plished automatically with an electric motorized damper which closes when the fan is off, or by an electropneumatic relay in the air line to the pneumatic damper operator. In either case, de-energizing the fan closes the outdoor air damper.

Seasonal Changeover

Where automatic changeover from *summer to winter* is to be provided under automatic control, there should be some period of inoperation of both heating and cooling. Otherwise, serious cycling from one function to the other will occur. This period of inoperation can be accomplished by a two-position controller with adjustable differential sensing outdoor temperature, or by a controller sensing the temperature at a representative conditioned space.

Lowered Night Temperature

Where lower temperatures are employed during unoccupied periods than are normally maintained during periods of occupancy, the proper day and night temperature time cycle is often established by an automatic timer. Sufficient time should be allowed in the morning to pick up the conditioning load well before there is any heavy load increase in the conditioned spaces.

PART III: CONTROL APPLICATIONS

Applications of controls to systems or apparatus of a general nature will be found in this section. Applications pertaining to specific systems or apparatus will be found in the chapters covering these subjects. The application of controls may conveniently be considered for the three divisions of a system indicated in Fig. 13: (1) *primary source apparatus*, (2) *distribution system*, and (3) *terminal equipment*.

The control of *primary source* apparatus is described in chapters of this volume treating system components, such as: Chapter 38, Compressors; Chapter 40, Absorption Air-Conditioning and Refrigeration Equipment; Chapter 45, Refrigerant Control Devices; Chapter 51, Automatic Fuel-Burning Equipment; Chapter 52, Heating Boilers, Furnaces, and Space Heaters; and Chapter 66, Heat Pumps.

The second and third divisions are considered here.

DISTRIBUTION SYSTEMS

The control of distribution systems is discussed separately for central fan systems, hot water systems, zoned steam systems, and zoned hot water systems, due to their differences.

CENTRAL FAN SYSTEMS

Since there are numerous control combinations that can be employed with central fan systems, the following sections will deal with only a few of the typical combinations for controlling outdoor- and return-air dampers, preheat coils, heating coils, cooling coils, and humidity control. The complete control system is obtained by combining the selected method for each item into an integrated set of controls. Proper consideration must be given to the interrelation of the several parts and the sequence of operation, etc.

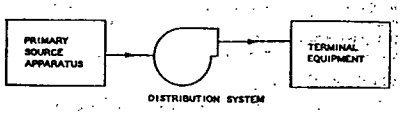


Fig. 13 .... Three General Divisions of Control Applications

Outdoor-Air Damper Control

Outdoor air for ventilation is usually controlled by a damper arrangement providing a homogeneous mixture of outdoor air and recirculated air. Outdoor air to meet minimum ventilation requirements should be available whenever the fan is running and is usually provided in one of the following ways:

a. By a minimum outdoor-air damper which is fully open when the fan is started. A maximum outdoor-air damper may also be provided if additional outdoor air for natural cooling is desired.

b. By an outdoor-air damper which opens to a minimum position when the fan is started. Additional outdoor air is provided by further opening of the damper under automatic control.

Recirculated-air and exhaust-air dampers are synchronized to operate with the outdoor-air dampers. Mechanical interconnections are preferable, but separate operators on each of the dampers can be used when mechanical interconnections are impractical. In most arrangements, provisions are made to prevent admission of more than the minimum outdoor air required for ventilation, both during heating operation and when the outdoor-air temperature is too high to provide some natural cooling. Provisions should also be made to close the outdoor-air and exhaust-air dampers and open the return-air damper whenever the fan is stopped.

Fig. 14 shows a system having manual adjustment for maximum outdoor air and an optional, but very desirable, mixed-air thermostat. This thermostat overrides the manual switch whenever the mixed-air temperature drops below its set point. This provides for a minimum mixed-air temperature for safety of downstream equipment. Whenever the fan motor is stopped, the outdoor-air and exhaust-air dampers close, while the return-air damper opens.

Fig. 15 shows an all-season ventilation control system with a fixed minimum quantity of outdoor air and automatic control of maximum outdoor- and return-air dampers. This arrangement is sometimes referred to as an economizer control of outdoor air. With outdoor-air temperatures below the set point of the summer thermostat, the mixed-air thermostat positions the outdoor- and return-air dampers. When outdoor-air temperature rises to the set point of the outdoor high-limit thermostat, usually about 70 F, the maximum outdoor-air damper is closed, and the return-air damper is opened. The minimum quantity of outdoor air is assured by the separate minimum outdoor-air damper. Both outdoor-air dampers are closed and the return-air damper opened whenever the fan motor is stopped. By the addition of a thermostat in the conditioned space or in the return-air duct, the opening of the maximum outdoor-air damper can be limited to only the desired minimum quantity of outdoor air, until the space heating requirements are satisfied. This feature is desirable for quick warm-up during winter heating.

