building also may be supplied by a separate fan delivering conditioned air to local mixing fans. In many cases the most economical and satisfactory scheme may be to employ a hot-water or steam reheater in each branch duct. Where vertical sectionalizing is not indicated, the building may be divided into horizontal groups, each handled by a central system and adequately zoned. In some large buildings, apparatus rooms for the systems may be located in the basement and attic and on intermediate floors.

In high buildings the necessity for horizontal sectionalizing may be suggested by the size of air supply and return risers, and by the extent to which they encroach upon usable space. Each story should be cut off by doors from other stories, as otherwise the cool air tends to collect in the lower story and the warm air is forced to the upper story.

Balconies and large lobbies in theatres and similar high rooms frequently justify the use of separate zoning fans, to counteract the tendency of the heavier, cooler air to collect at the lower levels of these spaces.

Fans operate at full capacity continuously in many systems, and therefore should be selected for good efficiencies. In winter when higher temperature differentials are used, it is sometimes practicable to deliver smaller air quantities than when cooling.

In climates where winter temperatures fall below freezing, the tempering coils should be of the steam-distributing type; or if they are heated by a liquid, this liquid should contain some anti-freezing substance such as ethylene glycol. If hot water is used in cold climates, the control of air temperature should be obtained by means of face and bypass dampers rather than by throttling the valves, to prevent damage due to freezing.

If zone reheaters placed in supply-duct branches are employed, they should be of such type as to be heated over the entire surface so that no temperature-stratification can occur in the delivered air. Steam-distributing-tube coils or mechanically-circulated water coils are satisfactory in such cases, and throttling valves may be used.

Refrigeration equipment must be carefully selected to satisfy the particular requirements of each installation. For some small plants the evaporator may be placed in the air stream, when type of refrigerant and nature of occupancy permit. In many cases, chilled water coils are required by considerations of safety. Where low temperature and relative humidity are necessary, brine, often of calcium chloride, may be indicated.

Condensing requirements must have economic analysis. Wells, public water service, cooling towers and evaporative condensers present possibilities for consideration. Condenser water may have a secondary use for roof sprays in hot weather, and is usually suitable for lawn sprinkling. Most health department rules in cities prohibit any connection from refrigerant condensers that might permit the water to be used for drinking or lavatory purposes.

Practically without exception, air cleaners should be provided for both outside and recirculated air.

Control of temperature and of relative humidity by automatic means is vital, if comfort and economical operation of air conditioning equipment are to be attained.

The insulation of ductwork may be necessary to prevent condensation of moisture either inside or outside of ducts, housings and fan encasements or to prevent a change of temperature in ducts passing through hot or cold spaces.

In general, the apparatus should be arranged to have a straight-line air

flow. Each change in direction increases air resistance and, in addition, elbows and offsets may cause eddy currents resulting in stratification. The usual order of equipment location, beginning at the outdoor-air intake, is: weather hood or louvers, outdoor-air dampers, return-air connection, filters, tempering coils, cooling coils or sprays, bypass connection with or without reheaters, reheaters, fan and distributing ducts.

Screens at the intake prevent the entry of large foreign matter, birds etc. A hood or louver at the outdoor-air intake prevents the entry of rain and snow. Since in most climates there are many days during which use of 100 percent outdoor air unheated or uncooled may be economical, the areas of all air-passing and treating apparatus should be large enough for such a volume, and the exhaust or spent-air equipment should be capable of discharging out of doors, all of the air admitted.

The bypass connection normally connects the return-air duct system with the apparatus casing between the conditioner and the supply fan. Usually the bypass opening is sized to handle about 50 percent of the fan capacity where a variable bypass is used though extreme load variations may require a larger size. It is at times good design to locate a reheating coil in the bypass connection to permit using some bypass air when heating is required. Since the relatively high resistance of the cooling coil or spray is to be balanced by the heating coil and bypass connection, enough heating surface can be provided to raise the temperature of the bypass air to the point where the mixture of bypassed air and conditioned air will have the required temperature. When a variable bypass is used, a damper working in opposition to the bypass damper should be placed across the face of the dehumidifier, for unless the resistances of the two are carefully balanced at all operating points, the proper mixtures of air will not be obtained. Outdoor air that has not been dehumidified should not be bypassed around a cooling coil or spray dehumidifier if accurate control of the delivered relative humidity is desired. Where the bypass is made a part of the dehumidifier or conditioner and is located on the top or side of it, the return-air connection should be arranged so that stratification of return air is insured, baffles being provided to accomplish this purpose if necessary. When return-air and bypass air connections are taken off a return duct system, it may be necessary to install a back-draft damper between the return-air connection and the bypass connection. When the bypass damper is at maximum opening it may be much easier for outside air to pass through the return damper, into the return duct connection and through the bypass, than for return air to pass through the bypass connection into the fan. Air tends to take the path of least resistance and, if the dehumidifier resistance is high, and if the return duct resistances are low, this situation is apt to occur. A recirculating air fan, instead of a back-draft damper, may be required for this case, if the failure of return air to reach the dehumidifier or conditioner is a serious matter under reduced load conditions.

LOCATION OF APPARATUS

In general, the outdoor-air intake, preheaters, and return air connections precede the conditioner, while the bypass, reheaters and fan follow it. In the case of a blow-through system, where the fan is located ahead of the conditioner, the leakage of air at the conditioner is outward, instead of inward, and may be accompanied by water leakage.

The location of the complete apparatus assembly, including the dehumidifier, will be dependent on the type of building, spaces available, structural characteristics, etc. The type of conditioner used may limit the location