The correction for 30 deg daily range is $\left(-\frac{30-20}{2}\right) = -5$.

Net total correction is $+12 - 5 = +7$.

The heat flow rate at 2:00 p.m. therefore is $(34 + 7) \times 0.13 = 5.32$ Btu per (hr) (sq ft).

A method of determining *heat flow rates*, when structure is not given in Tables 12 or 13, is illustrated in *Example 12*.

Example 12: A 4 in. stone concrete roof covered with an average depth of 4 in. cinder concrete ($k = 4.9$) on which is placed a $\frac{3}{8}$ in. thick felt roof with $\frac{1}{2}$ in. pitch and slag surface, is exposed to the sun. The location is the central part of the United States. Design temperatures are: outdoor 95 F; daily range 20 deg; indoor temperature 80 F. Find the heat flow rate at 2:00 p.m. for a day in July.

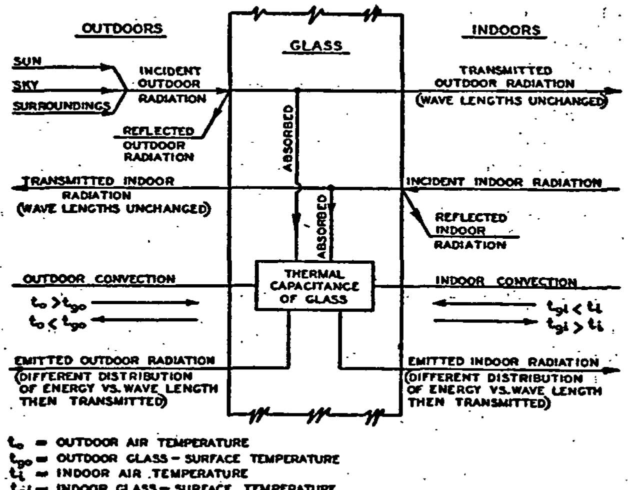

FIG. 3. INSTANTANEOUS HEAT-BALANCE CONDITIONS ON A GLASS SECTION

Solution: For the purpose of selecting the *equivalent temperature differential*, this construction is assumed to be equal approximately to an uninsulated 6 in. concrete roof, for which the equivalent temperature is found to be 38 deg in the 2:00 p.m. column of Table 12. Calculate the overall heat transmission coefficient U of the roof as follows:

$$U = \frac{1}{\frac{1}{1.2} + \frac{4}{12} + \frac{4}{4.9} + \frac{0.375}{1.33} + \frac{0.50}{1.00} + \frac{1}{4.0}} = 0.33.$$

The heat flow rate is then 38×0.33 equals 12.5 Btu per (hr) (sq ft).

TABLES FOR CALCULATING SOLAR HEAT GAIN THROUGH GLASS AREAS

Basic Principles

In order to set forth the principles involved in calculating heat flow through glass areas, the general instantaneous heat-balance relation will be presented. It will be shown schematically in Fig. 3. The net heat gain for the indoor space is the result of several contributing phenomena. Some observations concerning the behavior of glass with respect to radiant energy will lead to a better understanding of the heat-balance relation. To various degrees glass transmits radiation having wave lengths between 0.29 and 4.75 microns. Of the portion not transmitted, part is absorbed, and the remainder is reflected. Outside these limits glass is opaque, absorbing approximately 94 percent and reflecting 6 percent. Only a negligible amount of radiant energy from a surface at 450 F has a wave length shorter than 4.75 microns. It is therefore convenient to treat all forms of solar radiant energy separately from radiant energy from other sources, so long as the temperature of these sources is not over approximately 450 F.

The complete heat-balance for a glass section can be expressed for a unit time interval as follows:

$$\begin{bmatrix}\text{Total heat flow,}\\ \text{through glass section}\end{bmatrix} = \begin{bmatrix}\text{Transmitted,}\\ \text{solar radiation}\end{bmatrix} \pm \begin{bmatrix}\text{Heat flow by convective}\\ \text{and radiative exchanges at}\\ \text{the indoor surface}\end{bmatrix} \quad (7a)$$

The second term of the right side of Equation 7a can also be expressed by a heat balance equation as follows:

$$\begin{bmatrix}\text{Heat flow by convective}\\ \text{and radiative exchanges}\\ \text{at the indoor surface}\end{bmatrix} = \begin{bmatrix}\text{Absorbed}\\ \text{solar}\\ \text{radiation}\end{bmatrix} \pm \begin{bmatrix}\text{Radiative exchanges be-}\\ \text{tween outer surface of glass}\\ \text{and outdoor surroundings}\end{bmatrix}$$
$$\pm \begin{bmatrix}\text{Convective exchanges}\\ \text{between outer surface of}\\ \text{glass and outdoor air}\end{bmatrix} \pm \begin{bmatrix}\text{Heat storage}\\ \text{within the}\\ \text{glass section}\end{bmatrix} \quad (7b)$$

Equations 7a and 7b can be combined and expressed in symbolic terms by Equation 7c. Tabular values of the two bracketed terms of Equation 7a are presented later in this section for various types of glass for specific design conditions.

$$(q/A) = [\tau_D I_D + \tau_d I_d] + [\alpha_D I_D + \alpha_d I_d + \epsilon_{go} R_s - \epsilon_{go} R_{go} - f_{co}(t_{go} - t_o) - S],$$
Btu per (hr) (sq ft) (7c)

where

(q/A) = instantaneous rate of heat flow, Btu per (hour)(square foot).
τ_D, τ_d = transmittance of glass for direct and diffuse solar radiation, respectively.
I_D, I_d = incident direct and diffuse solar radiation, respectively, Btu per (hour) (square foot).
α_D, α_d = absorptance of glass for direct and diffuse solar radiation, respectively.
ϵ_{go} = emissivity of glass at temperature t_{go}.
R_s = low temperature radiant energy falling on glass from outdoor surroundings, Btu per (hour)(square foot).
R_{go} = low temperature radiant energy emitted by a surface with emissivity equal to 1.0 at temperature t_{go}.
f_{co} = outdoor convective conductance, Btu per (hour)(square foot) (Fahrenheit degree).
t_{go} = temperature of outdoor surface of glass, Fahrenheit degrees.
t_o = temperature of outdoor air, Fahrenheit degrees.
S = rate at which glass stores energy, Btu per (hour)(square foot).

Transmissivity and absorptivity vary with both wave length of the incident radiation and incident angle. Values of τ and α for a single sheet of the average ordinary drawn window glass are given in Table 15 for a standard distribution of solar energy.[2] Values for two air-spaced sheets