18. *Percentage Free Area:* The ratio of the free area to the core area expressed in percentage.

19. *Aspect Ratio:* The ratio of length of the core of a grille, face or register to the width.

20. *Throw:* The distance air will carry measured along the axis of an air stream from the supply opening to the position in the stream at which air motion reduces to 50 fpm.

21. *Envelope:* The outer boundary of an air stream.

GRILLE LOCATIONS

The location of supply and exhaust openings is extremely important if a satisfactory installation is to be secured. Very frequently, however, the room or building is planned and constructed with practically no consideration of this problem. The engineer of today is more likely than not to have as his problem a building that was constructed long before any consideration whatever was given to air conditioning it. Consequently, the room shapes, the location of columns and beams, and other details of architecture frequently make it difficult to properly locate the supply openings. In general, for a cooling installation, the grilles should be located high enough from the floor to prevent the discharge of air directly upon the occupants of the room, and far enough down from the ceiling to

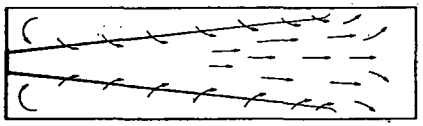

FIG. 1. PLAN VIEW LONG THROW SUPPLY OPENING



FIG. 2. PLAN VIEW SHORT THROW SUPPLY OPENINGS

minimize the possibility of streaking, and to permit induction of air from all sides of the stream. If the stream actually strikes the ceiling, but at a small angle, the throw will be increased somewhat if the ceiling is smooth. If the angle at which the stream hits the ceiling is 20 deg or more, or if the flow along the ceiling is obstructed by panel mouldings or beams, air velocity may be rapidly lost and a decreased throw result. The air stream also should be so directed that it will not strike nearby columns or beams in such a way as to cause misdirection of the air stream or drafts. Where the room is of irregular shape, as an ell, or where it has an alcove in one side, consideration should be given to obtaining satisfactory circulation in these corners. Frequently this cannot be done except by the use of multiple supply openings. In using multiple supply openings, care must be taken that the several air streams do not interfere with each other, until their velocities have been reduced to values which will not cause high turbulence and a drafty condition. Beams and offsets in the ceiling will cause little difficulty when substantially parallel to the direction of flow, unless they are of considerable depth, but, when positioned across the air stream, may cause drafts and failure to secure satisfactory circulation in that portion of the room farthest from the supply opening. In the case of a heating installation, down-drafts produced by such obstructions may not be serious, because the air will rapidly lose its downward motion, but the possibility of failure to obtain satisfactory circulation still exists.

The location of supply openings should, if possible, be such as to take advantage of the maximum velocity permissible from a noise standpoint. For instance, the spaces illustrated in Figs. 1 and 2 may be satisfactorily served by either arrangement. However, by taking advantage of the long throw, to which the arrangement in Fig. 1 lends itself, fewer supply openings are required and additional savings are effected in the sheet metal work.

In solving the problem of properly conditioning a room of irregular shape, where multiple wall supply grilles are objectionable, a ceiling supply opening of the type illustrated in Figs. 3 and 4 may very often be the best solution.

In choosing the most desirable location for the return air grille, consideration should be given to its effect on circulation of the air through the room. It is generally true that the return air grille should be placed on the same wall as the supply and near the floor level. This results in a U-shaped air path (Fig. 5) which covers the room thoroughly. The arrangement shown in Fig. 6 should be avoided, because it tends to create

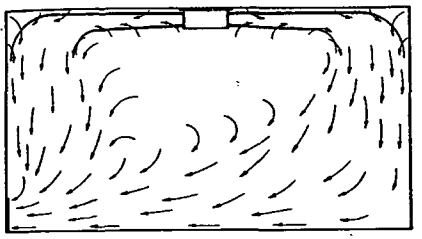

FIG. 3. ELEVATION VIEW, CEILING SUPPLY OUTLET WITH RETURN OPENING IN WALL

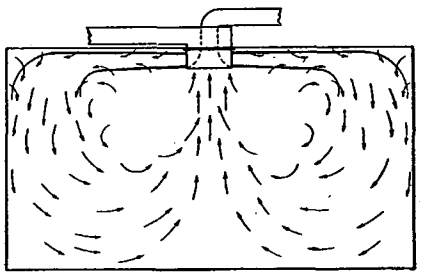

FIG. 4. ELEVATION VIEW, CEILING SUPPLY AND RETURN OPENINGS

a stagnant section below the supply grille. What would otherwise be an unsatisfactory dead spot in a room may in some instances be taken care of by location of the return air grille near that area (Fig. 7).

STANDARDS FOR SATISFACTORY CONDITIONS

The most satisfactory air condition cannot be definitely stated for any particular individual without conducting a series of tests with that individual as subject; some persons are less sensitive than others to variations in temperature, humidity, air velocity and noise. The best that can be done is to attempt to set limiting conditions leaning toward the values of these variables which produce a condition of comfort for the greatest number of individuals. On a cooling installation, the allowable deviation from average room temperature, that is, the temperature of puffs of air which may strike a person momentarily, is a function of the room temperature as well as the velocity of the air. For instance, in a room controlled at 72 F, a puff of air at 70 F might be uncomfortable to an individual, even at relatively low velocities, whereas if the average room temperature were 80 F, air at 78 F, even at moderate velocities, might be very satisfactory. However, air at 78 F in an average room