HEATING PLANTS
GENERAL DESCRIPTION AND FUNDAMENTALS

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1. GENERAL

1.01 This section covers general descriptions, terminologies, and basic fundamentals of low-pressure heating boilers, warm air furnaces, automatic fuel burning devices, and associated controls. Also, heating systems, heating plant sizing, heat sources, combustion air, and space requirements are discussed in this section.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 The objective of this section and subsequent sections is to recommend systems, equipment, and controls to provide a safe and economical heating system. These systems can be installed in telephone buildings either as a new installation or replacement of obsolete or improperly sized equipment.

1.04 The recommendations contained in this section are minimum requirements. Other codes having jurisdiction will apply if they are more stringent. Engineering judgment, based on a specific job, may dictate more stringent requirements.

1.05 Economics must deal with life-cycle costing which includes energy conservation. This must be considered for each job on an individual basis.

1.06 The illustrations used in this section have been selected to show typical examples of equipment referred to in the text. They are not intended to endorse or recommend any manufacturer's product, nor are they intended to be used as design criteria or as examples of preferred layout. For detailed information on any specific unit, consult the manufacturer's literature.

2. BOILER CLASSIFICATIONS

2.01 Boilers are classified by construction materials into two groups: cast iron and steel.

CAST-IRON BOILERS

2.02 Cast-iron boilers are divided into two general classifications:

(1) ***Boilers With Round Horizontal Sections:*** These are normally limited to very small buildings or locations requiring a maximum heating capacity of approximately 500 MBh (1000 British thermal units [BTUs] per hour) gross output.

(2) ***Square or Rectangular Boilers With Vertical Sections:*** These are used for any application up to capacities of approximately 13,000 MBh gross output. Most of these boilers are of the internal push-nipple type; however, some are constructed with external headers and screw nipples.

A. Round Cast-Iron Boilers

2.03 Round cast-iron boilers are made up of stacked horizontal sections. These boilers are economical and dependable. The trend in smaller telephone buildings, however, has been toward heating systems of a type requiring less maintenance, eg, hot air systems and electric heating. As a result, the round boiler is not often used in Bell System buildings.

B. Sectional Cast-Iron Boilers

2.04 Sectional cast-iron boilers are square or rectangular in shape and have stacked vertical sections. The sectional boiler can be expanded or enlarged by adding sections. The heating surface of this type boiler is large in comparison to its water volume and has excellent steaming, internal water circulation, and efficiency characteristics.

2.05 There are two basic types of sectional boilers:

(1) ***Internal Push Nipple:*** This type is most commonly used for telephone buildings.

(2) ***External Header or Drum:*** This type utilizes screw nipples.

Internal Push Nipple

2.06 The sections of internal push-nipple boilers are joined with tapered nipples and pulled tightly together with tie-rods or bolts. (See Fig. 1.) These tie-rods are not necessary to hold the boiler together. The tapered design and the ground surfaces of the nipples and the openings into which they fit are such that when the sections are drawn together with the tie-rods, the joints will remain tight, even though the rods are removed. They are left in the boiler merely for convenience in reassembling the sections in case of repair at a later date.

2.07 Internal push-nipple boilers can be fired with either gas or fuel oil. Boilers of this type that are designed exclusively for gas fuel are constructed with minimum-sized combustion chambers. (See Fig. 2.) These, along with studs cast into the sections, provide for a maximum of heat absorbing surface.

External Header or Drum

2.08 External header or drum (manifold) type boilers have the sections individually connected to the header drums (manifolds) with screw nipples. (See Fig. 3.) A common arrangement is a steam drum at the top with two return drums at the bottom, one on each side. Individual sections may be disconnected and replaced without disturbing the rest of the assembly.

STEEL BOILERS

2.09 Steel boilers are divided into two general classifications:

(1) ***Fire-Tube Boiler:*** This is where gases of combustion pass through the tubes, and water circulates around them.

(2) ***Water-Tube Boiler:*** This is where gases circulate around the tubes, and water is contained in the tubes.

Note: Most low-pressure, steel, heating boilers are of the fire-tube type.

2.10 Capacities of steel fire-tube boilers range from those required for small buildings up to about 26,000 MBh output. This type boiler has a large water storage capacity giving it the ability to dampen the effect of wide and sudden fluctuations in steam demand. The fire-tube boiler is widely used for heating systems; however, it is limited to applications where the demands for steam are relatively small as compared to those of large power station installations that use water-tube boilers.

2.11 Fire-tube steel boilers can be further classified as:

- External furnace
- Internal furnace.

A. External Furnace Boilers

2.12 In the external furnace boiler, which may be brick set or steel jacketed, it is essentially surrounded by a refactory rather than water. The best example of an external furnace boiler is the horizontal return tubular (HRT) boiler. (See Fig. 4.) These boilers are primarily designed for use as high-pressure boilers and are used for industrial process steam applications, although many are operated at low pressure for heating buildings.

B. Internal Furnace Boilers

2.13 Internal furnace boilers may have the furnace in the form of a straight flue completely sur-

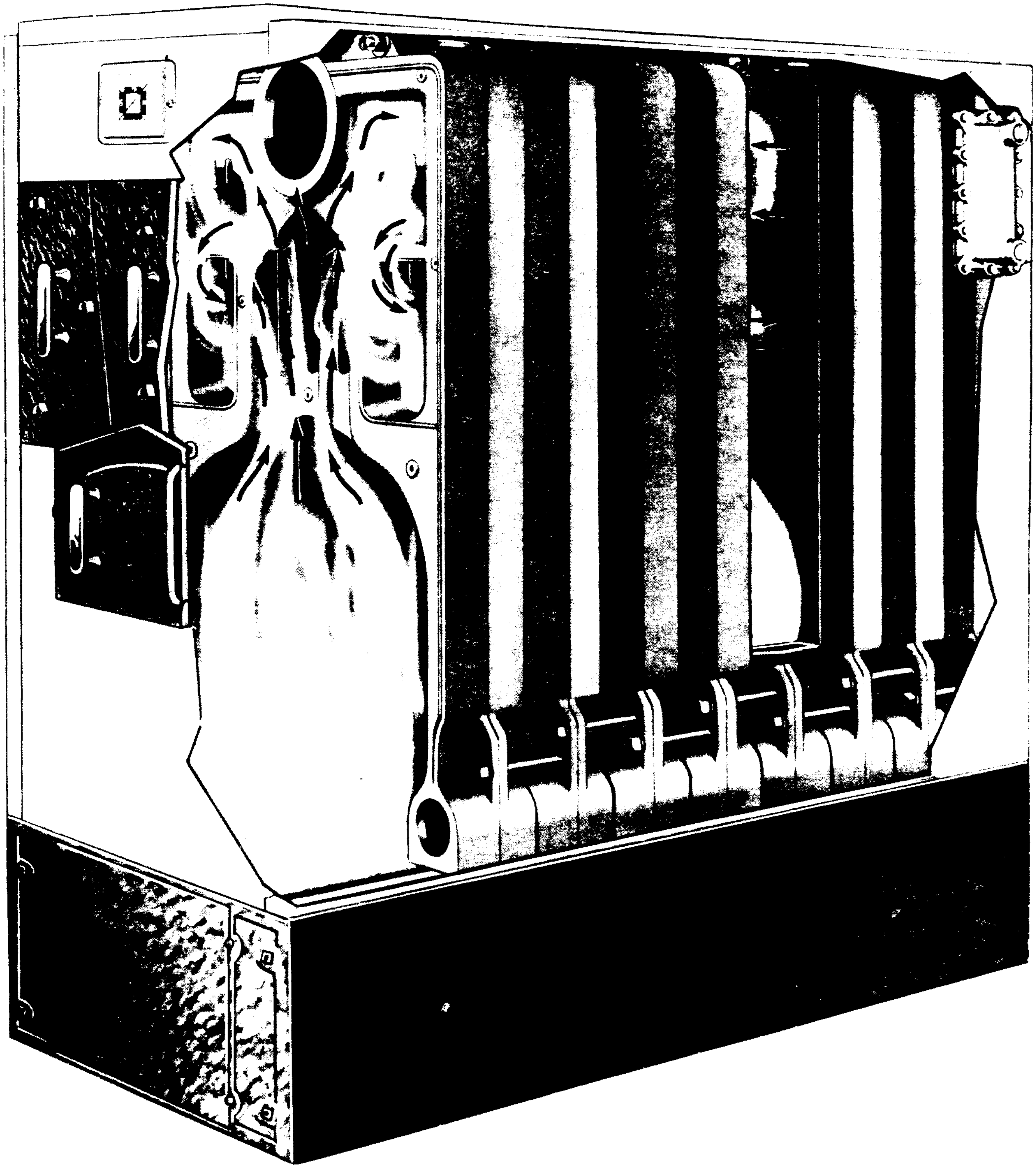


Fig. 1—Internal Push-Nipple Boiler (Reprinted with permission, H. B. Smith Co, Inc)

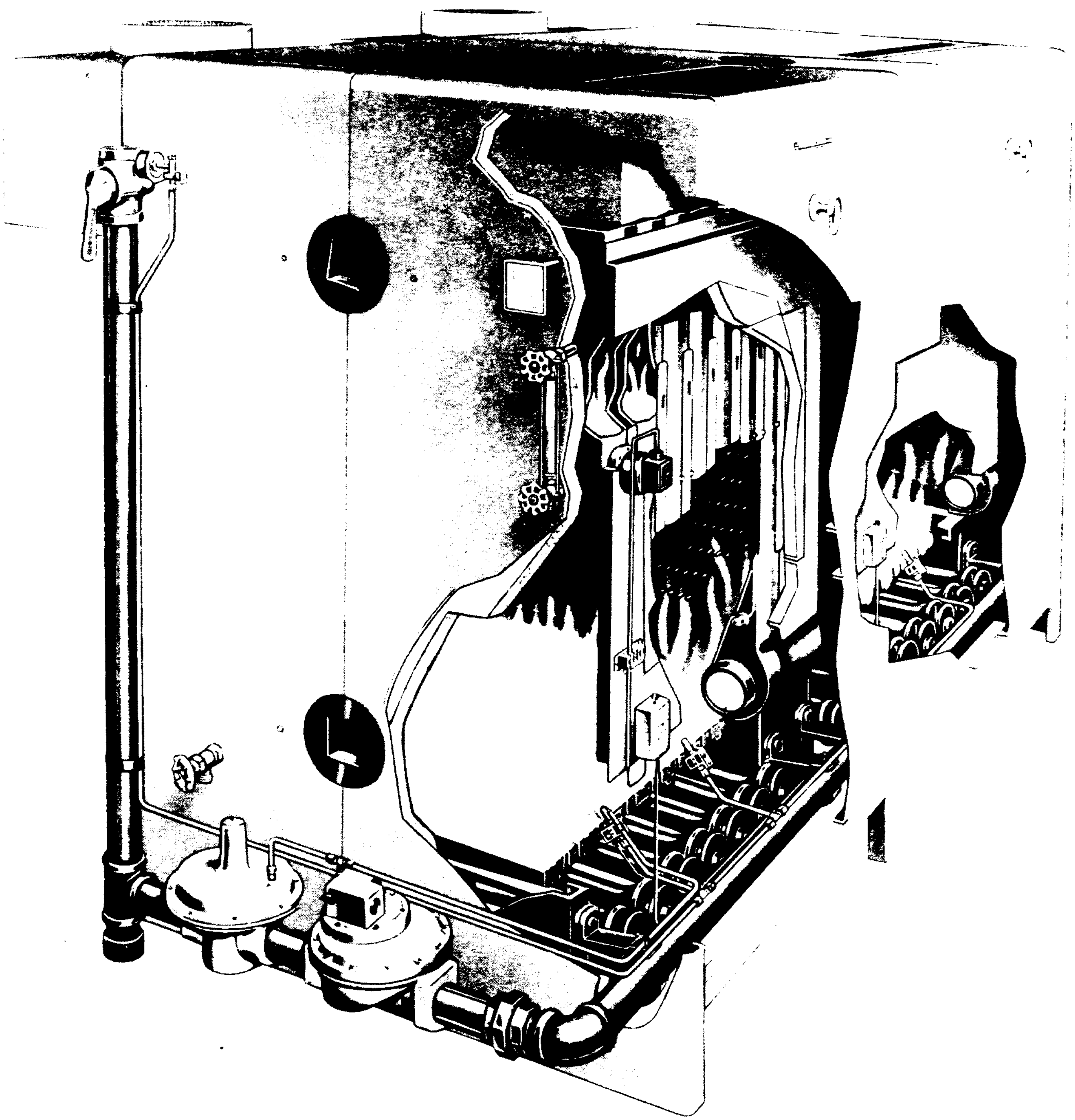


Fig. 2—Cast-Iron Boiler Exclusively Designed for Gas Fuel (Reprinted with permission, American Radiator and Standard Sanitary Corp)

