low, reference should also be made to sections of this chapter on Outlet Location and Selection as well as on Specific Applications.

Wall Outlets

Wall type openings in general use are: perforated grilles, vaned outlets, registers, slotted outlets, ejector nozzles, and wall diffusers.

1. *Perforated Grilles.* Due to the non-adjustibility and small vane ratio these outlets, although inexpensive, have not met with favor as wall type supply openings. They are useful primarily where directional air control is unnecessary, and for return air intakes.

2. *Vaned Outlets.* Outlets equipped with either vertical and horizontal adjustable vanes or both are particularly suited to sidewall distribution. For proper control over the air flow, the vane ratio should be from 1 to 2. Outlets with non-adjustable vanes may be employed but they should only be used where the performance is not critical or can be adequately predicted. Vanes should be properly designed to prevent an increase of noise above permissible level.

3. *Registers.* Perforated grilles or vaned outlets equipped with a vane damper are termed registers. They are used primarily for residential heating systems, where the outlet distribution is not critical and low cost is of importance.

4. *Slotted Outlets.* Slotted outlets essentially consist of either flat steel plates containing a number of long narrow slots or a single long narrow slot. In order to give a good conversion from static pressure to velocity pressure, the sides of the slots are rounded to give a venturi effect. Due to their high aspect ratio, the slotted outlets have a greater induction effect than the comparable vaned outlets of equal area and consequently the throw is reduced. They are primarily useful where an unobtrusive means of distribution is desired, and where it is desirable to submerge the outlets into the room decoration and to minimize the effect of obstructions in the line of discharge. They are adaptable to narrow rooms having low ceilings. In this case the slots should extend the full length of the room. In all applications air quantity and distribution must be carefully planned as correction after installation is difficult.

5. *Ejector Nozzles.* These are outlets operating at high static pressure. They give a high conversion from static in the duct to velocity pressure in the outlet, and have a high induction effect due to their high outlet velocity. They are chiefly used for long throw and industrial process installations, such as drying, freezing, cooking, etc. Another type of ejector is sometimes referred to as a *louver nozzle* having a 45 to 90 deg elbow, which can be rotated similarly to a universal joint about an axis perpendicular to the surface to which it is fastened. These outlets give a considerable degree of adjustability and are, therefore, desirable for use in confined spaces where spot cooling is employed. The use of very high velocities is gradually disappearing due to noise difficulties.

6. *Wall Diffusers.* These outlets incorporate design features originally developed for ceiling outlets and use therefore semi-conical or semi-pyramidal guide vanes instead of the straight vanes of the conventional side wall outlet.

Ceiling Outlets

Generally used ceiling outlets are: plaques, ceiling diffusers, and perforated ceilings and panels; a discussion of each follows.

1. *Plaques.* Plaques are of simple design. The air from the supply opening impinges on a plate, which permits the air to be discharged horizontally in all directions. Plaques, although inexpensive, are difficult to control and are not generally satisfactory. In certain applications a properly designed plaque yields satisfactory results.

2. *Ceiling Diffusers.* Ceiling diffusers are round or rectangular outlets installed on or parallel to the ceiling, discharging supply air in a variety of directions and planes. Performance of the different designs varies according to principle employed. Some have no internal induction, but hasten external induction by supplying air in multiple layers. Others have internal induction and distribute air over an entire half sphere. The induction effect is greatest in the direction of the axis of the outlet, and least in the plane perpendicular to the axis and located at the ceiling level. Thus the induction is greatest in the vertical direction where the least throw can be tolerated and least in the horizontal plane at the ceiling where the greatest blow is both desired and permissible.

3. *Perforated Ceilings and Perforated Panels.* This method obtains air diffusion by discharging air through perforations in the ceiling, or part of the ceiling or walls. Some perforated panels feature a control plate frame which is inserted in the conventional ceiling duct. Supply air enters the plenum above the distribution plates through an adjustable air valve which can be set for varying air quantities and velocities. The advantages are unobtrusive appearance and the ready application of sound absorbing material to the design. Also, if designed properly, this system provides a low rate of room air motion and consequently lends itself to applications having high load or high ventilating requirements. The perforations should be kept free of accumulations of dirt, as clogging will cause uneven distribution and result in smudging of the ceiling. Best results are obtained in systems having efficient cleaning devices.

In present practice relatively low velocities are used because the perforated material offers only small resistance to the air flow. Therefore, great care must be taken to distribute the primary air at uniform velocities over the perforated panels to avoid uneven air distribution and primary air streams of undesirable velocities and direction.

OUTLET LOCATION AND SELECTION

In selecting the location of outlets, consideration must be given to the factors of physical construction, physical appearance, location of heating or cooling loads, and outlet performance:

1. The *physical construction* of a building, particularly of old buildings, immediately places limitations on the type of distribution system which can be employed. The first factor in the selection of outlet locations, therefore, is a consideration of the possible location of the supply duct, that is, whether it is above the ceiling, within the walls, through furred spaces above corridors, or in the conditioned space, etc. A particular method of distribution may be highly desirable but its execution, due to the location of beams and masonry walls, may be impossible.

2. The *physical appearance* of the outlets should conform to the esthetic appearance of the room. In factories, warehouses, etc., the esthetic demand may not be high; however, in department stores, clubs, theaters, etc., the location of the grilles may be dictated largely by such demands.

3. The *location of heating or cooling loads* in a room dictates to a great extent the general location of the outlets. The outlets should be located