Note that actual thicknesses of lumber are used in the computations rather than nominal thicknesses.

On account of the fact that the internal resistances of metal and single thicknesses of building paper (used because of its value as a wind stop only) and roofing felt are very small, these resistances were neglected in the calculations, in accordance with standard practice. The computations for wood shingle roofs applied over wood stripping are based on 1 by 4 in. wood strips, spaced 2 in. apart. Since no reliable figures are available concerning the conductivity of Spanish and French clay roofing tile, of which there are many varieties, the figures for such types of roofs were taken the same as for slate roofs, as it is probable that the values of U for these two types of roofs will compare favorably.

The coefficients of transmission of the pitched roofs in Table 31 apply where the roof is over a heated attic or top floor, such that the heat passes directly through the roof structure including whatever finish, if any, is applied to the underside of the roof rafters. By a heated attic is meant an attic to which heat is supplied directly from the furnace or boiler by means of radiators, warm-air registers, or other means.

If the attic is unheated, the roof structure and ceiling of the top floor must both be taken into consideration, and the combined coefficient of transmission determined. The formula for calculating the combined coefficient of transmission of a top-floor ceiling, unheated attic space and pitched roof, per square foot of roof area, is as follows:

$$U = \frac{U_r \times U_{ce}}{n \times U_r + U_{ce}} \tag{10}$$

where

U_r = coefficient of transmission of the roof.
U_{ce} = coefficient of transmission of the ceiling.
n = the ratio of the area of the roof to the area of the ceiling.

In using this formula, a correction-factor must be applied. As the amount of heat transferred through an air space is proportional to the difference of the fourth powers of the absolute temperatures of the surfaces enclosing the air space, a greater amount of heat is absorbed or emitted by radiation by the surfaces enclosing an unheated attic than by the surfaces of a wall or ceiling in a room under still-air conditions, where the surrounding objects are only slightly higher in temperature than the interior surfaces of the walls and ceiling. For example: According to the most reliable information at present available, the average coefficient of a surface in still air is 1.34 Btu per hour per square foot per degree Fahrenheit, whereas the average coefficient of an air space in an outside wall is about 1.10 Btu per hour per square foot per degree Fahrenheit difference between the two surfaces, at a mean temperature of 40 F. An air space coefficient of 1.10 is equivalent to a surface coefficient of 2.20 for each of the two surfaces enclosing the air space, where the over-all transmission is computed by using the coefficients of the two surfaces enclosing the air space instead of the coefficient of the air space itself. Hence, in determining the values of U_r and U_{ce} to be used in the formula, the coefficients for the surfaces of the roof and ceiling enclosing the attic should be increased to allow for the additional amount of heat

transferred by radiation, and a coefficient of 2.20 may be used with sufficient accuracy for each of these surfaces, although in very precise work a correction should be made to allow for the fact that the area of a pitched roof over an unheated attic is greater than the area of the ceiling, and hence, the amount of heat absorbed by radiation by each square foot of roof surface is less than is given off by radiation by each square foot of ceiling surface.

The following example will illustrate the use of this formula: Determine the combined coefficient of transmission of a roof constructed of asbestos shingles applied over wood sheathing on rafters, an unheated attic, and a wood lath and plaster ceiling, based on a roof having a ⅓ pitch, for which the value of n is 1.2.

$$U_r = \frac{1}{\frac{1}{4.02} + \frac{1}{2.20} + \frac{1}{6.00} + \frac{0.781}{1.00}} = 0.605$$

$$U_{ce} = \frac{1}{\frac{1}{1.34} + \frac{1}{2.20} + \frac{1}{2.00}} = 0.588$$

Substituting these values in the preceding formula:

$$U = \frac{0.605 \times 0.588}{1.2 \times 0.605 + 0.588} = 0.271$$

Btu per hour, *per square foot of roof area* per degree difference in temperature between the air near the underside of the ceiling and the outside air.

Combined coefficients for many common types of pitched roofs and top-floor ceilings for unheated attics are given in Table 32.

If the unheated attic space between the roof and ceiling has no dormers, windows or vertical wall surfaces, the combined coefficients given in Table 32 may be used for determining the heat loss through the roof construction between the attic and top-floor ceiling, but it should be noted that the coefficients given in Table 32 should be multiplied by the roof area and not by the ceiling area. If the unheated attic contains windows, ventilators or vertical wall surfaces, which would tend to reduce the temperature in the attic to a temperature approaching or equaling the outside temperature, the roof should be neglected and only the top-floor ceiling construction and the corresponding ceiling area taken into consideration, using the coefficients given in Tables 26 or 27. The attic temperature should then be taken the same as the outside temperature. In this case the reasoning regarding the loss of heat from a surface by radiation, referred to in the preceding discussion regarding the determination of the combined coefficients of a ceiling, unheated attic and roof, does not apply to the heat loss from the attic floor or top-floor ceiling, on account of the fact that the undersurface of the roof will have about the same temperature as the attic floor. As stated before, if the attic is heated, the top-floor ceiling should be neglected, and only the roof structure, with whatever ceiling is applied to the underside of the roof rafters, taken into consideration in determining the heat losses through the roof.

The temperature in an attic space containing no dormers, windows,