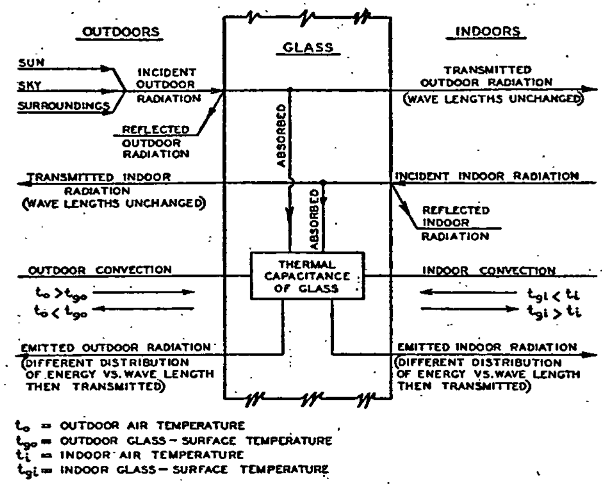

FIG. 5. INSTANTANEOUS HEAT-BALANCE CONDITIONS ON A GLASS SECTION

falling upon the inside surface, because this latter is principally in the longer wave lengths.

A recent analysis has served to demonstrate the effects of the various controlling variables upon the heat gain from glass in relation to air-conditioning problems.[12] The practical results for a single sheet of common window glass will be cited here. For average conditions, the design equation for the instantaneous rate of heat transfer from the indoor glass surface to the conditioned space (for single sheets of common window glass only) in Btu per (hour) (square foot of sunlit surface) was found to be:

$$\left(\frac{q}{A}\right) = 1.04\,(t_o - t_i) + 0.022\,I_d + 0.0165\,I_s + \tau_d I_d + 0.778\,I_s. \qquad (10)$$

where t_o = outdoor air temperature, Fahrenheit degrees.

t_i = indoor air temperature, Fahrenheit degrees.

I_d = intensity of solar or direct radiation on the outer glass surface, Btu per (hour) (square foot of sunlit surface).

I_s = intensity of sky radiation on the outer glass surface.

τ_d = transmissivity of the glass for solar radiation, dimensionless, given as a function of the angle of incidence in Table 17.

Similar equations with other numerical constants apply to other types of

TABLE 17. TRANSMISSIVITY OF SINGLE-SHEET COMMON WINDOW GLASS FOR DIRECT SOLAR RADIATION

ANGLE OF INCIDENCE[a] DEG	TRANSMISSIVITY τ_d	ANGLE OF INCIDENCE[a] DEG	TRANSMISSIVITY τ_d	ANGLE OF INCIDENCE[a] DEG	TRANSMISSIVITY τ_d
0	0.87	50	0.83	80	0.41
20	0.86	60	0.77	90	0
40	0.85	70	0.65		

glass or glass areas in other arrangements (heat-absorbing glass or glass in multiple layers, for example).

Equation 10 may be clarified further by explanations of the numerical constants involved:

1.04 = overall unit conductance for heat transfer under *summer* conditions, Btu per (hour) (square foot) (Fahrenheit degree). (Note that this is the transmittance U taken at 1.13 for winter conditions in Chapter 9.)

0.022 = fraction of I_d which is absorbed and then transferred to the indoor space from the indoor glass surface, dimensionless. (Note that, of the total absorption, part goes inside and part goes outside.)

0.0165 = fraction of I_s which is absorbed and then transferred to the indoor space from the indoor glass surface, dimensionless.

0.778 = transmissivity of the glass for sky radiation, dimensionless.

Magnitudes of the quantities I_d, I_s and t_o entering into Equation 10 would depend upon the time of the day, time of the year, atmospheric conditions, latitude of the receiving surface, and the orientation of the receiving surface. Principles and data needed for the calculation of I_d and I_s have been given previously in this chapter. Weather data, such as the sol-air temperatures in Tables 10 and 11, give data on t_o throughout a design day.

Table 18 has been prepared to expedite practical calculations of the heat gain through glass areas; tabulated values are magnitudes of the sum $(0.022\,I_d + 0.0165\,I_s + \tau_d I_d + 0.778\,I_s)$ from Equation 10 for a solar declination of 18 deg. This declination corresponds to a nominal August 1 design day, although the values tabulated may be used with safety to represent average conditions from July 15th to August 15th.

It is possible to use the heat-gain data of Table 18 for other single-thickness glass materials than common window glass, through the introduction of approximate correcting factors. Table 19 gives such factors. The range of transmissivities in Table 19 extends from high-transmission crystal-like glass to low-transmission heat-absorbing glass. The transmissivity of 0.87 is that of common window glass.

By using two or more layers of glass separated by airspaces, the absorptivity is increased and the transmissivity decreased. Values for some combinations appear in the literature.[12] A rough approximation, which holds fairly well until the angle of incident radiation becomes large, is that the transmissivity of the combination is the product of the transmissivities of the component layers, while the absorptivity of the combination is the absorptivity of the outer glass, plus the product of the absorptivity of the inner glass and the transmissivity of the outer.

Heat-gain quantities from Table 18 may also be used for other times of the year than August 1 if a correction is made for solar declination. Solar heating calculation for glass areas can also be based upon these data. Table 20 gives solar declinations for various times of the year. The rule for procedure is the following:

To find the radiation heat gain for some declination of the sun other than 18 deg, use the latitude in Table 18 equal to that of the locality in question, plus (18 deg— solar declination involved).

For example, consider that the instantaneous heat gain is required for Philadelphia in the middle of June. The latitude of Philadelphia is 40 deg North. The solar declination in mid-June is about 23.5 deg. The section of Table 18 to be used is that for a latitude of 40 + (18 − 23.5) = 34.5 deg; say 35 deg.

Caution: This method gives only approximate values and its use should be limited. It may be used for Eastern and Western exposures for all hours, 8:00 a.m. to 4:00 p.m.,