be contributed by fans, motors, duct work, and other items of conditioning equipment. The control of noise from these sources is another problem (see Chapter 30). Where sound control is important, the actual room sound level without conditioning equipment should be known. If feasible, the contribution of the conditioning equipment, less outlets, should be estimated to secure the working sound level. If this correction is not made, the use of the first value errs in the direction of safety.

It is evident that the point within the room which should concern the designer in this problem is that at which the outlet noise is greatest. A tentative standard *listening point* relative to the outlet is suggested later in this discussion, and it is assumed that the outlet noise data are taken with reference to this point. If it is desired that the outlet noise result in an inaudible addition to the existing noise level, it is safe to assume the total outlet noise to be 5 db below room level. This results in an increase in total noise of slightly over 1 db, which is unnoticeable. If an increase of 3 db is permissible, the outlet noise level may be equal to the room noise level alone. All outlets in the room must be considered, as will appear later, and the returns may be ignored only if they are so sized that the velocity of air through them is much less than through the outlet.

DISTRIBUTION FACTORS IN ROOM COOLING

In attempting to design a satisfactory air distributing system, it is first necessary to properly locate the grilles in accordance with the recommendations already stated. Assuming that the best locations have been selected, it then becomes necessary to choose the proper grille for that location. The considerations involved are the amount of air to be handled, the velocity permissible from the standpoint of noise, and the distance the air should carry. The distance it will carry, assuming no obstructions, is affected by a number of factors which are listed below:

1. The temperature difference between incoming and room air.
2. Height of grille above floor.
3. Face velocity.
4. Core area.
5. Core aspect ratio.
6. Design of grille.

The manner in which the above factors affect throw may be generally stated. All other things being constant, a lower temperature of incoming air will result in shorter throw; a greater height above the floor will affect a longer throw; a higher velocity will produce a longer throw; greater area will give longer throw; larger aspect ratio will decrease throw. The variation in throw with type of outlet will, of course, depend upon the design characteristics of the outlet.

In consideration of what constitutes the possible throw of an outlet under a given set of conditions, it is important to remember that the throw may be unsatisfactory for any one of several reasons:

1. It may be so long that it will strike the far side of the room and come down the wall with velocities higher than are permissible,
2. It may be so short that it will fail to carry the full length of the room, and short-circuit to the return air outlet, or
3. It may spill into the center of the room.

In the first case, the system fails for lack of uniform distribution and the presence of cold areas. In the second case, the standards as to velocity and temperature difference in the zone of occupancy may be satisfactorily met, but air distribution and circulation throughout the entire room is not accomplished, with the result that the end of the room away from the outlet would not be satisfactorily conditioned. In the third case, the shortcomings of both case one and case two are present. It is evident, therefore, that for a given outlet discharging air at a given velocity, there is a maximum and a minimum length of room which can be satisfactorily handled. In the latter, the velocity of the air down the far wall is just within the maximum permissible, while in the former, satisfactory circulation is barely accomplished.

In general, the higher the outlet is above the floor, the greater may be the difference between room air and incoming air temperatures.

Assuming that proper supply outlets for a given installation have been selected, unsatisfactory performance may still result due to the construction of the duct work immediately back of the outlets. Performance data on the grilles and registers of various manufacturers should be based upon results obtained with the air approaching the grille perpendicularly and at uniform velocity over the entire duct cross-section. Where this condition does not exist in practice, performance predictions based on published data cannot be expected to be realized. Every precaution should be taken to secure as nearly ideal conditions in the approaching air stream as are possible.

In addition to disturbances due to the construction of the duct work itself are those which may be created by dampers immediately behind the grille. Where either multiple louvre or single blade dampers are used, considerable deflection of the air stream may result, if it is throttled appreciably by these means. This is particularly true when the fins of the register core are perpendicular to the damper blades. If the core has sufficient depth and the fins are parallel to the blades, there is a marked tendency to straighten the air stream, although some deflection may still result.

Any attempt to secure a low face velocity and high duct velocity by the construction of any expanding chamber immediately behind the grille is very likely to be unsuccessful. In order to expand from a small duct to a larger one, and have the air stream fill the duct at the end of the diverging section without turbulence, angle *A* in Fig. 8 should be about 3 deg for four-sided expansion and about 5 deg for two-sided expansion. From this it is apparent that an attempt to secure equivalent results with a short connection would be futile. What actually happens when this is attempted is illustrated by the arrows in Fig. 8. When localized high velocities through the outlet exist from this cause or any other, the noise produced will naturally exceed that which the outlet area and average face velocity would lead one to expect. This fact should be remembered in considering the use of register dampers, particularly in those cases where there must be considerable throttling with the damper to balance a poorly designed system. Where reduction of noise is important, it is recommended that balancing dampers be placed in the duct *ahead* of the acoustic duct lining.

Similar unequal face velocities, aggravated by a deflection of the air