THE VENTILATION OF PUBLIC BUILDINGS.

By General Morin.

(*With Engravings.*)

The renewal of air in buildings is only rendered necessary by the vitiation resulting from the respiration and exhalations of the occupants, and by the accumulation of the products of combustion from artificial lighting: and the writer has been led by his own observations and the consideration of the results obtained by others, to the following conclusions as to the principles on which the ventilation of buildings should be based:—

First—Ventilation consists in getting rid of all vitiated air and replacing it by fresh air.

Secondly—The principal object of ventilation is to get rid at once of all vitiated air. It ought to be removed in general from the point nearest to the place where the vitiation takes place, in order to prevent any further diffusion into the room; and on the contrary fresh air ought to be introduced at the point furthest removed from the occupants of the room.

Thirdly—The different arrangements that proceed by Suction, when well proportioned and well carried out, are more effectual than those which depend exclusively on blowing in the fresh air, as the latter do not in every instance and at all times ensure the vitiated air being uniformly and continuously expelled.

Fourthly—The quantity of fresh air required, whatever may be the height from which it has to be drawn, and whatever the quantity, can be obtained by suction alone, and without the aid of any blowing apparatus, by giving to the inlet openings for the fresh air sufficiently large dimensions, and by suitable arrangement.

Fifthly—Suction can easily be obtained either by means of the ordinary open fireplaces with chimneys or similar heating apparatus, or by means of special fireplaces placed at the bottom of the exhausting flues and acting as auxiliaries when the rooms are large. The air to be removed ought to flow towards the bottom of these fireplaces, and wherever possible by means of special air flues leading from openings close to the sources of vitiation.

Sixthly—Ventilation by suction by means of fireplaces and chimneys can be adapted to the proportions and arrangements of every kind of room, as it resembles the ordinary and natural ventilation of rooms, and the volume and temperature of the fresh air supplied can be varied as required. It only requires the construction at a small expense of fireplaces with their chimneys, and of air flues, which when once constructed cost but little to keep up; and also the regular feeding of the fireplaces, which any common attendant is competent to do. On the contrary, ventilation by means of blowing or other mechanical apparatus necessitates, besides the flues and chimneys common to both systems, the addition of blowing machines and engines with special air passages, special artisans, engineers, and firemen, and involves an extra cost for keeping up.

Seventhly—In hospitals with several stories, the blowing-in system does not afford the same guarantee as that of suction against the diffusion of the vitiated air from one room to another through the openings of the discharging flues, when it happens that the pressure and movement of the air of the room are disturbed by the opening of doors and windows.

Suction produced by simple fireplaces and chimneys, with sufficient area of opening for allowing the fresh air to replace the vitiated air, and without any mechanical apparatus, is consequently the most desirable means in the writer's opinion for effecting the ventilation of buildings, except in rare cases; and where special circumstances may necessitate the forcing in of fresh air by mechanical means, the action of a strong suction should also be added. This necessity never occurs in buildings where a continuous supply and removal of a nearly uniform quantity of air is required, but only when on the contrary this service has to be varied frequently between different portions of the same building, and when the quantities of air to be removed differ greatly from one day or from one hour to another; as in the case of St. George's Hall, Liverpool, where mechanical ventilation exclusively is adopted, and the quantity of air required varies in the extreme proportion of 1 to 50. In such cases it may become necessary, or at least useful, to employ mechanical apparatus in addition to the action of suction in order to ensure a sufficient supply of fresh air.

The following proportions for the quantity of air required to be supplied per hour for each person are based upon the results of a large number of experiments by different observers, and though higher than the rates formerly adopted are not in the writer's opinion at all exaggerated:—

Hospitals for ordinary patients	2,000 to 2,400	Cubic Feet.
Ditto, in cases of epidemic	5,000	,,
Workshops, ordinary trades	2,000	,,
Ditto, unhealthy trades	3,500	,,
Prisons	1,700	,,
Theatres	1,400 ,, 1,700	,,
Meeting Halls	1,000 ,, 2,000	,,
Schools for Children	400 ,, 500	,,
Ditto for Adults	800 ,, 1,000	,,

The temperature of the air in places abundantly ventilated, and having a continuous renewal of the air, can be allowed to be maintained at a higher point than in rooms not well ventilated; but as a general rule the temperature should not exceed, in

	Degs.
Hospitals	61 to 64 Fahr.
Workshops, Barracks, and Prisons	59 ,,
Schools	66 ,, 68 ,,
Meeting Rooms	66 ,, 72 ,,
Theatres	68 ,, 72 ,,

The fresh air supplied should be at nearly the same temperature as the one to be maintained in the room; but this has to be increased to as high as 85° or 95° Fahr., if there is a large cooling surface of glass; or to be diminished where the room is heated by a large number of lights or a large concourse of persons. For the purpose of regulating the temperature, the supplied air, warmed by some heating apparatus, has to be received first into a chamber into which cold air can be introduced for mixing with it.

The following relations between the volume and temperature of the air and the areas of the air flues have been obtained from theory and practice combined:—

$$V = C\sqrt{(T - T')\,H}$$

$$Q = CA\sqrt{(T - T')\,H}$$

In which A = sectional area of the exhausting flue.
H = height of exhausting flue.
T = average temperature of air in flue.
T′ = temperature of external air.
C = coefficient, constant for each air flue as regards its proportions and arrangements.
V = average velocity of air in the flue.
Q = volume of air passed per second.

The results derived from these relations are that the velocity of the escaping current is proportional to the square root of the excess of the temperature of the heated air in the flue over the external air, and also to the square root of the height of the flue or chimney: and the volume of air extracted is consequently proportional in addition to the sectional area of the flue.

The position of the openings for the admission and removal of the air is a point of great importance; and none of these should be made at the level of the floor, as is too often the case, because they are then exposed to obstruction by sweepings and rubbish from the floor. The openings for the admission of fresh air, whether warm or cold, should be placed near the ceiling, or at such a height that no person may receive the impression of a draught. The openings for the abstraction of the air should on the contrary be placed generally in the lower part of the room.

The velocity of the air should continually increase through the several passages of the building, from its entrance to its final discharge, which is best effected by the use of a single shaft for taking off the air from the whole building; and the velocities should be about—

2·3 to 2·9	feet	per second	at the entrance.
3·3 ,, 3·9	,,	,,	in the first passage.
4·3 ,, 4·6	,,	,,	in the second passage.
5·9 ,, 6·6	,,	,,	in the discharging shaft.

These speeds can be easily obtained in most cases by an excess of 70° to 80° in the temperature of the discharging shaft over the external air, except in the case of theatres, where a difference of 95° to 105° is required, on account of the complication of the passages. When the supply openings are in the ceiling,