air intake, the fan discharge, the conditioned space or the return air. Instruments are available which, with an adequate arrangement of dampers, will cause a maximum quantity of outdoor air to be handled until it becomes more economical to utilize return air.

4. *Cooling and dehumidifying* may be controlled by means of thermostats, and hygrostats or dew-point thermostats, which regulate dampers and mixing valves to maintain air of the proper temperature and humidity in the discharge from the central fan plant. Such controlling instruments normally are located in the fan discharge or in the return air, or both, and they may be associated with thermostats or hygrostats in the conditioned spaces.

5. Where a *separate duct serves each zone* of an area with which a central fan system is associated, a room thermostat in each zone may operate mixing dampers in the inlet to each zone duct, determining the quantity of warm air which is required from that portion of a plenum chamber into which heated air is delivered, and the quantity of cool air which should be taken from the other portion of the double plenum chamber. In many instances, separate zone heating and zone cooling coils are employed, instead of mixing dampers.

6. The control hook-up for a typical *year 'round air conditioning system*, including automatic change-over from heating to cooling, is indicated in Fig. 1 and described as follows:

Whenever the fan is started, solenoid air valve or relay E-1, actuated by the fan motor starter, opens minimum outdoor air damper D-1, places hygrostat H, in service, and allows duct thermostats T-3 and T-4 to control the maximum outdoor air damper D-2 and the return air damper D-3.

When the fans stop, E-1 is de-energized to close the outdoor air dampers and also to close humidifier valve V-4.

Thermostat T-1 positions steam valve V-3 on the reheater coil, to maintain a constant space temperature. As the space temperature rises, T-1 positions reheater valve V-3 to a closed or to a minimum open position, as determined by low limit discharge thermostat T-5. Duct thermostat T-6, in the preheater discharge, positions preheater coil valve V-1 to maintain a constant preheater discharge temperature.

On rising outdoor temperature, between 30 F and 65 F, duct thermostat T-3, located in the outdoor air intake, moves maximum outdoor air damper D-2 toward the open position. At 65 F outdoor, D-2 will be fully open and return air damper D-3 will be fully closed.

As the outdoor air temperature rises above 65 F, duct thermostat T-3 positions V-5 in such a way as to by-pass low limit thermostat T-5, so that reheater coil valve V-3 is operated directly from thermostat T-1. As outdoor air temperature rises from 65 F to 75 F, duct thermostat T-4 gradually closes maximum outdoor air damper D-2 and opens return air damper D-3.

Cooling thermostat T-2 positions cooling coil valve V-2 to admit more chilled water as the space temperature rises.

Hygrostat H positions humidifier valve V-4 to maintain the desired humidity in the conditioned space.

7. The arrangement of automatic control for a *constant temperature and constant humidity air conditioning system*, using 100 per cent outdoor air, is shown in Fig. 2, and the control description follows:

Whenever the fan is running, relay or solenoid air valve E-1, actuated by the fan motor circuit, is energized, opens outdoor air damper D-1, and also permits hygrostat H, in the conditioned space, to control humidifier valve V-2.

When the fan stops, E-1 closes outdoor air damper D-1 and humidifier valve V-2.

Remote bulb thermostat T-2, with bulb located in preheater discharge, operates valve V-3 on the preheater coil, to maintain a constant preheater discharge temperature.

On rising temperature, thermostat T-1, in the conditioned space, closes reheater valve V-1 and, through relay C-1, opens face damper D-2, for cooling. On rising humidity in the conditioned space, hygrostat H closes humidifier valve V-2, and likewise, through C-1 may open face damper D-2 for dehumidification.

For closer control, the face and by-pass dampers should be eliminated, and cooling means continuously provided whenever the outdoor dew-point rises above a predetermined maximum. Reheating and humidifying may be required to provide the desired conditions. However, such a system will be less economical in operation.

DISTRICT HEATING CONTROL

There are three general means of obtaining centralized control of heat output of radiators in district heating systems.

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.

PANEL HEATING CONTROL

Automatic controls for radiant and convective heating differ somewhat due to the thermal inertia characteristics of the panel heating surface, and the increase in the mean radiant temperature within the space under increasing loads for panel heating.

Effect of Inertia of Panel

If a panel has considerable heat storage capacity (as compared with a convector or conventional radiator) it will continue to emit heat for some time after the room thermostat has become satisfied and shut off the supply of heating medium. This will cause uncomfortably warm conditions to exist in a space. Also, there will be a considerable delay between the time the thermostat calls for heat and the time heat is actually delivered to the space (because of the large part of the heat that must first be stored in the