such fashion that rotational circulation is set up by the system rather than having the heaters discharge in random and counter directions.

Usually hot blasts in the working zone are objectionable, so heaters mounted on the floor should have their discharge outlets above the head line and suspended heaters should not be placed so low or turned in such direction that the heated air will penetrate the working zone. In the interest of economy, however, the elevation of the heater outlet and the direction of discharge should be so selected that the heated air is brought as close to the head line as possible, but not into the working zone.

Unit heaters should be carefully air vented and usually a blast type trap of at least 50 per cent excess capacity should be used to take care of the load during the heating-up period. During that period the temperature of the air entering the heaters is low and the heaters therefore condense more steam than they do when the building is up to temperature. Steam pressures below 5 lb. can be used with safety for re-circulating heaters when proper provision is made for returning the condensation. If heaters are to take in air that might be at a temperature below freezing, a steam pressure of at least 5 lb. should be maintained on the heater coils.

Stopping the fan motor but with steam on the coils reduces the heat output 70 or 80 per cent, depending upon the design of the heater. Thus room temperatures can be controlled by starting or stopping the fan motor on one or more of a group of units. This can be done manually or by means of a simple thermostat which makes and breaks the circuit either direct to the motor for fractional horsepowers or through an automatic starting switch. Of course the heat output of the heater may also be controlled by the throttle valve to the heater coil. This can be done thermostatically either with a graduated or with an on and off action. In some applications thermostatic controls to both the motor and the steam valve are used in conjunction.

What has been said relates generally to units in which steam or hot water is used as the heating medium. On rare occasions electrical resistances are used as the heating element but are applied only where electric power is abundant and cheap and other forms of fuel scarce and expensive.

DIRECT FIRED UNITS

In places where these heating mediums are not available the direct fired type of heater is used. Here the heating element is a fire box in which coal, coke, oil or gas is burned directly. This fire box is enclosed in a casing in which fans are mounted so as to draw air over the fire box, and combustion chamber and discharge it directly into the room. This type of heater is also used for temporary heat or where the installation of a steam or hot water plant is for some reason not justified.

CHAPTER XI

GRAVITY WARM-AIR FURNACE HEATING

IN this chapter of THE GUIDE consideration will be given to the design of gravity circulating warm-air heating systems. For fan circulating systems see Chapter XXI on Design and Construction of Air Ducts. Complete engineering data, including the procedure to be followed in designing a typical system, are presented in the first part of the chapter, while the last part of the chapter presents a Standard Code Regulating the Installation of Gravity Warm-Air Heating Furnaces in Residences, approved by the *National Warm Air Heating and Ventilating Association*, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *National Association Sheet Metal Contractors*, *Western Warm Air Furnace and Supply Association*, and the *Midland Club*, as a workable Code for furnacemen.

DEFINITIONS

In general, warm-air furnace heating plants consist of a fuel burning furnace or heater enclosed in a casing of sheet metal or brick, which is placed in the basement of the building. The heated air, taken from the top or sides near the top of the furnace casing, is distributed to the various rooms of the building through sheet metal warm-air pipes. The warm-air pipes in the basement are known as leaders, and the vertical warm-air pipes which are run in the inside partitions of the building are called stacks. The heated air is finally discharged into the rooms through registers which are set in register boxes placed either in the floor or in the side wall, usually at or near the baseboard.

The air supply to the furnace may be taken (1) entirely from inside the building through one or more recirculating ducts, or the air supply may be taken (2) entirely from outside the building, in which case no air is recirculated. Sometimes a combination of the inside and outside air supply system is employed.

Furnace heating plants may be (1) of the gravity circulating type in which the motive head producing flow depends upon the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing, or (2) of the fan circulating type in which a fan may supply all or part of the motive head producing flow. In most house installations, the former type of system is in general use.

Material for this section was prepared especially for THE GUIDE by Arthur C. Willard, Professor of Heating and Ventilation and Head of the Department of Mechanical Engineering, University of Illinois, Urbana, Illinois.

All figures and much of the engineering data which follow are from Bulletin No. 141, "Warm Air Furnaces and Heating Systems," Part II, by Professors A. C. Willard, A. P. Kratz and V. S. Day, Engineering Experiment Station, University of Illinois.