

are necessary. There is no connection between the heating elements and the casing except at the front or firing end. Large units have locomotive-type shaking grates, and small units have circular firepots and grates. In large units the dome above the fire is kept 4 ft or more above the normal fire level.

Furnaces for use with fans must incorporate in their design the feature of longest fire travel and maximum surface commensurate with construction economy and durability, and the maximum in heating surface for impingement of the circulating air. The fuel to be used is a factor, anthracite being less desirable than bituminous coal, oil or gas. The use of a high radiation fuel bed is likely to result in overheating and reduced life of the firebox walls. For this reason it is common practice to have the surface adjacent to the fuel lined with cast-iron or fire-clay material. Sometimes these linings are arranged as tuyeres to preheat the air for combustion. Expansion and contraction must be minimized by designing equal thicknesses of metal, by ribbing, long fire travel and sectional construction.

The proper design of the heater hinges largely on the kind of fuel to be burned. Accordingly, various manufacturers are making special units for coal, oil and gas. Each class of fuel requires a distinct type of heater for the highest efficiency and economy obtainable. Briefly the characteristics of a heater to obtain the best efficiency and economy for each of the fuels are as follows:

1. COAL BURNING:

- a. *Bituminous*—Large, open combustion spaces, and self-cleaning heating surfaces.
- b. *Anthracite*—Large firebox capacity.

2. OIL BURNING:

- a. Long tortuous fire travel.
- b. Extensive heating surface.

3. GAS BURNING:

- a. Extensive heating surface.
- b. Numerous small flue passages.

A combustion rate of from 5 to 8 lb of coal per square foot of grate per hour is recommended for residential heaters depending upon the ratio of grate surface to heating surface, firing period and available draft. A rate of from 10 to 14 lb is permissible with larger heaters if the available draft is sufficient, and the ratio of grate to heating surface is high. Where oil fuel is used care must be exercised in selecting the proper size and type of burner for the particular type of heater used.

Direct fired heaters should be designed for blow-through installation, that is, the combustion vessel should be under external pressure so that there can be no leakage of the products of combustion into the ventilating system.

Ratings and Capacities of Fan Furnaces

This class of equipment usually is rated in one of three ways, as follows:

1. The temperature rise of the air is listed over a certain range of velocities through

the free area of the heater for varying combustion rates, for a certain heating value of the fuel.

2. The volume of air in cubic feet per minute is listed over several temperature rises with the necessary fuel consumption, taking coal of some known heating value as a standard.

3. The Btu imparted to the air is listed for varying combustion rates.

Either of the first two methods is preferable to the third because of the inaccuracies that are apt to creep into the latter, due to the fact that for the same combustion rate on any given heater, the Btu imparted to the air will not remain constant, but will vary with the volume of air passed over the heater.

The capacities of heaters for large commercial and industrial buildings range from 400,000 to 1,800,000 Btu per hour per unit. The capacities of heaters for residences and other small buildings range from 50,000 to 400,000 Btu per hour per unit.

The emission of heat from the heating surface of these furnaces will vary from 2,000 to 3,000 Btu per square foot per hour. The average is about 2,500 Btu. Higher rates of emission may be obtained by increasing the air velocities over the heating surfaces, and the velocity of movement of the combustion gases on the inside of the heating surfaces.

In commercial sizes the ratio of the heating surface to the grate surface will vary from 30 to 1 to 50 to 1. Heavy duty heaters average about 40 to 1 and residential heaters about 20 to 1. For oil or gas extra large heating surface area is required.

The free area through the heaters and resistance to the flow of air at varying velocities are characteristics depending upon the heater in question. The resistance of heaters should not exceed one-half the total static resistance in the system.

Arrangement of Fan Furnace Heaters

Fan-furnace heaters are readily arranged for any combination of one or more heaters in battery. Any variation of the following arrangements may be used (See Figs. 1 to 8, inclusive):

1. Battery of any number of units with one plenum chamber.
2. Separate batteries of heaters with separate fans and plenum chambers.
3. Heaters in battery with separate division casings and louvers at rear for cut off of air supply to each heater.
4. Tempered air in addition to warm air chamber.
 - a. By recirculating small portion of heated air back to fan inlet;
 - b. By connecting warm air chamber to tempered air chamber with control damper; or
 - c. By mixing cold air below heaters to warm air from plenum chamber.
5. Automatic control of temperature by
 - a. Controlling quantity of heated air entering room;
 - b. Controlling temperature by mixing dampers; or
 - c. Controlling temperature by regulation of fuel.

Control of Fan Furnaces

Control of various units of a plant can be easily arranged by electric or pneumatic cut-off dampers. This will provide means of heating por-