

4 12 in. x 18 in. enameled valve registers, complete \$ 0  
 2 cast iron slides to smoke flues  
 2 15 in. collars to smoke flues  
 Arches over two fire places and wrought iron camber bars  
 Ash dumps and cast iron soot doors in cellars  
 Trimmer arches and concrete to within 1½ in. from floor  
 Vent flues from gallery ceiling, two to be carried up into wall of  
 tower and one in vestry; chimney stack up to eave line  
 Cleaning down walls, removing stains and defects, bedding tim-  
 bers, building in strips for battens, pointing to windows and  
 door frames, grooving for flushing, beam filling, bolts for  
 coping, etc., etc., complete  
 Scaffolding as required and remaining for other trades  
 Deduction if A 1 and 2 is not carried out  
 A 1 deduction, pressed brick omitted and instead left rough for  
 plasterer  
 A 2 deduction, pressed brick omitted and instead left rough for  
 plasterer

NOTE.—Brickwork is measured cube and in Montreal the number of  
 bricks given in estimating is 20 bricks to the cubic foot, and is ascertained  
 thus:

$$\begin{array}{r} 6 \text{ bricks long say } 4' 0'' \\ 9 \text{ " high " } 2' 0'' \\ \hline 54 \\ 3 \text{ brick thick} \\ \hline 8 \mid 162 \text{ 20 to the foot.} \\ 16 \end{array}$$

The openings are measured and deducted from the solid work. Concrete  
 when not deep is measured by the superficial yard, thus: 3 ft. x 3 ft. gives  
 one yard. Concrete in heavy work is measured cube, 3 ft. x 3 ft. x 3 ft., or  
 27 ft. to the cubic yard. Arches, etc., are given in numbers and other  
 items noted as above.

(To be Continued.)



### VENTILATION.\*

SOME extracts from various reports of scientific men on the  
 subject of the ventilation of Halls of Assembly which from many  
 years of study I believe to be the best solution of a very difficult  
 problem:

Two systems of ventilation so far appear to have been adopted,  
 viz, the upward or the downward exhaust.

The fundamental principles of ventilation are:

1st. Heated air is relatively lighter than colder air, and will  
 continue to ascend and the cold air to descend so long as they  
 are free to move.

2nd. More or less than a given quantity of air practically con-  
 sidered cannot occupy an apartment and cannot be introduced  
 unless an equal quantity be withdrawn, or withdrawn unless an  
 equal quantity be introduced.

These two simple and self-evident propositions will explain  
 nearly all the phenomena observable in ventilation. The first  
 method adopted by engineers and architects to give movement  
 to air for the ventilation of mines and buildings was to heat an  
 upflowing column, thus lessening its specific gravity and causing  
 it to rise with corresponding force. That system was employed  
 in the British Houses of Parliament, where in many of its towers  
 a charcoal fire was kept burning and thus a force obtained to  
 propel the air through the building. It has been practically  
 demonstrated, however, that one pound of coal burned in the  
 furnace of a steam boiler to drive a fan blower will generate as  
 much force and consequently is capable of producing as strong  
 a current of air as 38 pounds expended in heating a column of  
 air to act by its diminished gravity. If heated air is introduced  
 into an apartment containing air at a lower temperature through  
 registers at the floor, it rises rapidly to the ceiling, and if there  
 are openings at the ceiling it escapes without (except in a very  
 slight degree) mixing with the air in the apartment. The air  
 that passes off in this manner is absolutely lost and the heat  
 imparted to it wasted. It does not remove the vitiated air con-  
 tained in the lower part of the apartment, it does not form with  
 it a homogeneous mixture and does not communicate to it more  
 than a small portion of its heat.

But if, instead of escape openings at the ceiling they are placed  
 at the floor, the phenomena observed will be widely different.  
 The heated air will as before rise to the ceiling, but instead of  
 escaping, will press the colder air downward to the exit ducts  
 and fill the apartment with pure warm air; the air vitiated by  
 breathing will at once sink below the level of the mouth and in  
 a few seconds will be carried off, no accumulation of foul air  
 being possible.

Various opinions are given as to the amount of fresh air  
 necessary to render the products of transpiration and respiration  
 innocuous. These estimates made by distinguished observers  
 vary from 2 to 50 cubic feet per minute. These estimates are  
 generally based upon the hypothesis that the fresh air introduced  
 into an apartment mixes uniformly and homogeneously with the  
 vitiated air and dilutes it to an extent to render it innocuous;  
 but if instead of mixing with the air of the apartment, the warm  
 pure air should rise to the ceiling and escape, all conclusions  
 based on the hypothesis of homogeneous mixture would be fal-  
 lacious. If the air that has once been respired could be imme-

diately removed without being the second time taken into the  
 lungs, it is obvious that so far as respiration is concerned no  
 more need be introduced into an apartment than can be  
 breathed; this amount is easily calculated.

