fan systems except that it is considered desirable to open the outdoor-air damper before starting the fan. With this arrangement, a manual switch operates damper D-1. A mercury contactor mounted on the damper starts the fan when the damper is *fully* open. It also stops the fan when the damper *starts* to close.

Insertion thermostat T-1 maintains a temperature of 65 F at the preheat coil discharge by operating preheat coil valve V-1. This serves as a low limit for the fan discharge temperature during heating operation. When V-1 is closed, thermostat T-1 then gradually opens maximum-outdoor-air damper D-2 and closes return-air damper D-3 proportionately. At 65 F outdoor temperature D-2 is wide open and D-3 is closed. Exhaust air damper D-4 opens and closes in synchronization with D-2. At 75 F outdoors, when the outdoor air is no longer useful for natural cooling, T-2 closes D-2 and D-4 and opens D-3.

Reheater coil valve V-3 is controlled by submaster thermostat T-3 in the fan discharge. This thermostat is automatically readjusted over an appropriate range of temperature by room thermostat T-4 so that the discharge temperature matches

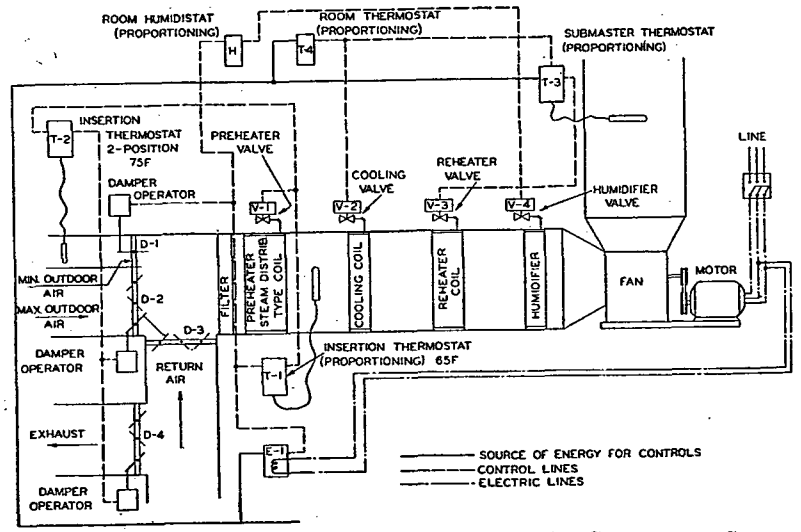


FIG. 9. CONTROL DIAGRAM FOR TYPICAL CENTRAL FAN AIR CONDITIONING SYSTEM

the space requirements. When the room temperature tends to rise above a predetermined value, T-3 has been readjusted downward far enough to keep reheat valve V-3 closed. T-4 then controls cooling coil valve V-2 directly to maintain the desired space temperature.

Humidistat H operates humidifier valve V-4 to maintain the desired humidity in the conditioned space. It is usually adjusted to maintain 30 to 40 percent relative humidity, and therefore keeps the humidifier off during cooling operation when the humidity is higher.

AUTOMATIC CONTROL OF UNIT HEATERS

The controls for a unit heater can either provide (1) *on-off* operation of the unit fan or (2) continuous fan operation with modulation of the heat output.

For *on-off* operation a room thermostat is used to start and stop the fan motor. A limit thermostat, often strapped to the supply pipe, prevents fan operation in the event heat is not being supplied to the unit coil.

Continuous fan operation practically eliminates the intermittent blasts of hot air resulting from *on-off* operation, and the stratification of temperature from floor to ceiling which often occurs during the *off* periods. In this arrangement a proportional room thermostat controls a modulating valve in the steam or hot water supply line to the coil. A limit thermostat or auxiliary switch stops the fan when the valve is closed.

Unit heaters may be used in summer as a means of circulating air to give some measure of comfort due to air motion. In such cases the source of heat should be shut off and the thermostat should be provided with a bypass switch which will permit fan operation independently of the controls.

AUTOMATIC CONTROL OF 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.

PART III—DESIGN COORDINATION

A heating or cooling system is designed to meet maximum conditions but functions at partial capacity much of the time. The ability to properly