

Fig. 1 .... Horizontal Forced Warm Air Furnace

over the heat exchanger and through the duct work distribution system. A fuel-burning warm air furnace consists of the following basic components: (1) the heat exchanger, (2) combustion or fuel-burning equipment including burners, grates, etc., (3) casing or cabinet forming the enclosure, (4) blower and motor, (5) air filter, and (6) other accessories such as a humidifier, electronic air cleaner, etc.

The furnace may be designed and manufactured to combine those components in a variety of ways to best suit the end use. The relative positions of the components in the different types of furnaces are described below:

1. The *horizontal* furnace (Fig. 1) has the blower located behind the heat exchanger with the air entering one end and traveling horizontally through the blower and over the heat exchanger and discharged out the opposite end.

Such furnaces are used for locations with limited head room, such as attics, crawl spaces below floors or suspended under the ceiling. These units are often designed so that the components may be rearranged so that air flow may be from left to right or from right to left.

2. The *upflow* or *high-boy* furnace (Fig. 2) has the blower beneath the heat exchanger discharging vertically upward. Air

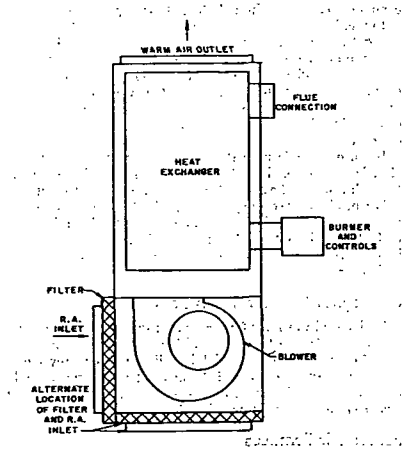

Fig. 2 .... Upflow (High-Boy) Forced Warm Air Furnace

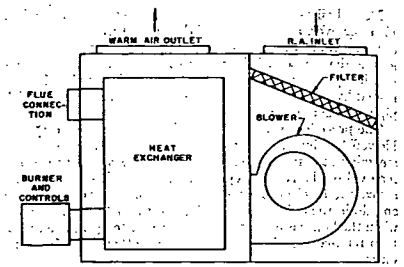

Fig. 3 .... Basement (Low-Boy) Forced Warm Air Furnace

enters through the bottom or the side of the blower compartment and leaves at the top. Such furnaces may be used in utility rooms on the first floor of homes without basements or in basements with the return air ducted down to the blower compartment entrance.

3. The *basement* or *low-boy* furnace (Fig. 3) is a variation of the upflow furnace and requires less head room. The blower is located along-side the heat exchanger at the bottom. The air enters the top of the cabinet, is drawn down through the blower, discharged over the heat exchanger and leaves vertically at the top.

4. The *downflow* or *counterflow* furnace (Fig. 4) has the blower located above the heat exchanger discharging downward. The air enters at the top and is discharged vertically at the bottom. This style furnace is used with a perimeter heating system in a house without a basement.

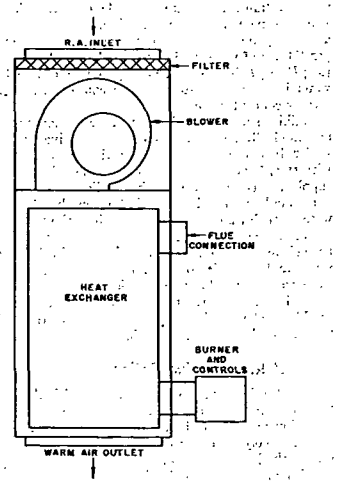

Fig. 4 .... Downflow (Counterflow) Forced Warm Air Furnace

Gravity Furnaces

While most furnaces today are of the forced air type with a blower, many gravity furnaces are still sold and a large number are being used at the present time. The gravity furnace has the air passages through the casing or cabinet and over the heat exchanger more generously proportioned so that the convection currents created by the air being warmed furnishes the motive power for the circulation of the air through the ducts. Filters are not used with gravity furnaces since the resistance to air flow must be kept as low as possible.

DESCRIPTION OF COMPONENTS

Heat Exchanger

The fuel being used has a definite influence on the design of the heat exchanger. In a coal furnace, the heat exchanger must include storage space for the burning fuel and ash in addition to combustion space. In gas or oil furnaces where the fuel is burned as rapidly as it enters the heat exchanger some space is required for burners or a combustion chamber but less space is required for combustion. Sufficient combustion volume must be allowed for the requirements of the fuel being used. Most heat exchangers have a primary combustion volume and secondary flue-gas passageways in which the products of combustion are brought into close contact with the heat exchanger surfaces.