At a temperature of from 65° to 70° Fahrenheit the following  
 average results are given by Dr. Wetherill for the respiration of  
 an adult: Number of respirations per minute, 20; cubic inches  
 of air inhaled at each respiration, 20; cubic inches per minute,  
 400. The carbonic acid exhaled is stated to be 15 cubic inches  
 per minute, and the surrounding air vitiated is 2½ cubic feet per  
 minute. Four hundred cubic inches is less than one fourth of a  
 cubic foot and this is all that can be taken into the lungs per  
 minute.

The House of Representatives at Washington is provided  
 with 60 cubic feet per man per minute, and yet the vitiated air  
 is not removed. The quantity of air introduced is twenty times  
 as great as the quantity that could be vitiated by respiration  
 provided there was a homogeneous mixture. The facts which  
 are daily observed prove that such a homogeneous mixture does  
 not exist under the present system. If nineteen-twentieths of the  
 heated air which enters the apartment escapes without being  
 utilized, it follows that nearly all the fuel consumed in heating it  
 has been wasted.

In the process of respiration 15 cubic inches of carbonic acid  
 per man per minute are ejected from the lungs. This gas in  
 course of time would diffuse itself throughout the apartment, but  
 it is well known that its density is so great that it can be poured  
 from one vessel into another, or if poured into an inclined trough  
 it will flow downwards, extinguishing successively a row of lights.

The specific gravity of this gas is 1.52 or 52 per cent. heavier  
 than air. Its tendency would therefore be when exhaled to sink  
 below the level of the mouth and occupy the lower portions of  
 an apartment near the floor, but it has been supposed that the  
 elevated temperature at which it is projected from the lungs  
 causes this gas to rise and escape at the roof; the fallacy of  
 such an opinion can, however, be readily proved. Even if the  
 temperature at which carbonic acid escapes from the lungs  
 should be so elevated as to render it momentarily lighter than  
 the surrounding air, it would soon part with the excess of heat  
 and then seek the level due to its superior density—but in fact  
 under the condition of things which actually exists there is only  
 20° difference in temperature between the air when first expelled  
 from the lungs and that of the apartment. As air increases in  
 volume 1.466 of its bulk for each degree of Fahrenheit, the  
 effect of increasing the temperature 20° would be to reduce the  
 specific gravity less than ten per cent., and the carbonic acid  
 upon leaving the lungs would still be 40 per cent. heavier than  
 the air of the apartment. It would seem impossible for this  
 dense gas to rise to the ceiling and escape at that level without  
 a violation of the laws of pneumatics, unless by powerful me-  
 chanical means.

Dr. Wetherill reports that each flame of gas consumes as  
 much oxygen and gives out as much carbonic acid as five human  
 beings.

General Morin reported that a ventilation of 14½ cubic feet  
 per man per minute principally downward left no percep-  
 tible odor in a lecture room, while the upward ventilation of the  
 Halls of Congress with 60 cubic feet per minute, is notoriously  
 defective.

As regards the direction the products of respiration take after  
 leaving the body, the evidence in support of the tendency to rise  
 is from a report from the Smithsonian Institution; its author  
 seems to have smoked a pipe at the Institute and the smoke  
 ascended—but the objection to this experiment is that tobacco  
 smoke is not one of the ordinary products of respiration. The  
 experiment does not prove that the gray smoke which was seen  
 to rise was carbonic acid. The experimenter does not state in  
 what direction were the ventilating currents in the apartment or  
 how produced, and there was nothing in the experiment to prove  
 that with a gentle downward ventilation the smoke would not  
 have moved downward instead of upward—in fact it proved  
 nothing at all in reference to the direction of the products of  
 respiration.

Lewis L. Leeds quite agrees with General Herman Haupt in  
 conclusions both as to theory and the necessity for putting in  
 practise a system of exhaust for ventilation from the floors of the  
 house, and says very extensive practise and close observation  
 for many years past have fully convinced him that the  
 human breath, which is the great source of contamination  
 tends first towards the floor in a still room of 70°, and  
 that there is a probability in a closely occupied room that  
 there will be quite an excess in the accumulation there. This  
 applies to rooms warmed exclusively by heated air. The contrary  
 opinion—that is the assumption that the breath and the impuri-  
 ties exhaled from the body rise to the ceiling and accumulate  
 there—was advocated strongly in the ventilation of the English  
 House of Parliament, and it is reported that some two or three  
 millions of dollars were spent in endeavoring to heat and venti-  
 late that building comfortably, and as the proceedings in regard  
 thereto were spread over the world to an extent probably one  
 hundred times greater than any previous publication or action in  
 regard to ventilation of any public building, that theory of ven-  
 tilation became strongly impressed upon the public mind as being  
 the correct one. I consider that idea erroneous, hence all theo-  
 ries of ventilation based upon it are consequently wrong. In the  
 majority of our rooms the heated air entering (which, of course,

\*Paper by Thos. Fuller, Chief Architect, Dominion Board of Works, read by Mr.  
 Billings at the Second Annual Convention of the Ontario Association of Architects.