heaters are useful in conserving and localizing heat delivery at definite points. They are not suitable for general air heating.

Radiant electric heaters, which deliver most of their heat by radiation, have heating elements with reflectors to concentrate the heat rays in the desired directions. They are not satisfactory for general air heating, as radiant heat rays do not warm the air through which they pass. They must first be absorbed by walls, furniture, or other solid objects which then give up the heat to the air. For a discussion of electrically heated panels as applied to radiant heating, see Chapter 23.

Gravity convection electric heaters, designed to induce thermal air circulation, deliver heat largely by convection, and should be located and used in much the same manner as steam and hot water radiators or convectors. They generally have heating elements of large area, with moderate surface temperature, and are enclosed to give a stack effect to draw cold air from the floor line. The flexibility possible with electric heating elements should discourage the use of secondary mediums for heat transfer. Water

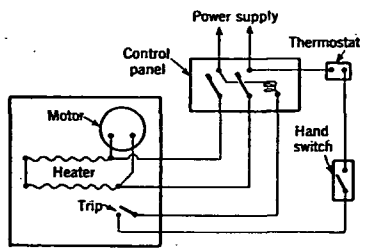

FIG. 1. WIRING DIAGRAM FOR UNIT HEATER

and steam add nothing to the efficiency of an electric heater and entail expensive construction and maintenance.

Induction and dielectric heaters are described in a later section.

UNIT HEATERS

Electric unit heaters include a built-in fan unit which circulates room air over heating elements. They are adapted to the same uses as other types of unit heaters, if conditions are favorable to electric heating. They are very adaptable for heating of small offices, locker rooms, etc., in otherwise unheated buildings. In small unattended equipment rooms, thermostatically controlled electric unit heaters are frequently used to maintain a temperature above freezing.

The best location for electric unit heaters depends upon local conditions. Various designs and arrangements are available, as with steam unit heaters (see Chapter 24).

The arrangement of the wiring circuits is very important. In principle, they are all the same and include as essential elements, a magnetic control contactor, a thermostat, and a master hand switch. All heaters should be designed with a safety thermal trip wired in series with the magnetic contactor, and with the hand switch and thermostat. A typical wiring diagram for single phase power supply is shown in Fig. 1. A main disconnect switch should be provided. For three-phase power supply, a 3-pole contactor should be used with the heater arranged for 3-phase connection. On large sizes, separate over-load protection for the motor should be provided.

If the line voltage is more than 120 to ground, it is advisable to supply the thermostatic control circuit through a transformer.

CENTRAL HEATING AND AIR CONDITIONING

Electric heating elements can be used for the prime source of heat in a central fan heating system or in the heating phase of an air conditioning system. They can be used in the same manner as steam heating units for tempering, preheating or reheating the air at the main supply fan location, and as booster heaters at the delivery terminals of the duct system. In the humidification phase of air conditioning, electric heating elements can be used to provide moisture by the evaporation of water.

In coordinating the input of heat energy and the volume of air circulation, a basic difference between electric heating and steam heating enters into the problem. Steam is approximately a constant-temperature

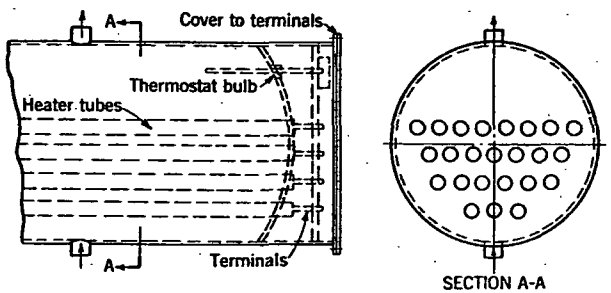

FIG. 2. RESISTANCE TYPE BOILER FOR STEAM OR HOT WATER

source of heat for any given pressure, and a change in air volume flowing over steam coils does not greatly affect the temperatures of the coil surface. The amount of steam condensed (heat input) varies in proportion to the air volume, but the surface temperature of the steam coils remains about the same. Electric heat is quite different, having a constant input of energy. If the volume of air flow over electric heating elements is changed, and no change is made in the electrical power input, there will be a corresponding change in the temperature of the air delivered. This occurs because the electrical energy input remains constant, and the surface temperature of the heating elements will vary as is necessary to force the air to accept all the heat. With electric heat the total heat is constant unless some compensating action is performed by controls. Automatic variation of the electrical heat input synchronized properly with the air flow, can be successfully accomplished by various special methods of control. By-pass dampers as used with steam units will not control electric heat.

Electric heaters are useful in balancing the heat distribution in central fan systems. Even in those instances where steam is the principal heat source, the temperature of individual rooms can be controlled locally by separate electric booster heaters. These heaters can be installed in branch ducts or behind the air outlet grilles in each room. With this arrangement, the central heating unit distributes air at an average temperature, controlled from a thermostat centrally located, such as in the main return duct. The electric booster heaters may be controlled by thermostats