12. *Vane Ratio:* The ratio of depth of vane to minimum 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 deflected horizontally in all directions.

14. *Diffuser:* An outlet discharging supply air in various directions and planes.

15. *Primary Air:* The air delivered to the outlet by the supply duct.

16. *Induction:* The induction of room air drawn into an outlet by the primary air stream (commonly called *aspiration*).

17. *Entrainment:* The entrainment of room air by the air stream discharged from the outlet (commonly called *secondary air motion*).

18. *Total Air:* The mixture of discharged air and entrained air.

19. *Entrainment Ratio:* The total air divided by the discharged air.

20. *Throw (Blow):* The horizontal or vertical axial distance an air stream travels on leaving the outlet (grille) before the maximum velocity is reduced to 50 fpm.

21. *Drop:* The vertical distance, the lower edge of a horizontally projected air stream drops between the outlet and the end of its throw.

22. *Rise:* The converse of drop.

23. *Envelope:* The outer boundary of an air stream moving at a perceptible velocity.

24. *Spread:* The divergence of the air stream in a horizontal or vertical plane after it leaves the outlet.

25. *Diffusion:* Distribution of air within a space by an outlet discharging supply air in various directions and planes.

26. *Radius of Diffusion:* The horizontal distance from the diffuser outlet to the perimeter of the space, within which air motion in the occupied zone is reduced to 50 fpm maximum.

27. *Outlet Velocity:* The average velocity of air emerging from the outlet, measured in the plane of the opening.

28. *Terminal Velocity:* The average air stream velocity at the end of the throw.

29. *Temperature Differential:* Temperature difference between primary and room air.

30. *Temperature Variation:* Temperature difference between points of the same space.

STANDARDS FOR SATISFACTORY CONDITIONS

The object of air distribution in warm air heating, ventilating and air conditioning systems is to create in the occupied zone of the conditioned room (floor to 6 ft above floor level) the proper combination of temperature, humidity and air motion. To obtain comfort conditions within this zone, standard limits have been established as acceptable *effective temperatures.* This term comprises air temperature, motion, humidity, and their physiological effect on the surface of the human body. Any variation from accepted standards of one of these elements may result in discomfort to the occupants. The same effect may be caused by lack of uniformity of conditions within the space or by excessive fluctuation of conditions in the same part of the space. Such discomfort may arise due to excessive room air temperature variations (horizontally, vertically, or both), excessive air motion (draft), failure to deliver or distribute the air according to the load requirements at the different locations, or too rapid fluctuation of room temperature or air motion (gusts).

With reference to permissible room air motion it is not possible to establish a specific standard covering the entire complex problem of air distribution. Velocities less than 15 fpm generally cause a feeling of air stagnation, whereas velocities higher than 65 fpm 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, with the lower values used in cooling applications, and the higher values on heating jobs. The permissible air motion depends to some degree on the geographic location of the air conditioning installation. In addition the noise level created by the introduction of supply air should be kept within acceptable limits, and streaking or smudging of walls or ceilings should be prevented.

Reference should be made to Chapter 6, Physiological Principles, for information on effective temperature and comfort lines, and to Chapter 40, Sound Control, for acceptable room noise levels and noise generated by air outlets. Material in Chapter 46, Process and Product Air Conditioning, covers temperature and humidity requirements for products and manufacturing processes, and for health, safety and efficiency of workers.

PRINCIPLES OF AIR DISTRIBUTION

Conditioned air is supplied to air outlets at temperatures and velocities which differ greatly from those in the occupied zone of the room. Proper air distribution, therefore, calls for (1) entrainment of room air by the primary air stream outside of the zone of occupancy in order that air motion and temperature differences will be reduced to acceptable limits before the air enters the occupied zone, and (2) counteraction of the natural convection and radiation effects within the room.

Practical room air distribution is predominantly an art depending upon clear recognition of physical principles, good judgment, and the cumulative benefits of extensive experience. The characteristics and performances of air outlets are evaluated by experiment, and full-scale models are employed in order to develop satisfactory installation recommendations for specific applications. Frequently the performance of the air distribution system is checked in the field before the installation is turned over to the customer. Adjustments may be necessary before all requirements are met. Manufacturers' literature is available to provide data for the performance and application of various outlets which are usually based upon observations in full-scale test rooms.

The complexity of practical room air distribution is due to innumerable variations in building construction, system design, and operating requirements, and makes the exploration of the basic character of air distribution imperative. Research at the ASHAE Research Laboratory[1] and cooperative programs at *Case Institute of Technology*[2] since 1937 have advanced considerably the fundamental knowledge in air distribution.

A comprehensive survey of the literature relevant to air distribution problems was made at the ASHAE Research Laboratory in connection with the experimental investigation of ventilation jets.[1(b)] This survey deals with fundamentals of turbulence, jet behavior, and miscellaneous problems, and is sufficiently complete to permit the study of these problems without requiring recourse to the original papers. Therefore, the survey is an indispensable and timesaving tool for every researcher in air distribution.

VENTILATING JETS IN AIR DISTRIBUTION

The theory concerning the distribution of conditioned air within an enclosure is still far from complete but a considerable fund of knowledge supported by experimental guidance is available for free jets, and particularly for axial-flow type free jets, both singly and in combination.[2] For many conditions of jet discharge, therefore, it is possible to analyze jet performance, and to determine (1) the angle of divergence of the jet boundary, (2) the velocity patterns along the jet axis, (3) the velocity profile at any cross section in the zone of maximum engineering importance, and (4) the entrainment ratios in the same zone. In other words, it is possi-