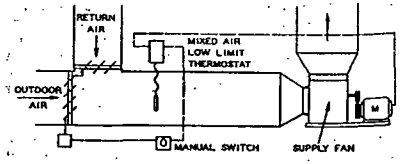


Fig. 14 .... Manual Adjustment of Outdoor-Air Quantity With Low-Limit Control of Mixture Temperature

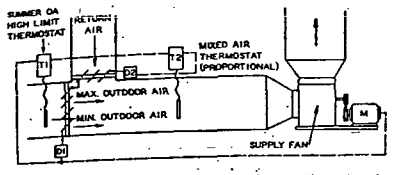


Fig. 15 .... All-Season Ventilation Control With Fixed Minimum Outdoor Air Plus Additional Outdoor Air when Practicable

Preheater Coil Control

The function of a preheater is to temper the outdoor air to prevent the possibility of freezing beyond the coil. Care must be taken to avoid freezing in the coil itself. The proper selection, installation, and sizing of steam traps are very important to assure rapid elimination of condensate to prevent freezing. Other important features are vaccum breakers to insure condensate removal, provisions for rapid air elimination from coil, and the use of vertical rather than horizontal tubes wherever possible.

Fig. 16 shows a simple application of an outdoor thermostat, usually set for 35 F, controlling the preheat coil valve. Careful sizing of the coil is very important with this type of control. The temperature rise through the coil should be limited to a maximum of 30 deg when the entering air is 35 F. A higher temperature rise will very likely cause overheating of the space. If more than a 30-deg temperature rise is needed, multiple coils should be used and their control valves operated in sequence at selected outdoor temperatures.

Fig. 17 offers a method of control which reduces the overheating problem outlined for Fig. 16. Here, a mixed-air thermostat operates an outdoor-air bypass damper in conjunction with the exhaust- and return-air dampers. The use of bypassed outdoor air makes it possible to control the mixed-air temperature without endangering the preheat coil. A minimum quantity of outdoor air is assured by use of a two-position face damper on the coil.

Steam-distributing type coils can be controlled by a proportional-type thermostat set for 55 F or higher, and located downstream from the coil to operate a valve in the steam supply line. Where a temperature rise of more than 30 deg is required, two or more coils in series should be used, each having a separate valve. This arrangement is shown in Fig. 18. The valves should be arranged to operate in sequence, with the valve on the upstream coil opening first.

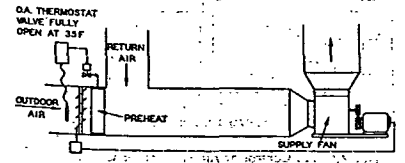


Fig. 16 .... Control of Preheat Coil From Outdoor Air

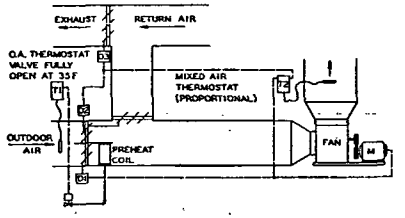


Fig. 17 .... Control of Preheat Coil From Outdoor Air With Damper Control From Mixed Air

Hot water preheat coils should be controlled by face-and-bypass dampers operated by a thermostat downstream from the coil, with continuous water circulation when the outdoor air is below freezing. A pressure switch to stop the fan in case of pump failure is often employed. Further freeze protection can be accomplished by a thermostat in the coil outlet, arranged to stop the fan if the water temperature drops to 35 F. In all applications where face and bypass dampers are used, precautionary measures must be taken to prevent stratification of the mixture beyond the coil. One method is to locate the bypass damper above the face damper, so that the cooler bypassed air will tend to drop while the warmer air through the face damper tends to rise, thereby mixing the air by gravity.

Heating Coil Control

Heating coils, when used for tempering air for ventilation, can be controlled by a proportional type of insertion thermostat, preferably located in the fan discharge where the air is usually least stratified. This thermostat operates the heating coil valve or valves, or face and bypass dampers, to maintain a constant discharge air temperature. When face and bypass dampers are used, it is good practice to have a valve on the coil which closes as the face damper closes to prevent overheating due to damper leakage or heat picked up by air wiping the exposed coil face.

Fig. 19 shows a typical control arrangement for a heating coil when the fan system is used for heating as well as

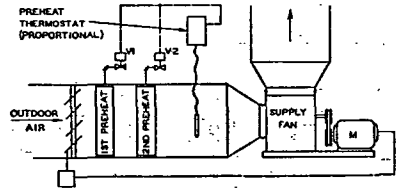


Fig. 18 .... Proportional Control of Two Preheat Coils in Sequence