perature reaching a maximum of 93 F as shown by the temperature curve in Fig. 3 and an indoor temperature of 78 F and 50 per cent relative humidity.

The heat flow shown in Figs. 2 and 3 is a combination of normal transmission and solar radiation transmission and is the total heat flow through the wall or roof. Due to the heat capacity of walls and roofs there is a time lag[5] in the transmission of heat through them as shown by the curves. For the types of construction covered in Figs. 2 and 3 and for the conditions indicated, the heat flow through the inside surface at any given time can be read directly. For other types of construction, the curves may be used as a guide in estimating the heat flow. The time lag for

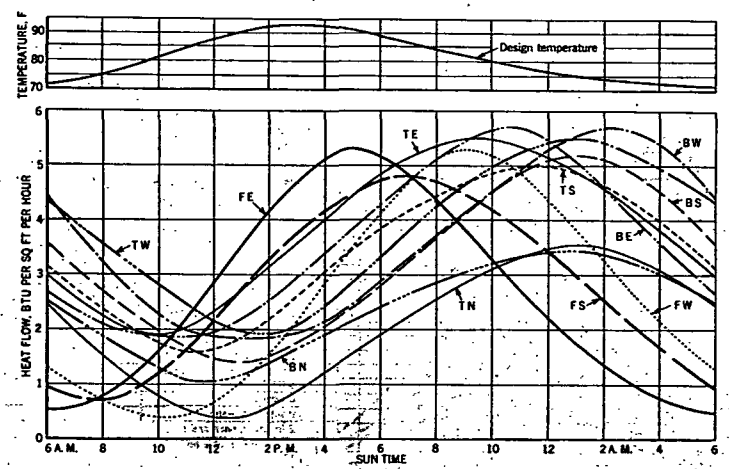

FIG. 3. RELATION BETWEEN TIME AND HEAT FLOW THROUGH THE INSIDE SURFACE OF WALLS OF DIFFERENT CONSTRUCTION AND ORIENTATION ON A 93 F DESIGN DAY WITH 90 PER CENT OF DESIGN SOLAR RADIATION

Walls BE, BS, BW and BN—12 in. solid brick and plaster facing east, south, west and north respectively.
Walls TE, TS, TW and TN—4 in. brick veneer, 8 in. tile and plaster facing east, south, west and north respectively.
Walls FE, FS and FW—4 in. brick veneer, building paper, ⅞ in., matched sheathing, 2 x 4 in. studs, metal lath and plaster facing east, south and west respectively.

other types of construction is included in Table 6 which was prepared by the A.S.H.V.E. Laboratory from data collected by it and by other authorities.

Solar Radiation Transmitted Through Glass

Windows present a problem somewhat different from that of opaque walls, because they permit a large percentage of the solar energy to pass through. A small amount is reflected and a portion is absorbed by the glass. The amount absorbed depends upon the character and thickness of the glass and the angle between it and the sun's rays. The temperature of the glass is raised by the absorbed heat and this heat is then delivered

[5]Loc. Cit. Note 2.

TABLE 6. TIME LAG IN TRANSMISSION OF SOLAR RADIATION THROUGH WALLS AND ROOFS

TYPE AND THICKNESS OF WALL OR ROOF	TIME LAG, HOURS
1-in. yellow pine horizontal roof, water proofing, smooth black finish	1
2-in. yellow pine horizontal roof, water proofing, smooth black finish	1¾
4-in. reinforced clay tile horizontal roof, water proofing, slag finish	2¼
2-in. gypsum horizontal roof, water proofing, slag finish	2¼
Slate and slaters felt on 2¼ in. tongue and grooved yellow pine, sloped roof	2½
4-in. gypsum horizontal roof, water proofing, slag finish	4½
6-in. concrete horizontal roof, water proofing, slag finish	5
1-in. concrete, 4-in. cinders, 1½-in. concrete, water proofing, smooth black finish	8
Wood siding, 1-in. sheathing, 2 x 4 studs, lath and plaster	2
Wood siding, 1-in. sheathing, 2 x 4 studs (studding space filled with insulation) lath and plaster	5
4-in. brick, 1-in. sheathing, 2 x 4 studs, lath and plaster	7
4-in. brick, 8-in. tile and plaster	10½
13-in. brick, plastered	12
9-in. brick, 3¾-in. tile, 5¼-in. air space, 3¾-in. tile and 1¼-in. plaster	16

to the air on each side in proportion to the difference between the glass and air temperatures[6].

The A.S.H.V.E. tests[7] 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.

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 7 are taken from these tests.

TABLE 7. 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

[6]Heat Absorbing Glass Windows, by W. W. Shaver (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 287).

[7]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). A.S.H.V.E. RESEARCH REPORT No. 1180—Heat Gain Through Western Windows With and Without Shading, by F. C. Houghten and David Shore (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 251).

[8]Loc. Cit. Note 7.