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 the coefficient f_i varying with the character of the wall material. The symbol f_i 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 the inner surface of the wall per hour by both radiation and convection is:

$$H_1 = f_i\,(t - t_1)\,S \tag{1}$$

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,

$$H_1 = H_2 = f_o\,(t_2 - t_o)\,S \tag{2}$$

Now f_o may not equal f_i, in which case $(t_2 - t_o)$ will not equal $(t - t_1)$. Usually, in an actual wall exposed to wind on the outside, f_o (Table 5) is greater than f_i and $(t_2 - t_o)$ 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 k is the thermal conductivity expressed in B.t.u. transmitted per hour per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

$$H_1 = H_2 = H_C = \frac{k}{x}\,(t_1 - t_2)\,S \tag{3}$$

where x = wall thickness in inches.

These equations (1), (2) and (3) are fundamental and are used for determining values for f_i, f_o and k 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_o, it is necessary to use the 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 many common types of construction are given in Tables 12 to 36, inclusive. The heat H transmitted per hour from air inside to air outside is then computed as follows:

$$H = U\,(t - t_o)\,S \tag{4}$$

and since $H = H_1 = H_2 = H_c$, the right-hand members of equations (1), (2), (3) and (4) are all equal.

The coefficient U may be computed for any wall provided values for f_i, f_o and k are known. By proper substitution in the four equations, the unknown temperatures t_1 and t_2 can be eliminated and the value of the transmission coefficient for a simple wall x inches thick is:

$$U = \cfrac{1}{\cfrac{1}{f_i} + \cfrac{1}{f_o} + \cfrac{x}{k}} \tag{5}$$

and for a compound wall of several materials having thicknesses in inches of x_1, x_2, x_3, etc., the coefficient is:

$$U = \cfrac{1}{\cfrac{1}{f_i} + \cfrac{1}{f_o} + \cfrac{x_1}{k_1} + \cfrac{x_2}{k_2} + \cfrac{x_3}{k_3} + etc.} \tag{6}$$

As in the case of the simple wall, f_i and f_o, are always the inside and outside surface coefficients for the two materials in contact with air. If the air is still (no wind), then for the same material f_i and f_o are the same, and $f_i = f_o$; but, if the outside air is in motion, then f_o is always greater than f_i and will increase as the wind velocity increases. Values for f_i in still air, as determined by various investigators, are given in Table 4.

TABLE 4. SURFACE COEFFICIENTS (f_i) FOR VARIOUS BUILDING MATERIALS UNDER STILL AIR (NO WIND) CONDITIONS

THE VALUES IN THE TABLE ARE IN B.T.U. PER SQUARE FOOT OF WALL SURFACE PER HOUR PER 1 DEG. FAHR. DIFFERENCE BETWEEN THE MEAN AIR TEMPERATURE IN THE ROOM AND THE INSIDE SURFACE TEMPERATURE OF THE WALL.

Building Material	Surface Coefficient f_i (Still Air)	
	Harding and Willard	Wood
Asbestos (sheet)	1.40	....
Brickwork (ordinary)	1.40	....
Cement Plaster (finished)	0.93	....
Concrete	1.30	....
Corkboard	1.25	1.20
Glass (window)	1.50	1.90[a]
Magnesia (blocks)	1.45	....
Wood (finished surface)	1.40	....
Building paper	....	1.40
Average of all values	1.34	....

[a]Average of both sides of glass 0.12 in. thick and for 70 deg. fahr. total temperature difference from air to air with moving air on one side. Probable value for still air on both sides 1.60.

Values for k and C, the conductivity and conductance of building materials and insulations, are given in Tables 7, 8, 9, 10 and 11, and are taken from the published values of various investigators. It should be noted that values of k and C as well as U are dependent on the temperature range, and it is therefore desirable that the investigator determine heat-transmission values under conditions approximating those existing under actual conditions.

In the case of air-space construction, an air-space coefficient for each air space must be inserted in either equation (5) or (6). Thus for a simple wall with one air space,

$$U = \cfrac{1}{\cfrac{1}{f_i} + \cfrac{1}{f_o} + \cfrac{1}{a} + \cfrac{x}{k}} \tag{7}$$

and for a simple wall of several air spaces having conductances of a_1, a_2, a_3, etc., the coefficient is: