

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 hygrometers 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 hygrometers 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 hygrometer 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.

Hygrometer 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 hygrometer 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, hygrometer 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 bypass 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.

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 thermally "heavy" radiant surface). Whenever inertia exists in the source of heat supply, uncomfortable cycling of space conditions will result unless means of anticipating load changes *before* they occur in the space, or means of setting the basic energy supply rate from load conditions, is provided.

If a thermally heavy radiant surface is used the primary control should be actuated by outdoor temperature (load) to determine the basic temperature of the heating medium supplied to the radiant surface. To allow for variations in internal load, an inside thermostat should be used as a high limit to reduce further the heat input if necessary. If a thermally *light* radiant surface is used, controls may be applied in the same manner as for typical convection heating.

The terms *thermally heavy* and *thermally light*, referring to capacity for heat storage, are comparative and descriptive rather than exact. For example, a concrete floor panel in a frame structure without insulation would represent a *heavy* panel in a *light* structure. A frame type (metal lath and plaster) panel in a concrete structure would represent a *light* panel in a *heavy* structure. As indicated previously a *heavy* panel in a *heavy* structure provides comfortable conditions if outside controls are used in addition to the inside thermostat. But if a *heavy* panel is used in a *light* structure, rapid changes in outdoor conditions may cause discomfort in spite of outdoor controls, because the structure reacts so much more rapidly than the radiant heating surface.

Compensation for Increase of MRT

In order to maintain comfort, the air temperature in a panel heated space should be lowered as the heating load increases. Usually the required reduction in air temperature is not great and a conventional fixed control point room thermostat may be used unless a rather large infiltration load exists, or if untempered mechanical ventilation is used. Because of the relationships existing between MRT (mean radiant temperature) and air temperature in the space (and the variable MRT from point to point in the space), a conventional type of room thermostat (either fixed or variable control point as previously determined) may provide simple and satisfactory control.

Lowered Night Temperature

In general, lowered night temperature control is not recommended with *heavy* panels though it may be satisfactory with *light* panels. Best practice