under conditions of unrestricted flow of air to the ventilator, are given by the equation:

$$Q = A \times \left[\frac{36 \times \sqrt{H \times \left(t_i - t_o\right)}}{6 + V} + 20. \times V \right]$$

where

Q = cubic feet of air exhausted per hour through a ventilator having a free area at the throat of A square inches, mounted on a roof at a height of H feet from the center of the ventilator outlet to the floor, and with a wind velocity of V miles per hour, and average temperature t_i inside t_o outside.

The height H has been given as the height above the floor; strictly speaking, it is the height of the column of warm air in the building, which is approximately equal to the height above the location of the air inlet to the building. This location is usually near the floor. If, however, the inlet is much higher, as shown for instance in Fig. 83, the height H is indeterminate, but may, in general, be taken as halfway between the center of the air inlet and the floor.

Highest class ventilators, for instance those of the ejector type, will, under favorable conditions, discharge continuously 25 per cent more air than these conservative figures indicate. Capacities are lower, on the other hand, if ventilators of lower efficiency are used, or if the flow of air into or through the building is restricted, or if the ventilator is not exposed to the free sweep of the wind. Tests occasionally show considerably higher discharge rates over short periods of time. These abnormally high results are produced by the action of the wind upon certain openings of the building; they are not due to the ventilator itself, and cannot be depended upon for continuous ventilation if the direction of the wind changes. In the smaller sizes of ventilators (12 in. or less in throat diameter) the air discharge per square inch of cross-sectional area is reduced, on account of the frictional resistance and, in the rotary types, on account of reduction of free area by the supports, bearings, etc.

Example.—What is the capacity of an 18 in. ventilator, located 35 ft. above the floor, with 6 miles per hour wind velocity, 50 deg. fahr. outside temperature, 68 deg. fahr. inside temperature?

Answer.—$A = 0.7854 \times (18)^2 = 255$ sq. in.

$$Q = 255. \times \left[\frac{36. \times \sqrt{35 \times \left(68 - 50\right)}}{6 + 6} + 20 \times 6 \right] = 50{,}000 \text{ cu. ft. per hr.,}$$

average capacity under these conditions.

VENTILATION REQUIREMENTS

The air supply per person and per hour, or the number of the renewals of air contents per hour is given on p. 166.

To obtain effective, uniform ventilation and avoid local drafts, the ventilators should not be placed more than 30 ft. apart; 20 ft. apart is a good average. It is best, although not absolutely necessary, to locate the

ventilator at the ridge of the roof, unless the building exceeds 40 ft. in width, in which case two rows of smaller ventilators should be used. Where the building to be ventilated is surrounded by higher buildings which obstruct air currents, it is desirable to extend the ventilators above the buildings by mounting them on stacks.

Example.—A foundry building is 40 ft. wide, 200 ft. long, with an average height of 40 ft.; the ventilators are to be mounted at the ridge of the roof, at a height of 55 ft. above the floor. What number and size of ventilators are required?

Answer.—In this case, ventilation is especially necessary in summer. The air in the building should not be over 10 deg. fahr. warmer than the outside air. The wind velocity may be as low as 4 miles per hour. Spacing the ventilators, tentatively, 25 ft. apart, 8 ventilators would be required. Under average conditions, 10 air renewals per hour are sufficient. If the foundry is small and cramped, and pouring takes place over a large section of the floor space, 15 or more air renewals per hour may be needed. On the basis of 10 renewals per hour, the capacity of each ventilator must be:

$$Q = \frac{10 \times (200 \text{ ft.} \times 40 \text{ ft.} \times 40 \text{ ft.})}{8} = 400{,}000 \text{ cu. ft. per hour}$$

The discharge per square inch of throat area under these conditions is;

$$\left[\frac{36 \times \sqrt{55 \times 10 \text{ deg.}}}{6 + 4 \text{ mi./hr.}} + 20 \times 4 \text{ mi./hr.} \right] = 165. \text{ cu. ft. of air per hr.}$$

The required throat area per ventilator is

$$\frac{400{,}000}{165.} = 2420. \text{ sq. in.}$$

if there is no resistance and no wind pressure.

The diameter is $\sqrt{\dfrac{2420.}{.7854}} = 55.5$ inches. Standard sizes are 54 in. and 60 in. Either eight—54 in. or else seven—60 in. ventilators could be used, spaced respectively 25 ft. or 28 ft. apart.

The foregoing is based on the use of high class ventilators. If ventilators of lower efficiency are used, or if the air flow into the building is restricted (as in winter) larger ventilators may be required.

CONTROL OF VENTILATION

The ideal ventilator would be one which utilized to the very best advantage even the very lowest wind velocities; attained full capacity at a wind velocity of 4 or 5 miles per hour; and then automatically controlled the air flow so that the discharge remained constant at all higher wind velocities. Such an ideal ventilator does not exist.

The best types now on the market do, however, fulfill very well the first two requirements; for the last one, hand regulation is depended upon. For this purpose either a butterfly damper is provided in the throat of the ventilator, or, in some of the rotary types, louvres are sometimes arranged at the discharge opening of the ventilator. The damper or louvres may be operated by chains from the floor of the building, or the butterfly damper electrically controlled by push button. The louvres with their operating device have the disadvantage of restrict-