64**	147.2				199	**390**	734
			18.2	**65**	149.0				204	**400**	752
			18.9	**66**	150.8						

TEMPERATURE CONVERSION FORMULA

To find Fahrenheit temperature when Centigrade temperature is known—(Centigrade Reading $\times$ 1.8) + 32 = Fahrenheit.

To find Centigrade temperature when Fahrenheit temperature is known—$\frac{(\text{Fahrenheit Reading} - 32)}{1.8}$ = Centigrade temperature. See Temperature Conversion Tables.

INSULATION

Insulation holds the heat in a building and keeps out the cold. In properly insulated buildings, there should be at least 25% lesser fuel consumption than in buildings which are not insulated. It is customary to figure that the insulated building requires from ten to twenty per cent less radiation and boiler capacity, as well as relatively smaller pipe sizes, than would be required for the same building if not inuslated. The reduction is, of course, dependent upon the completeness of insulation used, and, therefore, should be estimated on that basis.

Especially is it a saving proposition to insulate the ceiling on the top floor, as these in most buildings are only lath and plaster without even flooring on the top of the joists. The heat lost through lath and plaster is very high and consequently heat travels very fast through such ceiling material into the attic space. Therefore, stopping this excessive heat transmission will mean a corresponding reduction in fuel consumption.

BOILERS AND ENGINES

Standard adopted by American Society of Mechanical Engineers defines the boiler horsepower as the equivalent evaporation of 34.5 lb of water from and at 212 degrees per hour. This is the same as 33,479 Btu per hour.

The best designed boilers, well set, with good draft, and skillful firing, will evaporate from 7 to 10 pounds of water per pound of first-class coal.

On 1 square foot of grate can be burned on an average from 10 to 12 pounds of hard coal, or 18 to 20 pounds of soft coal per hour, with natural draft. With forced draft nearly double these amounts can be burned.

Compound engines will develop a horsepower on 15 pounds of steam.

Single condensing engine will develop a horsepower on 22 to 28 pounds of steam.

Automatic non-condensing engines will develop a horsepower on 28 to 32 pounds of steam.

Slide-valve throttle-governing engine will develop a horsepower on 62½ pounds of steam.

Horsepower of a Steam Engine

a—Area of the piston in square inches.
p—Mean velocity pressure of steam on piston per square inch.
v—Velocity of piston per minute.

$$\text{Then H P} = \frac{a \times p \times v}{33{,}000}$$

The mean pressure in the cylinder when cutting off at

¼ stroke = boiler pressure multiplied by .597
⅓ " = " " " " .670
⅜ " = " " " " .743
½ " = " " " " .847
⅝ " = " " " " .919
⅔ " = " " " " .937
¾ " = " " " " .966
⅞ " = " " " " .992

To find the diameter of a cylinder of an engine of a required nominal horsepower:

$$\frac{5500}{v} \text{ multiplied by H P} = a$$

To find the weight of the rim of the fly-wheel for an engine:

$$\frac{\text{Nominal H P multiplied by 2,000}}{\text{Sq. of velocity of circumference in ft. per second}} = \text{wt. in cwts.}$$

SPECIFIC HEAT OF SOLIDS, LIQUIDS AND GASES

Materials	Temperature F.	Specific Heat	Authority
Alloys			
Brass, Red	32	0.0899	S
Brass, Yellow	32	0.0883	S
Bronze (80*Cu*, 20*Sn*)	57-208	0.0862	S
Monel Metal	68-2370	0.127	S
Aluminum	80-212	0.212	S
Asbestos	68-208	0.195	S
Brickwork	....	0.195	H
Carbon (Graphite)	104-1637	0.314	I
Coal	....	0.278	H
Coke	....	0.201	H
Concrete	....	0.270	H
Copper	64-212	0.0928	S
Fire Clay Brick	77-1832	0.258	I
Glass			
Crown	50-122	0.161	S
Flint	50-122	0.117	S
Gold	64	0.0312	S
Gypsum	....	0.259	H
Ice	32	0.487	S
Ice	−40	0.434	S
Iron, Pure	32	0.1043	S
Iron, Pure	32-600	0.127	M
Iron, Cast	68-212	0.1189	H
Iron, Wrought	59-212	0.1152	H
Lead	32	0.0297	S
Nickel	32	0.1032	S
Masonry	....	0.2159	H
Plaster	....	0.2	H
Platinum	58-212	0.0319	S
Rocks			
Gneiss	63-210	0.196	S
Granite	54-212	0.192	S
Limestone	59-212	0.216	S
Marble	32–212	0.21	S
Sandstone	....	0.22	S
Silver	32	0.0536	S
Steel	....	0.1175	H
Sulphur	240-320	0.220	S
Silica Brick	77-1832	0.263	I
Tin	77	0.0548	S
Woods (Average)	68	0.327	S
Zinc	32	0.0913	S

