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Heating and Ventilation

Blydon Ellery Kenyon
University of Rhode Island

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B. E. Kenyon,

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That the developement of the mind and body is much higher in some countries than in others, is an obvious fact. This superiority has long been considered due to the influence of climate. Intense cold renders the senses inactive and prevents physical developement, while tropical heat necessitates indolence of mind and body. In the temperate climate we have the highest degree of civilization together with the best intellectual and physical developement; and here, because of the variable temperature, is felt the greatest need for heating and ventilation.

In considering the matter of heating and ventilation the fact must not be forgotten that we are dealing with gases and that they obey definite physical laws; in planning apparatus then, we must fit our ideas to those laws, instead of attempting to make them conform to ours.

If we consider of what the air with which we have to deal is composed, and also some general atmospheric laws, we shall notice that air in the free state contains the following elements in parts per ten thousand; oxygen 2099, nitrogen 7898, carbon dioxide 3, and a certain amount of dust, either organic or inorganic. The atmosphere exerts a pressure on the earth of about fifteen pounds to the square inch, and has the property of penetrating nearly all building material; as was illustrated by an exhibit made at Paris in 1889, in which 120 liters of air was passed through 1 square meter of brick wall under a pressure of 30 Kg.

The property of the diffusion of gases must be fully considered in ventilation. It is generally supposed that the heavier gases, as carbon dioxide, will be found near the floor in rooms; that this is not true, experiment will show. Fill two flasks with hydrogen and carbon dioxide respectively. A given volume of carbon dioxide is forty four times as heavy as the same volume of hydrogen; but on turning the flasks together with the hydrogen uppermost and allowing them to remain a short time, a test of the whole mass will show that each flask contains the same relative amount of the two gases.

The difference in specific gravity between hot and cold air has been known for many years in the art of ventilation, for previous to the fan ventilation in the House of Commons, flues led from the audience room to the top of the building, and in these flues fires were made so as to cause air circulation below. The arrangement was effective when the fires were started before the room was warmed; but if the room was heated first, the flues reversed their action and the cold air descended on the heads of the people.

We have considered the air as found in its pure state and some of the general laws relating to it. But in contrast with pure air we have vitiated air, or air that has been contaminated coming in contact with matter rendering it unfit to breathe. The main sources of vitiated air are living animals and decaying organic matter. Animal bodies give off carbon dioxide from the lungs, effluvia from the pores of the skin and the breath; also certain nitrogen compounds and hydrogen sulphide. Decaying organic matter produces the same except effluvia. Air may also contain fine particles of dust and bacteria. This last mentioned form of vitiation is one that needs careful consideration in ventilation work, as results obtained from experiments in Davis Hall would indicate. The amount of dust was determined by placing a carefully weighed cheese cloth over a register in one of the rooms and allowing it to remain for one hour, when it was again weighed and the gain found to be 11.5 grains. Cultures for bacteria were exposed for five minutes at the external opening of the air-supply duct and afterwards in one of the rooms. That taken at the supply duct had only one colony, while that taken in the room had four colonies. Another test was made when the supply was drawn from the halls instead of outside. The air was being drawn in at the rate of 300 feet per minute at a temperature of 72°F. This air was delivered to the rooms at a velocity of 750 feet per minute with the temperature raised to 190°F. The test showed fourteen colonies in the culture exposed for five minutes where the supply was taken, and fifty colonies in that taken in one of the rooms. These results indicate the vitiating effect of a number of persons the air.

Another source of vitiation sometimes present in the air of rooms where coal or wood fires are burning, especially if the stoves become heated to redness, is the carbon mon-oxide or incompletely oxidized carbon. This gas acts as a virulent poison on the human system. Carbon dioxide in its pure state is not a deadly poison, but may be present in the air in considerable quantities without injury to health; but when combined with the elimination from the body, the limit of safety is fifteen to 20 parts in ten thousand.

The necessity of ventilation has been proved so often that laws have been made which call for a continuous supply of pure air at the rate of two thousand feet per capita every hour in nearly all of our public buildings. The effects of breathing impure air are as injurious to health, as though we exposed ourselves to some contagious disease. The only difference is in the time required for impure air to become evident. Some of our school buildings are so poorly ventilated that a person entering from outside is at once disagreeably affected by their condition. Of all buildings where we should have good ventilation, school-houses are among the most important; for in order that the brain may work to the best advantage, a large supply of pure air is necessary. How many have stopped to think that sending children into a poorly ventilated schoolroom is not only a waste of time d energy, but a detriment to health ?

