least to the distance between the vanes. If the *vane ratio* is less than unity, effective control of the air stream discharged from the grille by means of the vanes is impossible. If it is higher than two, further improvement is slight.

A grille discharging air uniformly forward (vertical vanes in straight position), will have a *spread* of 14 to 24 degrees, depending on type of outlet, duct approach, and discharge velocity. Turning of the vanes will influence the direction and the throw of the discharged air stream.

A grille with *diverging vanes* (vertical vanes with uniformly increasing angular deflection to a maximum at each end of 45 deg) will have a spread of approximately 60 deg and the throw will be reduced considerably. With increasing divergence the quantity of air handled by the grille for a given duct static pressure will decrease.

A grille with *converging vanes* (vertical vanes with uniformly decreasing angular deflection) will have a slightly higher throw than a grille with straight vanes, but the spread will be the same for both settings. The air stream will converge slightly for a short distance in front of the outlet, and then spread somewhat more than the air discharged from a grille with straight vanes.

In addition to vertical vanes which normally spread the air horizontally, horizontal vanes may be used to spread the air vertically. However, spreading the air vertically entails the risk of hitting beams or other obstructions, or of blowing primary air at excessive velocities into the occupied zone.

3. *Effect of Type of Outlet*. Ceiling diffusers distribute the air with a horizontal spread of 360 deg and also have a downward air motion. Therefore, both throw

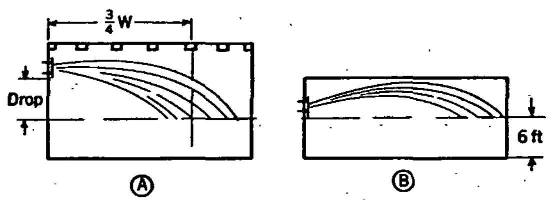

FIG. 12. THROW OF WALL OUTLETS

(radius of diffusion) and mounting height are important and interdependent factors. Due to the 360 deg spread, the rate of induction is higher and the throw shorter than that for a wall grille handling the same air quantity at the same outlet velocity. Therefore, ceiling diffusers will frequently permit the use of higher air velocities than wall outlets, and consequently may be sized smaller to handle the same air volumes. If ceiling outlets are installed flush with the ceiling, impingement of the air stream along the ceiling surface restricts induction of secondary air, and the throw is increased approximately 40 percent above that of an unrestricted air stream. (Refer to Radial Jets and Effect of Walls and Ceilings in section Ventilating Jets in Air Distribution).

Slotted outlets, due to their high aspect ratio, have higher induction than comparable round or square vaned outlets of equal area handling the same air quantity, and their throw is shorter. (Refer to Discharge From a Long Slot in section Ventilating Jets in Air Distribution).

The perforated panel is an excellent device for producing a large diameter stream with a uniform velocity across its entire area. Although this type of outlet can handle the greatest amount of air in proportion to room size, jet velocities must be kept low. (Refer to Perforated Panels in section Ventilating Jets in Air Distribution).

For all types of ceiling outlets the following considerations should be noted: (1) if the temperature of the supply air is below that of the room, it should be thoroughly mixed with the room air before it enters the occupied zone; (2) air slightly above room temperature will usually be properly distributed by outlets selected for cooling; and (3) if the temperature of the supply air is substantially higher than that of the room, it should be projected downward in a broad diverging pattern to avoid stratification and to obtain proper mixing and controlled air flow.

4. *Drop*. The air discharged from a wall outlet should not reach the occupied zone until the velocity has fallen to about 50 fpm. Therefore, the outlets should be located high enough for the air stream at the termination of the throw to be not less than 5 or 6 ft above the floor level, or in other words, the drop should not be more than the difference between mounting height and zone of occupancy (Diagram A of Fig. 12).

As illustrated in diagram B of Fig. 12 the maximum permissible throw for a given ceiling height may be obtained by locating the outlet low on the wall, arching the blow, and sweeping the air across the flat area. The air, as it traverses, will adhere to the ceiling. The objection to this method is the possible streaking of the ceiling with dirt.

Capacity

The quantity of air to be handled is determined by the heating, cooling, or ventilating requirements. (Refer to Chapters 11, Infiltration and Ventilation, 12 Heating Load, and 13 Cooling Load). Manufacturers' rating sheets are usually consulted for selection of the proper number, size, and type of outlets for a given air quantity. The basis of rating should be carefully noted to make certain that resulting velocities are suitable for the application.

Temperature Differential

The temperature difference between supply and room air is highly important, because temperature control in the conditioned room is strongly affected by this difference. The greater the temperature differential, the greater the change in room temperature for a given change in the heating or cooling load. The use of outlets which cause a large amount of room air to be mixed with the supply air, permits the use of greater temperature differentials.

Refer to section Air Quantity and Temperature Differential, Chapter 29, Central Systems for Air Conditioning.

Room Air Motion

To achieve a constant air motion in the occupied zone without exceeding acceptable velocity limits is one of the most important problems in air distribution. Some of the factors which may cause air motion to exceed these limits are: excessive air discharge velocities; high air volume per cubic foot of space (often referred to as number of air changes per hour); premature drop of cold air into the occupied zone; overblow causing spilling of high velocity air into the occupied zone; heating in severe climates by means of downward projection of hot air. These factors will not affect equally the various designs and types of air outlets, and their effect will also depend on the temperature differential, the mounting height of the outlet, and other circumstances. For instance, certain outlets will handle safely more air per cubic foot of space at higher discharge velocities than others, and downward projection of air may sometimes even be necessary if the supply air temperature is substantially higher than the room temperature. (Refer to *section on Throw*).

Sometimes excessive air motion may be encountered in correctly designed air distribution systems due to drafts occurring, if stairways or exit doors are left open, or if windows are opened when design of system requires that they be closed. Discomfort is frequently attributed to drafts when it is actually due to too low room temperature. This may occur during the heating as well as the cooling season. Systems designed for heating and ventilation only may easily cause complaints of drafts when cooling is added.

Permissible Noise Level

The increase of the noise level caused by an outlet is primarily a function of its discharge velocity and its size. The maximum acceptable noise level in a space may dictate completely the selection of the permissible out-