TABLE 2. SPECIFIC HEAT OF LIQUIDS

Liquid	Temperature F.	Specific Heat	Authority
Alcohol, Ethyl	32	0.548	S
Alcohol, Methyl	59-68	0.601	S
Glycerine	59-122	0.576	S
Lead (Molten)	360	0.041	H
Mercury	68	0.03325	S
Petroleum	70-136	0.511	S
Sea Water			
Sp. Gr. 1.0043	64	0.980	S
Sp. Gr. 1.0463	64	0.903	S
Water	59	1.000	S

TABLE 3. SPECIFIC HEAT OF GASES AND VAPORS

Substance	Temperature F.	Specific Heat at Constant Pressure	Ratio of Specific Heat Cp/Cv	Specific Heat at Constant Volume (Computed)	Authority
Air	32-392	0.2375	1.405	0.169	S
Ammonia	80-392	0.5356	1.277	0.419	S
Carbon Dioxide	52-417	0.2169	1.3003	0.1668	S
Carbon Monoxide	79-388	0.2426	1.395	0.1736	S
Coal Gas	68-1900	0.3145	....	....	S
Flue Gas	......	0.24 (Approx.)	....	....	H
Hydrogen	70-212	3.41	1.419	2.402	S
Nitrogen	32-392	0.2438	1.41	0.1729	S
Oxygen	55-404	0.2175	1.3977	0.155	S
Water Vapor	212	0.421	1.305	0.322	S
Water Vapor	356	0.51	....	....	S

NOTES: When one temperature is given the true specific heat is given, otherwise the value is the mean specific heat between the given limits.

AUTHORITIES: S—Smithsonian Physical Tables, 1933; I—International Critical Tables; H—Heating, Ventilation and Air Conditioning, by L. A. Harding and A. C. Willard; M—Engineers' Handbook, by Lionel S Marks.