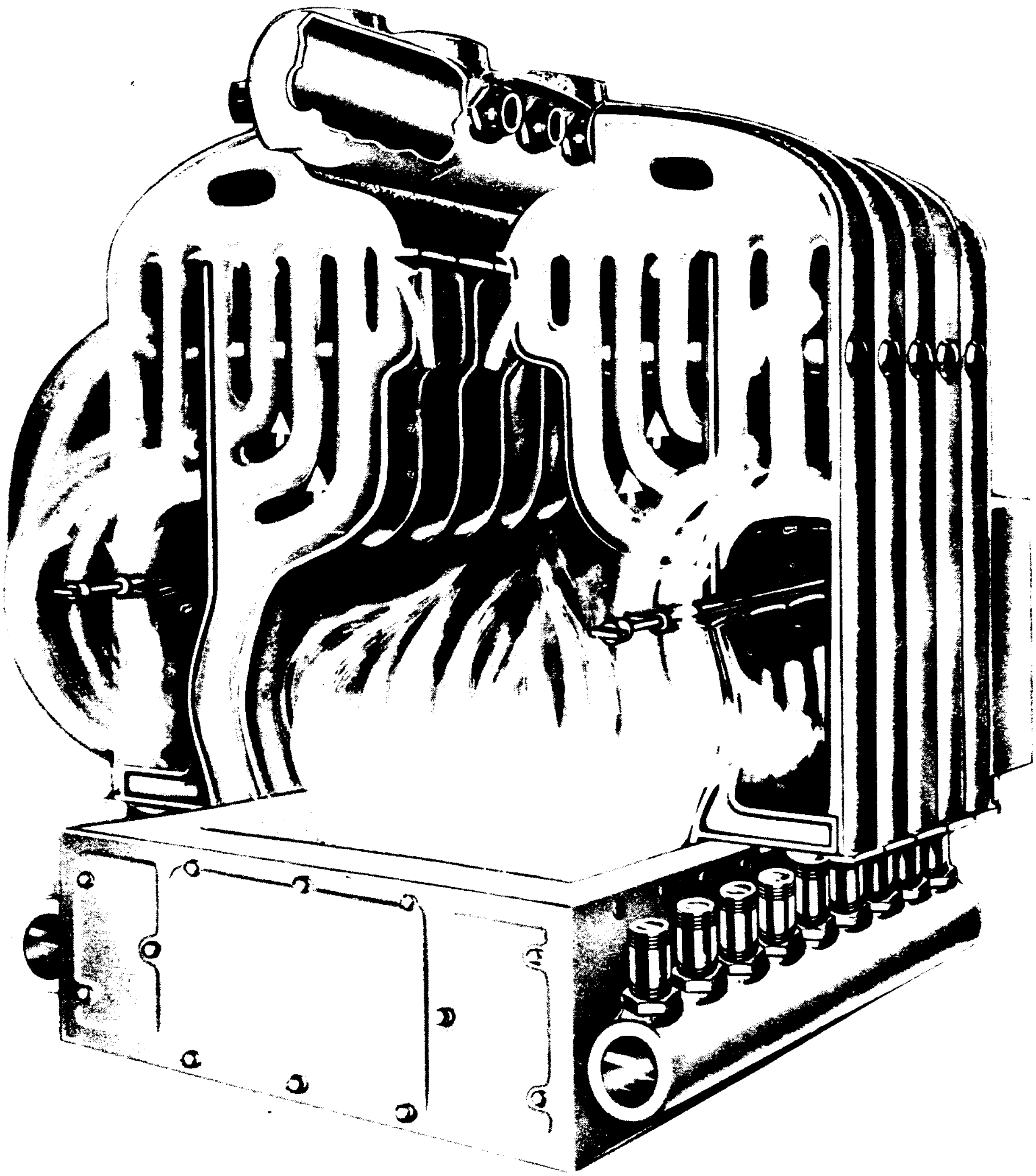


Fig. 3—External Header Boiler (Reprinted with permission, H. B. Smith Co, Inc)

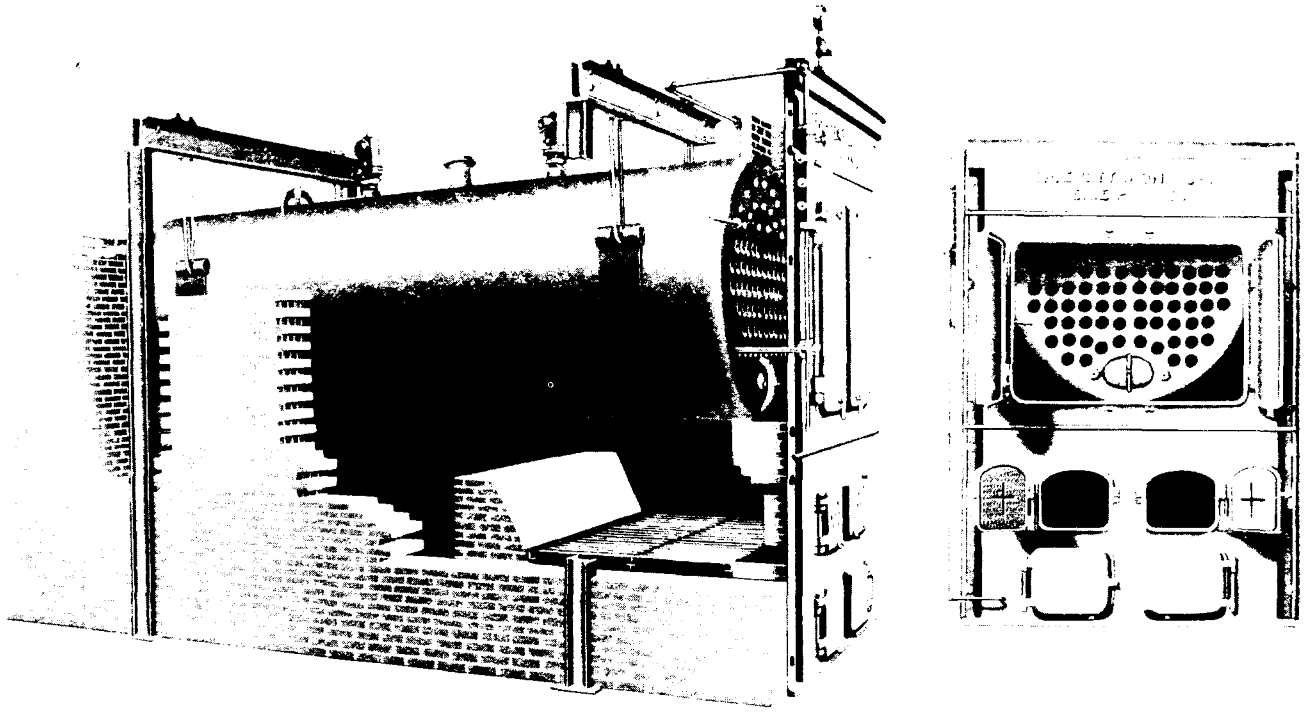


Fig. 4—Horizontal Return Tubular Boiler Showing Cut-Away Section and End View (Reprinted with permission, Erie City Iron Works)

rounded by water, as in the Scotch type. The boilers may have the furnace substantially surrounded as in a firebox boiler where the water-cooled surface is brought down to grate level on each side, but is omitted on the bottom. (See Fig. 5 and 6.)

2.14 The portable firebox boiler, also called a compact or smokeless boiler, is very popular for commercial and industrial installations and is one of the types commonly used in telephone buildings. It is a water-leg boiler with two lengths of tube nests providing three passes for gas flow. It can be furnished for use with either natural gas, oil, or coal. This type boiler is available for field assembly or can be purchased as a package with burner, controls, and fittings installed at the factory.

2.15 The Scotch boilers used in modern heating systems are similar to those originally designed for shipboard installation and are sometimes called Scotch Marine Boilers. This boiler is available for both field assembly or package assembly. In some cases, the boiler is test fired and adjusted for maximum efficiency at the factory. This type boiler has a relatively low-water capacity and therefore can be brought up to operating pressure quickly. It is economical in cost, simple to install, and requires little headroom.

2.16 Scotch boilers are manufactured in two designs, the wet-back (Fig. 7) and the dry-back (Fig. 8), plus a modification of the former known as a wet-top or partial wet-back. The gas-flow patterns vary from two pass to four pass. While these boilers can be adapted to any fuel, they are ideally suited for natural gas or oil. (See Fig. 9.)

2.17 Most package Scotch boilers are of the dry-back or partial wet-back type and are arranged for multiple gas passes. This design allows for a minimum use of refractory lining material and provides a maximum capacity per square foot of heating surface.

2.18 Water-tube boilers are primarily used in steam generating utility plants, but smaller sizes are being used for low-pressure heating boilers. Factory-assembled package water-tube boilers that

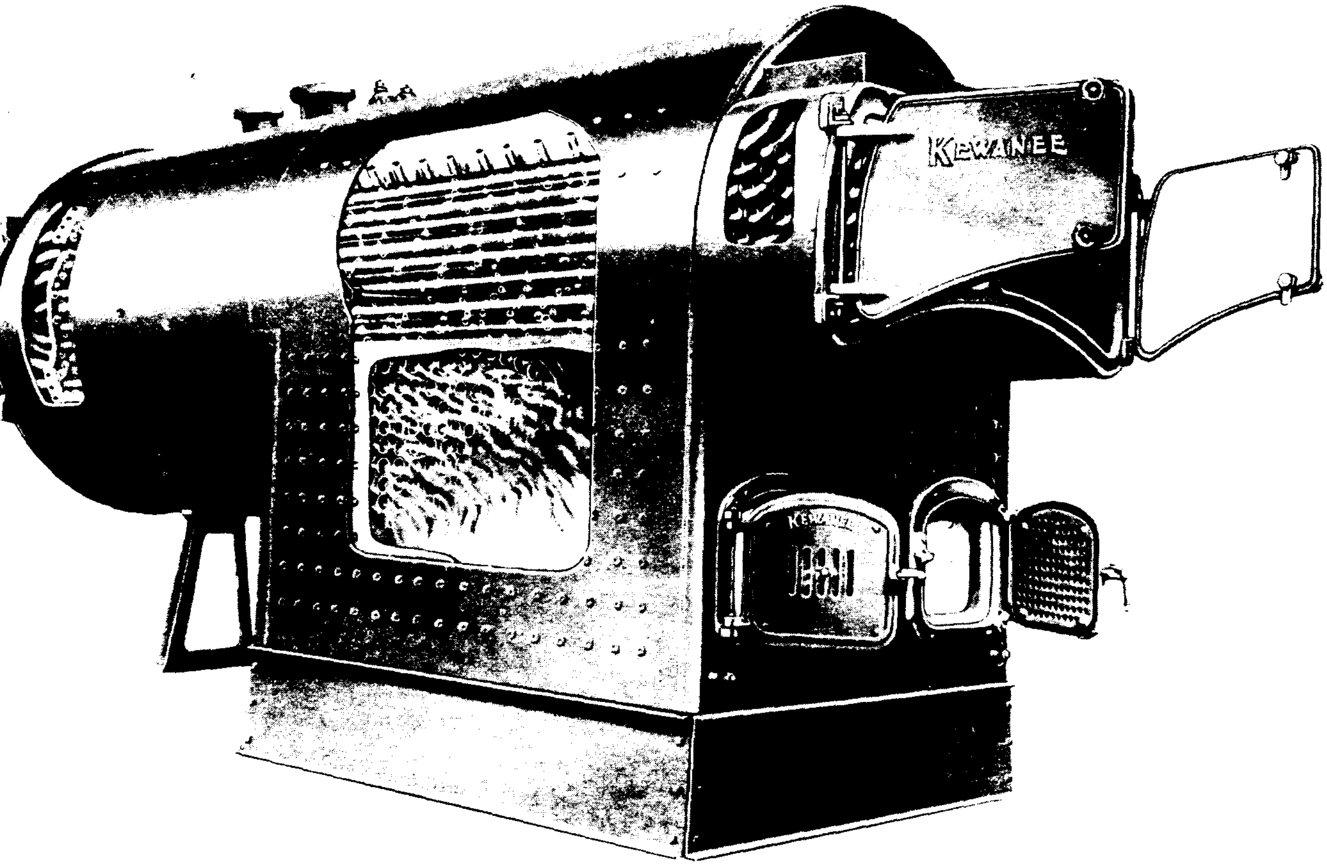


Fig. 5—Short Firebox Water-Leg Boiler (Reprinted with permission, Industrial Division, American Radiator and Standard Sanitary Corp)

will fit through a 3-foot wide door are available in capacities up to 6000 MBh. Water-tube boilers have a higher efficiency rating than fire-tube boilers, but require more maintenance. See Fig. 10 for an example of a modern package water-tube boiler suitable for either low-pressure steam or hot water heating.

