1. *Throw.* The throw of a wall outlet must be sufficient to produce satisfactory conditions over the area to be conditioned. Underblowing may cause heated air to rise too rapidly above the occupied zone and thus create excessive vertical temperature variation (stratification); in cooling operation it may cause cold air to drop into the occupied zone before a satisfactory mixing of supply and room air has been accomplished by induction and thereby create a condition of acute discomfort (draft). On the other hand, overblowing will result in objectionable downdrafts from any surface the primary air stream may strike.

On the average it is considered most practicable to select throw as $\frac{3}{4}$ of the distance toward an exposed wall or window, as shown in A of Fig. 5. However, structural characteristics, mounting height, temperature differential and resultant drop or rise, or location of greatest heating or cooling loads strongly affect the selection of the optimum throw. 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 and producing objectionable drafts.

In the case of ceiling diffusers air is distributed with a spread of 360 deg horizontal. In addition there is a downward component of air motion. Therefore, both throw (radius of diffusion) and mounting height are important and interdependent factors. Due to the 360 deg spread of air diffusion the rate of induction will be higher and the throw shorter than that of a wall grille opening 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 such 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 20 per cent above that of an unrestricted air stream.

In the use of perforated ceiling plates as air distributing devices the term throw could hardly be applied in its proper meaning. Although this type of outlet can handle the greatest amount of air in proportion to room size, jet velocities must be kept low.

In all types of ceiling air distribution the following should be noted:

If cold air is used it must be brought to the proper temperature by mixing with room air before entering the zones of occupancy.

Air slightly above room temperature will usually be properly distributed by outlets selected for cooling.

When delivering warm air the same may be projected downward and the amount of dispersal of the jet varied to obtain 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. 5 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.* Various features may cause room air motion to exceed acceptable standards. Some of these are: excessive air discharge

velocities; high air volume per cu ft 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. It should be realized that these factors will not equally affect all types or designs of outlets at different temperature differentials, mounting heights, etc. For instance, certain outlets may safely handle more air per cubic foot of space at higher discharge velocities than others, and downward projection of supply air will sometimes not be considered excessive if the supply air temperature is substantially higher than the room temperature.

4. *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 application.

5. *Temperature Differential.* This is one of the most important factors affecting outlet performance. The quality of the temperature control, or the extent of the control problem, is directly a function of temperature difference. Obviously a system which carries under design conditions only a 5 deg difference between supply air stream and room temperature would require no control at all, for even a 50 per cent change in load could only effect a $2\frac{1}{2}$ deg change in room temperature under the worst conditions. Because of the self-equalizing nature of most load factors, even this extreme is never realized. It is obvious that the greater the temperature differential between supply air and room temperature, the greater will be the change in room temperature for a given change in load. The use of outlets that give rapid mixing permits greater temperature differentials. These principles apply in both heating and cooling practice.

6. *Dirt.* 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. 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.

7. *Noise.* The increase of noise level caused by an outlet is primarily a function of its air discharge velicity and its size. The maximum acceptable noise level in a space may dictate completely the selection of the permissible outlet velocity. In addition, however, noise may be caused by excessive restriction of 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. Such high frequency noises due to excessive turbulence are especially annoying (see Chapter 42 for discussion of permissible room noise levels and noise generation by outlets).

TYPES OF AIR OUTLETS

Two types of air supply outlets are commonly used; side wall and ceiling. A variety of designs has been developed for both types and the final selection depends to a large degree upon the specific problems arising in the air distribution system to be used.

In addition to the comments on use and application of outlets which fol-