CIRCUMFERENCES AND AREAS OF CIRCLES

Diameter in Inches	Area		Circumference		Diameter in Inches	Area		Circumference	
	Sq. In.	Sq. Ft.	Inches	Feet		Sq. In.	Sq. Ft.	Inches	Feet
¼	0.049	0.0003	0.785	0.0652	28	615.8	4.276	87.97	7.330
½	0.196	0.0014	1.571	0.1309	28½	637.9	4.430	89.54	7.462
¾	0.442	0.0031	2.356	0.1964	29	660.52	4.587	91.11	7.592
1	0.785	0.0054	3.142	0.2618	29½	683.5	4.747	92.63	7.725
1¼	1.227	0.0085	3.927	0.3273	30	706.8	4.909	94.25	7.854
1½	1.767	0.0123	4.712	0.3927	31	754.8	5.241	97.39	8.116
1¾	2.405	0.0167	5.498	0.4582	32	804.3	5.585	100.5	8.378
2	3.142	0.0218	6.283	0.5236	33	855.3	5.940	103.7	8.639
2¼	3.976	0.0276	7.069	0.5891	34	907.9	6.305	105.8	8.901
2½	4.909	0.0341	7.854	0.6546	35	962.1	6.681	109.9	9.163
2¾	5.939	0.0412	8.639	0.7200	36	1018.0	7.069	113.1	9.425
3	7.069	0.0491	9.425	0.7854	37	1075.0	7.467	116.2	9.686
3¼	8.296	0.0576	10.21	0.8510	38	1134.0	7.876	119.4	9.948
3½	9.621	0.0668	10.99	0.9160	39	1195.0	8.296	122.5	10.21
3¾	11.04	0.0767	11.78	0.9818	40	1256.0	8.727	125.6	10.47
4	12.57	0.0873	12.57	1.047	41	1320.0	9.168	128.8	10.73
4¼	14.19	0.0986	13.35	1.113	42	1385.0	9.621	131.9	10.99
4½	15.90	0.1104	14.14	1.178	43	1452.0	10.08	135.1	11.26
4¾	17.72	0.1231	14.92	1.243	44	1521.0	10.56	138.2	11.52
5	19.64	0.1364	15.71	1.309	45	1590.0	11.04	141.4	11.78
5¼	21.65	0.1504	16.49	1.374	46	1662.0	11.54	144.5	12.04
5½	23.76	0.1650	17.28	1.440	47	1735.0	12.05	147.7	12.30
5¾	25.97	0.1840	18.06	1.505	48	1810.0	12.51	150.8	12.57
6	28.27	0.1964	18.85	1.571	49	1886.0	13.09	153.9	12.83
6¼	30.68	0.2131	19.64	1.637	50	1963.0	13.64	157.1	13.09
6½	33.18	0.2304	20.42	1.702	51	2043.0	14.19	160.2	13.35
6¾	35.79	0.2486	21.21	1.768	52	2124.0	14.75	163.4	13.61
7	38.49	0.2673	21.99	1.833	53	2206.0	15.32	166.5	13.88
7¼	41.28	0.2867	22.78	1.899	54	2290.0	15.90	169.6	14.14
7½	44.18	0.3068	23.56	1.964	55	2376.0	16.50	172.8	14.40
7¾	47.17	0.3276	24.35	2.029	56	2463.0	17.10	175.9	14.66
8	50.27	0.3491	25.13	2.094	57	2552.0	17.72	179.1	14.92
8¼	53.46	0.3713	25.92	2.160	58	2642.0	18.35	182.2	15.18
8½	56.75	0.3942	26.70	2.225	59	2734.0	18.99	185.4	15.45
8¾	60.13	0.4175	27.49	2.291	60	2827.0	19.63	188.5	15.71
9	63.62	0.4418	28.27	2.356	61	2922.0	20.29	191.6	15.97
9¼	67.20	0.4668	29.06	2.422	62	3019.0	20.97	194.8	16.23
9½	70.88	0.4923	29.85	2.488	63	3117.0	21.65	197.9	16.49
9¾	74.66	0.5185	30.63	2.553	64	3217.0	22.34	201.1	16.76
10	78.54	0.5454	31.42	2.618	65	3318.0	23.04	204.2	17.02
10½	86.59	0.6010	32.99	2.750	66	3421.0	23.76	207.3	17.28
11	95.03	0.6600	34.56	2.880	67	3526.0	24.48	210.5	17.54
11½	103.9	0.7215	36.13	3.011	68	3632.0	25.22	213.6	17.80
12	113.1	0.7854	37.70	3.142	69	3739.0	25.97	216.8	18.06
12½	122.7	0.8520	39.27	3.273	70	3848.0	26.73	219.9	18.33
13	132.7	0.9218	40.84	3.403	71	3959.0	27.49	223.1	18.59
13½	143.1	0.9937	42.41	3.535	72	4072.0	28.27	226.2	18.85
14	153.9	1.069	43.98	3.665	73	4185.0	29.07	229.3	19.11
14½	165.1	1.146	45.55	3.796	74	4301.0	29.87	232.5	19.37
15	176.7	1.227	47.12	3.927	75	4418.0	30.68	235.6	19.63
15½	188.7	1.310	48.69	4.058	76	4536.0	31.50	238.8	19.90
16	201.1	1.396	50.27	4.189	77	4657.0	32.34	241.9	20.16
16½	213.8	1.485	51.84	4.321	78	4778.0	33.18	245.0	20.42
17	226.9	1.576	53.41	4.451	79	4902.0	34.04	248.2	20.68
17½	240.5	1.670	54.98	4.582	80	5027.0	34.91	251.3	20.94
18	254.5	1.767	56.55	4.712	81	5153.0	35.78	254.5	21.21
18½	268.8	1.867	58.12	4.845	82	5281.0	36.67	257.6	21.47
19	283.5	1.969	59.69	4.974	83	5411.0	37.57	260.8	21.73
19½	298.6	2.074	61.26	5.105	84	5542.0	38.48	263.9	21.99
20	314.2	2.182	62.83	5.236	85	5675.0	39.41	267.0	22.25
20½	330.1	2.293	64.40	5.367	86	5809.0	40.34	270.2	22.51
21	346.4	2.405	65.97	5.498	87	5945.0	41.28	273.3	22.78
21½	361.1	2.508	67.54	5.629	88	6082.0	42.24	276.5	23.04
22	380.1	2.640	69.12	5.760	89	6221.0	43.20	279.6	23.30
22½	397.6	2.761	70.69	5.891	90	6362.0	44.18	282.7	23.56
23	415.5	2.885	72.26	6.021	91	6504.0	45.17	285.9	23.82
23½	433.7	3.012	73.83	6.153	92	6648.0	46.16	289.0	24.09
24	452.4	3.142	75.40	6.283	93	6793.0	47.17	292.2	24.35
24½	471.4	3.274	76.97	6.415	94	6940.0	48.19	295.3	24.61
25	490.9	3.409	78.54	6.545	95	7088.0	49.22	298.4	24.87
25½	510.7	3.547	80.11	6.676	96	7238.0	50.27	301.6	25.13
26	530.9	3.687	81.68	6.807	97	7390.0	51.32	304.7	25.39
26½	551.6	3.832	83.25	6.938	98	7543.0	52.38	307.9	25.66
27	572.6	3.976	84.82	7.069	99	7698.0	53.46	311.0	25.92
27½	593.9	4.125	86.39	7.199	100	7854.0	54.54	314.2	26.18