3. BOILER SYSTEMS

STEAM BOILER

3.01 ***Warning: Both hot water and steam boilers may be seriously damaged and may rupture if dry fired, eg, firing with no water or water below the lowest permissible water level in paragraphs 3.02 through 3.06.***

3.02 A steam boiler is a self-contained closed vessel in which water is heated and steam generated under pressure or vacuum by the direct application of heat. A low-pressure boiler generates steam at a pressure not exceeding 15 pounds per square inch gauge (psig).

3.03 The heat energy is transmitted in the form of steam by pressure differential from the boiler(s) to the heat exchanger(s) to be heated, eg, standing cast-iron radiation, finned-tube radiation (convectors), finned-tube heating coils in a duct system, finned-tube heating coils in a unit heater. (See Fig. 11.) The heat is transferred from the steam to the air by conduction and moved to various parts of the space to be heated by convection or fan action. When the heat leaves the steam, it condenses and forms water (condensate). This water is returned by gravity to a collection tank and pump set. Automatic controls start and stop the pump which returns the water to the boiler.

3.04 The returned condensate is reheated into steam in the boiler and the cycle repeated.

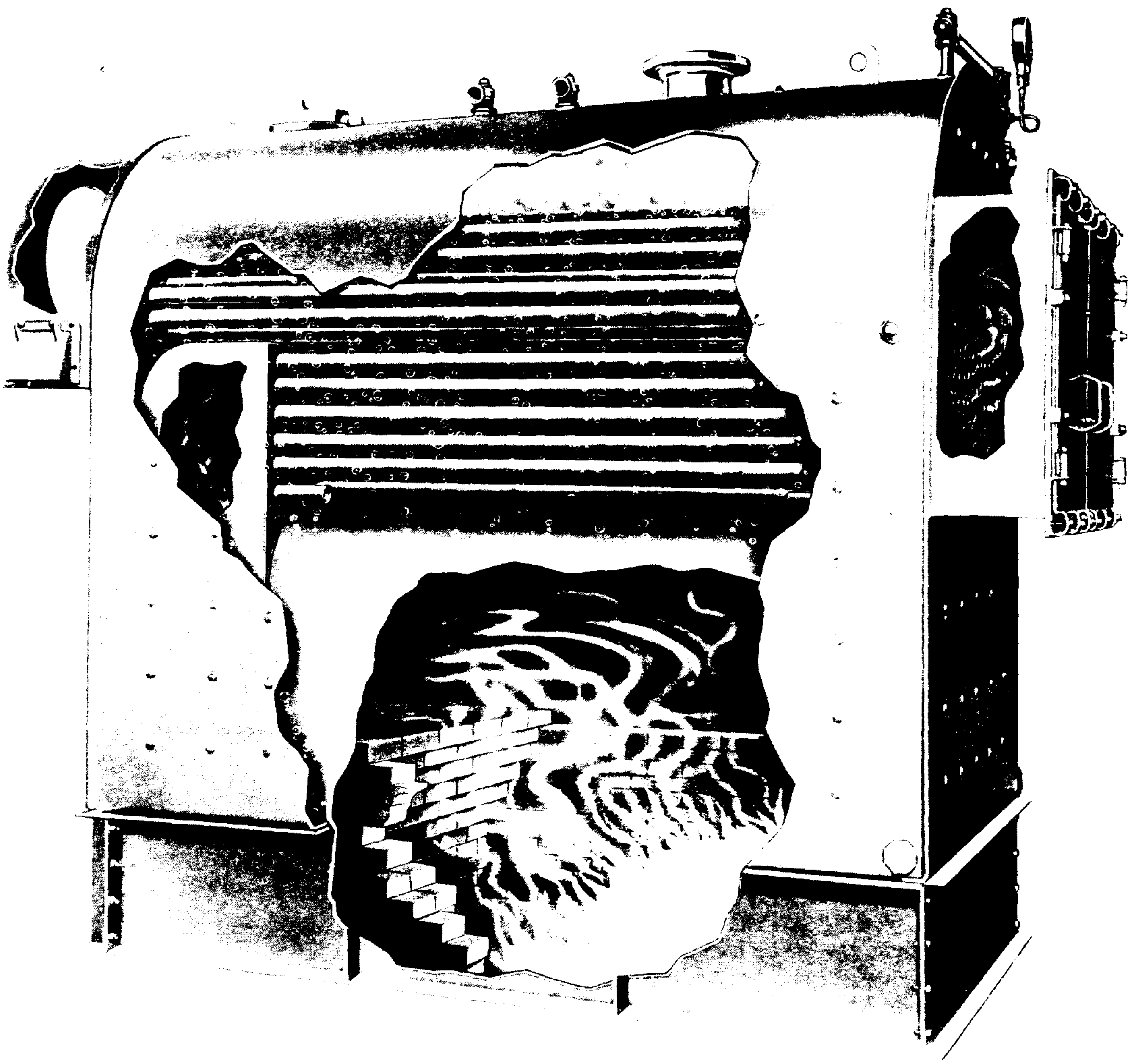


Fig. 6—Portable Firebox Boiler (Reprinted with permission, Industrial Division, American Radiator and Standard Sanitary Corp)

Any water lost through leakage or vapor venting is replaced by makeup water introduced into the collection tank.

HOT WATER BOILER

3.05 A hot water boiler is a self-contained closed vessel in which water is heated and no steam generated. A low-pressure hot water boiler produces hot water at a pressure not exceeding 160 psig and at a temperature not exceeding 250°F.

3.06 The heat energy is transmitted in the form of hot water circulated by a pump(s) to the heat

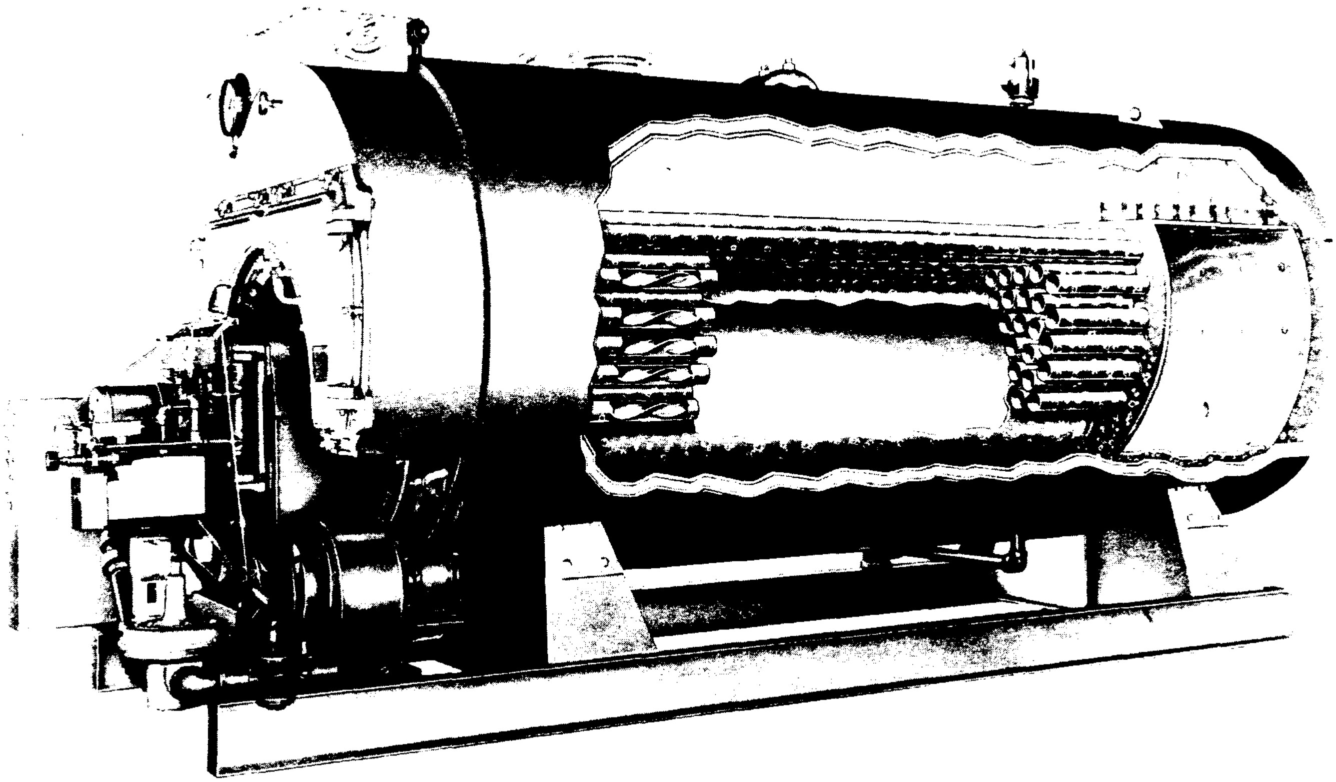


Fig. 7—Scotch Boiler, Wet-Back Type (Reprinted with permission, Industrial Division, American Radiator and Standard Sanitary Corp)

exchangers to be heated, eg, standing cast-iron radiation, finned-tube radiation (convectors), finned-tube heating coils in a duct system, finned-tube heating coils in a unit heater. (See Fig. 12.) The heat is transferred from the water to the air by conduction and moved to various parts of the space to be heated by convection or fan action. The cooled water is returned to the boiler where it is reheated. On older systems, gravity flow caused by difference in water density was used to circulate the water. This is not a practical way to circulate water when there is more horizontal than vertical circulation distance. In addition, gravity flow requires larger sized pipe to reduce friction loss, which is not cost-effective.

4. WARM AIR FURNACES

4.01 ***Warning: Warm air furnaces may be seriously damaged and may cause a fire if operated without air passing through the heat exchanger in paragraphs 4.02 through 4.08.***

4.02 Warm air furnaces are classified as:

- Central
- Duct
- Wall
- Direct-vent wall
- Unit heaters.

4.03 Central furnaces, duct furnaces, and some unit heaters are connected to duct systems for heat distribution. Roof-mounted furnaces are classified as central furnaces and are also capable of being connected to duct work. In some cases, the entire air discharge is connected to one combination supply-return diffuser.

A. Central Furnace

4.04 A central furnace is a self-contained, indirect-fired appliance designed to supply heated air

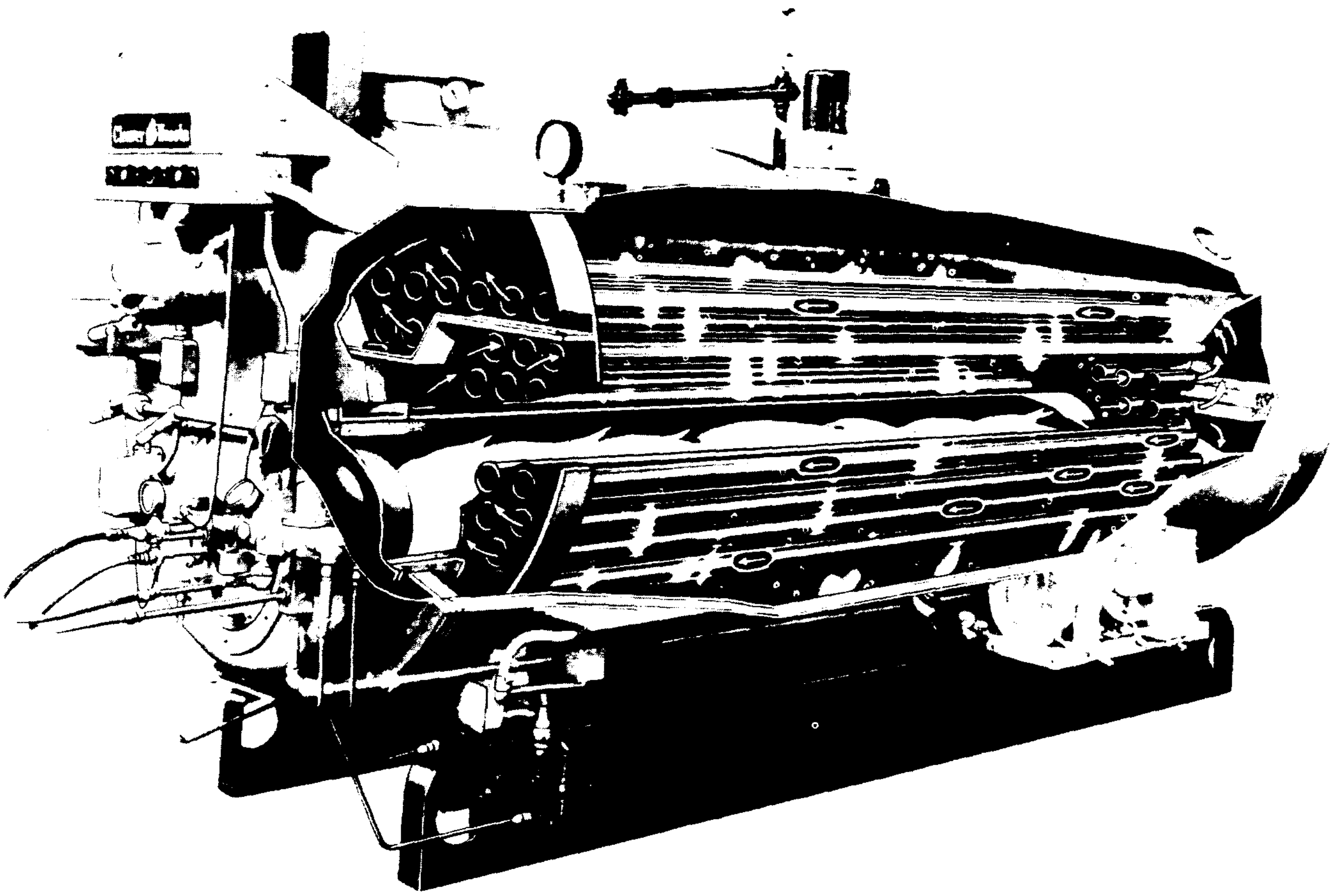


Fig. 8—Scotch Boiler, Dry-Back Type (Reprinted with permission, Cleaver-Brooks, Division of Aqua Chem, Inc)

through ducts to spaces remote from or adjacent to the furnace location. It may be fired by gas or oil or use electric resistance heating. (See Fig. 13.)

