7. *Make a study of the heating system and heating requirements.*
   a. Provide thermometers and recording pressure gages so that the heating system may be operated with full knowledge of what is being accomplished.
   b. Keep daily consumption records and check against the theoretical requirements.
   c. Study the system and understand its functions and its operations.

AUTOMATIC TEMPERATURE CONTROL

As stated in Chapter 34, Automatic Control, properly applied to heating, ventilating and air conditioning systems, makes possible the maintenance of desired conditions with maximum operating economy. The use of adequate temperature control provides more healthful, comfortable, and efficient working conditions in buildings.

There are three general means of obtaining centralized control of heat output of radiators.

1. *Controlling the rate of steam flow* into the radiators. This is accomplished by equipping the radiator inlets with orifices and controlling the flow of steam through them into the radiator by controlling the difference in pressure between the supply and return.

2. *Controlling the temperature of steam* in the radiators by varying its pressure. This involves the use of high vacuums to obtain low steam temperatures. This must be supplemented by some other type of control for low heat output.

3. *Controlling the length of time steam flows* into the radiators by admitting steam to a heating system intermittently and varying the length of the *on* and *off* periods. Two types of controls are used. (1) A clock control providing *on* and *off* settings of various lengths, which can be changed in accordance with outside temperatures. In most cases these changes are made automatically by means of a thermostatic bulb, placed outdoors. (2) A control, having an outdoor bulb and a bulb attached to the radiator, which varies the length and frequency of the *on* intervals in such a way that the radiator temperature is varied according to the outside temperature. In some cases heat supply is controlled by combinations of the three methods described.

Before installing any type of modern temperature control equipment, it is necessary to see that the heating system is put in good operating condition. In general, the heating system in a building is not given the attention that other mechanical equipment is given because it will continue to function, after a fashion, even though changes in piping, location of radiation, settlement of piping, and the normal wear and tear or other changes have taken place. Because of this depreciation of the system, operation becomes more and more costly and parts of the building have to be greatly overheated in order to prevent underheating in other parts. Vents, traps, vacuum pumps, and valves should be given a careful inspection and replaced or repaired if required. The piping should be of adequate size and graded properly. The return piping should be inspected, and any pockets or lifts removed and properly vented. These inspections and repairs are not costly and may prevent a much greater outlay in future years. In most cities district heating companies will be willing to make a survey of heating systems and offer recommendations in regard to operation and changes in piping layout.

The selection of control equipment depends upon the type and size of building and the degree of saving which may be obtainable.

REFERENCES

1—Code for Pressure Piping, B 31-1, 1942, *American Standards Association*, Paragraph 408, p. 116.
2—Principles of Economical Heating, *National Association of Building Owners and Managers.*

Chapter 30

ELECTRIC HEATING

Resistors, Heating Elements, Electric Heaters, Unit Heaters, Central Fan Heating, Electric Boilers, Electric Hot Water Heating, Heating Domestic Water Supply, Control, Calculating Capacities, Radiant Drying, Induction and Electrostatic Heating, Power Problems

ELECTRIC heating deals with the conversion of electrical energy into heat and the distribution and practical use of the heat so produced. In certain regions, where the cost of electricity is favorable, electric heating is used extensively. Its use is also frequently dictated by special conditions.

DEFINITIONS

Definitions of general terms used in fuel heating are given in Chapter 1. Terms which apply particularly to electric heating are as follows:

Electric Resistor: A material used to produce heat by passing an electric current through it.

Electric Heating Element: A unit assembly consisting of a resistor, insulated supports, and terminals for connecting the resistor to electric power.

Electric Heater: A complete assembly of heating elements with their enclosure, ready for installation in service.

RESISTORS AND HEATING ELEMENTS

Solids, liquids, and gases may be used as resistors, but most commercial electric heating elements have solid resistors, such as metal alloys, and non-metallic compounds containing carbon. In some types of electric boilers, water forms the resistor which is heated by an alternating current of electricity passing through it. One of the more common resistors is nickel-chromium wire or ribbon which, in order to avoid oxidation, contains practically no iron.

Commercial electric heating elements are made in many types. Some have resistors exposed to the air being heated. The resistors may be coils of wire or metal ribbon, supported by refractory insulation, or they may be non-metallic rods, mounted on insulators. This type of element is used extensively for operation at high temperatures when radiant heat is desired, also at low temperatures for convection and fan circulation heating, especially in large installations.

Some elements have metallic resistors embedded in a refractory insulating material, encased in a protective sheath of metal. Fins or extended surfaces may be used to add heat-dissipating area. Elements are made in many forms, such as strips, rings, plates and tubes. Strip elements are used for clamping to surfaces requiring heat by conduction, and in some types of convection air heaters. Ring and plate elements are used in electric ranges, waffle irons, and in many small air heaters. Tubular elements may be immersed in liquids, cast into metal, and, when formed into coils, used in electric ranges and air heaters. Cloth fabrics woven from flexible resistor wires and asbestos thread are used for many low temperature purposes such as heating pads, aviators' clothing and radiant panel heating installations.

Special incandescent lamps are used as heating elements in certain applications where radiant heat is desired. These use carbon or tungsten