Metric and English Measures

	Metric			English	
Length	1	metre	=	39.37	inches
				3.28	feet
	.3048	metre	=	1	foot
	1	centimetres	=	.3937	inch
	2.54	centimetres	=	1	inch
	1	millimetre	=	.03937	in. (1-25 in., nearly)
	25.4	millimetres	=	1	inch
	1	kilometre	=	1093.61	yards
Surface	1	sq. metre	=	10.764	square feet
	.0929	sq. metre	=	1	square foot
	1	sq. cent.	=	.155	square inch
	6.452	sq. cents.	=	1.	square inch
	1	sq. mill.	=	.00155	square inch
	645.2	sq. mills.	=	1	square inch
Volume	1	cubic metre	=	35.314	cubic feet
	.02832	cubic metre	=	1	cubic foot
	1	cubic decim.	=	61.023	cubic inches
				.0353	cubic foot
	28.32	cubic decims.	=	1	cubic foot
	16.387	cubic cent'ms.	=	1	cubic inch
	1	cubic cent.	=	1	millimetre
				.061	cubic inch
Capacity		litre = 1 cu. decimetre	=	61.023	cubic inches
				.0353	cubic foot
				.2642	gallon (U.S.)
				2.202	pounds of water at 62 degrees Fahr.
	28.317	litres	=	1	cubic foot (7.481 U.S. gallons)
	4.543	litres	=	1	gallon (Imperial)
	3.785	litres	=	1	gallon (U.S.)
Weight	28.35	grammes	=	1	ounce avoirdupois
	1	kilogramme	=	2.2046	pounds
	.4536	kilogramme	=	1	pound
	1	metric ton	=	.9842	ton of 2240 lbs., or
	1000	kilogrammes		19.68	cwts. of 2204.6 lbs.
	1.012	metric ton	=	1	ton of 2240 pounds
	1016	kilogrammes			
Pressure and Weight	1	lb. per sq. inch	=	144	lb per square foot
				2.0355	inches of mercury at 32 degrees Fahr.
				2.0416	inches of mercury at 62 degrees Fahr.
				2.309	ft. of water at 62 degrees Fahr.
				27.71	inches of water at 62 degrees Fahr.
	1	Atmospheric (14.7 lb. per sq. in.)	=	2116.3	lb per square foot
				33.947	ft. of water at 62 degrees Fahr.
				30	inches of mercury at 62 degrees Fahr.
				29.922	inches of mercury at 32 degrees Fahr.
				760	millimetres of mercury at 32 degrees Fahr.
	1	Foot of Water at 62 degrees F.	=	.433	lb per square inch
				62.355	lb per square foot
	1	Inch of Mercury at 62 degrees F.	=	.491	lb or 7.86 oz. per sq. in.
				1.132	ft. of water at 62 degrees Fahr.
				13.58	inches of water at 62 degrees Fahr.

