oxygen from the air actually breathed. This does not necessarily indicate the effect on the air in the room occupied. The same air may be re-breathed for a limited time without apparent harmful effect. Air may be filtered, washed, cooled and recirculated with evident satisfaction.

The air handled by the ventilating system may consist entirely of air taken in from the outside or it may consist partly of new air and partly of recirculated air.

HEAT FROM OCCUPANTS, LIGHTS, EQUIPMENT

In a crowded place of assemblage the heat given off by the occupants, together with that given off by the lighting and power equipment, is usually more than the normal heat loss through the structure to the outside air, even in winter under cold climatic conditions. This means that in order to preserve an equilibrium of effective temperature the entering air must be cooler than the leaving air, so that the problem is usually one of cooling and ventilating, rather than of heating and ventilating.

A typical case for winter might show about 300 B.t.u. of body heat, plus 100 B.t.u. per person from light, etc., being given up to the building against about 200 B.t.u. heat loss from the building, per person per hour. This would mean that 200 B.t.u. per person must be carried away by the air. (See page 60, Chapter I.)

If the flow of air is upward, or from the side, so as to bring the incoming air into direct contact with the occupants, the temperature of the incoming air should not be more than 5 deg. below the temperature of the air leaving the occupant, otherwise the conditions will be drafty and uncomfortable. Where the air is admitted through the ceiling, and the ceiling is high, the temperature difference may be slightly increased and, in some cases, the air quantity may be slightly decreased.

If a room is crowded in weather of 85 deg. outside temperature, with relative humidity of 70 per cent while giving each occupant 30 cu. ft. of air per minute, it may be assumed, that there will be an increase of temperature of at least 5 deg., due to body heat and heat from equipment. The moisture increase, from the bodies of the occupants, may be assumed as 10 grains per minute, or 0.30 grains per cubic foot of air handled.

Under such a condition some method of air cooling will be needed to obtain satisfactory ventilation. A good air washer may reduce the temperature of the air passing through it about 70 per cent of the difference between the wet and the dry bulb temperatures. Its operation would hardly be worth while without a water supply of 50 deg. temperature or less because of increasing relative humidity with a decreasing temperature. The beneficial effect of an air washer will increase in proportion as the relative humidity of the outside air is lower.

It will be understood that the example cited is an extreme case of temperature and humidity.

Experience, however, shows that a supply of fresh air which proves to be adequate for maintaining a desirable effective temperature in winter will prove inadequate for the same purpose in hot weather. While an increased volume of air supply is often of material benefit, the use of

refrigeration brings the final hot weather solution, not so much in actual temperature drop as in humidity control.

When using an upward system of air supply, as through floor mushrooms, drafts will be felt with the introduction of air at temperatures of more than 5 deg. cooler than the average room temperature. For this reason, and for the additional reasons of sanitation and control, the downward system of ventilation is perhaps more efficacious in large and intensively occupied places of assemblage. The air should be brought in at a point high enough to permit of its being diffused before coming into contact with the occupants.

RECIRCULATION

Where recirculation of air in ventilation work is utilized care should be taken that the recirculated air is suitable. In many cases it must be reconditioned by cleaning, dehumidifying and deodorizing. The saving in operating costs obtainable by recirculation of the air in ventilation systems, while very considerable, must not be obtained at the expense of quality. A reduction in the quality of the ventilation when recirculation is used can be prevented by the installation and use of complete mechanical ventilation equipment available for this purpose.

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 should the recirculated air exceed 75 per cent of the total air supply.

Toilets and similar rooms, 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.

PSYCHOLOGICAL AND PHYSIOLOGICAL REACTIONS

The engineer who disregards the psychological factor in ventilation is indeed short sighted. As in most human contacts and activities, the effect on the mind of air conditions is profound.

Consideration must always be given to the elimination of objectionable noise from machinery and to air friction noises. It is usually helpful if the occupants of a ventilated room may visualize some indication that air is moving. It helps if they may, when they wish, place their bodies or portions thereof, in sensible air currents, to demonstrate that ventilation is in effect. Periodical or occasional temperature reductions, or increases in air movement, possibly accompanied by muscular exercises, are of great value, psychologically as well as physically.

After a good ventilating system is designed the engineer is only fairly well started on the road to good ventilation. A system is not a ventilating system until it ventilates. Here is where the operating man and proper supervision of operation come in. It is recommended that the engineer who designs a ventilation plant should supervise its installation, and that his interest and responsibility should be maintained during the operation of the plant.