let velocity. In addition, however, noise may be caused by excessive restriction of the free outlet area due to outlet design, by unnecessary turbulence due to one-sided air flow through the outlet, or by the impingement of high velocity air on sharp edges.

The origin of excessive noise may be spotted by removing the outlet without stopping the air supply. If noise is still evident, other elements of the air conditioning system or entirely different sources are at fault. High-pitched, rushing noise indicates that the duct system or excessive velocities in the duct are the cause, low-pitched rumbling noise points to the mechanical equipment of the air conditioning plant.

When very high duct velocities are used, sound absorbing lining or special acoustical filters (sound traps) must be provided. High pressure or high velocity outlets for multi-room and other buildings are equipped with a special pressure reduction and sound attenuation box. (Refer to section Types of Air Outlets).

For a general discussion of permissible room noise levels and air supply outlet noises, refer to Chapter 40, Sound Control.

Smudging

All air outlets have their particular *smudging* problems which have been studied by various investigators but cannot yet be considered solved. Smudging is due to dirt in the room air and in the air discharged by the outlets. Although the primary air may be carefully filtered, small particles of dirt and dust will not be captured by mechanical filters, and may finally be deposited on the walls or ceiling. With ceiling outlets, dirt streaking may be minimized by carefully controlling the discharge of the outlets, or by the use of special deflecting plates or anti-smudge rings. With wall outlets, dirt streaking may be minimized by preventing direct impingement of the air on any ceiling or room surface. Floor outlets may offer objection as dirt collectors.

TYPES OF AIR OUTLETS

Air supply outlets for commercial, industrial and residential applications are either side wall or ceiling type outlets. In homes, baseboard and floor type outlets are also used. (Refer to Chapter 19, Warm Air Heating Systems.) As a great variety of outlets of various design are available in these four types, the final selection of a supply air outlet depends to a large degree upon the specific problems of the air distribution system to be used.

In addition to the comments which follow on use and application of outlets, reference should also be made to sections Outlet Location and Selection and Specific Applications of this chapter.

Wall Outlets

Side wall outlets in general use are (1) perforated grilles, (2) fixed and adjustable bar and vane grilles, (3) registers, (4) wall diffusers, (5) slotted wall outlets, and (6) high pressure or high velocity wall outlets.

1. *Perforated Grilles.* These grilles have a small vane ratio and are not adjustable. They are useful primarily where directional air flow is unnecessary, and for applications where the grille size can be increased in order to provide the required free area.

2. *Fixed and Adjustable Bar and Vane Grilles.* Grilles with fixed bars or vanes are used for wall, floor or baseboard applications when the performance is not critical or can be adequately predicted. Adjustable grilles are equipped with either vertical or horizontal adjustable bars or vanes or both, and are used where proper control of air motion is essential. Vanes should be designed for quiet operation.

3. *Registers.* Grilles equipped with dampers or adjustable valves for controlling volume distribution of the supply air are called registers.

4. *Wall Diffusers.* These outlets incorporate design features originally developed for ceiling outlets, and therefore make use of semi-conical or semi-pyramidal guide vanes instead of the straight vanes of the conventional side wall outlet. In warm air perimeter systems they are used to blanket the outside wall with the warm supply air.

5. *Slotted Outlets.* These outlets are available in a great variety of designs, consisting either of elongated outlets with perforations, or flat outlets with a number of long narrow slots or a single narrow slot, or straight long outlets with one long slot or diffusing vanes. Due to their high aspect ratio, slotted outlets have higher entrainment than comparable round or square vaned outlets of equal area and consequently, the throw is reduced. (Refer to Discharge From a Long Slot in section Ventilating Jets in Air Distribution).

Slotted outlets are particularly useful in connection with the linear design motif in architecture, for applications where it is desired to merge air outlets unobtrusively with the room decoration. They may be used for either ceiling or wall air distribution, including the so-called under-the-window application. In all applications, capacity limitations, proper duct approaches and correct balancing of slotted outlets must be carefully considered, as correction after installation is difficult.

6. *High-Pressure or High-Velocity Outlets. Ejector nozzles* operate at high static pressure and convert this pressure into velocity pressure with resulting high induction of room air. They are mainly used for industrial process installations, particularly drying. Another type of ejector nozzle is sometimes referred to as a *louver nozzle* and has 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, useful for spotcooling in confined spaces.

High-pressure or high-velocity air conditioning systems installed in multi-room and other buildings, use very high velocity and pressure so that the size of the ducts can be reduced. This in turn requires the use of *high-pressure or high-velocity air outlets* which reduce the velocity and pressure and attenuate the sound to predetermined values at the point where the air is discharged. It is also possible, of course, to use high velocity only in part of the system, for example in the main trunk ducts, and conventional velocities in the branch ducts. Special high-pressure control units are then installed at the end of the main duct, and the air is discharged through conventional air outlets in the various spaces of the building.

Various high-pressure or high-velocity outlets of different design, but usually consisting of a pressure reduction and sound attenuation box and a grille or diffuser, have been developed for high-velocity systems and are described in the literature of the manufacturers. These outlets may be used in the ceiling or in the wall of the air conditioned space, including under-the-window installation, or in the ceilings of corridors.

Refer to Induction Convectors for multi-room buildings in Chapter 29, Central Systems for Air Conditioning.

Ceiling Outlets

Ceiling outlets in general use are (1) ceiling plaques, (2) ceiling diffusers, (3) high pressure or high velocity ceiling outlets, and (4) perforated ceilings and panels.

1. *Ceiling Plaques.* (Diagram C of Fig. 1). Plaques are of simple design. The air from the supply opening impinges on a plate and is discharged horizontally. Plaques are inexpensive, but as the air is not always uniformly discharged in all directions, proper control is difficult.

2. *Ceiling Diffusers.* Ceiling diffusers are round, square, rectangular or slotted outlets of various designs installed on, or parallel to, the ceiling. Performance of the different designs varies according to the 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 hemisphere. 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 throw is desired.

Refer to section Slotted Outlets under Wall Outlets.