plate of bakelite, 2 ft. square and ⅛ in. thick. This plate is equipped with thermocouples which are so constructed as to operate as differential pyrometers. A difference in temperature between the two surfaces of the plate produces a difference in electrical potential between the thermocouples.

The plate is calibrated so that this difference in potential, when measured, can be converted into terms of heat transmission through the plate. In connection with this plate, it is also necessary to use several other thermocouples to give the temperature of the air within the building, the temperature of the interior surface of the wall or roof, the temperature of the plate itself, the temperature of the exterior of the wall or roof and the temperature of the exterior air.

Tests have been conducted with the Nicholls heat meter on many types of wall construction, and the results obtained are in close agreement with the computed values for these same constructions.

If tests are made to determine heat transmission coefficients, the inside and outside air temperatures should correspond with those actually existing in heating practice, and the amount of air movement, both on the inside and outside of the test wall, should be definitely stated in reporting the coefficients. Since actual temperature differences vary widely in different parts of the country, it is desirable to adopt some standard basis for testing, such as 80 deg. inside and 0 deg. outside, and in very precise work make a correction for other temperatures. It has been found that the absolute mean temperature of the wall affects the coefficients materially. The coefficient increases with the absolute mean temperature.

If the hot-box method is used, tests are usually run under still-air conditions, which means there was no wind movement during the test over the surfaces of the wall. In practice, some wind movement over the exterior surface of the wall should always be allowed for; hence, still-air coefficients cannot be used in actual work as they do not provide for the normal wind movement over the outside of the building in the locality in question during the heating season. Moreover, still-air transmission coefficients cannot be corrected to provide for moving-air conditions by multiplying by a single constant factor.

It would be obviously impossible to determine the air-to-air heat transmission coefficients of every type of wall construction in use with the heat meter or the hot-box on account of the great amount of time involved. Hence, the method of computing the coefficients from fundamental constants must be resorted to in most cases, but heat-meter and the hot-box tests can be used to good advantage in checking the accuracy of the computed values.

TRANSMISSION COEFFICIENTS BY COMPUTATION

Symbols and Definitions

The following symbols which are in agreement with the recommendations of the Committee on Heat Transmission of the *National Research Council* are used in the heat transmission formulae in this chapter:

U = Thermal transmittance or overall coefficient of heat transmission and is the amount of heat expressed in B.t.u. transmitted in one hour per square foot of the wall, floor, roof or ceiling for a difference in temperature of 1 deg. fahr. between the air on the inside and outside of the wall, floor, roof or ceiling.

k = Thermal conductivity and is the amount of heat expressed in B.t.u. transmitted in one hour through 1 sq. ft. of a homogeneous material 1 in. thick for a difference in temperature of 1 deg. fahr. between the two surfaces of the material. The conductivity of any material depends on the structure of the material and its density. Heavy or dense materials, the weight of which per cubic foot is high, usually transmit more heat than light or less dense materials, the weight of which per cubic foot is low.

C = Thermal conductance and is the amount of heat expressed in B.t.u. transmitted in one hour through 1 sq. ft. of a non-homogeneous material for the thickness or type under consideration for a difference in temperature of 1 deg. fahr. between the two surfaces of the material. Conductance is usually used to designate the heat transmitted through such heterogeneous materials as plaster board and hollow clay tile.

f = Film or surface conductance and is the amount of heat expressed in B.t.u. transmitted by radiation, conduction and convection from a surface to the air surrounding it, or vice versa, in one hour per square foot of the surface for a difference in temperature of 1 deg. between the surface and the surrounding air. To differentiate between inside and outside wall (or floor, roof or ceiling) surfaces, f_i is used to designate the inside surface or film-conductance and f_o the outside surface or film-conductance.

a = Thermal conductance of an air space and is the amount of heat expressed in B.t.u. transmitted by radiation, conduction and convection in one hour through an area of 1 sq. ft. of an air space for a temperature difference of 1 deg. fahr. The conductance of an air space depends on the mean absolute temperature, the width, the position and the character of the materials enclosing it.

R = Resistance or resistivity, the reciprocal of transmission, conductance or conductivity, *i.e.:*

$\frac{1}{U}$ = overall or air-to-air resistance.

$\frac{1}{k}$ = internal resistivity.

$\frac{1}{C}$ = internal resistance.

$\frac{1}{f}$ = surface or film-resistance.

$\frac{1}{a}$ = air-space resistance.

x = thickness in inches.

Fundamental Formulae

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_o 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 warmer than the inside surface of the wall, when the inside air temperature t is greater than the outside air temperature t_o. 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