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

$$\frac{V_1}{V_2} = \frac{Q_1 + Q_2}{Q_1} = \frac{Q_3}{Q_1} = r \tag{3}$$

where

Q_1 = volume of primary air, cubic feet per minute.
Q_2 = volume of secondary air, cubic feet per minute.
Q_3 = volume of mixture of primary air and induced air, cubic feet per minute.
r = induction ratio.

Jet Pattern From Round or Rectangular Openings in a Large Room

The relation between the shape of the discharge of a jet and the shape of the conventional outlet has long been the subject of research. It has been proved to be incorrect to assume that the jet retains the outlet shape when it discharges into a free open space [1]. Air streams from rectangular outlets having low aspect ratios develop a symmetrical or cone shape within a few diameters from the outlet face. From there on, the jet continues to expand at a fairly constant rate. Beyond 20 diameters there is very little difference between round and rectangular jets. The assumption can be made that the apex of the cone is in the same position for any jet having a small aspect ratio. For the more usual problems of the conventional room with outlets near the ceiling, there are insufficient experimental data to justify a definite statement on the effect of aspect ratio.

If the round or rectangular opening is divided into a number of orifices having straight sides, the performance of the air stream will be similar to that of a plain opening.

Velocity Across Jets

Results of many tests [1] indicate that the ratio of centerline velocity to average velocity is about 3, irrespective of outlet size, shape or initial velocity. This statement is true for stream cross-sections located beyond 10 diameters from the outlet, and is fairly accurate for distances up to 50 diameters. Experimental data are lacking for distances beyond 50 diameters.

Effect of Aspect Ratio on Entrainment

In slotted outlets, the air entrainment of the primary jet is a function of aspect ratio [1]. This effect is most pronounced when large changes in the ratio are made. A comparison between a slot of aspect ratio 24 and a square opening of the same area is given in curves *A* and *B* of Fig. 1. At a distance of 8 ft from the outlet, the entrainment of the slot is 8.1 as compared with 6.9 for the square, or an increase of about 17 per cent.

Curve *C* shows the further increase in entrainment obtained by using an aspect ratio of 48. An increase of 40 per cent is obtained over the 24 in. x 1 in. slot. This indicates that long narrow slots produce air streams that give high induction of secondary air.

Parallel Slots

The use of several slots in parallel to vary the rate of air entrainment depends mainly on the distance between the slots. If close together, the air pattern is about the same as for a single opening of equal area. Spacing the openings farther apart gives an increase in entrainment as shown on curves D and E of Fig. 1. It will be noted that 2 openings 24 in. x ¼ in. located very close together will obtain an entrainment which is about the same as obtained with one 24 in. x ½ in. opening. However, if the slots are spaced 6½ in. apart there is a marked increase in entrainment.

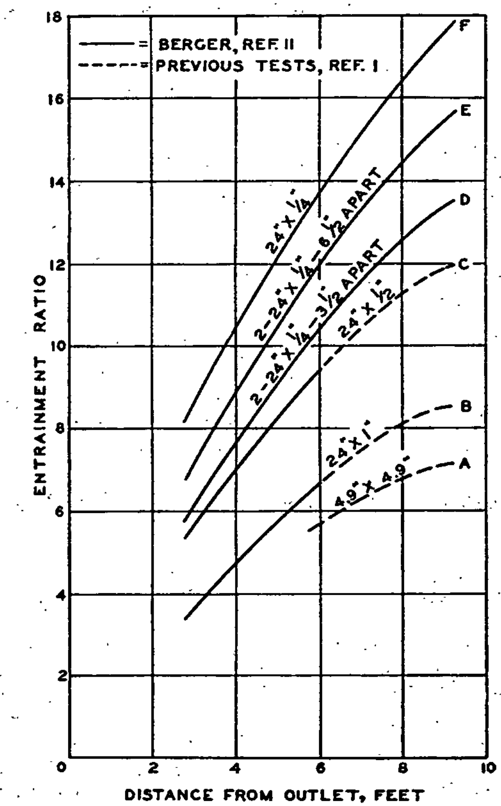

Fig. 1. Typical Relation of Entrainment Ratio to Distance from Outlet for Slotted Outlets. (Based on 800 fpm Outlet Velocity.)

Throw

Equations for the throw of straight flow side wall outlets have been developed on the basis of the momentum theory. Equation 4 states the throw in terms of the area of the outlet and the primary air volume[2]:

$$L = 0.82 \frac{Q_1}{\sqrt{A_1}} \tag{4}$$

where

L = throw, ft.
A_1 = effective outlet area, in square inches = (gross measured area) x (percentage of free area/100) x (discharge coefficient).

The discharge coefficient is approximately 0.8.