B. Duct Furnace

4.05 A duct furnace is a self-contained, indirect-fired appliance normally installed in distribution ducts to supply warm air for heating. This appliance does not have its own air-circulating fan. It may be fired by gas or oil or use electric resistance heating. (See Fig. 14.)

C. Wall Furnace

4.06 A wall furnace is a self-contained, indirect-fired appliance installed in a wall or partition furnishing heated air, circulated by gravity or fan into the space to be heated through openings in the casing. It may be fired by gas or oil or use electric resistance heating.

D. Direct-Vent Wall Furnace

4.07 A direct-vent wall furnace is constructed so that all air for combustion is obtained from the outdoor atmosphere, and all flue gases are discharged to the outdoor atmosphere. It may be fired by gas or oil. (See Fig. 15.)

E. Unit Heater

4.08 A unit heater is a self-contained, automatically controlled, direct- or indirect-fired air-heating appliance usually suspended from above and normally equipped with a propeller fan. It is

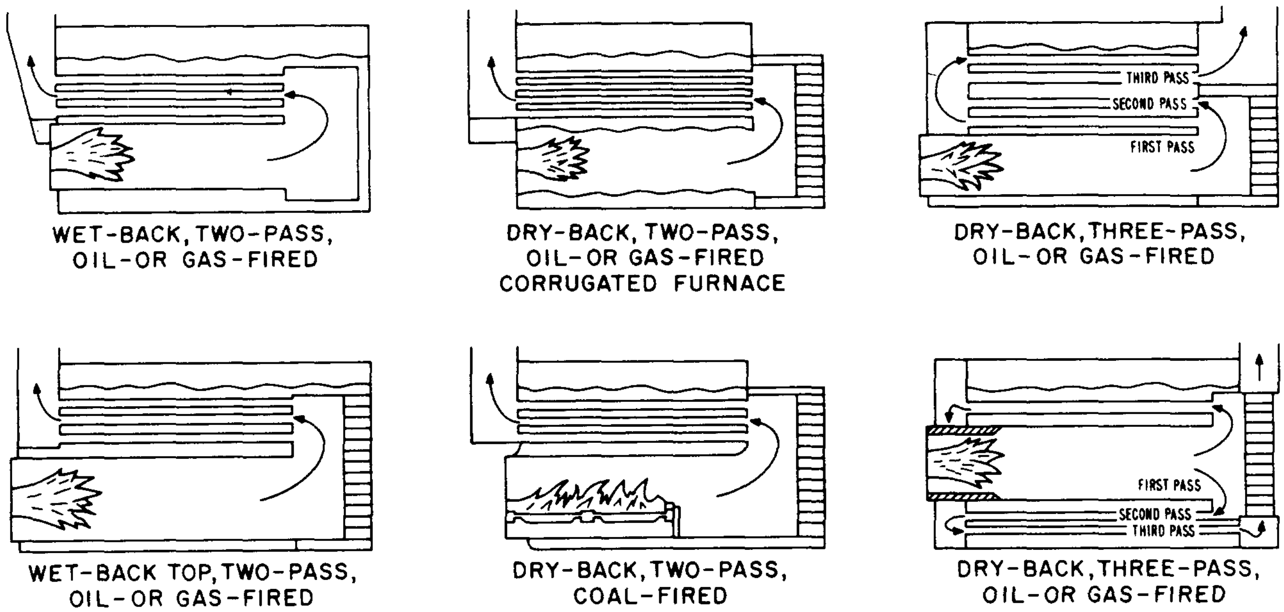


Fig. 9—Gas Flow in Scotch Boiler Types (Reprinted with permission, BOILERS by C. D. Shields. Copyright 1961. McGraw-Hill Book Co)

equipped with louvers for air direction control. Some unit heaters are designed for duct connection. It may be fired by gas or oil, use electric resistance heating, or be supplied with steam or hot water. (See Fig. 16, 17, and 18.)

5. HEATING PLANT SYSTEM SELECTION

5.01 The selection of the type of heating system, eg, steam, hot water, or warm air furnace, and the choice of fuel and output capacity of the heating plant are governed by a number of considerations. The following paragraphs discuss different considerations and the reasons for their choice.

5.02 Design of a new building has the full freedom of choice. A warm air furnace, which readily lends itself to a full air-conditioning system, is a good choice for a smaller-type building. A multistory building of reasonable floor area per story lends itself to steam heating. Hot water is at a disadvantage because the height of the building directly affects the operating pressure of the hot water boiler. Every 2.3 feet of height equates to 1 psig. Although hot water boilers can be rated at 160 psig, they are still classified as low-pressure heating boilers. These boilers are not as readily available, with all the controls, as are the 30- and 40-psig rated boilers. A low structure, one to three stories with large floor areas, does not lend itself to steam heating. Steam system return lines having a horizontal run of a few hundred feet and requiring a pitch of 1/4 inch per 10 feet would create problems with door or window interferences. In the same situation, a hot water heating system will not require pitching of the pipe because the water is circulated by a pump.

Note: Building additions or extensions generally require staying with the existing type of system.

5.03 Choice of fuel, natural or petroleum gas (LPG), or light or heavy oil is frequently determined by availability. Oil generally requires more maintenance than gas fuel burners. Light oils, No. 2 through No. 4, do not require preheating. To reduce the viscosity of heavier oils, No. 5 and No. 6, preheating is required. Preheating generally requires additional equipment maintenance. Heavy oils have a greater heating value than light oils. The LPG has 2.5 times the heating value of natural gas but is less desirable from a safety point of view. The LPG is heavier than air and will settle in low areas in event of a leak, whereas natural gas is lighter than air and will rise. For this reason, natural gas is easier to ventilate and disperse. The LPG is usually consid-

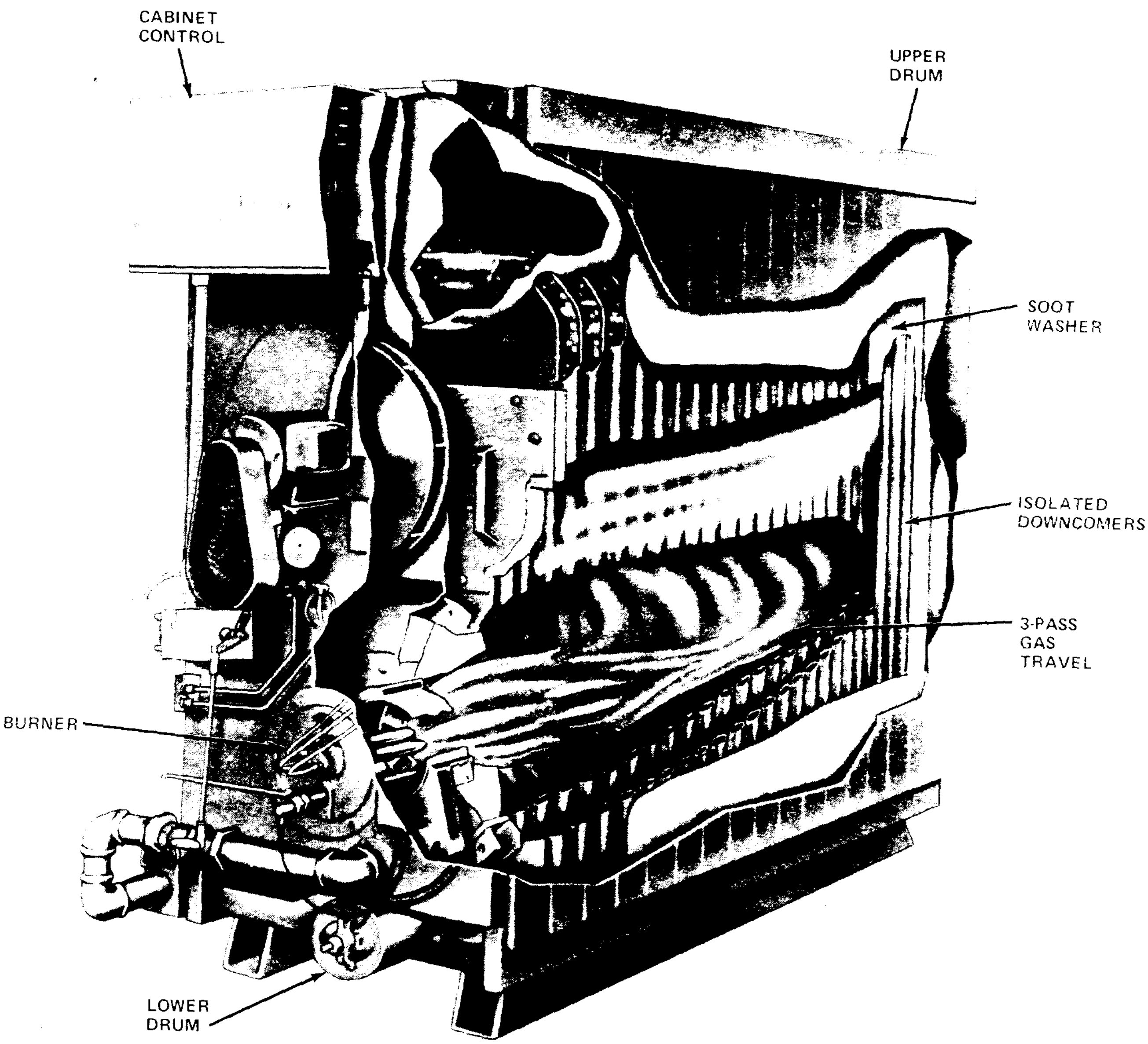


Fig. 10—Water-Tube Boiler (Reprinted with permission, Cleaver Brooks, Division of Aqua-Chem, Inc)

ered a rural fuel and not readily available in urban areas.

5.04 The chemical condition of available water, either community system or on-site well, should be considered in choosing a heating system. A steam boiler generally requires more water for makeup than a hot water boiler. Continued addition of poor chemical quality makeup water would build up concentrations of precipitates which cause scale, corrosion, and sludge in a steam boiler. Whereas, a hot water boiler with no change of state of the heating medium and a low rate of makeup water probably would not build up concentrations within the boiler. For additional information on water treatment, see Sections 770-230-300 and 770-230-302.

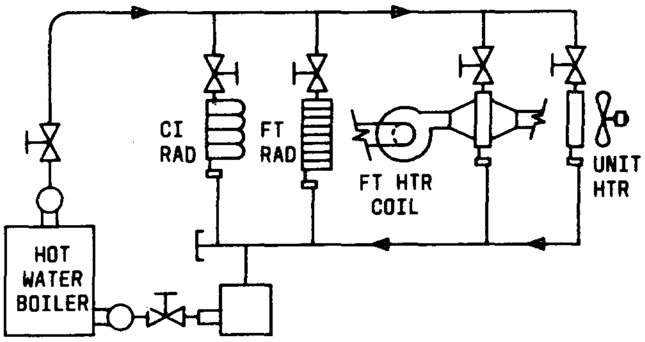
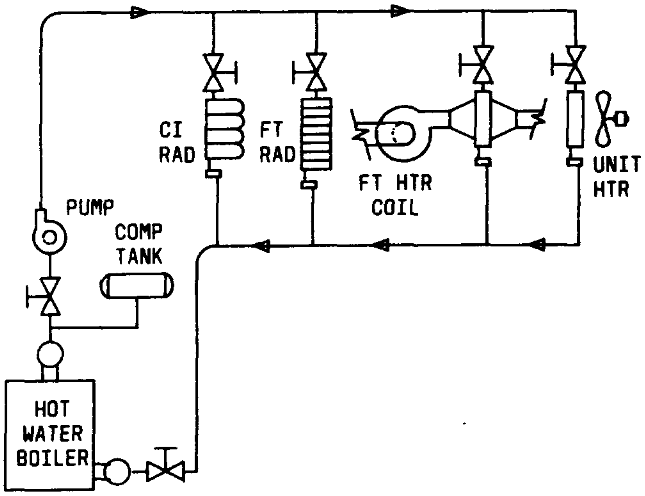


Fig. 11—Steam Boiler System



LEGEND:
COMP - COMPRESSION

Fig. 12—Hot Water Boiler System

5.05 Sizing of the heating plant is based on the load it will have to carry. If the boiler selected is sized to the initial building heating load, it may require one or more of the following upon building expansion:

- A change in firing rate
- Addition to the boiler itself
- Installation of another boiler at the time of the first building addition/extension.

5.06 Cast-iron boilers can have additional sections added to increase capacity, whereas steel boilers are fixed at their ultimate size initially.

5.07 The use of modular, multiple boilers with a sequential firing control offers advantages for capacity growth and a firing rate matched to the load during all times of the heating season. Oversizing boilers and burners lends to inefficient short-cycle firing.

5.08 Internal heat gains from central office (CO) equipment, computer rooms, building lighting, etc, should be subtracted from the total building heating load. Buildings with high internal heat gain may generate sufficient heat to be self-heating. If the ultimate equipment is not installed initially, consideration should be given to the use of temporary heat during the growth period. The electric power dedicated to temporary electric heat can be diverted for other uses when the unit heaters are removed from service.

6. FUEL SELECTION

HEAT SOURCES

6.01 Heat sources for heating plants are fuel oil (grades 1 through 6), gas, both natural and liquified petroleum, and electrical energy.

6.02 The principal fuels used to heat telephone buildings are oil and gas. The choice of fuel should be based on dependability, cleanliness, quality, availability, economy, maintenance, operating requirements, and control.

6.03 Natural gas is a popular fuel for heating telephone buildings. It burns clean without smoke, soot, or ash and is very flexible from a combustion standpoint. High-boiler efficiency can be achieved since gas is burned with relatively little excess air. Burner flexibility permits easy automatic control under varying load conditions. This fuel has a calorific value of approximately 1000 BTUs per cubic foot. As this gas is normally distributed through underground piping, it requires no storage facilities.

6.04 The LPG is also used to heat telephone buildings. It has a much higher heating value (2500

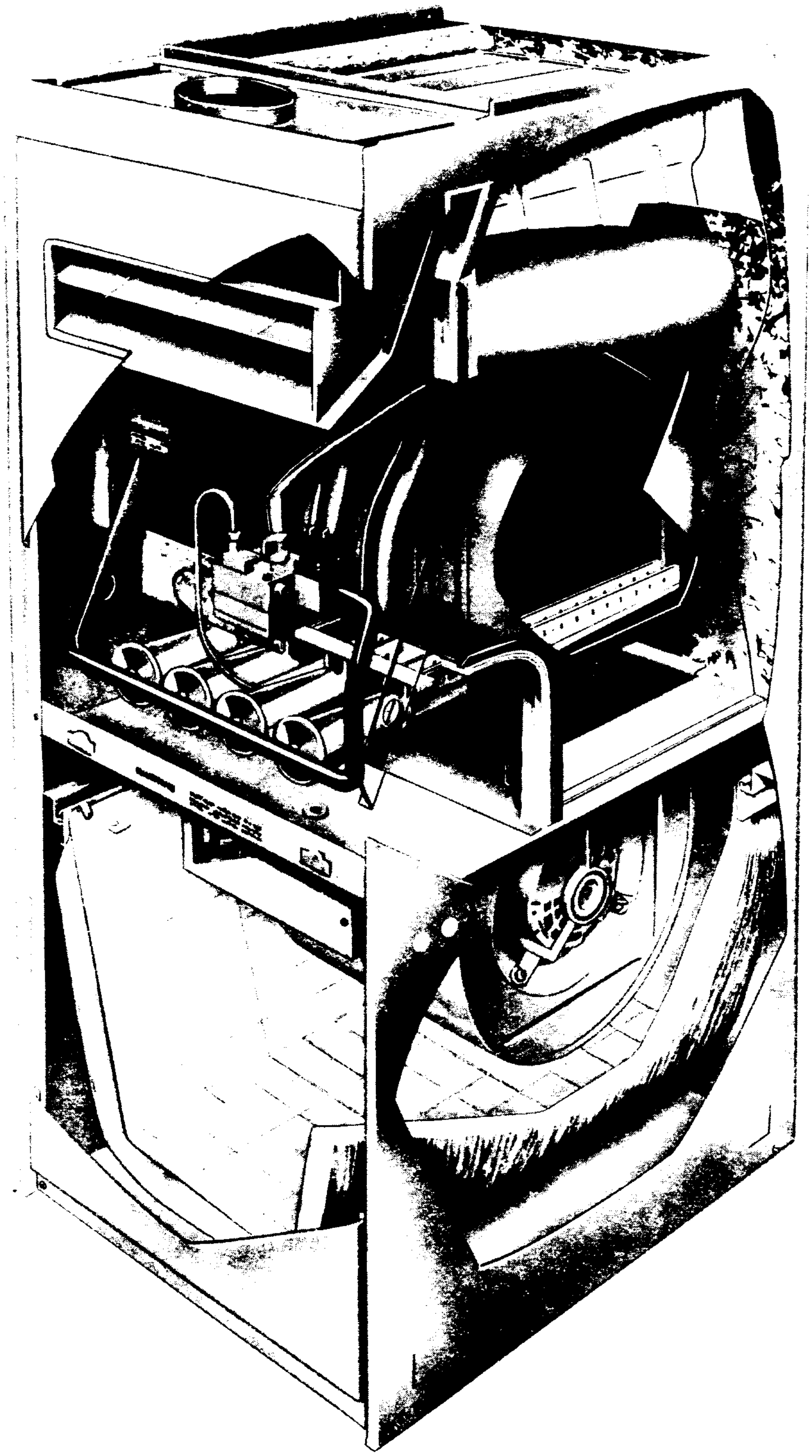


Fig. 13—Central Warm Air Furnace (Reprinted with permission, Lennox Industries)

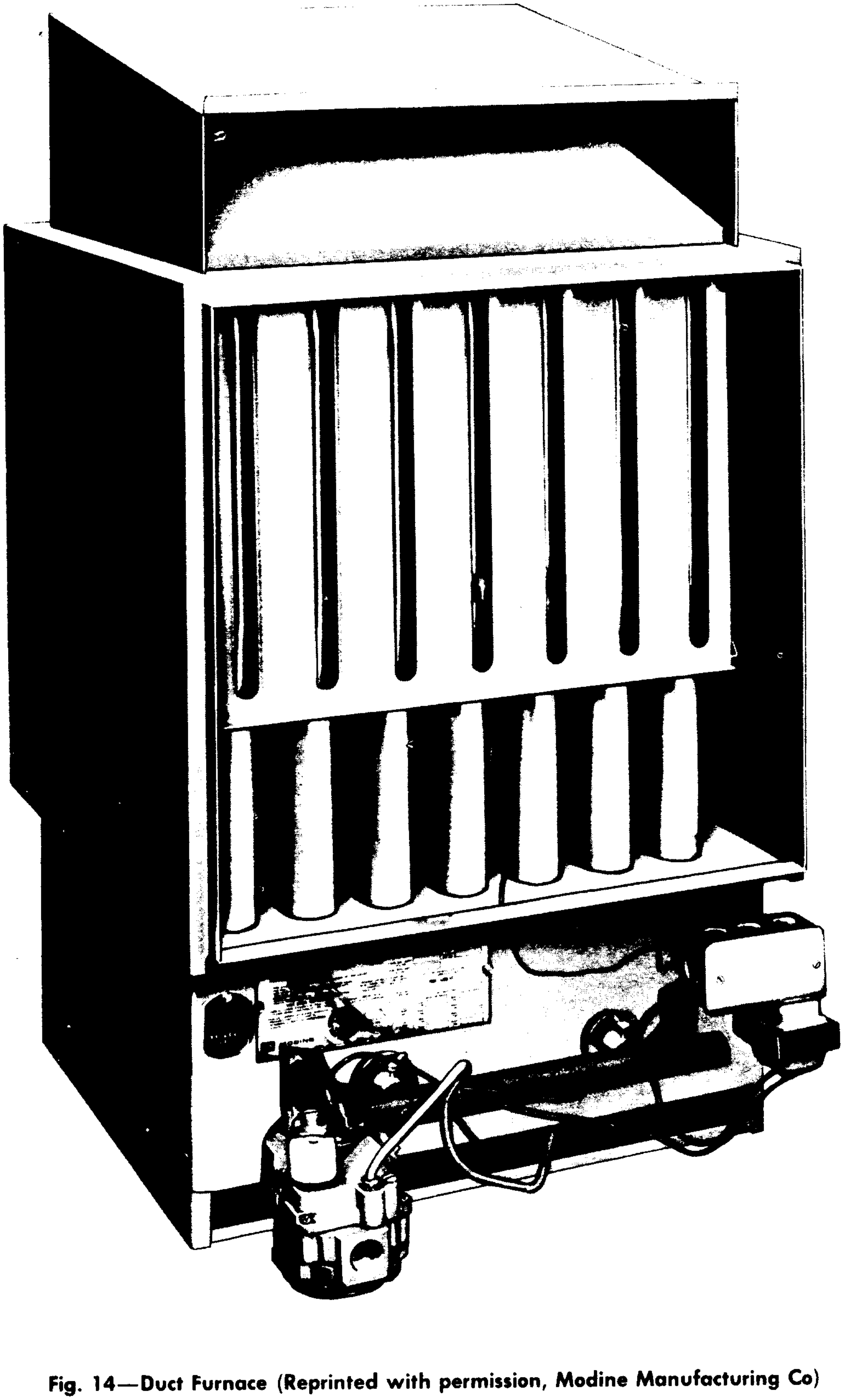


Fig. 14—Duct Furnace (Reprinted with permission, Modine Manufacturing Co)

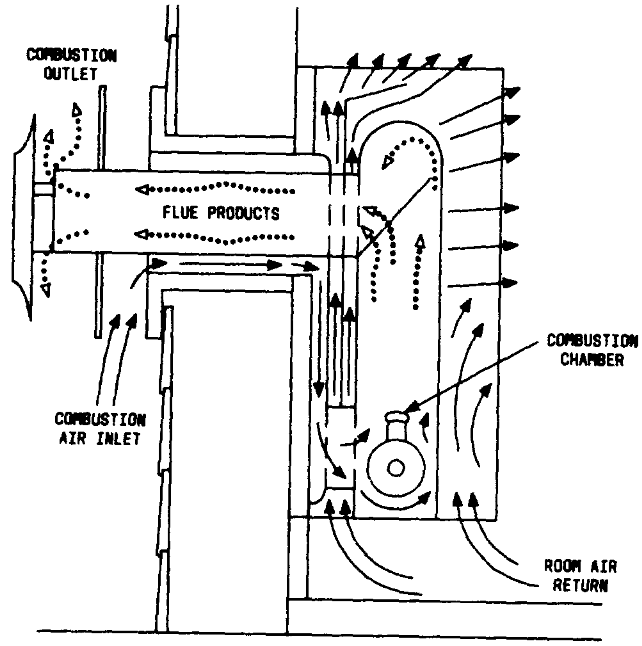


Fig. 15—Direct-Vent Wall Furnace

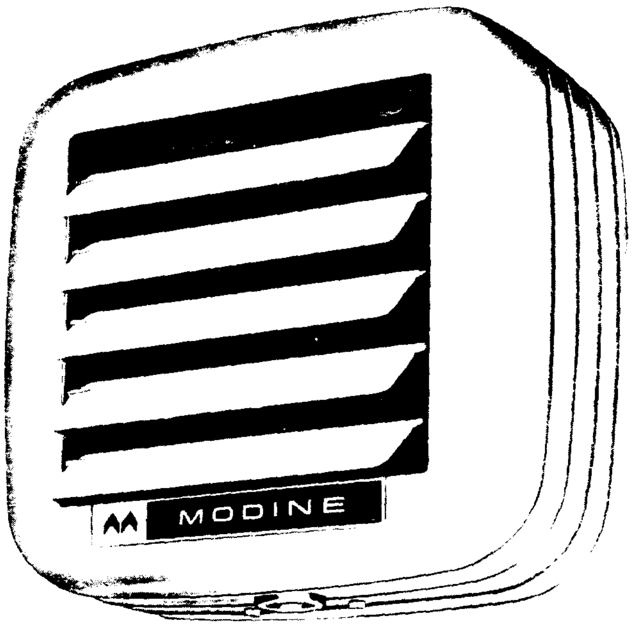


Fig. 16—Unit Heater—Horizontal-Delivery Type HS (Reprinted with permission, Modine Manufacturing Co)

BTUs per cubic foot) than natural gas (1000 BTUs per cubic foot). To reduce volume, LPG is stored in a liquid state at 165 psig at 90°F, which requires storage tanks designed for these pressures. The larger storage tanks (horizontal) are designed to the American Society of Mechanical Engineering (ASME) Unfired Pressure Vessel Code, Section XIII, and have their relief valves set at 250 psig. The smaller vertical tanks, called cylinders, come under the Department of Transportation and have their relief valves set at 375 psig.