Miscellaneous

1	gramme per square millimetre	=	1.422	lb. per square inch
1	kilogramme per square millimetre	=	1422.32	lb. per square inch
1	kilogramme per square centimetre	=	14.223	lb. per square inch
1.0335	kg. per sq. centimetre 1 atmosphere	=	14.7	lb. per square inch
0.070308	kilogramme per square centimere	=	1	lb. per square inch

General Data

1 Calorie	=	3.968	Btu
1 Btu	=	0.252	calorie
1 lb per sq. in.	=	703.08	kilogrammes per m²
1 Kilogramme per m²	=	.00142	lb per sq. in.
1 Calorie per m²	=	.3687	Btu per sq. ft.
1 Btu per sq. ft.	=	2.712	calories per m²
1 Calorie per m² per degree difference Cent.	=	.2048	Btu per sq. ft. per degree difference Fahr.
1 Btu per sq. ft. per degree difference Fahr.	=	4.882	calories per m² per degree difference Cent.
1 Btu per lb.	=	.556	calories per kilog.
1 Calorie per kilog.	=	1.8	Btu per lb.
1 Litre of Coke at 26.3 lb per cubic foot	=	.93	lb
1 lb of Coke at 26.3 lb per cu. ft.	=	1.076	litres

Water expands in bulk from 40 degrees to 212 degrees............ = One twenty-third.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic foot of steam (approximately).

RULES RELATIVE TO THE CIRCLE

To Find Circumference

Multiply diameter by 3.1416, or divide diameter by 0.3183.

To Find Diameter

Multiply circumference by 0.3183, or divide circumference by 3.1416.

To Find Radius

Multiply circumference by 0.15915, or divide circumference by 6.28318.

To Find Side of an Inscribe Square

Multiply diameter by 0.7071, or multiply circumference by 0.2251, or divide circumference by 4.4428.

To Find Side of an Equal Square

Multiply diameter by 0.8862, or divide diameter by 1.1284, or multiply circumference by 0.2821, or divide circumference by 3.545.

Square

A side multiplied by 1.1442 equals diameter of its circumscribing circle.

A side multiplied by 4.443 equals circumference of its circumscribing circle.

A side multiplied by 1.128 equals diameter of an equal circle.

A side multiplied by 3.547 equals circumference of an equal circle.

Square inches multiplied by 1.273 equals circle inches of an equal circle.

To Find the Area of a Circle

Multiply circumference by one-quarter of the diameter, or multiply the square of diameter by 0.7854, or multiply the square of circumference by 0.7958, or multiply the square of ½ diameter by 3.1416.

