high- or low-pressure type with substantially the same control methods. It is often applied to high-velocity systems with long distribution mains, and consequently high-static fan pressures; although extremely high static pressures are seldom justified. With two supply mains, the system static pressures vary as a result of changing demands for heating or cooling. Thus volume regulation often becomes necessary. Extreme variations of flow to different rooms may be somewhat limited by static-pressure regulators and volume dampers at selected points along the mains. There are some installations where volume control at each room supply is desirable to maintain close control regardless of static-pressure changes in the ducts, and incidentally to facilitate balancing of the distribution system.

Air-capacity requirements are generally governed by summer cooling loads, and general practice is to supply the cold air to the cold-air duct at 25 to 30 deg below the established room temperature, this being satisfactory with suitably designed room outlets.

Fan and Coil Units

Another type of room convector used in connection with central cooling and heating plants is known as the *Fan and Coil* Unit (see Fig. 5, Chapter 16).

These units, like induction units, are located around the periphery of a building, usually under windows, and are equipped with fans and a water-type heating-cooling coil. They normally take air for ventilation directly from outdoors, and have a manual damper for adjusting the quantity of outdoor air within certain limits. Positive closing of this damper when the fan stops, can be obtained by adding a damper operator actuated by the fan-motor switch. Hot water supplied during the heating season frequently is varied in accordance with outdoor temperature. Cold water for use during the cooling season should be supplied at a fixed temperature low enough to provide the proper amount of dehumidification.

These units sometimes are used with a primary-air system that supplies the outdoor ventilation air and handles the latent load. In such cases the primary air unit is controlled as explained under the section Unitary-Central Systems, and may be of either the low- or high-pressure type.

The combined heating-cooling coil of each unit may be controlled by a valve in the water supply line to each unit, actuated by a thermostat in the room or recirculated air of the unit. The thermostat is of the heating-cooling type.

EVAPORATIVE COOLING

In climates where, on the hottest days, the outdoor wet-bulb depression is relatively great, it may be possible to replace mechanical refrigeration, or other cooling sources, and use the evaporative cooling effect. A well-designed air washer using recirculating sprays will reduce the entering dry-bulb temperature to within a degree or two of the entering wet-bulb condition. Thus, it may be possible that, with air entering at 100 F dry-bulb, 60 F wet-bulb, a leaving condition of 62 F dry-bulb, nearly saturated, can be obtained. Under some conditions of latent and sensible heat load, this evaporative cooling may be adequate.

At times when the outdoor wet-bulb temperature is not low enough to permit the use of straight evaporative cooling, it is still possible to use precooling convectors with refrigeration, well water, or a cooling tower, as the basic source of sensible heat removal to reduce the wet-bulb temperature of the air before it enters the spray chamber. Where internal heat loads are high, this scheme may be more economical than one using return air. Where the required supply-air dew point is too low to permit straight evaporative cooling, and where the sensible heat load is not too great, intentional partial saturation may be employed. In this case the low dew point of the outdoor air is utilized by permitting some of this air to pass through the humidifying sprays untreated, or to bypass the humidifier. All of these remarks with regard to evaporative cooling are based on the assumption that all of the supply air will be taken from outdoors. Provision should be made in most cases for the return of some air from the conditioned spaces for control purposes, as well as for economy of fuel in winter.

PRECOOLING

Where sufficiently cold water from wells or streams is available, a saving in refrigeration may be obtained by the use, in location ahead of the dehumidifier, of precooling coils through which the cold water is circulated. The resultant cooling of the air decreases the load to be carried by the dehumidifier and refrigeration plant. In normal practice the water, after passing through the precooling coils, may be further utilized in the refrigeration plant condenser. The economic advantages of this scheme are apparent, and it is frequently used.

SENSIBLE COOLING WITH UNWETTED COILS

Under favorable atmospheric conditions where a large wet-bulb depression exists and the dew point of the outdoor air is sufficiently low at all times, acceptable cooling may be obtained by removing only the sensible heat from the outdoor air delivered to the rooms. Under this condition of a great wet-bulb depression, a temperature-reducing coil may be located in the air stream and supplied with water from a cooling tower. When humidity control is desired, sprays to saturate or partially saturate the air may be used downstream from the unwetted coil. Saturation or partial saturation after the coil will reduce further the dry-bulb temperature and the air quantity required. This system has very definite application in hot dry climates.

SELECTION OF TYPE OF SYSTEM

Low buildings with large floor areas may be divided into sections or zones with separate central air-supply systems to facilitate temperature control. In the case of large department stores it may be possible to provide a single conditioner, with a fan delivering the conditioned air to local mixing fans which supply the various departments or spaces. This application is limited by the practicability of running the large conditioned-air ducts to the various recirculating fans. Each vertical section of the 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 theaters 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 antifreezing 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 outdoor 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 preheaters, 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 no stratification of return air will occur, 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 outdoor 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 under certain conditions. Where cooling coils employing chilled water or brine as the cooling agent are used, there are few limitations with regard to location other than those of pumping power, working pressures, piping costs, etc. Where spray dehumidifiers are used, very definite limitations present themselves, and these may require certain extraneous equipment to make the system workable. If several spray-type dehumidifiers are located on different levels, thus involving different water pressures, a surge or storage tank, to which the return water