3. *Controlling the length of time steam flows* into the radiators by admitting steam 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.

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, and settlement have taken place. Because of this depreciation of the system, operation becomes more costly, and parts of the building may 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.

HOT WATER HEATING SYSTEMS

Some of the more generally accepted methods of controlling hot water heating systems are

1. Controlling the flow of water supplied to the system while maintaining a constant water temperature in the boiler or converter storage tank by:
   a. Starting and stopping the circulating pump by means of a room thermostat.
   b. Maintaining a constant pump circulation and stopping the water circulation to a zone or several zones by the use of positive acting valves under the control of room thermosats.
2. Varying the temperature of the water supplied to the system in accordance with the variations of the outside weather conditions, while maintaining constant water circulation to the system, and
   a. Regulating the volume of water to each room or zone by gradual acting valves under the control of room thermostats.
   b. Stopping the flow of water to each room or zone by positive acting valves under the control of room thermostats.
   c. Arranging the piping and regulating valves, such as three-way valves, under the control of room thermostats to further modify the water temperature in accordance with the heating requirements of the room or zone.

Whatever the mechanical features of the regulator may be, its function is to dictate the flow impulse, or rate of flow, in such a way as to maintain the desired indoor temperature in a zone, regardless of the fluctuations in the outdoor temperature.

UNIT HEATERS

The standard method is to stop and start the fan by means of a two-position room thermostat. A limit control may be provided to prevent operation of the fan when no heat is being supplied by the connecting services. Sometimes a separate manual switch may be connected so as to permit operation of the fan for ventilating purposes at times when no heating is desired.

A proportioning room thermostat may control a modulating valve in the connecting service pipes, if continuous fan operation is maintained.

UNIT VENTILATORS

Many different control cycles are available. The principle difference in the various cycles pertains to the amount of outdoor air delivered to the room during normal periods of heating. The choice may be governed by compulsory ventilation codes.

Usually a room thermostat controls both a valve to regulate the heat supply and a damper to regulate the supply of cool outdoor air. An insertion thermostat at the unit ventilator prevents the discharge of air below the desired minimum temperature. Any auxiliary heating devices in the same room should be controlled, by the room thermostat, in the proper sequence to fit into the unit ventilator cycle during the following stages:

Warm-up Stage. All control cycles function to provide rapid warm-up by having all heating valves wide open and the outdoor damper closed. Thus 100 percent room air is recirculated and heated until the room temperature approaches the desired temperature level.

Heating and Ventilating Stage. As the room temperature rises into the operating range of the thermostat, ventilation is accomplished by the partial or complete opening of the outdoor damper according to the cycle used. Valves on auxiliary heating devices are often closed at about the same time. As the room temperature continues to rise the unit ventilator valve is throttled as required to control the heat supply.

Cooling and Ventilating Stage. When the room temperature rises above the normal level, cool air is discharged into the room. The room thermostat accomplishes this by throttling the valve further, and then closing it and opening the outdoor damper, if necessary, to prevent the room from overheating. The insertion thermostat frequently takes control during this stage to prevent the discharge of objectionably cold air.

The three basic control cycles commonly used are as follows:

Cycle X. A fixed percentage (often 100 percent) of outdoor air is admitted at all times except during the *warm-up stage.*

Cycle Y. A minimum amount of outdoor air (normally 25 to 50 percent) is admitted during the *heating and ventilating stage.* This percentage is gradually increased to 100 percent, if needed, during the *cooling and ventilating stage.*

Cycle Z. Except during the *warm-up stage* a variable amount of outdoor air is admitted as needed to maintain a fixed temperature of air entering the heating coil. This is controlled by the insertion thermostat which must be set low enough (often 60 F) to provide cooling when needed.

Day-night thermostats are often used with unit ventilators. Separate switching circuits are used to permit daytime temperatures in some areas and lowered temperatures in others for maximum economy. Several day-night arrangements are in common use. One uses the unit as a convector. Another turns the fan on and off like a unit heater. More elaborate arrangements are available.

UNIT COOLERS

Although most unit coolers can be adapted to any control cycle, continuous fan operation is recommended to avoid stratification and wide fluctuations in space temperature. Should the unit be completely self-contained, control of the direct expansion refrigeration unit may be obtained from the temperature of the recirculated air and from suction pressure. In the case of multiple unit systems supplied with refrigerant or chilled water from a central source, a valve in the supply to each cooling coil may be controlled thermostatically from space temperature.

REFRIGERATION AND DEHUMIDIFICATION EQUIPMENT

Typical control equipment and its functions are described in the following paragraphs.

Well Water. Where well water is used directly in air washers or cooling coils,