based on the maximum intensity of solar radiation observed at the A.S.H.V.E. Laboratory during a three-year study, so results based on these curves will be amply high. It will be noted that Table 4 gives the amount of heat delivered through the window as 97 per cent of the solar radiation, which is greater than is indicated by the figures for absorption in the preceding paragraph. The explanation is that much of the radiation absorbed by the glass is delivered to the room.

Although 97 per cent of the heat from solar radiation is delivered to a room through bare window glass, more recent tests[7] have indicated that in the case of buildings having floors of high heat capacity such as concrete floors on which the solar radiation falls, approximately one-half of the heat entering a bare window is absorbed by the floor and does not immediately become a part of the cooling load but is delivered back to the air in the building at a slow rate over a period of 24 hours or longer.

Fig. 1 shows that the maximum solar intensity on any surface is of limited duration. In the case of windows the total energy impinging on the glass before and after the time of maximum intensity is further reduced by increased shading of the glass from the frame, or wall. The cooling load due to solar radiation therefore does not have to be figured as a steady load. Another point which should be noted is that the maximum solar radiation load on an east wall occurs early in the morning when the outside temperature is low.

In a paper by the A.S.H.V.E. Research Laboratory[8] it was shown that ordinary double strength window glass transmits no measurable amount of energy radiated from a source at 500 F or lower; that it transmits only 6.0 and 12.3 per cent of the total radiation from surfaces at 700 F and 1000 F, respectively; and that it transmits 65.7 per cent of the radiation from an arc lamp, 76.3 per cent of the radiation from an incandescent tungsten lamp, and 89.9 per cent of the radiation from the sun. Thus, glass windows in a room constitute heat traps, which allow rather free transmission of radiant energy into the room from the sun to warm objects in it, but do not allow the transmission of re-radiated heat from these same objects.

Tests[4] *have been made which indicated that sunshine through window* glass is the most important factor to contend with in the cooling of an office building. At times it was shown to account for as much as 75 per cent of the total cooling necessary. Because of the importance of the sunshine load, cooling systems should be zoned so that the side of the building on which the sun is shining can be controlled separately from the other sides of the building. If buildings are provided with awnings so that the window glass is shielded from sunshine, the amount of cooling required will be reduced and there will also be less difference in the cooling requirements of different sides of the building. The total cooling load for a building exposed to the sun on more than one side is of course less than the sum of the maximum cooling loads in the individual rooms since the maximum solar radiation load on the different sides occurs at different times. *In determining the total cooling load for a building if the time* when the maximum load occurs is not obvious, the load should be calculated for various times of day to determine the time at which the sum of the loads on the different sides of the building is a maximum.

[7]Cooling Requirements of Single Rooms in a Modern Office Building, by F. C. Houghten, Carl Gutberlet, and Albert J. Wahl (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, April, 1935).

[8]Radiation of Energy Through Glass, by J. L. Blackshaw and F. C. Houghten (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934).

Heat and Moisture Leakage

An allowance must be made for the heat and moisture in the outside air introduced for ventilating purposes or entering the building through cracks, crevices, doors, and other places where infiltration might occur.

The volume of air entering due to infiltration may be estimated from data given in Chapter 6 using wind velocities from Table 1, Chapter 8. Information on the amount of outside air required for ventilation will be found in Chapter 3.

The heat gain resulting from the outside air introduced may be estimated from the following formula:

$$H_i = 60\, Q d_o\, (\Theta_o - \Theta), \qquad (2)$$

where

H_i = heat to be removed from outside air entering the building, Btu per hour.
Q = volume of outside air entering the building, cubic feet per minute.
d_o = density of outside air, pounds of dry air per cubic foot of outside air, at the temperature t_o.
Θ_o = heat content of mixture of outside dry air (at temperature t_o) and water vapor, Btu per pound of dry air.
Θ = heat content of mixture of inside dry air (at temperature t) and water vapor, Btu per pound of dry air.

Heat and Moisture Sources

Figs. 8 to 11, Chapter 3, show the heat and moisture given off by human beings under various conditions of activity. For average conditions where a person is normally at rest, as in a theater, or doing very light work, as in a restaurant or residence, the total amount of heat given off will average

TABLE 5. HEAT GAIN DUE TO VARIOUS DEVICES, BTU PER HOUR

Lights and electrical appliances	3,413 per kw
Motors with connected load in same room[a]	
Nameplate rating, 1/8 to 1/2 hp	4,250 per hp
Nameplate rating, 1/2 to 3 hp	3,700 per hp
Nameplate rating, 3 to 20 hp	2,950 per hp
Restaurant coffee urns, 10-gal capacity	16,000
Dish warmers per 10 sq ft of shelf	6,000
Restaurant range—4 burners and oven	100,000
Residence gas range	
Giant burner	12,000
Medium burner	9,000
Oven	1,000 per cu ft of space
Pilot	250
Electric range	
Small burner, 1000 to 1350 watts	3,413 per kw
Large burner, 1700 to 2200 watts	3,413 per kw
Oven, 2000 to 3000 watts	3,413 per kw
Appliance connection, 660 watts	2,250
Warming compartment, 300 watts	1,025

[a]Deduct 2545 Btu per hp if connected load is outside of room.