The A.S.H.V.E. tests[6] indicate that a single pane of double strength glass 0.127 in. thick absorbs approximately 11 per cent of the solar radiation passing through it when the impingement is normal. For smaller angles of impingement, the glass retards percentages of the total radiant energy approximately in proportion to the sine of the angle. Other experiments[7] indicate a glass absorption of 16.7 per cent for one pane of glass and 37.5 per cent for two ¼ in. panes separated by a 1¾ in. air space.

The amount of solar radiation delivered to an unshaded glass surface may be obtained from Tables 2, 3, 4 or 5. These values must be used only for the net glass area on which the sun shines and not the entire glass area. Tests at the A.S.H.V.E. Research Laboratory[8] have determined the percentage of heat from solar radiation actually delivered to a room with various types of outdoor and indoor shading. The data in Table 8 are taken from these tests.

The percentage values in this table were obtained by dividing the total amount of heat actually entering through the shaded window by the total amount of heat calculated to enter through a bare window (solar radiation plus glass transmission, based on observed outside glass temperature). For bare windows on which the sun shines, the transmission of heat from outside air to glass may be small or negative as the glass temperature is raised by the solar radiation absorbed. On the other hand, at times when the solar intensity is low, the heat gain as a result of solar radiation may be less than that due to normal transmission.

TABLE 8. SOLAR RADIATION TRANSMITTED THROUGH SHADED WINDOWS

Type of Appurtenance	Finish Facing Sun	Per Cent Delivered to Room
Canvas awning	Plain	28
Canvas awning	Aluminum	22
Inside shade, fully drawn	Aluminum	45
Inside shade, one-half drawn	Buff	68
Inside Venetian blind, fully covering window, slats at 45 deg	Aluminum	58
Outside Venetian blind, fully covering window, slats at 45 deg	Aluminum	22

In calculating the total heat gain through windows on the sunny side of buildings, it is sufficiently accurate to figure the total heat gain to a window as follows:

Consider the total heat gain as that resulting from solar radiation and neglect the heat transmission through the glass caused by the difference between the temperatures of the inside and outside air. This method should be used except at times when the calculated heat gain per square foot due to normal transmission exceeds the solar intensity. At such times, solar radiation may be neglected and the total heat gain considered as resulting from normal transmission.

[6]A.S.H.V.E. RESEARCH REPORT No. 974—Radiation of Energy Through Glass, by J. L. Blackshaw and F. C. Houghten (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 93). A.S.H.V.E RESEARCH REPORT No. 975—Studies of Solar Radiation Through Bare and Shaded Windows by F. C. Houghten, Carl Gutberlet, and J. L. Blackshaw (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 101).

[7]A.S.H.V.E. RESEARCH REPORT No. 924—Field Studies of Office Building Cooling, by J. H. Walker, S. S. Sanford, and E. P. Wells, (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 285).

[8]Loc. Cit. Note 6.

The solar heat transmission through windows or skylights may be expressed by the formula:

$$H_G = A_G f I$$

where

H_G = Solar radiation transmitted through a window, Btu per hour.
A_G = Net area of glass exposed to sun's rays, square feet.
f = Percentage of solar radiation (expressed as a decimal) transmitted to the inside (Table 8). For bare windows, $f = 1$.
I = Intensity of solar radiation striking surface, Btu per hour per square foot (Tables 2, 3, 4 and 5).

Although the tests from which Table 8 was obtained showed that approximately all of the heat from solar radiation is delivered to a room through bare window glass, other tests[9] have indicated that in the case of a building 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 hr or longer.

The maximum solar intensity on any surface is of limited duration as shown in Fig. 1. 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 calculated as a steady load. Another point which should be noted is that the maximum solar radiation load on the east wall occurs early in the morning when the outside temperature is low.

In a paper[10] by the A.S.H.V.E. Research Laboratory it was shown that ordinary double strength window glass transmits no measureable 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 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

[9]A.S.H.V.E. RESEARCH REPORT No. 1002—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. TRANSACTIONS, Vol. 41, 1935, p. 53).

[10]Loc. Cit. Note 6.