A = outlet wall area, square feet.

Z = 0.6 (reduction factor to allow for supply air stream 20 per cent and furniture obstruction 20 per cent, at point where supply air stream occupies 20 per cent of the room cross-section).

Since $Q_3 = Q_1 r$ by definition, and $r = \frac{V_1}{V_3}$ from Equation 2, and V_3 is assumed to be about 200 fpm for total induction in actual practice, then from Equation 10:

$$V_r = \frac{Q_1}{A} \times \frac{V_1}{V_3} \times \frac{1}{Z} = \frac{FV_1}{120}$$

or

$$F = \frac{120\,V_r}{V_1} \tag{11}$$

where F is the room circulation factor expressed in cubic feet per minute per square foot of outlet wall area. Thus room air motion is directly a function of outlet velocity and air volume per square foot of outlet wall area. Hence Equation 11 and Table 1 can be used to determine the probable acceptability of a particular installation from the standpoint of proposed air volume, outlet wall area, and grille velocity.

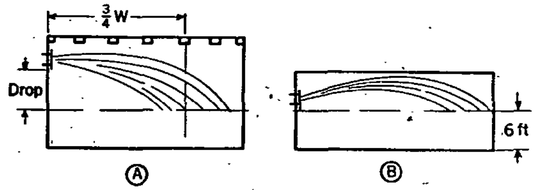

Fig. 3. Throw of Wall Outlets

Outlet Performance

The factors of outlet performance, throw, drop, capacity, noise, dirt and room air motion place considerable limitations on the design of a satisfactory distribution system.

1. *Throw.* The throw of wall or ceiling outlets should be selected to cover three-quarters of the distance toward an exposed wall or window as shown in A of Fig. 3. The throw must be sufficient to produce satisfactory conditions over the area to be conditioned. In some ceiling outlets, plaques or similar units, the throw is along the ceiling. The air tends to hug the ceiling and the throw is increased approximately 20 per cent above the throw of an unrestrained air stream. Overblowing is considerably more serious than underblowing, as an overblow will create objectionable down drafts from any surface it strikes; although underblowing in the case of heated air may be serious in that the warm air may rise too rapidly and thus cause stratification in the occupied zone. In spaces with beamed ceilings, the outlets should be located below the bottom of the lowest beam level, and preferably low enough so that an upward or arched blow may be employed. The blow should be arched sufficiently to miss the beams and, at the same time, in such a manner as to prevent the primary or induced air stream from striking furniture and obstacles producing objectionable drafts. If an outlet is adjusted downward to avoid a beam, cold air may enter the zone of occupancy long

before the desired induction has taken place, thus causing serious discomfort.

In ceiling applications, since there is a component downward, the ceiling height and throw are both very important factors. If cold air is used, it must be brought to the proper temperature before entering the zone of occupancy. If perforated plates are used in the ceiling in cooling, the jet velocity must be low. Air slightly above room temperature will usually be properly distributed by outlets selected for cooling. When delivering warm air the stream may be projected downward and the amount of dispersal of the jet varied to get proper mixing and control.

2. *Drop.* The outlets should be located so that the air stream at the termination of the blow is not less than 5 or 6 ft above the floor level. As illustrated in B of Fig. 3 the maximum permissible blow 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 ceiling. The air, as it traverses the room, will adhere to the ceiling. The objection to this method is the possible streaking of the ceiling with dirt.

3. *Room Air Motion.* The factors leading to high air motion are excessive velocity, high air volume per square foot of floor area, overblow, striking of beams causing a spilling of the air into the zone of occupancy, and heating in severe climates by means of ceiling outlets which are directed downward.

4. *Dirt.* Although the primary air may be carefully filtered, dirt from the conditioned space may be deposited on the walls or ceiling wherever there is considerable secondary air motion. With ceiling outlets, dirt streaking may be minimized by carefully controlling the discharge of the outlets. 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.

5. *Noise.* The noise of an outlet is primarily the function of the outlet velocity and size, and secondarily of the outlet construction. The maximum acceptable noise level in a space may completely dictate the permissible outlet velocities that may be employed. (See Chapter 42 for discussion of permissible room noise levels and noise generated by outlets.)

6. *Capacity.* The quantity of air to be handled is determined by the heating, cooling, or ventilating requirements. 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 used should be carefully noted to make certain that resulting velocities are suitable for the type of occupancy.

Ceiling outlets will in general handle more air per outlet, without objectionable air motion, than either comparable sidewall or floor outlets.

Temperature Differential

The use of outlets that give rapid mixing permits use of higher supply temperatures for heating and lower supply temperatures for cooling. To facilitate control it is frequently desirable to handle more air at a lesser temperature difference with the room, rather than less air at a greater temperature difference, in order that two areas temporarily loaded differently will not differ too greatly in temperature.