Recent Developments in the Theory of Ventilation

By CHAS. L. HUBBARD, in the "Architectural Record"

The term, recent, as used above, has a somewhat broader meaning than is usually given to it, as the developments referred to had their beginning some ten or twelve years ago. However, it is only within the past three years or so that a general discussion of the matter has appeared to any extent in the technical journals, and at the present time investigations are still being carried on to reduce these theories to a practical working basis.

It is proposed in the present article to review the matter in a simple manner, giving what seems to be the general opinion of a majority of those who have made a special study of the subject and who should be able to give reliable information to those interested. As these new developments, when finally worked out, are likely to call for more or less change in building construction, as regards the ventilating arrangements, it would seem that the matter should have an especial interest for the architect.

Air has two principal functions: a chemical and a physical; it aerates the blood and absorbs the body heat. In order to perform the first of these it must contain a sufficient amount of oxygen and a minimum of harmful gases. Absorption of bodily heat depends upon the temperature, humidity and motion of the air. If the air of a room is not renewed its oxygen is gradually consumed and it becomes laden with heat and moisture from the bodies of the occupants.

Until within a comparatively short time all efforts toward better ventilation have been directed to chemical improvement instead of physical.

The theory upon which all systems of ventilation were formerly designed was that the percentage of oxygen must be maintained as nearly as possible to correspond with that of outside country air and that the proportion of carbon dioxide, or carbon acid gas, must be kept below a certain maximum. The method employed for obtaining this condition was that of dilution or the supplying of large volumes of fresh air at the room temperature or higher, depending upon the the system of heating employed. Normal outside air contains approximately 21 per cent. of oxygen and from 3 to 5 parts of carbon dioxide in 10,000 parts of air. It has been assumed, arbitrarily, that the carbon dioxide should not be allowed to rise above 10 parts in 10,000, and for the best results 6 to 7 parts have been considered the limit.

The harmful results of an insufficient air supply were supposed to come principally from the poisonous effects of the carbon dioxide coupled with the corresponding diminution of oxygen. Later it was thought the effect of poor ventilation was due, not only to the presence of carbon dioxide, but to certain harmful gasses and organisms which were given off in the process of respiration. As these substances were supposed to exist in a fixed proportion to the carbon dioxide, the latter was still considered to indicate the quality of the air, although in itself it was thought to be less harmful, especially in small quantities.

The common allowance of 30 cubic feet of air per occupant per hour is based on an increase of carbon dioxide from 4 parts in 10,000 of air to slightly less than 7 parts. A maximum of 6 parts in 10,000 calls for a supply of 50 cubic feet per minute under the same conditions. As already stated, the sole object of ventilation was one of dilution, so as to keep the carbon dioxide content and its accompanying products of respiration below a certain percentage. While this has been the accepted theory of the heating engineer and the general public until a comparatively recent date, there has been some doubt among those engaged in laboratory research as to the importance of the chemical purity of the air to the exclusion of its physical characteristics, and it was only with the advent of the air washer that we began to learn of the advantages of air "conditioning."

The perfection of the air washer was the outgrowth of the demand for a filter which would be more effective and more nearly automatic in its action than the older forms of dry filter, which were extremely bulky when made of the proper proportions and required frequent removal for cleaning in order to limit the resistance to air flow. While the primary use of the air washer was for the removal of dust and soot from city air, its field was soon extended to air moistening, cooling, and the removal of some of the products of respiration.

Although most of the ventilating systems at the present time are designed along the same general lines as in the past (with the exception of air washing in large city buildings), the *theory* of ventilation, as accepted by many of the leading authorities at home and abroad, has radically changed, the idea being that the physical characteristics of the air we breathe are of much greater importance than chemical purity.

While there are still some who give considerable importance to the chemical theory, a majority of those who have made an exhaustive study of the matter seem to have discarded the older theory and recommend that future development in the design of ventilating equipment be along the line of improvement in temperature and humidity control and in air movement.

Briefly stated, the chemical composition of the air, as regards contamination through respiration under ordinary conditions, is negligible, as compared with the removal of bodily heat and moisture. It will be interesting at this point, before considering the physical effects of air, to examine briefly into the reasons for this change in theory in regard to the chemical characteristics, as related to bodily health and comfort.

In order to show the relative importance of changes in the percentage of oxygen and carbon dioxide in the air for breathing, it is necessary to have a clear understanding of the process of respiration and the changes which take place in the air within the passages of the respiratory tract. At the beginning, it should be clearly understood that the lungs are never filled with *pure* air, even under the most favourable conditions, because breathing is only a frequently repeated slight dilution of the air remaining in the throat and larger bronchial tubes after expiration.

So far as its chemical composition is concerned, this is air which has passed out of the lungs, and after