In a coal furnace, where the resistance of the fuel bed must be overcome by chimney draft, the total draft requirement of the appliance is greater than for oil burning, for which only a slight draft is required in the combustion space, or for gas burning for which the appliance requires no chimney draft except to remove the products of combustion from the furnace outlet.

Flue-gas passages must be readily accessible for cleaning, when coal or oil is burned, for the purpose of removing soot and scale. In gas furnaces they must be accessible for cleaning where: (a) the products of combustion are drawn below the level of the burner, (b) the temperature of the combustion products is less than 250 F when the furnace is operated at normal test pressure with the gas rate within plus or minus 2 percent of the manufacturer's hourly Btu input rating, or (c) the width of any flue-gas passage is less than 1½ inches.

Flue-gas passages in coal-burning furnaces must be larger than for other fuels due to a greater volume of flue products as well as their tendency to collect soot (especially when burning soft coal).

The majority of the furnaces for coal, gas, or oil firing are now made of hot- or cold-rolled low carbon steel with welded seams. Some welded coal furnaces also have the joints riveted since they can be more subject to overheating than oil or gas furnaces in which the combustion rate is carefully controlled. Frequently, in heavy duty furnaces, alloy steels containing chromium and nickel may be used for higher temperature operation. Heat exchangers may also be protected against oxidation at somewhat higher temperatures by ceramic coating or by the use of aluminized steel in which the aluminum coating changes into an iron-aluminum alloy which will withstand higher temperatures than the low carbon steel.

Publications of the American Gas Association and underwriters' Laboratories give the maximum allowable temperature for the various materials commonly used.

Combustion Equipment and Performance

Gas. Gas-designed furnaces may burn natural, manufactured, mixed, liquefied petroleum, and liquefied petroleum-air gases.

Most residential gas furnaces are equipped with one of two heat exchanger types. Either a single combustion chamber is used (usually cylindrical in shape) with extended flue-gas passageways which may be adjacent to the combustion chamber or encircle it, or the heat exchanger may be made of a series of individual sections connected near the bottom and connected to a common flue-gas breeching at the top. The former design will usually be equipped with a burner of the single port design and the latter, known as a sectional furnace, will usually have individual burners under each of the flues, cross-connected to ignite from a single pilot burner ignition source.

Oil. Oil furnaces consist of a single primary heat exchanger plus additional flue-gas passageways which provide secondary heating surface. In residential furnaces, the high-pressure, low-pressure, and rotary burners are most frequently used.

With the pressure-type burners, it is usually necessary to provide a combustion chamber that will keep the temperatures in the combustion zone high enough to promote rapid vaporization of the oil and at the same time protect the side walls of the heat exchanger from the flame temperature. Insulating-type refractory either in molded or felted form or high-temperature chrome-nickel steel may be used.

In heavy duty furnaces, it is often possible to burn the flame in suspension without the aid of an inner combustion chamber. In this case the heat exchanger itself will be made of chrome alloy steel in the combustion zone.

Most furnaces designed for oil are available as complete packages including the furnace and the oil burner. In the smaller sizes, they are completely assembled at the factory and are shipped ready for installation.

Casing or Cabinet

Forced air furnaces for both oil and gas are enclosed in cabinets that are usually rectangular in shape. The cabinet provides the passageway for the air over the heat exchanger and also usually encloses the blower, motor, filters, burners, controls, and draft hood.

The cabinet is insulated in the heat exchanger compartment with aluminum-faced mineral wool or asbestos or by a metal liner to assure cabinet surface temperatures that are not dangerous to touch and do not offer a fire hazard to adjacent combustible materials. Cabinets are usually finished in baked enamel. Flanged openings are usually provided for supply and return air duct connections. Removable access doors or panels are included for access to all parts.

Blowers and Motors

Centrifugal blowers with forward-curved blades of the double inlet type are almost exclusively used as the air circulation means in forced warm air furnaces. These blowers are selected to overcome the resistance of the furnace air passageways as well as the resistance of the filters and the duct work. They may also be sized to provide the additional air requirement for cooling and to overcome additional static resistance through cooling coils.

The blower wheel may be mounted directly on the motor shaft to run at motor speed but it is usually belt-driven by a V-belt in which case a fixed pulley is mounted on the blower shaft and a variable-pitch drive pulley is mounted on the motor shaft to permit adjustment for proper fan speed. Means are provided for shifting the motor position to obtain proper belt tension after pulley adjustment.

The electric motors used for driving furnace blowers are usually designed for that specific purpose. Since the blower does not pick up its full load until it is up to operating speed,