on desks and may result in a sensation of draft. Air velocities of 25 to 35 fpm in the occupied zone are most satisfactory, but air motion of 20 to 50 fpm will usually be acceptable, particularly when the lower part of this range of velocity is used in cooling applications and the higher values on heating jobs. In any case, it is certain that the effect of room air motion on comfort or discomfort depends on air temperature and direction as well as on velocity.

Reference should be made to Chapter 12, Physiological Principles, for information on effective temperature and comfort zones. Material in Chapter 42, Sound Control, covers acceptable room noise levels and noise generated by air outlets.

DEFINITIONS

The following definitions referring to air distribution equipment have gained general acceptance.

1. *Supply Opening or Outlet:* Any opening through which air is delivered into a space which is being heated, or cooled, or humidified, or dehumidified, or ventilated.
2. *Exhaust Opening or Return Intake:* Any opening through which air is removed from a space which is being heated, or cooled, or humidified, or dehumidified, or ventilated.
3. *Outside Air Opening:* Any opening used as an entry for air from outdoors.
4. *Damper:* A device used to vary the volume of air passing through a confined cross-section by varying the cross-sectional area.
5. *Grille:* A covering for any opening and through which air passes. A supply grille discharges air axially with a limited spread.
6. *Register:* A grille equipped with a damper.
7. *Free Area:* The total minimum area of the openings in the air outlet or inlet through which air can pass.
8. *Core Area:* The total plane area of the portion of a grille, bounded by a line tangent to the outer edges of the outer openings through which air can pass.
9. *Mean Area:* The total of the core and free areas divided by two.
10. *Percentage Free Area:* The ratio of the free area to the core area expressed in percentage.
11. *Aspect Ratio:* The ratio of length of the core of a grille to the width.
12. *Vane Ratio:* The ratio of depth of vane to shortest opening width between two adjacent vanes.
13. *Plaque:* A ceiling outlet in which the supply air impinges against a plate or series of parallel plates and is discharged horizontally in all directions.
14. *Diffuser:* An outlet discharging supply air in various directions and planes, thereby effecting its mixture with the room air.
15. *Primary Air:* The air delivered to the outlet by the supply duct.
16. *Induction:* The entrainment of room air by an air stream.
17. *Internal Induction:* The induction of room air drawn into an outlet by the primary air stream. (Commonly called *aspiration*).
18. *External Induction:* The induction of room air by the air stream discharged from the outlet (commonly called *secondary air motion*).
19. *Induced Air:* The room air entrained by the primary air through internal induction or by the discharged air through external induction or both.
20. *Total Air:* The mixture of primary air and induced air.
21. *Induction Ratio:* The total air divided by the primary air.
22. *Throw (Blow):* The horizontal distance an air stream travels on leaving the outlet (grille) to a position at which air motion reduces to a maximum velocity of 50 fpm.
23. *Drop:* The vertical distance, the lower edge of the air stream drops between the outlet and the end of its throw.
24. *Rise:* The converse of drop.
25. *Envelope:* The outer boundary of an air stream moving at a perceptible velocity.

26. *Spread:* The divergence of the air stream in a horizontal or vertical plane after it leaves the outlet.
27. *Diffusion:* Distribution and mixing of air within a space, accomplished by an outlet discharging supply air in various directions and planes in order to effect the desired air conditions in the occupied zone of that space.
28. *Radius of Diffusion:* The horizontal distance from the diffuser outlet to the perimeter of the space, within which effective diffusion is accomplished and air motion in the occupied zone is reduced to 50 fpm maximum.
29. *Outlet Velocity:* The average velocity of air emerging from the outlet measured in the plane of the opening.
30. *Terminal Velocity:* The average air stream velocity at the end of the throw.
31. *Temperature Differential:* Temperature difference between primary and room air.
32. *Temperature Variation:* Temperature difference between points of the same space.

MECHANICS OF AIR DISTRIBUTION

In the mechanics of air distribution, two major problems are involved: (1) complete mixing of the primary air and 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.

The theory concerning the distribution of conditioned air within an enclosure is still incomplete and no general law governing outlet performance has been formulated. The characteristics and performances of the various existing types of outlets must therefore be evaluated largely by experimental work. Some progress has been made concerning the theoretical analysis of the characteristics of a primary air stream discharged in an unconfined space, i.e., a space large enough so that the primary air stream is not disturbed by contact with surfaces, or by adjacent streams. The approach to this problem is usually made by means of the momentum theory. Development of this theory has so far been confined to side wall distribution of air, because this is its most elementary application. Fundamentally, the same laws apply also to ceiling distribution, but a great amount of additional research is still required to adapt them to the more complicated conditions of deflection of air up to 90 degrees, spread up to 360 degrees and the resulting rapid induction. There is also an element of downward diffusion which usually is not obtainable with side wall grilles.

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 measurable length of the air stream. This relationship may be expressed by Equation 1:

$$M_1V_1 + M_2V_2 = (M_1 + M_2)V_3 \qquad (1)$$

where

M_1 = mass of primary air.

M_2 = mass of induced air.