efficients are always based on the difference between the air temperatures on the inside and the outside of the wall.

Transmission Coefficients by Computation

If heat transmission coefficients are to be computed, and in many, if not most cases, they should be computed, the following analysis of the transmission of heat through a simple, solid wall is used as the basis for such computations.

The diagram in Fig. 1 exhibits four important temperatures: *First* the air temperature t inside of the building; *second*, the temperature t_1 of the inside surface of the wall; *third*, the temperature t_2 of the outside surface of the wall, and *fourth*, the air temperature t_0 outside of the building. Heat reaches or enters the inside surface of the wall by radiation and convection, since the air and objects A within the building are *always*

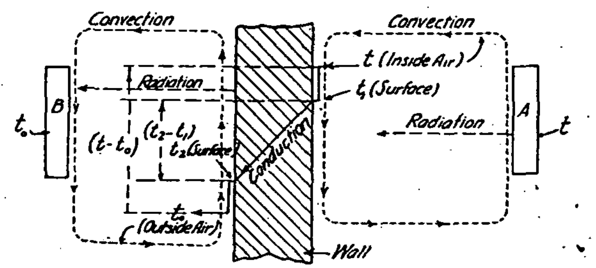

FIG. 1. TEMPERATURE CURVE OR GRADIENT FROM AIR INSIDE TO AND THROUGH WALL TO AIR OUTSIDE, WALL MATERIAL ASSUMED AIR-TIGHT

A represents warm surfaces at temperature *t* of inside air; *B* represents cold surfaces at temperature *to* of outside air. For an actual temperature gradient curve see Fig. 2.

warmer than the inside surface of the wall, when the inside air temperature t is greater than the outside air temperature t_0. This heat must then pass through the material of the wall from inside to outside surface by conduction, and is finally given off from the outside surface by radiation and convection, provided, of course, that equilibrium has been established and all four temperatures are constant.

The amount of heat reaching or entering the wall per hour depends on t and t_1 and a coefficient K_1 varying with the character of the wall material. K_1 may be defined as the B.t.u. per hour entering each square foot of wall surface per degree difference between the inside air temperature t and the inside surface temperature t_1. Hence the heat received by inner surface of the wall per hour by both radiation and convection is

$$H_1 = K_1 (t - t_1) S \qquad (1)$$

where S is the inner wall surface area in square feet and the other terms are as heretofore indicated.

Whatever amount of heat H_1 enters the inner wall surface must be given off from the outer wall surface, so that if H_2 represents heat emitted from outer surface

$$H_1 = H_2 = K_2 (t_2 - t_0) S. \qquad (2)$$

Now K_2 may not equal K_1, in which case (t_2-t_0) will not equal $(t-t_1)$. Usually, in an actual wall exposed to wind on the outside, K_2 (Table 5) is greater than K_1 and (t_2-t_0) must be less than $(t-t_1)$. Moreover, the heat H_c passing through the wall by conduction is equal to H_1 and H_2, and if C is the coefficient of conduction = B.t.u. transmitted per hour per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

$$H_1 = H_2 = H_c = \frac{C}{x} (t_1 - t_2) S \qquad (3)$$

where x = wall thickness in inches.

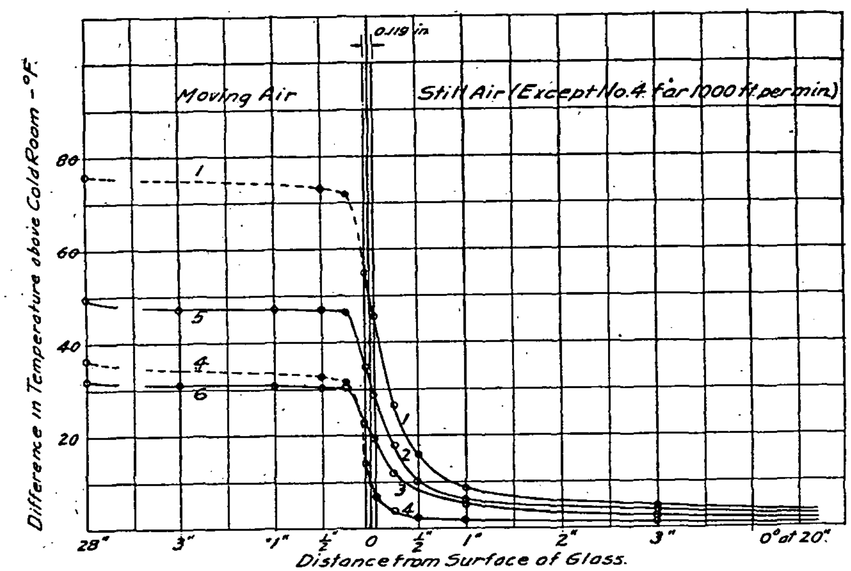

FIG. 2. TEMPERATURE GRADIENT CURVES FOR GLASS (TAKEN FROM BULLETIN NO. 24, ENGRG. EXP. STA., PENNSYLVANIA STATE COLLEGE)

These equations (1), (2) and (3) are fundamental and are used for determining values for K_1, K_2 and C for actual wall materials by test. They cannot be used for computing heat losses in an actual building, since the surface temperatures t_1 and t_2 are seldom known, although these surface temperatures can be determined in a test by means of thermocouples. Hence, for actual conditions where the only temperatures known are the inside and outside air temperatures t and t_0, it is necessary to use a transmission coefficient U = B.t.u. transmitted per hour per square foot of wall surface per degree difference between the inside and outside air temperatures. Values of U for a limited number of walls are given in Tables 6-12. The heat H transmitted per hour from air inside to air outside is then computed as follows:

$$H = U (t - t_0) S \qquad (4)$$