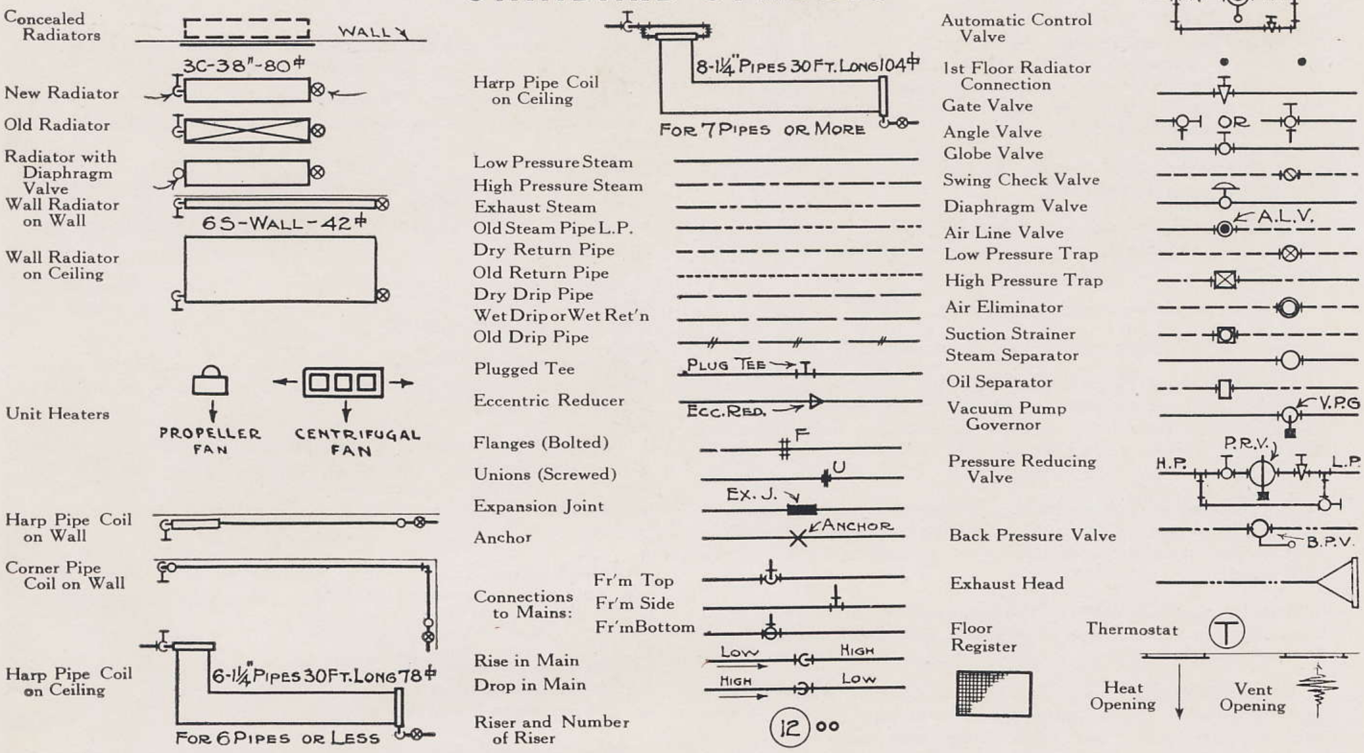
To Find the Surface of a Sphere or Globe

Multiply the diameter by the circumference, or multiply the square of diameter by 3.1416, or multiply 4 times the square of radius by 3.1416.

ABBREVIATIONS

Alternating-current..........ac
Ampere..........amp.
Area..........A
Atmosphere..........atm
Average..........avg
Boiler pressure..........bp
Boiling point..........bp
British thermal unit..........Btu
Cubic foot..........cu ft
Cubic feet per minute..........cfm
Cubic feet per second..........cfs
Degree..........deg or °
Degree Fahrenheit..........°F
Diameter..........D or diam
Direct-current..........dc
Foot..........ft
Gallon..........gal
Gallons per minute..........gpm
Gallons per second..........gps
Horsepower..........hp
Inch..........in.
Ounce..........oz
Revolutions per minute..........rpm
Square foot..........sq ft
Square inch..........in. sq

STANDARD SYMBOLS



Figs. 887B—888A

GLOSSARY OF HEATING TERMS

Actual Evaporation: By this term is meant the total quantity of water (in pounds) evaporated from the temperature of the feed water to steam at 212 degrees Fahrenheit. (See paragraph on Equivalent Evaporation.)

Atmospheric Pressure: The pressure exerted by the atmosphere may be established by the simple experiment of taking a glass tube with an area of 1 square inch and approximately 30 inches high, with one end closed; filling same with mercury and inverting the tube in mercury, it will be found at the sea-level that the mercury will stand in the column 29.9 inches high, or practically 30 inches. As 1 cubic foot of mercury weighs 850 pounds, 1 cubic inch would weigh 0.49 pounds; and as the mercury in the tube under the pressure of the atmosphere stands 30 inches high, and the area is 1 square inch, there would be 30 cubic inches of mercury in the tube, which would weigh 30 x 0.49 or 14.7 pounds. As this column of mercury, weighing 14.7, is entirely sustained by the pressure of the atmosphere, it may be stated that the normal pressure at sea-level is 14.7 pounds per square inch. This pressure varies with the altitude and under different conditions of the barometer.

Boiler Heating Surface—Direct: That surface which receives the radiant heat of the fire, or that surface on which the fire shines.

The transmission of heat through direct surface is practically constant for like temperature differences.

Boiler Heating Surface—Indirect Flue: That surface in a boiler on which the fire does not shine, but through which the constantly cooling gases pass to the smokestack.

