fiber thread, are employed for many low-temperature purposes such as heating pads, blankets, aviators' clothing, and some radiant panel heating installations.

Special incandescent lamps are used as heating elements in certain applications where radiant heat alone is desired. These may have tungsten or carbon filaments as resistors, and are designed to produce maximum energy in the infra-red portion of the spectrum.

ELECTRIC HEATING UNITS

In general, an electric heating unit is considered to be a structure containing one or more heating elements, electric terminal connections or leads, electrical insulation, and a frame, casing or other supporting means, all assembled together into a unit. There are many varieties, designated by such characteristics as shape and size of housing, material and arrangement of heating elements, operating temperature of resistors, ratio of radiant to convective heat delivery, directional control for radiation, natural or forced convection air circulation, thermostatic or manual control, and electric load-limiting features.

So-called *electric unit heaters* include a built-in fan which circulates room air over heating elements; they are employed for the same uses as other forms of unit heaters (steam, hot water, gas, oil), if conditions are favorable to electric heating. They are especially adaptable for supplemental heating, for small occupied rooms in otherwise unheated buildings and for unattended equipment enclosures in which temperature must be maintained above freezing. Location and arrangement of such unit heaters are discussed in Chapter 24. The typical wiring connection for a heater with single-phase power supply, shown in Fig. 1, has a safety thermal trip wired in series with the magnetic contactor, thermostat, and manual switch.

Forced-air duct heaters have collar frames designed to fit into rectangular cross-section ducts, within which are mounted closely nested resistors all wired to the terminal connections. Choice of resistor type and spacing depends on requirements for heat transfer to the air and on obtaining low air-flow resistance.

APPLICATIONS OF ELECTRIC HEAT

Until recently the predominating applications of electric space heating have been for convenience service, such as: (a) to supplement an existing system, locally, at times when the main system is shut down, (b) for local use, where the main system may be inadequate, (c) for temporary service requirements, (d) for special conditions involving separate or remote control, (e) for isolated locations, (f) where minimum initial cost is the dominant factor. Some of these requirements are readily satisfied with portable heating units. However, complete electric heating systems are now finding wide application, mainly in residences, but also in many commercial and and industrial establishments.

Small electric duct heaters or compact strip heaters are useful in balancing heat distribution in central fan heating systems operated with steam and hot water, and in improving temperature and humidity control for summer air conditioning. Such heaters can be installed in branch ducts or behind the air inlet grilles in each room.

In control of heating systems, employing electric units of the forced-air duct or similar types, a basic difference between electric heating and

steam should be taken into account. Steam is approximately a constant-temperature source of heat, at any given pressure, and a change in air quantity flowing over steam coils does not greatly alter the temperature 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 rate of energy input. If the air flow over electric heating elements is changed, but no change is made in the electric power input, there will be a corresponding change in 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 compel the air to accept all the heat.

Thus, with electric heat the total heating effect is constant unless some compensating action is performed by controls. Automatic variation of

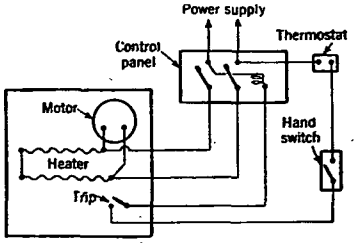

FIG. 1. WIRING DIAGRAM FOR UNIT HEATER

the electrical heat input synchronized properly with the air flow, can be successfully accomplished by certain special methods of control. Bypass dampers as used with steam units cannot control electric heat.

TYPES OF ELECTRIC HEATING SYSTEMS

The principles employed in electric house heating for heat transfer and distribution, and for temperature control and cyclic operation, and the variety of equipment that has found application, outnumber those for systems utilizing fuel. This can be ascribed to the inherent adaptability of electric energy for transmission, conversion and regulation, and more importantly to the relatively high unit cost in terms of thermal equivalent as compared with fuels traditionally used for house heating; this necessitates and justifies greater attention to efficient utilization.

Types of electric heating equipment and complete heating systems in current use are listed in Table 1. The sequence shown is for convenient reference only, and does not indicate the relative extent of use, quality of performance, or installation cost and operating expense. Installations of all types listed are in successful operation, but performance and cost depend in large measure on proper application to the local conditions.

EQUIPMENT AND INSTALLATION METHODS

Convector with Metallic Resistors

Standard heating units for wall mounting, of either recessed or surface type, are made with resistors of incandescent bare-wire or low-temperature