leeward face, or in sidewalls and roof near the leeward face, for egress of air, in which case the air moves through the building in the same general direction as the wind; or, with no openings in the windward face, but with openings provided in the suction regions in sidewalls and roof near the windward face for egress of air, and openings in the leeward end, or in sidewalls near the leeward end for ingress of air, in which case the air movement within the building is in a direction opposite to that of the wind. A knowledge of these facts and their application will often result in a better layout of operations and processes, and even in a more favorable orientation of a building with respect to the prevailing direction of the wind, so that heat and objectionable fumes may be removed more advantageously from an industrial building.

Where the wind comes at an angle to the building, the same general rules apply. The mean pressure of the wind on the oblique faces may be considered as being approximately equivalent to the normal component of the wind, except that when the wind's direction is within 15 or 20 deg. of parallelism, the splash from the corner begins to appear, and there will then be suction near the windward corner.

TEMPERATURE DIFFERENCE

Temperature difference inside and outside a building tends to produce flow as in a chimney. The total head or force arising from this cause is given approximately by equation (2).

$$p_t = 0.000028mD \tag{2}$$

where p_t is the total force or head in inches of water; m is the vertical distance between inlet openings below and outlet openings above; and D is the temperature difference.

The total force or head is consumed in forcing the air in at inlet openings, through the building, and out at the outlet openings. The force required to move the air through the building is usually negligible, so that the total head may be considered as being consumed at inlet and outlet openings. The part of the total head consumed in forcing the air to flow through the lower or inlet opening will be manifested as an excess of outside pressure over inside pressure at that level; while at the upper or outlet opening, the part of the total head consumed in forcing the air out will be manifested as a pressure inside, greater than outside. Thus the lower part of the building inside, will be in a state of partial vacuum with respect to the outside, while the upper part will be in a state of pressure. At some point between the levels of the two openings, the pressure state is neutral, and no flow will take place through an opening at that level. This level is called the *neutral zone.* For a discussion of the neutral zone, and effect of temperature difference in general, see paper by J. E. Emswiler, The Neutral Zone in Ventilation, TRANS. A. S. H. & V. E., Vol. 32, 1926.

RELATION BETWEEN HEAD AND FLOW

The relation between head or pressure difference on the two sides of an opening, and the velocity that will be created thereby, is given approximately by equation (3).

$$V = 4000\sqrt{p} \tag{3}$$

where V = velocity in feet per minute through an opening, and p is the pressure difference, in inches of water, existing at that opening from any causes or combination of causes.

With V known, the flow, Q, at the opening can then be easily computed by the familiar relation.

$$Q = AVC \tag{4}$$

where Q is the flow in C. F. M.; A is the area in square feet, and C is a coefficient.

For openings such as result from swinging or sliding windows and doors, where the aperture is essentially an orifice, the value of C will be about 0.60.

It would be comparatively easy to calculate flow through an opening, if the pressure difference could be determined. However, so many factors participate in the general action that it is very difficult to evaluate a pressure difference arising from a given wind velocity and temperature. The difficulty is further augmented by the fact that the pressure difference is likely to have a different value for every different opening or group of openings of a building.

Although it is almost out of the question to attempt to predetermine accurately the pressure difference from fundamental data of wind velocity, wind direction, temperature difference, building dimensions and disposition of openings, in most cases merely a general knowledge of how the forces of wind and temperature difference act, what their maximum magnitudes are, and how they are disposed in and about a building, will be helpful in planning ventilation. On this basis, the following simple rules are suggested:

1. In an industrial building where furnaces, that give off heat and fumes, are to be installed, it is better to locate them in the end of the building exposed to the prevailing wind. The strong suction effect of the wind at the roof near the windward end will then cooperate with temperature difference, to provide for the most active and satisfactory removal of the heat and gas laden air.

2. In case it is impossible to locate furnaces in the windward end, that part of the building in which they are to be located should be built higher than the rest, so that the wind, in splashing therefrom will create a suction. The additional height also increases the effect of temperature difference to cooperate with the wind.

3. In the use of monitors, windows on the windward side should usually be kept closed, since, if they are open, the inflow tendency of the wind, counteracts the outflow tendency of temperature difference. Openings on the leeward side of the monitor result in cooperation of wind and temperature difference.

4. In order that the force of temperature difference may operate to maximum advantage, the vertical distance between inlet and outlet openings should be as great as possible. Openings in the vicinity of the neutral zone are less effective for ventilation.

5. In order that temperature difference may produce a motive force, there must be vertical distance between openings. That is, if there are a number of openings available in a building, but all are at the same level, there will be no motive head produced by temperature difference, no matter how great that difference might be.

6. In the design of window ventilated buildings, where the direction of the wind is quite constant and dependable, the orientation of the building together with amount and grouping of ventilation opening can be readily arranged to take full advantage of the force of the wind. On the other hand, where the direction of the wind is quite variable, it may be stated as a general principle that windows should be arranged in sidewalls and monitors so that there will be approximately equal area on all sides.