The value of indirect, or flue surface, is extremely variable, because the escaping gases are constantly cooling; the rate of transmission becomes less and less as the gases approach the smoke outlet.

Btu: (British Thermal Unit, Heat Unit): The quantity of heat required to raise 1 pound of water 1 degree Fahrenheit.

Caking Coal: Term which is usually applied to coal which fuses together when burning, as opposted to free-burning coal.

Calorie: The Continental heat unit, or calorie, is the quantity of heat required to raise the temperature of 1 kilogram of water 1 degree Centigrade, and as 1 kilogram is equal to 2.205 pounds and 1 degree Centigrade is equal to 1.8 degrees Fahrenheit, it is obvious that one calorie measures the same quantity of heat as does 3.969 B. t. u. This is shown by multiplying 1.8 by 2.205. It is usual when translating from the English and American standard to the Continental or Metric standard of heat measure to call 1 calorie equal to 3.97 B. t. u.

Caloric Power of any combustible substance is the number of B. t. u. per pound, which is the measure of heat stored in the fuel.

Caloric Power Available: That portion of the calorific power which is absorbed by the water in the boiler, and transferred to the piping and radiation for heating purposes.

Calorimeter: A double-walled vessel is immersed in a tank of water. Within the inner vessel is placed a cartridge or shell. A small quantity of fuel is powdered and put in the cartridge, together with a sufficient amount of oxygen needed for complete combustion. The combustible is ignited by dropping therein a copper wire heated red-hot, or set off by an electric spark. As combustion takes place the cartridge is revolved so that the surrounding water comes in contact with the heated surfaces. A thermometer projected into the water records the initial temperature, and finally, the maximum temperature to which the water has been raised. As the water has been carefully weighed, it is easily established how many degrees temperature each pound of water has been raised. The maximum heat attained establishes the thermal value or heating power of the combustible.

By this means, the thermal values of the different varieties of coal are established.

Clinker: Term used to designate such part of fuel which fuses together, and is composed of non-combustible material.

CO: Symbol for carbon monoxide.

CO_2: Symbol for carbon dioxide or carbonic acid gas.

Co-efficient of Heat Emission: This term is usually applied to the heat emitted, or given off, by 1 square foot of radiation per hour for 1 degree temperature difference between the steam or water in the radiator and the surounding air.

Co-efficient of Transmission: Is the quantity of heat, expressed in terms of Btu which will pass through 1 square foot of surface in one hour for 1 degree temperature difference.

Combustion Chamber: That portion of fire-pot or fire-box between the surface of fuel-bed and the crowning surface of heater.

Combustion, Rate of: The rate of combustion is a term usually applied to the quantity of coal burned per square foot of grate per hour. The term may also be used to designate the quantity of fuel burned by the boiler per hour.

Condensation: The act of reducing vapor or steam to water by cooling.

Condensing Power (of Radiation): The condensing power of radiation is the quantity of steam (in pounds) which a radiator will condense per square foot per hour.

Conduction: Conduction is the transfer of heat between two bodies or parts of a body which touch each other. Internal conduction takes place between the parts of one continuous body, and external conduction through the surface of contact of a pair of distinct bodies.

Convection: Convection, or carrying of heat, means the transfer or diffusion of the heat in a fluid mass by means of the motion of the particles of that mass.

The conduction, properly so called, of heat through a stagnant mass of fluid is very slow in liquids, and almost, if not wholly, inappreciable in gases. It is only by the continual circulation and mixture of the particles of the fluid that uniformity of temperature can be maintained in the fluid mass, or heat transferred between the fluid mass and a solid body.

Efficiency (Boiler). (Based on Coal Consumption): The percentage of calorific power absorbed by the water in the boiler.

Equivalent Evaporation is the total quantity of water (in pounds) evaporated from a temperature of 212 to steam at 212 degrees Fahrenheit. (See Actual Evaporation, page 120.)

Evaporation: The act of resolving, or the state of being resolved, into vapor. The conversion of boiling water by heat into vapor or steam.

Evaporative Power (of a Boiler) is the quantity of water (in pounds) which 1 pound of coal burned in said boiler will evaporate.

Evaporative Power (of Fuel): The quantity of water (in pounds) which 1 pound of fuel will evaporate in burning. Theoretical evaporation is the quantity of water evaporated by 1 pound of fuel burning to perfect combustion.