6.05 The LPG has a specific gravity in excess of 1 and is heavier than air; therefore, it will not rise as does natural gas, and special care must be exercised to prevent pocketing of gas at low points within and outside telephone buildings. For this reason LPG is less desirable than natural gas.

OIL

6.06 Fuel oils are graded in accordance with specifications of the American Society for Testing

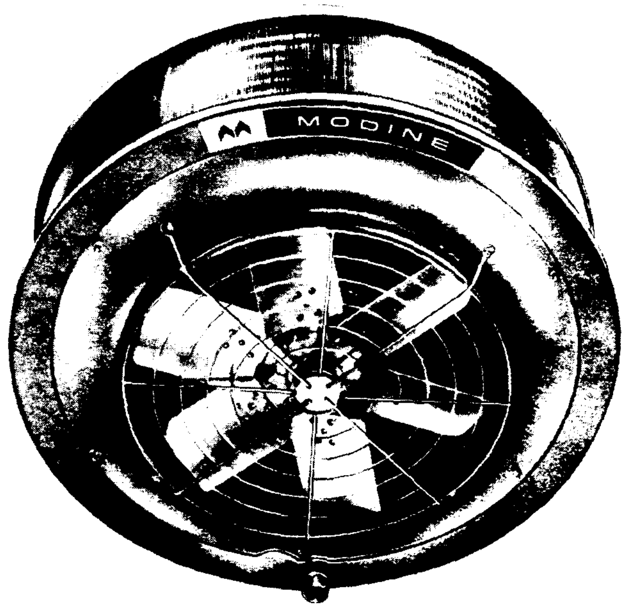


Fig. 17—Unit Heater—Power-Throw Type PT (Reprinted with permission, Modine Manufacturing Co)

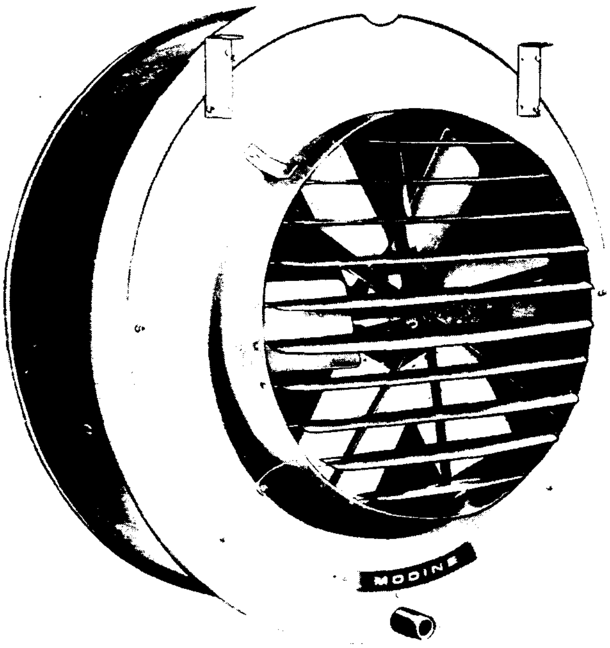


Fig. 18—Unit Heater—Vertical-Delivery Type V (Reprinted with permission, Modine Manufacturing Co)

Materials (ASTM). Oils are classified by their viscosities. Other characteristics of fuel oils, which determine their grade classification and suitability for given uses, are the flash point, pour point, water and sediment content, carbon residue, ash, and distillation characteristics. Fuel oils are prepared for combustion in most burners used in low-pressure boiler by atomization (spraying) and vaporization (heating). Atomization is further divided into three types: high-pressure, low-pressure, and centrifugal. Different fuel oil grades are as follows:

(a) ***Grade No. 1:*** This is a distillate oil with a heating value of 135,000 BTUs per gallon (gal) and weight of 6.8 pounds per gallon (lbs/gal). This is commonly called kerosene.

(b) ***Grade No. 2:*** This is a distillate oil used for general purpose domestic heating and for use in high- and low-pressure atomizing burners. Before going to a heavier grade fuel oil, careful consideration should be given to competitive prices, cost of fuel-burning equipment, maintenance, and availability of qualified service. The usual heating value of this oil is 138,000 BTUs/gal and weighs 7.1 lbs/gal.

(c) ***Grade No. 4:*** This is an oil for burners not normally installed with preheating equipment. This oil is generally used in burners employing centrifugal atomization (rotary cup burners) and modulating low-pressure gun-type burners. Because the oil is no longer available in many locations as a straight run distillate, but is a mix of Grades No. 2 and No. 6, it may be necessary in northern climates to provide tank heaters or small preheaters to ensure delivery of the fuel to the burner at a minimum temperature of 80°F. If the fuel is not blended properly under heat and pressure, Grades No. 2 and No. 6 may separate in time. Be sure the fuel supplier has these blending facilities. Many dealers blend the two grades of oil in the tank truck while delivering to the location. This results in physical separation of the two grades if left in the tank for any length of time. The usual heating value is 147,000 BTUs/gal and the oil weighs 7.7 lbs/gal.

(d) ***Grade No. 5:*** This is a residual-type oil for burner installations equipped with preheating facilities. The fuel is normally used in centrifugal atomizing burners. In the past, this grade has been divided into a hot No. 5 and cold No. 5. The hot grade had to be preheated, and the cold could be burned as is from the tank. But, because of the increased demand for distillate products, the residual oils are lower in quality and must be preheated for good results. Sometimes, Grade No. 5 is a mix of No. 2 and No. 6. The usual heating value for this grade oil is 152,000 BTUs/gal and 8.1 lbs/gal.

(e) ***Grade No. 6:*** This is an oil used in burners equipped with preheaters which permit the use of a high viscosity fuel. Grade No. 6 fuel oil is commonly referred to as Bunker C. The usual heating value for this grade is 153,000 BTUs/gal and the oil weighs 8.2 lbs/gal.

6.07 The correct temperature range must be used for each grade of preheated oil. Underheating or overheating affects the terminal viscosity and actually interferes with the atomizing process. Underheated oil is too viscous (poor flow qualities) for proper atomization, resulting in poor combustion, the generation of smoke and soot, and an excessively high oil consumption. Overheated oil, on the other hand, is too fluid for correct atomization and is subject to the same type of poor operating results as the underheated oil.

6.08 Electrical energy is also used to heat telephone buildings either as resistance heating, power for heat pumps, and as power for heat recovery distribution.

6.09 Electric resistance heating comes in the form of electric unit heaters, electric duct heaters, and electric radiation. Electric resistance heating produces 3414 BTUs of heat for each kilowatt (kW) supplied to the resistance heater.

6.10 Electrical power is the energy used to operate heat pumps which transfer the heat from outside air or water, elevate its temperature to a usable level, and distribute it to the space to be heated. This type of heating will produce approximately 2.5 to 4.5 kW of useful heat for each kW supplied to the heat pump. This will depend upon the heat source used, steam or hot water.

6.11 Heat recovery is a method that should be reviewed when any heating plant installation or major modification is planned, particularly in buildings which have both high heat producing equipment and administrative spaces. Electrical power is the energy supplied to operate fans, pumps, and compressors used to transfer heat from one space within the building to another. A detailed analysis of the overall efficiency of the heat recovery system in both heating and cooling modes must be made to avoid an operating cost penalty in one mode that may affect the savings in the other mode. A standard chiller will operate at about 0.8 kW per ton, and a reclaim chiller operates at about 1.2 kW per ton. When the reclaim chiller operates in the cooling mode, there is approximately a 0.4 kW per ton penalty. Refer to Section 760-570-500* for additional information on heat recovery.

7. BURNER SELECTION

7.01 The conventional means of burning fuel utilizes a device to mix the air and fuel in proper proportions for complete combustion. These devices are oil and gas burners.

AUTOMATIC OIL BURNING EQUIPMENT

7.02 An oil burner mechanically mixes fuel oil and air and burns it under controlled conditions. Two methods, atomization and vaporization, are employed to prepare the fuel oil for combustion. Air for combustion is supplied by a blower incorporated in the burner or by draft produced by the chimney. Ignition is accomplished by an electric spark, electric resistance wire, gas pilot flame, or oil pilot flame. Burner operation may be intermittent or continuous with high-low or modulating flame.

A. Pressure Atomizing (Gun-Type) Burners

7.03 Gun-type burners are designed to burn Grades No. 1 or No. 2 fuel oil. They may be divided into two classes: high-pressure atomization and low-pressure air atomization.

High-Pressure Atomization

7.04 The high-pressure atomizing type (Fig. 19) is characterized by an air or blast tube, usually horizontal, with an oil supply centrally located in the tube and arranged so that a spray of atomized oil is introduced at about 100 psi and mixed in the combustion chamber with the air stream emerging from the air tube. The oil rate can be changed by replacing the nozzle with one of different rating. Nozzle size should be based on the firing rate. Once the rate is determined, it should not be necessary to change the nozzle size. Small oil rate changes can be made by adjusting the oil pump pressure. The flame must not impinge on the brickwork or any heat transfer surface. The oil pump can function both as a pressure pump for atomization and as a suction pump to remove oil from the tank when it is below the burner. A blower is used to provide air for combustion. A damper (shutter) or other adjustable means at the burner and a draft regulator provide the proper air supply. Ignition is established by a high-voltage electric spark that may operate continuously while the burner is running, or just at the beginning of the running period.

7.05 The combustion process is completed in a combustion chamber constructed of refractory material. The size and shape of the chamber depend on the quantity of fuel oil and the shape of the burner flame. The effective performance of pressure atomizing burners requires that the fuel be completely atomized and that combustion take place while the fuel is in suspension. This process therefore requires that the air supplied for the combustion process must be carefully adjusted for maximum efficiency.

*Check Divisional Index 760 for availability.

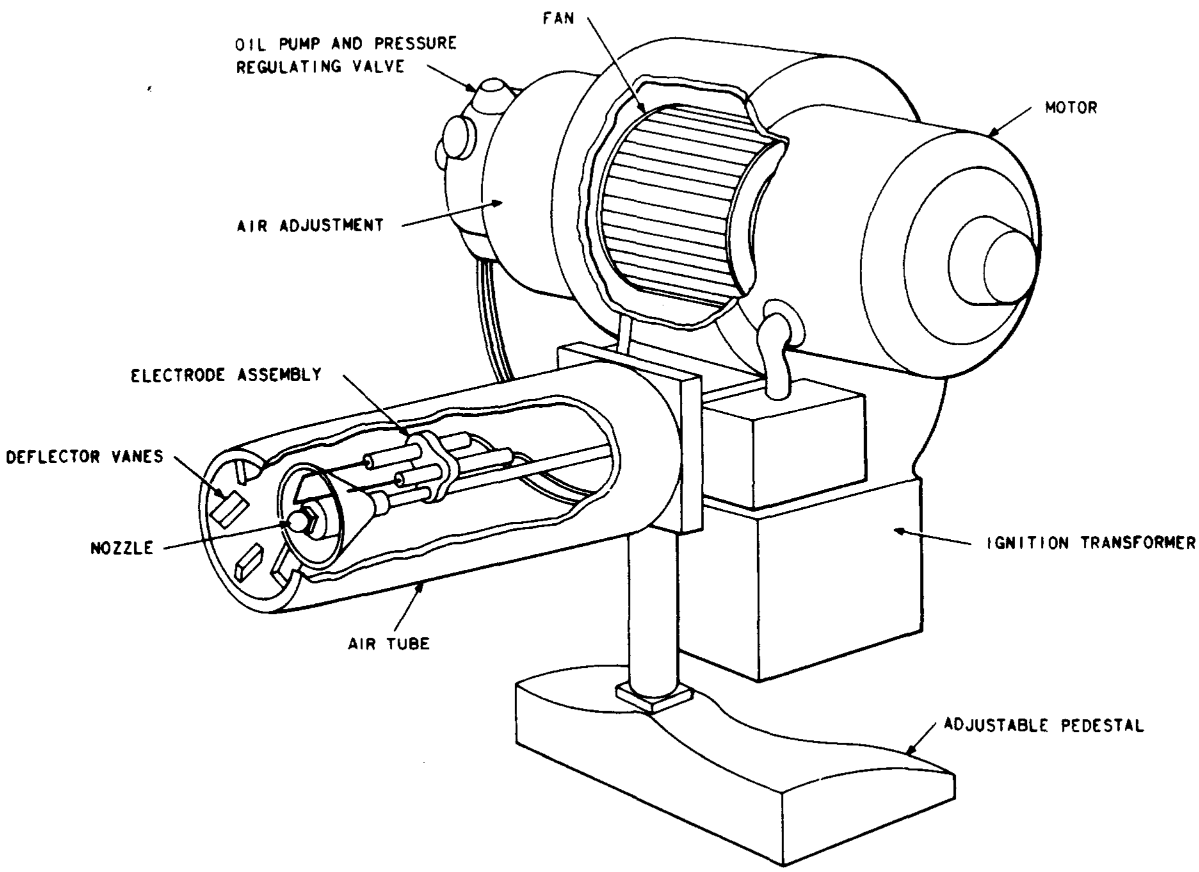


Fig. 19—High-Pressure Atomizing Burner (Reprinted with permission, ASHRAE Guide and Data Book, 1963)

Low-Pressure Air Atomization

7.06 The low-pressure air atomizing burner differs from the high-pressure type in that a primary air supply at 1 to 15 psig meets and atomizes the oil before leaving the burner. Upon entering the firebox or combustion chamber, this mixture meets another air stream referred to as secondary air. The secondary air provides the turbulence and oxygen required for combustion. The operating pressure of these burners is 1 to 5 psig.

