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 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 from each dehumidifier can be taken, is required. Should the water level in the pan of the dehumidifiers be low in relation to that of the surge tank, return-water pumps will be required, and these pumps will have to be operated until the water supply lines are drained in order to prevent flooding of the lower dehumidifiers. Where spray dehumidifiers are on the same level, equalizing lines between the pans may be required if a storage tank is not provided. It is exceedingly important that watertight drained floors be provided under all overhead cooling systems, since water condensed out of the air generally will be present and may damage the interior finish of the rooms below the apparatus.

All of the various pieces of equipment from the outdoor-air intake through the fan usually are connected together by sheet-metal casings. Frequently, the building structure or specially constructed walls or partitions may be used to form a portion of the casing. In any case the casing or connection must be sufficiently sturdy for the required duty. Sheet-metal work must be well braced not only to prevent vibration under pulsations in air flow, but also to withstand the abuse of normal usage. Casings should be braced wherever access doors are installed, and all large panels should be adequately reinforced by structural steel.

Accessibility for Service

Each apparatus layout should be made with accessibility in mind. Where cooling convectors are used, space for removing and repairing or replacing them should be provided. Adequate space should be provided for the servicing and replacement of eliminators. Filters must be so located that the proper cleaning, replacement, or routine servicing can be accomplished without difficulty. Free access to the bearings of all moving machinery is a necessity. Provision should be made for the replacement of any parts that are subject to wear, deterioration, or damage, such as filters, fanwheels, motors, pump impellers, or heat transfer surface.

CHAPTER 20

AIR DISTRIBUTION

Definitions, Standards for Satisfactory Conditions, Principles of Air Distribution Ventilating Jets in Air Distribution, Outlet Performance, Outlet Types, Outlet Location and Selection, Directional and Volume Control, Return and Exhaust Intakes, Specific Applications.

CORRECT air distribution is essential in warm air heating, ventilating, and air-conditioning systems. Even though a system delivers the required quantity of conditioned air to a room, unsatisfactory conditions result if the air is poorly distributed.

This chapter deals with room air distribution only; the transmission of air through ducts is treated in Chapter 21, Air Duct Design. The objectives of this chapter are to:

1. Present the principles of room air distribution with a discussion of ventilating jets in air distribution.
2. Present general information on practical air distribution problems involving outlet performance, outlet types, location, selection, and outlet control.
3. Illustrate the use of the basic concepts and of the practical experience gained in air distribution in making specific applications.

Further pertinent information on air distribution will be found in Chapter 6, Physiological Principles; Chapter 12, Heating Load; Chapter 13, Cooling Load; Chapter 15, Unit Ventilators and Unit Heaters; Chapter 16, Unitary Air Conditioning Equipment; Chapter 18, Warm Air Heating Systems; Chapter 19, Central Systems for Air Conditioning; Chapter 25, Sound Control; Chapter 44, Instruments and Measurements; Chapter 48, Transportation Air Conditioning.

DEFINITIONS

The following definitions referring to air distribution equipment have gained general acceptance.

1. *Supply Opening or Outlet:* Any opening through which air is delivered into a space which is being heated, cooled, humidified, dehumidified, or ventilated.
2. *Exhaust Opening or Return:* Any opening through which air is removed from a space which is being heated, cooled, humidified, dehumidified, or ventilated.
3. *Outdoor Air Opening:* Any opening used as an entry for air from outdoors.
4. *Damper:* A device used to vary the volume of air passing through a confined cross-section by varying the cross-sectional area.
5. *Grille:* A covering for any opening and through which air passes.
6. *Register:* A grille equipped with a damper or control valve.
7. *Free Area:* The total minimum area of the openings in the air outlet or inlet through which air can pass.
8. *Core Area:* The total plane area of that portion of a grille, included within lines tangent to the outer edges of the outer openings through which air can pass.
9. *Free Area Ratio:* The ratio of the free area to the core area.
10. *Coefficient of Discharge:* Ratio of area at vena contracta to area of opening.
11. *Aspect Ratio:* The ratio of length to width of an opening or core of a grille.
12. *Vane Ratio:* The ratio of depth of vane to minimum width between two adjacent vanes.
13. *Plaque:* A ceiling outlet in which the supply air impinges against a plate or series of parallel plates, and is deflected horizontally in all directions.
14. *Diffuser:* An outlet discharging supply air in various directions and planes.
15. *Primary Air:* The air delivered to the outlet by the supply duct.
16. *Induction:* The induction of room air drawn into an outlet by the primary air stream (commonly called *aspiration*).
17. *Entrainment:* The entrainment of room air by the air stream discharged from the outlet (commonly called *secondary air motion*).
18. *Total Air:* The mixture of discharged air and entrained air.
19. *Entrainment Ratio:* The total air divided by the discharged air.
20. *Throw (Blow):* The horizontal or vertical axial distance an air stream travels on leaving the outlet (grille) before the maximum velocity is reduced to 50 fpm.
21. *Drop:* The vertical distance, the lower edge of a horizontally projected air stream drops between the outlet and the end of its throw.
22. *Rise:* The converse of drop.
23. *Envelope:* The outer boundary of an air stream moving at a perceptible velocity.
24. *Spread:* The divergence of the air stream in a horizontal or vertical plane after it leaves the outlet.
25. *Diffusion:* Distribution of air within a space by an outlet discharging supply air in various directions and planes.
26. *Radius of Diffusion:* The horizontal distance from the diffuser outlet to the perimeter of the space, within which air motion in the occupied zone is reduced to 50 fpm maximum.
27. *Outlet Velocity:* The average velocity of air emerging from the outlet, measured in the plane of the opening.
28. *Terminal Velocity:* The average air stream velocity at the end of the throw.
29. *Temperature Differential:* Temperature difference between primary and room air.
30. *Temperature Variation:* Temperature difference between points of the same space.

STANDARDS FOR SATISFACTORY CONDITIONS

The object of air distribution in warm air heating, ventilating, and air-conditioning systems is to create in the occupied zone of the conditioned room (floor to 6 ft above floor level) the proper combination of temperature, humidity, and air motion. To obtain comfort conditions within this zone, standard limits have been established as acceptable *effective temperatures*. This term comprises air temperature, motion, humidity, and their physiological effect on the surface of the human body. Any variation from accepted standards of one of these elements may result in discomfort to the occupants. The same effect may be caused by lack of uniformity of conditions within the space or by excessive fluctuation of conditions in the same part of the space. Such discomfort may