Free-Burning Coal: Term applied to coal which does not fuse together when burning; otherwise a non-caking coal.

Heating Surface (H. S.): The heating surface of a boiler is that portion of the inner walls separating the fire or heated glass from the water.

Heat Transmission: When the temperature on opposite sides of any surface are unequal, the heat will flow through the material from the warmer to the cooler side. This is called heat transmission.

Ignition Temperature: The ignition temperature of a substance is that temperature to which it must be raised in the presence of oxygen to cause the two to unite by combustion. It is rather indefinite and varies for different types of fuel. The exact temperature can only be determined by direct experiment with the partciular variety of fuel under test. For coal it is approximately considered 800 degrees Fahrenheit.

Latent Heat is that quantity of heat necessary to evaporate 1 pound of water into steam at same temperature.

Radiation of Heat: Radiation of heat takes place between bodies at all distances apart, and follows the law for the radiation of light.

The heat rays proceed in straight lines, and the intensity of the rays radiated from any one source varies inversely as the square of their distance from the source.

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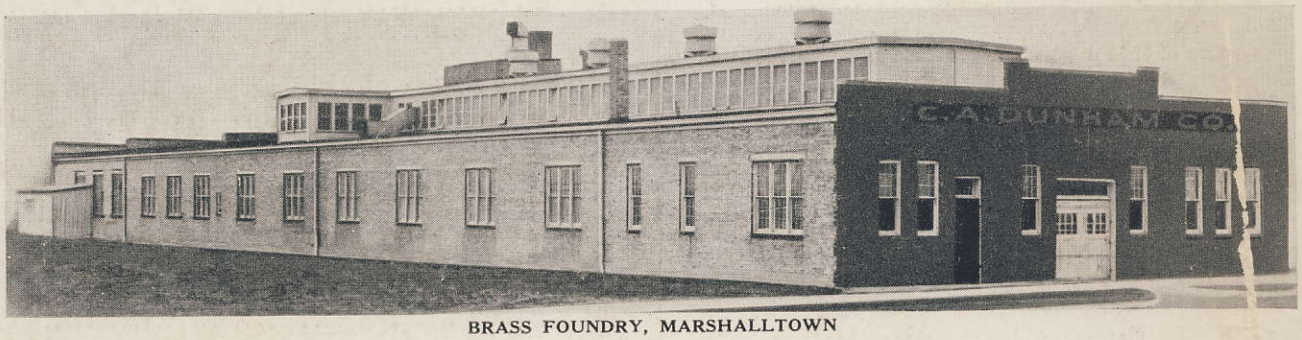

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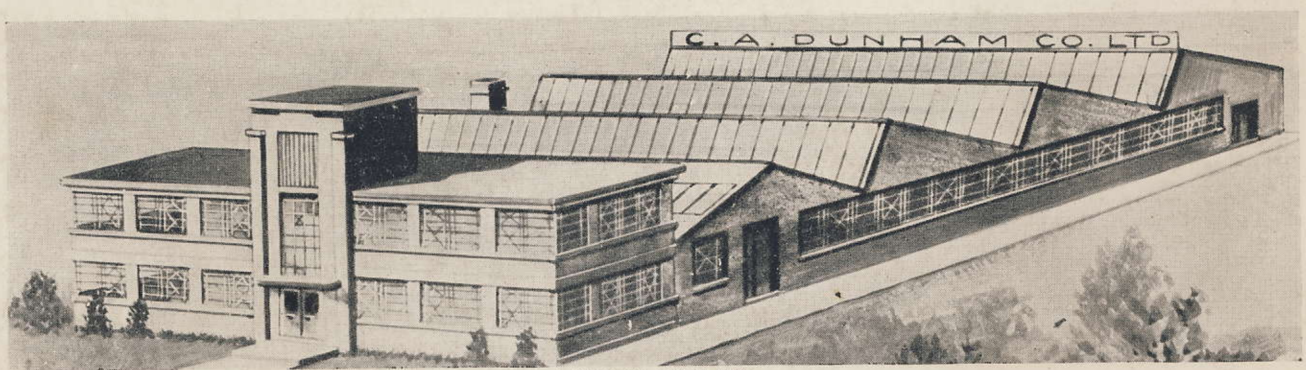

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