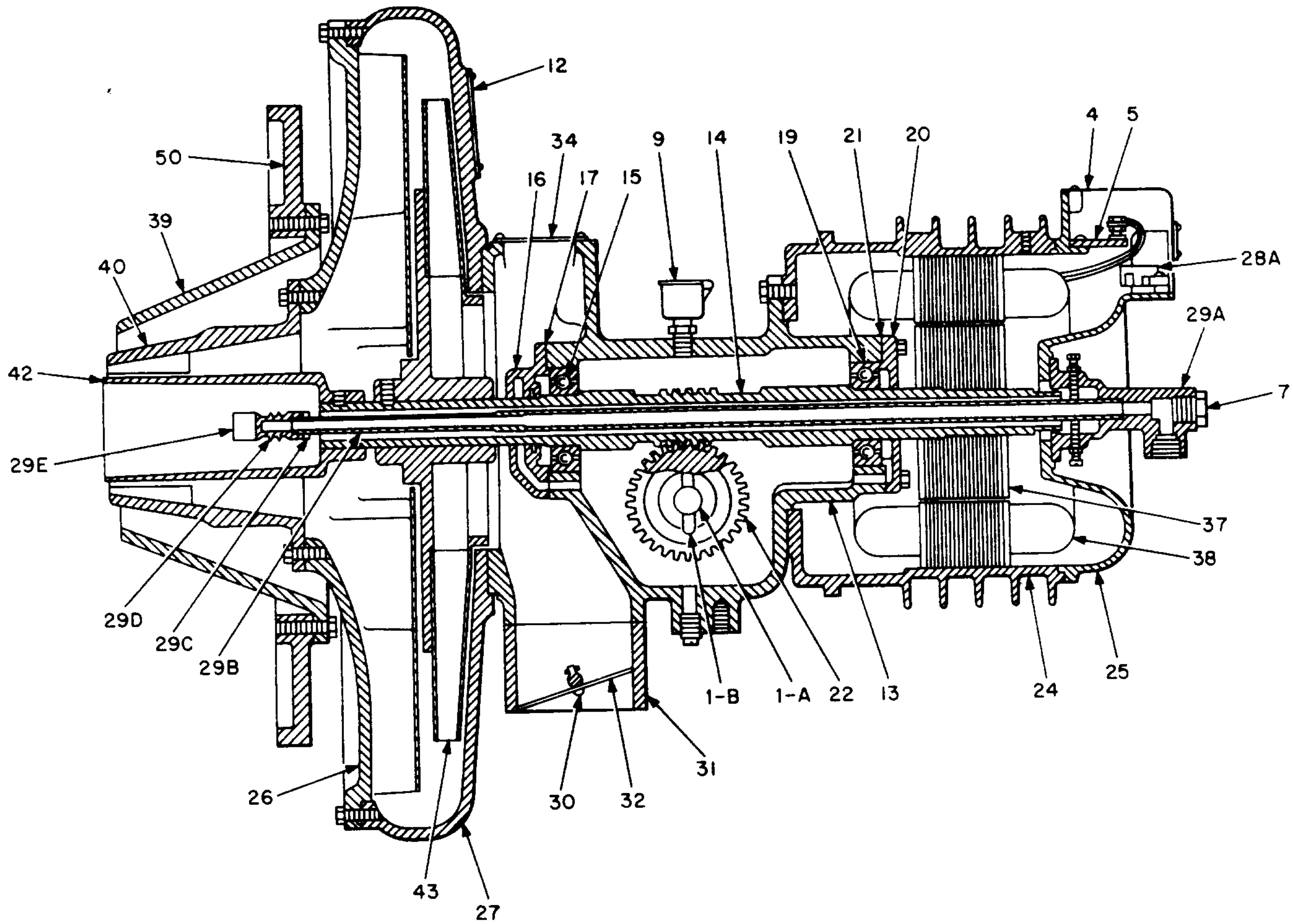
7.07 The nozzles, if properly maintained, will usually last for the life of the unit. Capacity of the burners is varied by making pump stroke or orifice changes on the oil pumps. These units do not need an external cartridge-type filter on the oil supply lines because they have built-in screen strainers in the oil pump.

B. Horizontal Rotary Cup Burner

7.08 The horizontal rotary burner (Fig. 20) utilizes the principle of mechanical centrifugal atomization. The oil is atomized for combustion by centrifugal force, spinning it off a cup rotating at high speed, usually 3450 rpm. This type has a range running from 5 to 320 gallons per hour (GPH) and can be used with all grades of fuel oil from Grades No. 2 to No. 6. Heavy oils are preheated before they reach the cup. Another desirable characteristic of these burners is modulated firing. The firing rate is controlled automatically by means of a modulating motor responding to the load demand of the boiler.

AUTOMATIC GAS BURNING EQUIPMENT

7.09 Burners for firing heating boilers with natural gas fall into two general classes: atmospheric and power. Because of the ease with which



1A - WORM GEAR SHAFT
1B - WORM GEAR PIN
4 - TERMINAL BOX COVER
5 - TERMINAL BLOCK ASSEMBLY
9 - OIL CUP STRAIGHT
12 - NAMEPLATE
13 - GEAR HOUSING
14 - BURNER SHAFT AND WORM
15 - FRONT BEARING
16 - FRONT BEARING COVER
17 - FRONT BEARING COVER GASKET
19 - REAR BEARING
20 - REAR BEARING COVER
21 - REAR BEARING COVER GASKET
22 - WORM GEAR
24 - MOTOR JACKET
25 - MOTOR JACKET COVER
26 - FAN CASE COVER ASSEMBLY
27 - FAN CASE
28A - STARTING RELAY (SIZE 5 SINGLE PHASE ONLY)
29A - TAIL PIECE
29B - FUEL TUBE ASSEMBLY
29C - LOCKNUT
29D - TIP
29E - VIBRATION DAMPER
30 - BUTTERFLY SHAFT
31 - BUTTERFLY HOUSING
32 - PRIMARY AIR BUTTERFLY
34 - HOUSING TOP PLATE
37 - ROTOR
38 - STATOR
39 - NOZZLE PROTECTOR
40 - NOZZLE ASSEMBLY
42 - ATOMIZING CUP
43 - FAN ASSEMBLY
50 - MOUNTING PLATE
71 - TAILPIECE PLUG

Fig. 20—Cross-Section of Direct Drive Rotary Burner (Reprinted with permission, Ray Burner Co)

gas fuel can be controlled, its use has become widespread, and gas burning equipment is available for all types of boilers.

A. Atmospheric Gas Burners

7.10 The atmospheric burners are used primarily on domestic- and commercial-type boilers. While all atmospheric gas burners are similar in the sense that all are of the Bunsen or injection type, they do differ in type of port and flame pattern as follows:

(a) ***Drilled-Port Burners (Bed-Type Burners):*** These are similar to those found in domestic gas ranges and are most frequently used on cast-iron boilers. The drilled ports produce many small flames on each burner. Burners are used in multiple to gain the desired capacity.

(b) ***Slotted-Port Burners:*** These are similar in design and appearance to drilled-port burners, but the gas and air mixture is fed through a slot that extends the length of the burner head. This produces a long ribbon flame at each burner. These burners are also used in multiple.

(c) ***Single-Port Burners:*** These feed all the gas-air mixture through a single port, producing one large flame per burner instead of the many small flames produced by the drilled-port burner, or the long ribbon flame of the slotted-port burner.

Single-port burners may be of the following types:

(1) ***Inshot:*** This type is where one or more burners are mounted on the front of the furnace or firebox and shoot flames into the combustion area. (See Fig. 21 and 22.)

(2) ***Upshot:*** This type is where the burner or burners are mounted in the bottom of the firebox and shoot flames up into the combustion area. Upshot burners usually employ a flame spreader of metal or ceramic material which directs the flames outward.

Single-port burners are normally used with natural draft applications. They are also very frequently employed as conversion burners when boilers designed for coal or oil are converted to natural gas firing.

B. Power Gas Burners

7.11 Power gas burners for natural gas fall into two general types:

(1) ***Pressure Gas Burners:*** The pressure type is used for smaller commercial applications, usually with natural draft or induced draft. The pressure gas burner supplies a mixture of gas and air to the combustion zone under pressure. In some types, the primary air and gas mixture is introduced through a nozzle while the secondary air is fed through an air diffuser, usually a ring-shaped opening concentric with the nozzle. In another

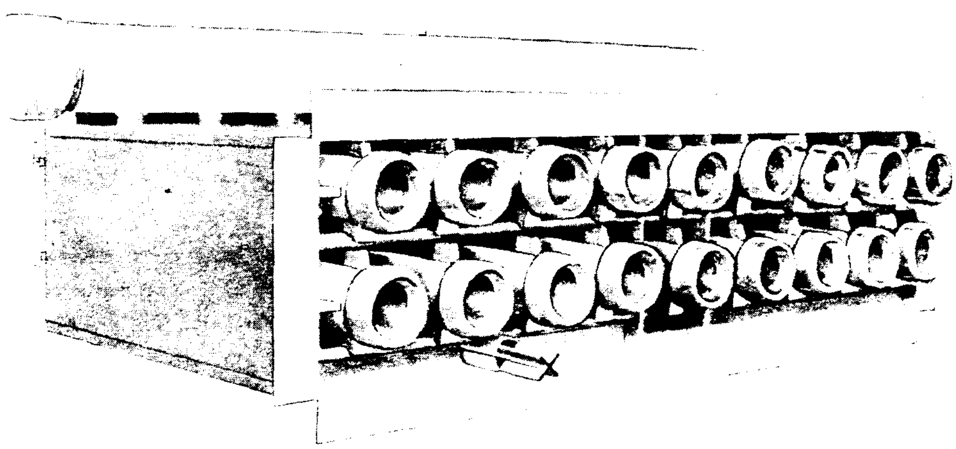


Fig. 21—Inshot Gas Burner—View From Combustion Side (Reprinted with permission, Ray Burner Co)

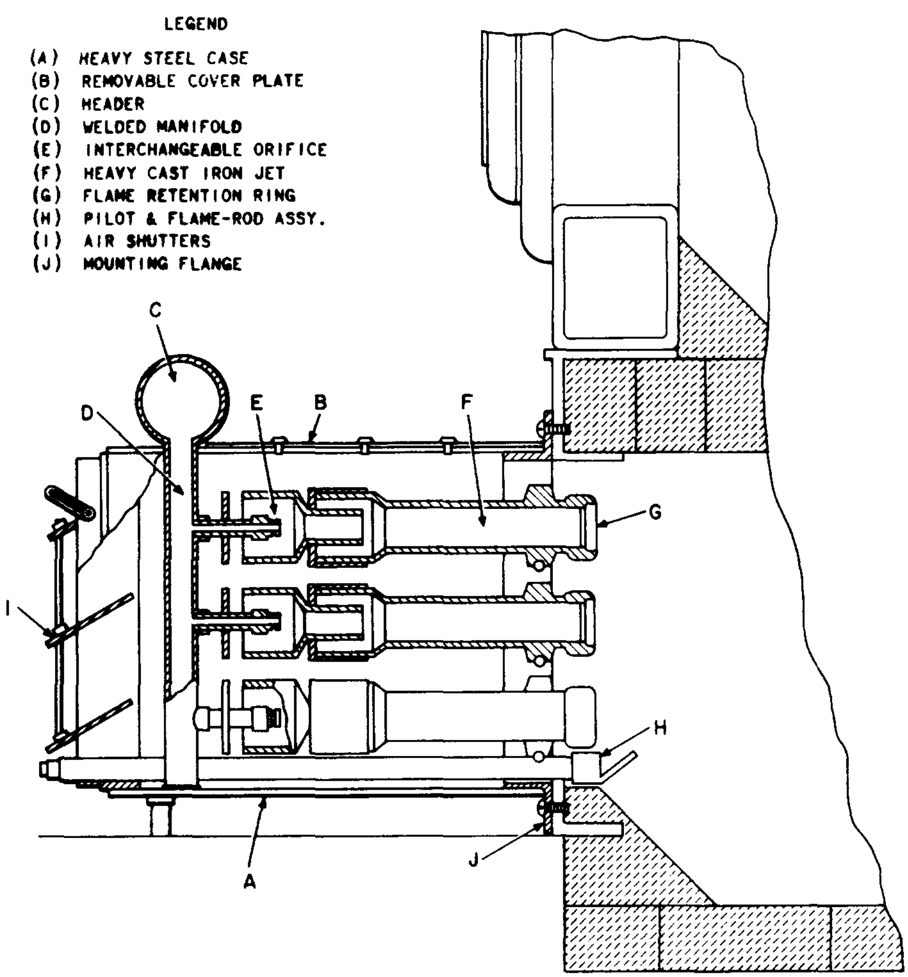


Fig. 22—Inshot Gas Burner—Cross-Sectional View (Reprinted with permission, Ray Burner Co)

type known as a ***premixing burner,*** all or nearly all of the combustion air is mixed with the gas and delivered through the burner nozzle or through a flame diffuser. Controls are provided for both types to modulate and properly proportion the air and gas supply for a variable firing rate.

