Ventilation of Buildings.

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Outline

I Definition of Ventilation.

II Need of Ventilation.

(1) Impurities caused by breathing.

(a) CO_2.

(b) Organic impurities.

(c) Aqueous vapors.

III Quantity of air required as signified by:-

(1) Normal quantity of CO_2 in air.

(2) Amount of CO_2 exhaled per person, per hour.

(3) Quantity required for adults at work.

" " " " " rest.

" " " women and children

(4) Illuminate employed.

IV Modes of Ventilation.

(1) Natural.

(a) Diffusion.

(b) Winds or motion of air.

(c) Gravity.

(d) Illustrations.

(2) Artificial.

(a) Aspirating or vacuum.

(a') By means of heat.

(b') " mechanical means.

(b) Extraction or plenum.

(a) By means of machinery.

(c) Relative merits of extraction and aspirating methods.

V Relative amount of application of natural and Artificial Ventilation.

I

Ventilation of Buildings.

Ventilation is the changing of the air in a room by withdrawing the impure air and substituting pure air from the outside.

Thorough ventilation is necessary. Though the air in a room does not differ from that without, if the room is inhabited by one or more individuals the air in the room soon deteriorates until the impurities therein reach a certain degree which is incompatible with health. This is due to the fact that with each breath a certain quantity of Carbon-dioxide organic impurities and aqueous vapor is exhaled. These products of respiration soon contaminate the air in the room until it is rendered impure and unfit for breathing. Besides the impurities caused by breathing there are also those which are given off by the skin. The secretion of the skin consists of sweat which is an acid watery fluid, containing about 1.8 percent of solids and of sebaceous matter. The quantity varies greatly according to the temperature and humidity of the air but may be taken as ranging from 800 to 1000 cu. cm during twenty four hours. Epithelial cells are also being constantly disengaged from the skin, and a considerable quantity of Carbon-dioxide is given off through the skin.

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An increase in the quantity of Carbondioxide and a porportionate increase of organic impurities are the results of respiratory and bodily vitiation of the air, and it has been agreed to regard the relative quantity of Carbon-dioxide as the standard of impurity. its increase serving as an index to the condition of the air.

The normal quantity of carbon dioxide in the air is .04 % or four volumes in ten thousand, and it has been determined that when the carbon dioxide reaches .06 % the maximum of air vitiation is reached, a point beyond which breathing of the air becomes dangerous to health.

A healthy avarage adult exhales in one hour .6 cu. ft. of carbondioxide. Having determined these two factors, the amount of carbon dioxide exhaled in one hour and the maximum of admissible impurity, we may determine the number of cu. ft. of air needed for one hour which is three thousand.

The relative quantity of fresh air needed will differ with adults at work and at rest. If the individuals are all adult males and are working, there must be a corresponding increase in the air [illegible] six thousand or nine thousand cu. ft or more per head, in certain occupations. This is the theoretical amount necessary for good ventilation but in practice it is found that it is possible to get along with safety and comfort with some what less fresh air, because some of the bodily impurities are at once carried away by draughts through the exits, or through cracks and crevices in the walls or ceilings, and the incoming air does not have to mix with and dilute that portion of the impurities that is so immediately removed. But usually the full theoretical amount is necessary to secure satisfactory results. Women and children require a less quantity of fresh air than men.

The amount required will also differ in sickness. In sick rooms and hospitals it is found that the organic matter exhaled from the sick is more offensive than that from the healthy, and is noticable to the senses when the respiratory carbondioxide is far below the usual percent.

Provision must also be made for diluting the impurities due to illuminating processes An ordinary three foot gas burner requires and ten times as much is required for every pound of oil consumed.

In determining the cubic space needed the height of the room as well as the floor space should be taken into consideration. As a rule the height of a room ought to be about one third of the cubic space and in ordinary rooms should not exceed twelve feet.

We now come to the question of the various modes by which changes in the air of a room is possible. Ventilation is natural or artificial according to whether artificial or mechanical devices are or are not used. Natural ventilation is only possible because our buildings and houses, their material and construction are such that there are numerous apertures and crevices through which the air may enter. The properties of air which render both natural and artifical ventilation possible, are diffusion, motion and gravity. These three forces are the natural agents of ventilation.

