stream, are obtained with the arrangement shown in Fig. 9. The latter may be corrected by inserting a turning member in the elbow back of the outlet face as shown in Fig. 10. The importance of straightening the air stream and affecting uniform distribution over the entire face of the outlet cannot be over-emphasized.

DISTRIBUTION FACTORS IN ROOM HEATING

The problem in the case of a heating installation is substantially the same as in cooling, with a few exceptions. Because the temperature of the incoming air is above that of the room, there is no tendency for it to drop and consequently the throw is not particularly affected by temperature difference in a low ceiling room. In general, the air should be deflected downward where the grille is above the occupancy zone, and this is particularly desirable where the ceiling is high. For the same reason, that is, to keep the heat in the occupancy zone and to avoid excessive

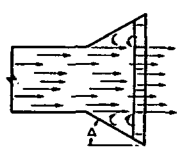

FIG. 8. EFFECTS OF EXPANDING DUCT

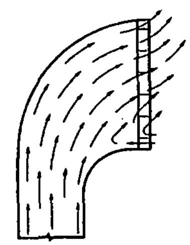

FIG. 9. UNEQUAL FACE VELOCITIES

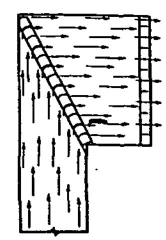

FIG. 10. EFFECT OF TURNING MEMBER

temperature at the ceiling, it is desirable to have the grille comparatively low on the wall, and just slightly above the occupancy zone. If the grille is lower than this, it may create an unsatisfactory condition of very warm air at quite high velocities where it can possibly strike the occupants of the room. Where the velocities are very low, the grilles may even be satisfactorily located below the 6 ft level, although the immediate vicinity of the supply outlets will probably be useless for occupancy because of high temperature. Essentially, the problem is to keep the incoming air up for cooling, and down for heating, until it is thoroughly mixed with the room air. Grilles and registers which are adjustable for deflection upward and downward, either by moving the fins or inverting the grille, are in general use.

AIR OUTLET NOISES

When air is introduced into a room through a grille or register at a constant velocity, sound energy is being introduced into the enclosure at a constant rate. Due to partial reflection at the boundaries of the enclosure, the intensity of sound at any point in the space builds up to some maximum value. In a large room at a point remote from the source of sound (the outlet) the intensity can be shown to be substantially proportional to the rate at which sound energy is generated and inversely

proportional to the number of sound absorption units (sabins) in the room. It would thus appear that doubling the sound absorption of the room would halve the intensity and result in a noise level decrease of 3 db. However, it is not satisfactory to consider the grille noise on this basis (wherein the sound power received directly from the source is small compared with that received by reflection) since in practice the occupants of the room may be quite close to the grille. The nearer the listener is to the sound source, the greater the proportion of the sound intensity which is due to direct transmission.

In the absence of generally accepted standards at this time it is suggested that the loudness level 5 ft from the lower edge of the outlet, measured downward at 45 deg in a plane perpendicular to the outlet at its center, represents about the maximum within the zone of occupancy. The cases where persons are nearer to the outlet than this are rare and are ignored in the consideration of this problem. Although the effect of sound absorbent material on the intensity at the 5 ft station is not nearly so great as at more remote points in the room, it should not be ignored without consideration of the error involved. An average living room may contain 100 sabins (absorption units). If this be decreased to 50 sabins, the *diffuse* or reflected sound level would be increased 3 db. However, at the 5 ft station the increase would be less than 2 db. If the absorption of the room be increased to 200 sabins, one might expect a reduction in diffuse noise of 3 db; but at the 5 ft station the reduction would be less than 1½ db. Furthermore, even though the absorption be increased without limit (as in free space) the reduction would still be less than 2 db because of proximity to the source.

In comparing sound ratings of various grilles, the following must be known if the information is to be intelligently applied:

1. The threshold intensity on which the decibel ratings are based.
2. The distance from the grille at which data were taken.
3. If stated as loudness level versus velocity for a given grille, the *core area* (not nominal area) must be known.
4. The sound absorbing characteristics of the test room.
5. Whether or not corrected for test room loudness level; if not, the room level (without grille noise) must be known.
6. Methods used for recording data.

Data mentioned in this chapter are assumed to have been referred to the following:

1. Threshold intensity = 10^{-16} watts per square centimeter[1].
2. Microphone location 5 ft from lower edge of outlet on a line downward at 45 deg and in a plane bisecting the outlet perpendicularly.
3. Where data are given as loudness level versus velocity, the rating is per square foot of core area.
4. The room is assumed to have 100 sabins absorption.
5. Plotted data are loudness levels of *outlets only*, correction having been made for test room level.
6. Data taken with a direct reading sound-level meter with frequency weighing network intended to approximate the response of the human ear.

[1]American Tentative Standards for Noise Measurement, *American Standards Association.*