7. *Single Louver Damper:* A damper having one adjustable blade.
8. *Face:* A grille with provision for attaching a damper.
9. *Register:* A face with a damper attached.
10. *Flange:* The portion (either integral or separate) of a grille, face, or register extending into the duct opening for the purpose of mounting.
11. *Frame:* The portion (either integral or separate) of a grille, face, or register extending around the duct opening for the purpose of mounting.
12. *Margin:* The margin of a grille, face, or register is one-half of the difference between the duct dimension and over-all dimension measured either horizontally or vertically.
13. *Fret:* The member separating the openings of a grille, face, or register.
14. *Free Area:* The total minimum area of the openings in the grille, face, or register through which air can pass.
15. *Core Area:* The total plane area of the portion of a grille, face, or register bounded by a line tangent to the outer edges of the outer openings through which air can pass.
16. *Mean Area:* The total of the core and free areas divided by two.
17. *Duct Area:* The area of a cross-section of the duct based on the inside dimensions at a point where the grille, face or register is mounted.
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 (Blow):* The distance an air stream travels on leaving the outlet (grille or register) to a position at which air motion reduces to a maximum velocity of 50 fpm.
21. *Envelope:* The outer boundary of an air stream moving at a perceptible velocity.
22. *Drop:* The vertical distance, h, in feet, the lower edge of the air stream drops between the outlet and the end of its throw.
23. *Rise:* The converse of drop.
24. *Induction:* The entrainment of room air by the air discharged from the outlet.
25. *Primary Air:* The air leaving the duct and entering the outlet (Q_1 in cfm).
26. *Secondary Air:* The room air picked up by the primary air through induction (Q_2 in cfm).
27. *Total Air:* The mixture of primary and secondary air (Q_3 in cfm).
28. *Induction Ratio:* The total air divided by the primary air equals r, or Q_3/Q_1.
29. *Outlet Velocity:* The average air velocity emerging from the outlet (V_1 in fpm) measured in the plane of the opening.
30. *Terminal Velocity:* The average air stream velocity at the end of the throw (V_T in fpm).
31. *Horizontal Spread:* The divergence of the air stream in the horizontal plane after it leaves the outlet (Degrees).
32. *Vertical Spread:* The divergence in the vertical plane (Degrees).
33. *Temperature Differential:* Temperature difference between primary and room air ($t_r - t_{as}$).
34. *Vane Ratio:* The ratio of depth of vane to shortest opening width between two adjacent grille bars.
35. *Radius of Diffusion:* The horizontally measured distance served by a ceiling outlet within which air motion is reduced to 50 fpm (maximum).

MECHANICS OF AIR DISTRIBUTION

In the mechanics of air distribution, two major problems are involved: (1) complete mixing of the primary air and secondary air outside of the zone of occupancy in order to reduce the temperature difference and air motion to acceptable limits before the air enters the occupied zone; and (2) counteraction of the natural convection and radiation effects within the room.

Momentum Theory

When air is discharged from an outlet into a free open space, the primary air stream entrains room air as it traverses the space. This

entraining effect increases the cross-sectional area and reduces the velocity of the resulting air stream. Induction takes place with the conservation of linear momentum; this has been confirmed by tests which indicate that the momentum remains almost constant throughout the entire measureable length of the air stream. This relationship may be expressed by the Equation 1:

$$M_1 V_1 + M_2 V_2 = (M_1 + M_2) V_3 \qquad (1)$$

where

M_1 = mass of primary air.
M_2 = mass of secondary air.
V_1 = velocity of primary air.
V_2 = velocity of secondary air (normally, $V_2 = 0$).
V_3 = velocity of the mixture.

Since the secondary air velocity is zero,

$$M_1 V_1 = (M_1 + M_2) V_3$$

or,

$$\frac{V_1}{V_3} = \frac{M_1 + M_2}{M_1} = r \qquad (2)$$

In Equation 2, r is called the induction ratio.

Since in many applications the densities of primary and room air are about equal, air volumes may be substituted for mass in Equation 2.

$$r = \frac{Q_1 + Q_2}{Q_1} \qquad (3)$$

where

Q_1 = volume of primary air, cubic feet.
Q_2 = volume of secondary air, cubic feet.

Throw

Mathematical statements for throw have been evolved from research[1] that have proved the following to be *approximately true* for outlets having aspect ratios below 50.

1. Residual velocity of an unrestricted air stream is directly proportional to the outlet velocity.

2. Residual velocity is directly proportional to the effective diameter of the outlet. Effective diameter is defined as a diameter of a circular area (effective area) which would give the same throw. It is the free area times a constant.

3. Residual velocity is inversely proportional to the distance from the outlet.

From these statements the following equation can be established [1].

$$V_r = \frac{C V_1 D_1}{X} = \frac{K V_1 \sqrt{A_1}}{X} \qquad (4)$$

where

V_r = residual maximum velocity in air stream, *i.e.*, the highest maintained velocity at the given cross section in the room.
V_1 = average velocity across the effective area of the outlet.
X = throw.
C and K = constants of proportionality.

$$K = \sqrt{\frac{4}{\pi}}\, C = 1.13\, C$$

D_1 = diameter of effective area of outlet.
A_1 = effective area of outlet.