For a long slot

$$\frac{Q_x}{Q_o} = \sqrt{\frac{2}{K'}} \cdot \sqrt{\frac{X}{H_o}} \qquad (8a)$$

where

Q_x = total volume flow rate at distance X from face of outlet, cubic feet per minute.

Q_o = discharge from outlet, cubic feet per minute.

X = distance from face of outlet, feet.

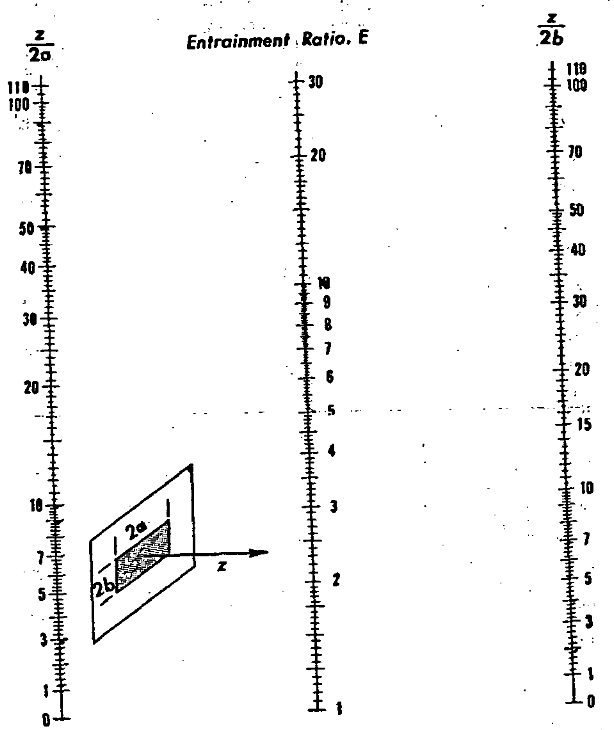

FIG. 11. NOMOGRAM FOR ENTRAINMENT RATIOS OF ROUNDED, RECTANGULAR JET SOURCES

K' = proportionality constant.

A_o = effective area of stream at discharge from an open-end duct or at a contracted section, square feet.

H_o = width of slot, feet.

Equations 8 and 8a have been used in plotting Fig. 9 for entrainment ratios.

The nomograms (Figs. 10 and 11) for center velocities and entrainment ratios for jets emitted from circular sources, and from rectangular sources of all aspect ratios, are based upon recently developed theory.[11]

OUTLET PERFORMANCE

The results of the studies undertaken in room air distribution which have been presented in the foregoing section can be used as a basis for engineering design of supply outlets if the following is kept in mind:

1. The method for finding jet velocities is based upon several approximations and the two recommended equations must be used with caution for extreme axial and radial distances.

2. The characteristics of the low-velocity regions of ventilating jets are not yet well understood, and for both axial and radial jets the effect of the Reynolds number is not fully known.

3. The quantitative treatment of the forces which govern room air distribution phenomena has been limited, and non-isothermal conditions involving buoyant forces have not yet been fully explored.

4. All investigations have been concerned with *free* jets, whereas air streams in practical room air distribution are not free streams but are influenced by walls, ceilings, floors and obstructions.

5. The science of air distribution has not yet reached its final stage where a basic theorem permits the exact mathematical solution of all problems, and velocity patterns in closed rooms, and of a great variety of outlets, such as radial and slotted outlets, diffusers and perforated panels, must be further studied before their performance can be predicted with confidence.

However, the air distribution research sponsored by THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has proved that the phenomena of room air distribution are amenable to scientific research and rational interpretation, and the ventilation jet problem has reached a stage where a definite technique of experimentation in combination with semi-empirical theories can be of great help in the design of air outlets.

6. In the design of air outlets, the days of unguided and unrelated experimentation should be over. Practical room air distribution, however, is still predominantly an art, where decisions depend on isolated tests and judgments must be based on the accumulated experience of the behavior of outlets in the laboratory and in the field. In designing a satisfactory air distribution system, the engineer must make use of such tests and draw on this experience, and weigh the different factors of the outlet performance which place considerable limitations on his proceedings. A short discussion follows regarding some of these factors which are: (1) jet pattern, (2) capacity, (3) temperature differential, (4) permissible room air motion, (5) permissible noise level, and (6) smudging.

Jet Pattern

Refer to section Ventilating Jets in Air Distribution for a general discussion of the jet pattern. In selecting the *throw* and *drop* of outlets the following considerations are important: (1) throw, (2) effect of vanes, (3) effect of type of outlet, and (4) drop.

1. *Throw*. The throw of a wall outlet must be sufficient to produce satisfactory conditions over the area to be conditioned. Underblowing may cause heated air to rise too rapidly above the occupied zone and thus create excessive vertical temperature variation (stratification); in cooling operation it may cause cold air to drop into the occupied zone before supply and room air are mixed sufficiently, and thereby create a condition of acute discomfort (draft). On the other hand, overblowing will result in objectionable downdrafts from any surface the primary air stream may strike.

On the average, it is considered most practicable to select a throw which is three-fourths of the distance toward an exposed wall or window, as shown in diagram A of Fig. 12. However, structural characteristics, mounting height of outlet, temperature differential, and resultant drop or rise, or location of greatest heating or cooling loads strongly affect the selection of the optimum throw. In spaces with beamed ceilings, the outlets should be located below the bottom of the lowest beam level, and preferably low enough so that an upward or arched blow may be employed. The blow should be arched sufficiently to miss the beams and, at the same time, in such a manner as to prevent the primary or induced air stream from striking furniture and obstacles, and producing objectionable drafts.

2. *Effect of Vanes*. Vanes affect grille performance if their depth corresponds at