is necessary to maintain a pressure of about 0.1 in. of water in the room or space to be ventilated or conditioned. This usually requires the introduction of a certain amount of outside air which depends on the particular conditions involved, and may vary over a considerable range.

In rooms in which the only source of contamination is the occupant the minimum quantity of outside or *new* air to be circulated appears to be that necessary to remove objectionable *body odors*. The concentration of body odors in turn depends largely upon the temperature of the air; the higher the temperature, the greater the amount of perspiration (sensible or insensible) given off from the skin, and the greater the concentration of odors.

Under proper temperature conditions, body odors may be reduced to a concentration that is not objectionable by as little as 10 cfm of outside air per person. This is the minimum amount specified in the Ventilation Standards adopted in 1932 by the Society. The ventilation laws of many states require the introduction of 30 cfm of outside air per occupant, but the present tendency is to supply a smaller amount of conditioned air.

The total quantity of air required to maintain the standards of temperature, distribution, and air motion is usually at least twice as great as that required to keep down body odors, owing largely to difficulties encountered with distribution systems.

NATURAL AND MECHANICAL VENTILATION

Under favorable conditions natural ventilation methods properly combined with means for heating may be sufficient to provide for the foregoing standards. As a rule, in instances in which the only source of contamination is the occupant, the requirements may be fulfilled when the following conditions prevail:

1. At least 50 sq ft of floor area for each occupant.
2. At least 500 cu ft of air space per occupant.
3. Effective openings in windows and skylights equal to at least 5 per cent of the floor area.

Whenever natural means are not sufficient to maintain the standards, resort must be made to whatever modifications or mechanical apparatus are necessary to secure such standards.

In large offices, large school rooms, and in public and industrial buildings, natural ventilation is uncertain and makes heating difficult. The chief disadvantage of natural methods is the lack of control: they depend largely on weather and upon the velocity and direction of the wind. Rooms on the windward side of a building may be difficult to heat and ventilate on account of drafts, while rooms on the leeward side may not receive an adequate amount of air from out of doors. The partial vacuum produced on the leeward side under the action of the wind may even reverse the flow of air so that the leeward half of the building has to take the *drift* of the air from the rooms of the windward half. Under such conditions no outdoor air would enter through a leeward window opening, but room air would pass out.

In warm weather natural methods of ventilation afford little or no

control of indoor temperature and humidity. Outdoor smoke, dust and noise, constitute other limitations of natural methods.

RECIRCULATION

The saving in operating costs due to recirculation of the air, while very considerable, must not be obtained at the expense of air quality. The percentage of recirculated air may be varied to suit the seasonal changes so as to conserve heat in winter and refrigeration in summer, but at no time during occupancy should there be taken from out of doors less than 10 cfm for each occupant. As a general rule, recirculation impairs the quality of the air by excessive humidity (if not conditioned), excessive odors, or both, and it tends to deprive the air of its ionic content[28], but the influence of this factor on comfort and health is at present a matter of speculation.

Toilets and similar rooms and all kitchens in buildings using recirculation should be separately, mechanically ventilated, with the exhaust in excess of the supply, in order to prevent objectionable odors from diffusing into other parts of the building. This air removal may in many cases be sufficient to insure an adequate replacement of outside air to the general recirculating system.

OZONE

The value of ozone in recirculated air has been greatly exaggerated in the past. Numerous researches[29], [30], [31] have shown that ozone in concentrations permissible in air conditioning work (0.1 to 0.5 parts per million parts of air) exerts practically no effect on pathogenic air-borne organisms and that it does not destroy the source of odors. Ozone, however, may mask odors by olfactory compensation. It requires at least 13 parts of ozone per million parts of air to influence bacteria[32]. Human beings are injuriously affected by ozone in concentrations of one part or more per million parts of air[32]. This amount will not destroy odors nor kill bacteria.

ULTRA-VIOLET RADIATION AND IONIZATION

In spite of rapid advances in air conditioning during the past few years, the secrets of reproducing indoors the natural climatic elements as they exist in open country under ideal weather conditions have not as yet been fully ascertained. Extensive studies have failed to discover the stimulating quality in open country air which is lost when the air is brought indoors, and particularly when it is treated mechanically. Ultra-violet light and ionization have been suggested but have not yet been identified.

It is generally recognized that total solar radiation in open air is the

[28] See A.S.H.V.E. research paper entitled, Changes in Ionic Content in Occupied Rooms Ventilated by Natural and Mechanical Methods, by C. P. Yaglou, L. C. Benjamin and S. P. Choate (A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931).

[29] Proceedings, Royal Society of London, by L. Hill and M. Flack (1911, B, Vol. 84, p. 404).

[30] Jordan and Carlson (*Journal American Medical Association*, 1913, Vol. 51, p. 1007).

[31] Konrich (Ztschr. f. Hyg., 1913, Vol. 73, p. 443).

[32] Preventive Medicine and Hygiene, by Milton J. Rosenau.