The air handled may consist entirely of air taken in from the outside or it may consist partly of new air and partly of recirculated air. On the basis that the air brought in from the outside is for oxygen supply and dilution only. The following cubic feet per minute per person would be required for the ventilation percentages shown, if all other factors are 100 per cent perfect.

In theatres, assembly rooms, auditoriums and other places of public amusement and assemblage there are usually several other factors to consider, such as the removal of excess heat, excess moisture, dust raised by the movement of the occupants and odors.

EFFECT OF HIGH TEMPERATURE AND HUMIDITY

For 85 deg. outside air and 70 per cent relative humidity in the summer the percentage of perfection would drop to 57 per cent without any change in the air from outside conditions.

Assuming that the air supply is 30 cu. ft. per person and that the body heat and heat from equipment will raise this 5 deg. Also that the vapor added per person is 10 grains per min. or 0.33 grains per cu. ft. of air handled, the effective temperature difference will be raised about 20, so that the percentage of ventilation, would drop about 5 more, leaving 52 per cent ventilation. It will be seen, therefore, that it would be difficult to get better than 40 to 60 per cent ventilation in summer without some method of air cooling.

Air motion will assist but unless increased beyond the usual 10 to 20 ft. per minute ordinarily obtained from the movement of the air through the room it will not improve the percentage of ventilation more than 1 to 2 per cent. By the use of refrigerating and dehumidifying apparatus the effective temperature can be maintained at any desired percentage of perfection.

The use of a good air washer should reduce the temperature about 70 per cent of the difference between the wet and dry bulb temperature. This for the case cited would reduce the effective temperature difference about 2 deg. corresponding to an increase of 5 per cent in the final percentage of the ventilation.

It will be understood that the example cited is an extreme case of temperature and humidity and that the final percentage will be improved by the air washer in a greater proportion if the relative humidity of the outside air is lower.

For a condition of 80 deg. dry bulb and 50 of relative humidity, the percentage for the entering air would be 77 per cent, the percentage leaving the occupants would be 70 per cent and the air washer would improve this to 81 per cent.

Assuming that 90 per cent ventilation is desired for places of assemblage, that distribution will be 75 per cent, dust 96 per cent, bacteria 98 per cent and odors 85 per cent, there will be a deduction of 1 per cent for dust plus 1 per cent for bacteria plus 1.5 per cent for odor making a total of 3.5 per cent and leaving a deduction of 6.5 per cent for effective temperature plus effective air supply.

Assuming that the effective temperature can be controlled in winter to within 1 deg. above or below the comfort line there would be a deduction of 2½ per cent for this, leaving a deduction of 4 per cent for effective air supply. With 75 per cent distribution this would leave 3 per cent deduction for CO_2, corresponding to an air supply of 10 cu. ft. per min. per person.

It will be seen then that 10 cu. ft. of air taken in from the outside, per person per minute, is sufficient for winter conditions but inadequate for summer weather, where heat and humidity are the determining factors, unless refrigeration is used. Increasing the air supply from 10 to 50 cu. ft. per person per minute gives little improvement unless some form of artificial cooling is used.

SUMMER CONDITIONS

It would seem that about 75 per cent ventilation is possible under reasonably severe summer conditions with an air supply of 30 cu. ft. per person, using an air washer, and that beyond this point there is little to be gained by increasing the air supply. The figures given are based on upward ventilation and that the cooling effect of from 5 to 10 deg. with air washers and of perhaps twice this amount with refrigeration will produce uncomfortable drafts on the occupants at times.

For this reason and for the additional reasons of sanitation and control, the downward system of ventilation is perhaps more efficacious in large and intensely used places of assemblage.

On account of transporting all of the heat from lights downward and of forcing the body-heated air back over the occupants it is usually necessary to do much more cooling of the air than can be done with the air washer, without refrigeration. On the other hand the air is brought in high enough to permit of its being diffused and brought to the proper condition before coming into contact with the occupants. It can be seen, therefore, that the air supply per person per minute for assembly-rooms could be 10 cu. ft. in winter, 30 cu. ft. in summer with air washers and anywhere between these two figures for the entire year with refrigeration.

Also that nothing better than about 75 per cent ventilation can be obtained in hot sultry summer weather without artificial cooling but that with such cooling especially if the air supply is taken from overhead and exhausted from below, most any desired percentage of perfection can be maintained.

RECIRCULATION

The foregoing does not take into consideration the matter of recirculation, but it can readily be seen that there is little to be gained by recirculation unless an appreciable amount of CO_2 and attendant impurities which get into the air can be taken out during recirculation. The handling of the larger quantity of air may be of value either to produce air motion or for use as a better cooling medium with less temperature difference between incoming and outgoing air. Recirculation may also be used as a purely economic feature during the warming up of the building or during