There is a constant diffusion of gases taking place in the air and is carried on even through stone walls and bricks. The more

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porous the material with which the building is constructed, the more readily does diffusion take place. Dampness, plastering, and paper serve to diminish diffusion. It is insufficient in itself to keep the air pure though it does much to favor this. Roscoe found that when he evolved carbon dioxide in a room the amount had decreased one half in ninety minutes. This was due to diffusion.

The second force, the motion of air or winds is the most powerful agent of ventilation, for even a slight imperceptible wind traveling about two miles an hour, is capable of changing the air of a room five hundred twenty eight times in one hour. providing the windows and doors are open. The objections to winds as a sole mode of ventilation are their inconstancy and irregularity. When wind is very slight its ventilating influence is very small, and on the other hand when it is strong it cannot be utilized as a means of ventilation on account of the strong air currents exerting deleterious effects on health. Most persons are affraid of air currents and cold air and therefore fail to admit sufficient fresh air losing sight of the fact that the body generates heat more rapidly when given uncontaminated air and can comfortably endure temperatures several degrees lower than when an insufficient amount of oxygen is present.

To utilize the perflating force of the wind opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts the following arrangements have been recommended.

1- The window should be so constructed that the top slopes inward when it is open. This causes the entering current of air to impinge against the ceiling. If windows are large as in churches or school buildings only a section of the upper part may be open in this way.

2. A glass louver may be substituted for the top centre pane.

3 Some of the panes in the window may be doubled, the outer with an open space at the lower edge, the inner with an open space at the upper edge. The air on entering is thus made to pass upward between the panes.

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4 Some of the panes may be made of perforated glass.

5 Part of a pane may be made to open or shut by a spring arrangement.

In some cases cross ventilation can be well maintained independently of opposite windows by means of transverse ventilating boxes or tubes situated at regular distances and in close proximity to the ceiling. These boxes or tubes extend from wall to wall and communicate with the external air at either end by air bricks. The sides are made of perforated zinc and there is a diaphragm in the centre of each to keep the air from blowing through. According to the direction of the wind one half the tube becomes an inlet for fresh air, which falls gently in the room through the perforated zinc, while the other half becomes an outlet for the vitiated air. This plan does very well for hospital wards having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of ventilation in the same way.

In several plans of natural ventilation

the perflating and aspirating powers of the wind are both taken advantage of. Thus as in Mr Sylvester's plan which was in use fifty years ago a large cowl surmounted the fresh air entrance shaft and by means of a vane always made to face the wind. The shaft was erected at a convenient distance above the building to be ventilated. In this way the air was blown into the cowl and down the entrance shaft into a chamber beneath the basement floor where it could be heated if necessary. It then ascended by tubes leading to the different parts of the building and finally passed out through a shaft projecting above the roof which was also fitted with a cowl turning away from the wind so as to act as an aspirator. By suitable arrangement of shafts and cowls this mode of ventilation may be made to work very well.

The third force of natural ventilation gravity, is the most constant and reliable and is the principal agent of ventilation. Whenever air is warmer in one place than in another the warmer air being lighter, and

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the cold air outside being heavier, the latter exerts a pressure upon the air in the room causing the lighter air to escape and be displaced by the heavier air from the outside thus changing the air in the room. This mode of ventilation is always constant and at work, as the very presence of living beings in the room warms the air, thus causing a difference from the outside air and effecting a change from the outside to the inside of the room.

The same inlets and outlets which are made to utilize wind, may also be used for the ventilation effected by the motion of air due to gravity. Any artificial warming of the air whether by illuminants or by the various methods of heating, will aid in ventilating the room, the chimneys acting as powerful means of removal for the warmer air. Various methods have also been proposed for utilizing the chimney even when no stoves are connected with it, by placing a gas light in the chimney to cause an up draught and consequent aspirating of the air of the room through it

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The inlet and outlet openings should be about twenty four inches square per head. Inlet openings should be short easily cleaned and sufficient in number to insure a proper distribution of air. They should be protected from the heat and provided with valves so as to regulate the inflow of air, and should be placed so as to allow the air passing through them to be warmed before entering the room.

Outlet openings should be placed near the ceiling, they should be straight and smooth and if possible should be heated so as to make the air in them warmer, Thus preventing a down draught as is frequently the case when the outlets become inlets.

Artificial ventilation is carried on by two methods. 1st. Plenum or forcing the air into a room and 2nd vaccum or drawing the air out of the room.

This subject is best treated in connection with warming as it is a difficult matter to insure in all cases that both ventilation and warming shall be efficient and satisfactory. The difficulty depends on the fact that the means employed in ventilating necessarily carry off a certain quantity of the heat which should be utilized for warming purposes.

In this country artificial ventilation and warming are usually provided for by open fireplaces. The ventilation being carried on by the constant current of heated air rushing up the chimney. Even when there is no fire the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept going the fresh air enters the room through every chink and opening provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of air. When this is the case the fire feeds itself by establishing a double current in the chimney the down current entering the room in puffs and carrying with it clouds of smoke.

One of the best fireplaces devised for the purpose of warming the air before it enters the room is the stove designed by Capt. Douglass Walton. It provides for an air chamber in the back in which the fresh air is heated before it enters the room. On the back of the stove broad iron flanges are cast so as to present as large a heating surface as possible. These project backward into the chamber and this heating surface is further supplemented by the smoke flue also of iron which passes through the chamber and is made continuous with the chimney. The fresh air heated in this manner enters the room through a louvred opening situated between the fireplace and ceiling

Kitchen stoves have been constructed on the same principal. Also the stoves suited for the center of halls or wards. The smoke flue of the latter is made to pass out under the flooring and inside the fresh air entrance channel. Thus supplying a larger heating area for the entering air.

For all ventilating stoves it is necessary that the fresh air channels should be removed from all sources of contamination, such as drains, closets etc. and it is advisable to protect the external openings

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by perforated bricks or gratings.

With the ordinary grate the ventilation of a room may be greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke the opening should be valved. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or valves in the outer walls near the ceiling.

The mistake which is common to the majority of houses is in providing an outlet and failing to provide an inlet. Whereas the essential principal of ventilation demands that there shall be at least two openings.

Large and compact buildings buildings such as hospitals, asylums and prisons can be very effectually warmed and ventilated by a suitable arrangement of steam coils or hot water pipes. The fresh air as it enters through openings properly distributed throughout the building is warmed by passing over the pipes, while the vitiated air may [illegible]

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heated pipes situated in extraction shafts.

Another mode of ventilation by extraction and one which is frequently used in prisons consists in having a large foul air extraction shaft, heated by a furnace at the bottom, and into which foul air flues leading from all parts of the building are conducted. The workmanship in this case must be very perfect so as to prevent any large currents of air reaching the shaft, except through the flues.

By a combination of these two methods viz: heating the fresh air before entering by hot water pipes, and securing the removal of the vitiated air by flues, leading to furnace shafts, the largest buildings can be warmed and ventilated. If necessary the hot water pipes may be made to pass through shallow basins of water to ensure a sufficiency of moisture in the contained air.

In theatres and other buildings of a similar discription the chandiliers should always be employed to extract the vitiated air. According to the experiments of General

Morin one cubic foot of gas can be utilized so as to cause the discharge of one thousand cu. ft. of air. Apart therefore from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas lights merits special attention, for as a common gas burner will burn nearly three feet of gas per hour, its extractive power could be utilized to remove three thousand cu. ft of vitiated air during the same period.

The "ventilating globe" light is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube and as this becomes heated, the air in the surrounding tube near the ceiling, becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion, and a steady current outward of the vitiated air.

The system of ventilation by propulsion was first introduced in 1734. It consists of a fan enclosed in a box which can be worked by hand, horse, water or steam power. The air enters through an opening in the centre of the box and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of the large hospitals, the air being forced into a basement chamber, where it is heated before entering the wards. St. Georges Hall Liverpool may be cited as an example of ventilation by propulsion. On the large scale the air is taken from the basement, and washed by being passed through a thin film of water thrown up by a fountain. In cold weather it is then passed into vessels for the purpose of being warmed and in which it can be moistened by a steam jet, and finally it is propelled along different channels into the hall. In summer the air in the conduits is cooled by the evaporation of water.

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Concerning the relative merits of extraction and propulsion, the balance of evidence is most decidedly in favor of the former, as regards cost, efficiency and stability

Only very large buildings can afford the machinery which is necessary in the propulsion method, while extraction affords numerous methods at very reasonable costs that can be afforded by any ordinary sized building

Concerning the application of the two modes Natural and Artificial the natural ventilation is far superior to the artificial. People usually depend on natural agents, for the ventilation of their homes and other small buildings, such as churches and school houses. It is only in the larger dwelling houses, in theatres, large city schools and hospitals in which the artificial methods are used.

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