In all ventilating work the following points must be taken into consideration: location of inlets and outlets in rooms, proper diffusion of air, prevention of draughts, location of main supply duct. In the past the proper position of inlets and outlets has caused much discussion, and the best authorities agree that the inlet pipe should be six or seven feet above the floor on an inner wall, and the outlet near the floor on the same side of the room. Then if heating is carried on in connection with ventilation the warm air on reaching the cold outside walls, drops gradually to the floor, will be used by the occupants and pass thence to the outlet. Experimental work on this point has shown this arrangement causes the air to be diffused more evenly, and the pure air is more likely to be used than if the outlet be situated elsewhere.

Draughts must be avoided in any arrangement for heating and ventilation; for they are not only disagreeable to the occupants of rooms but decidedly injurious to health.

The location of the main supply duct is a very important matter, for upon it depends the effectiveness of the whole system. The supply should be takoh from a place where there is as little dust as possible. If the duct is located so as to take the supply from a point several feet above ground level, the air will unquestionably contain less organic dust and bacteria. Of a number of systems visited, however, the air supply was drawn from the urface except in one case the Mayhew school in Boston, where expense of installation had not been considered. In all systems the air was screened at least once; and in the best, three times.

Three systems are used in heating and ventilation: direct, indirect, and a combination of the two. In the direct system the air is heated by contact with steam or hot water radiators, and unless special ventilating apparatus be used, ventilation can only take place spontaneously. Such systems are often insufficient for public buildings when the rooms are sometimes crowded or usually well filled. The direct system is common when heating and ventilation are combined. In this method the air is taken from outside and forced by means of a fan over steam pipes and thence through ducts to the various rooms. A combination of the direct and indirect systems is used very extensively in the heating and ventilation of school buildings. The direct keeps the halls and some of the rooms warm during the night, and the exhaust steam from the engine which operates the fan is economized in a tempering coil, where the cold air is partially heated before coming in contact with the live steam coils.

Each of the above systems is best adapted to a particular class of work. In selecting a system one must take into consideration the cost of installation, economy in operation and efficiency.

For shops and office buildings the direct method without ny ventilation other than through doors and windows is sufficient except in special cases where the vacuum method of forcibly drawing the air from the room is employed. In theaters and churches the gravity hot-air system is used. Here the air is introduced at the floor, and its less specific gravity will cause it to rise and pass out at the uppermost part of the room through properly arranged ventilators. This system is very efficient for this kind of work, and is perhaps the most economical in operation as it does not require the services of an experienced engineer.

In nearly all schools and public buildings some type of the blower system in connection with a subordinate direct system is used. A good example of this near home may be seen in the State Normal School at Providence. A plant costing over $20,000. consisting of a 12 ft. double cone fan is operated by a 12 H.P. Westinghouse engine. Steam is furnished by 4--50 H.P. boilers, burning two and one-half tons of coal per day, in average winter weather. There are 160,000 cu.ft. of air space in the building to be heated and kept at a temperature of 68°F.

Of many typical systems visited in Boston, the Roxbury High School may be mentioned as having one perhaps superior to any other for ventilation. A 12 ft. double cone fan furnished air to thirteen class rooms, hall and four other rooms. Steam was furnished by 2--100 H.P. boilers burning 6 tons of coal per day. The cost of this plant was about $27,000.

A test of the direct, indirect system in Lippitt Hall, installed by the Boston Blower Company of Boston--the details of which cannot here be given--has shown it to be one of the most efficient. Much less space, however, is allotted for its operation than in other places where a similar amount of work is done, which makes it correspondingly more difficult for an engineer to maintain a constant temperature in the rooms. But this matter belongs to the mechanics of ventilation and heating, as well as an equally important one, the transmission of heat through walls, which might well be the basis for a much more extended paper.

This short survey of the subject will show that good ventilation is necessary; that each building must be dealt with separately, and that the architect and heating engineer should work together in order to secure the best results.