(2) ***Forced Draft Gas Burners:*** These are used for the larger commercial installations and for industrial applications. They also deliver primary and secondary air under pressure by means of a blower. Gas is usually supplied from a ring with multiple ports (Fig. 23) that discharge into a forced-air annulus at an angle to provide for aspiration of the gas, fast mixing, and flame retention. Secondary air is supplied under pressure through an outer-air ring separated from the inlet rings by refractory material. These burners have modulating controls to provide a variable firing rate and can operate with either low- or high-pressure gas. The forced draft allows for efficient burning of fuel with reduced flue sizes, short stacks, or other conditions that will create adverse draft.

7.12 In addition, combination or dual-fuel burners are used in today's modern heating plant. This offers the opportunity to utilize an interruptible gas fuel as the primary fuel and oil as the secondary. Many natural gas utility company rates offer a low-priced gas with the understanding that the gas supply will be interrupted when the outside temperature falls to a predetermined level. This permits the utility company to provide for essential needs of resi-

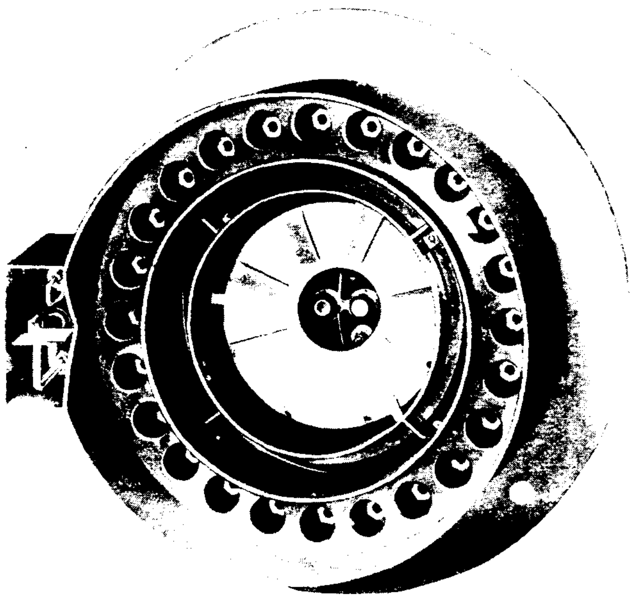


Fig. 23—Nozzle End of Forced Draft Combination Oil and Gas Burner (Reprinted with permission, Industrial Division, American Radiator and Standard Sanitary Corp)

dences, hospitals, nursing homes, etc, during the extremely cold months. Combination burners either are manually or automatically changed over from oil to gas.

7.13 Coal, as a heating fuel, is not addressed in this practice. It has and is being used in high-pressure steam generating facilities. Emission control requirements make this a somewhat difficult fuel to burn. The more sophisticated combustion methods including "fluid-bed firing" are not available for heating boilers of the size used in telephone company buildings.

8. COMBUSTION AIR

8.01 Combustion air is one of the three components of the "fire triangle" consisting of fuel, air, and ignition. Perfect or stoichiometric combustion occurs when the exact amount of air with 100 percent aeration reacts with the fuel.

8.02 To provide combustion air, a louvered opening shall be installed in the boiler/furnace room outside wall. The louver shall have not less than a net free area of 50 percent. The louver shall be sized as outlined in Fig. 24. The opening shall not be smaller than 1 square foot. If a damper is provided in this louver, a Micro Switch activated by a blade of the damper when it opens to the full open position shall be provided. This switch must be provided in the start-up circuit to prevent the burner from starting until the damper is fully open. End switches on the damper operator are not acceptable because the operator may be full open and slipped linkage would leave the damper closed. If the boiler/furnace room is provided with a ventilation system, the supply fan must be interlocked with the exhaust fan. An individual exhaust fan is not permitted because it may cause a negative pressure in the boiler/furnace room. This negative pressure could pull products of combustion from the firebox into the room and reduce the combustion air supply causing improper combustion and possibly a fireside explosion.

8.03 In boiler/furnace rooms where combustion air is supplied by a mechanically operated fan, an air-proving switch interlock must be provided in the start-up circuit. It shall prevent the burner from starting if there is low or no airflow. This is to assure sufficient combustion air. The fan shall be sized for 12 cubic feet per minute (CFM)/1000 BTUs of fuel consumed per boiler/furnace in the room firing at maximum rate.

> ***Note:*** Consideration should be given to ducting the combustion air to the burner front or as near as practical to reduce room cool-down and possibility of water pipe freeze-up in the normally cold climates. See Section 760-570-100.

9. CONTROLS

9.01 Boiler/furnace controls fall into the following categories:

(a) ***Operating Controls:*** These are pressure-sensing controls on steam boilers and temperature-sensing controls on hot water boilers and warm air furnaces. These controls, working in conjunction with space and outside air thermostats, start the burner of the boiler/furnace to maintain pressure or temperature. Water-level sensing devices automatically maintain a safe water level in steam boilers and will shut down the burner in event of a ***low-water*** condition until the proper water level is restored. Operating controls are automatic reset devices.

(b) ***Limit Controls:*** These are pressure- or temperature-sensing controls that prevent the

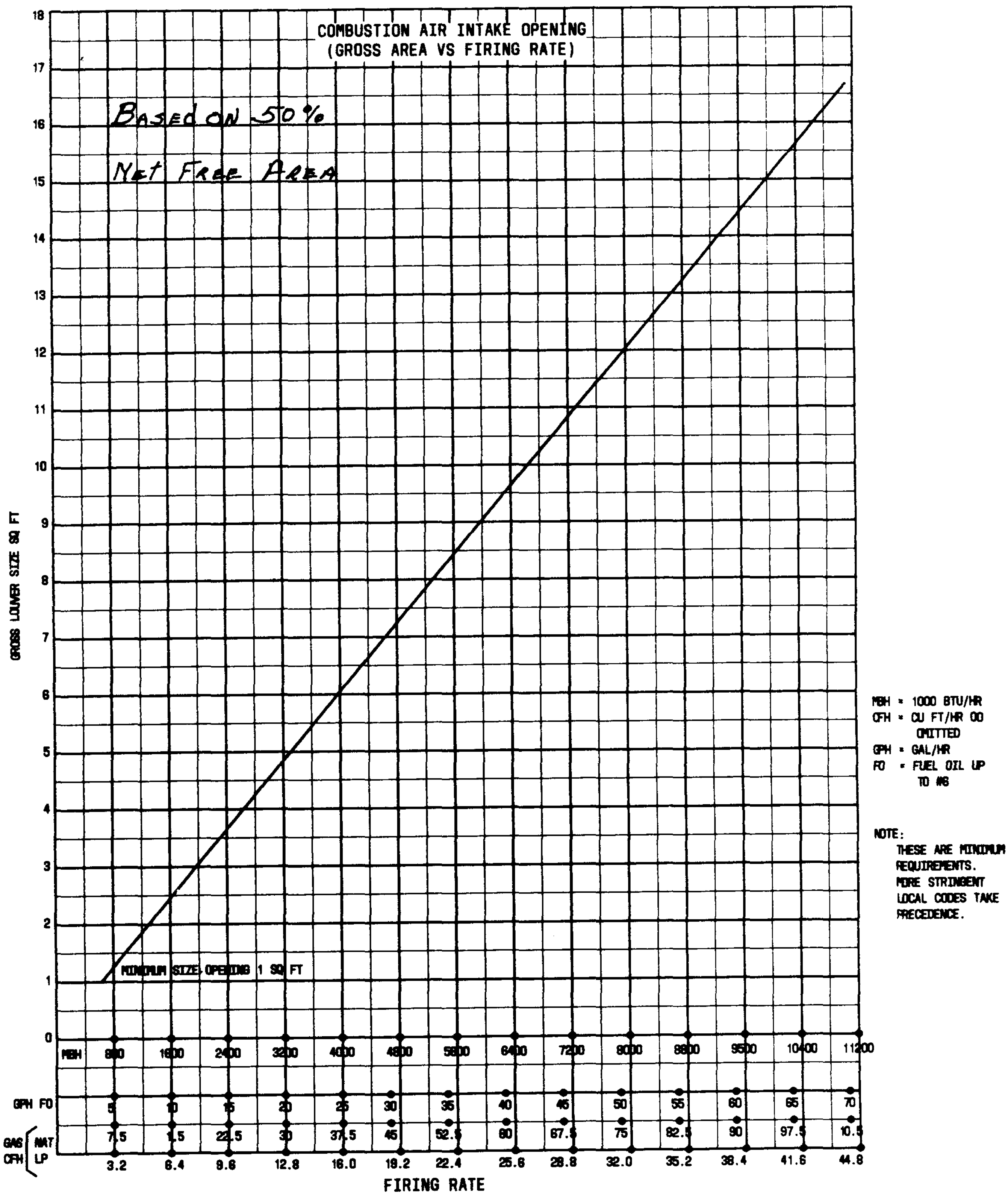


Fig. 24—Combustion Air Intake Opening (Gross Area Versus Firing Rate)

burners from raising pressures or temperatures above a preselected value. Operation of the unit above established values is considered unsafe. In addition, watér-level sensing controls shut down the boiler in event of an ***unsafe*** low water condition. All limit controls require manual reset to restart. See Section 760-530-108*.

(c) ***Flame Safeguard:*** This control monitors proper burner light off and operation causing a shutdown in event of loss of pilot or main flame during ignition or main burner running period. Flame safeguard controls require a manual reset to restart. See Section 760-530-110*.

9.02 Heating plants may be equipped with a veiwing port for observing the flame. On small units, there may be a hole with a metal cover in the vicinity of the burner. On large units, the burner front may be equipped with a viewing port of heat and ultraviolet resistant glass or may be located at the rear of the combustion chamber. It is important that the heating plant attendant be familiar with the characteristics of the flame for the particular type of burner and use the port for observations to assure that proper conditions are being maintained. To protect the eyes from intense light radiation, tinted goggles should be worn when viewing the flame through a clear or no-glass viewing port.

10. SPACE REQUIREMENTS

10.01 Space requirements for boiler/furnace rooms must include consideration of fresh air intake; ceiling height; front, side, and rear clearance around boiler; and space for an additional future boiler, if required.

10.02 The fresh air intake should not be located in the growth wall because this would lead to a ducted fresh air intake when the building is extended. In addition, keep the flue out of the growth wall as it would end up in an interior space after the building was extended. Allow for fresh air intake growth if additional boilers are planned.

10.03 Sufficient height should be provided in the boiler room so there is enough clearance above the boiler for maintenance routines. The floor of the boiler room may be depressed to gain the needed height.

10.04 The recommended minimum clearance for a boiler is:

- Front—6 feet
- Sides—3 feet
- Rear—4 feet.

This clearance is measured from any component of the boiler to a wall or another boiler. Provide a minimum clearance of 3 feet on the rear and side of a warm air furnace and 4 feet in front of the furnace.

10.05 Space for an additional boiler(s) should be considered in the initial building if the ultimate building size requires it. Connections to the flue, or a separate flue, may be constructed initially.

10.06 If a fire-tube boiler is selected, provide space for tube cleaning and replacement. Keep this space clear of pipe, conduit, and duct work.

10.07 Provide two means of exit from the boiler/furnace room. One door shall be a minimum of 3 feet wide and the other door a minimum of 2 feet 6 inches wide. Doors shall be fitted with a closer and have a minimum height of 6 feet 8 inches. All doors shall open in the outward direction.

*Check Divisional Index 760 for availability.