approximately the same, and if the coefficients of transmission are approximately equal, the temperature in the unheated space may be assumed to be the mean of the inside and outside design temperatures. If, however, the surface areas and coefficients are unequal, the temperature in the unheated space should be estimated by means of Equation 5.

$$t_u = \frac{t(A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.}) + t_o\,(A_aU_a + A_bU_b + A_cU_c + \text{etc.})}{A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.} + A_aU_a + A_bU_b + A_cU_c + \text{etc.}} \quad (5)$$

where

t_u = temperature in unheated space, degrees Fahrenheit.
t = inside design temperature of heated room, degrees Fahrenheit.
t_o = outside design temperature, degrees Fahrenheit.
A_1, A_2, A_3, etc. = areas of surface of unheated space adjacent to heated space, square feet.
A_a, A_b, A_c, etc. = areas of surface of unheated space exposed to outside, square feet.
U_1, U_2, U_3, etc. = coefficients of transmission of surfaces of A_1, A_2, A_3, etc.
U_a, U_b, U_c, etc. = coefficients of transmission of surfaces A_a, A_b, A_c, etc.

Example 4. Calculate the temperature in an unheated space adjacent to a heated room having surface areas (A_1, A_2, and A_3) in contact therewith of 100, 120 and 140 sq ft and coefficients (U_1, U_2, and U_3) of 0.15, 0.20 and 0.25 respectively. The surface areas of the unheated space exposed to the outside (A_a and A_b) are respectively 100 and 140 sq ft and the corresponding coefficients are 0.10 and 0.30. The sixth surface is on the ground and is neglected in this example. Assume $t = 70$ and $t_o = -10$.

Solution. Substituting in Equation 5:

$$t_u = \frac{70[(100\times0.15)+(120\times0.20)+(140\times0.25)]+-10[(100\times0.10)+(140\times0.30)]}{(100\times0.15)+(120\times0.20)+(140\times0.25)+(100\times0.10)+(140\times0.30)}$$

$$t_u = \frac{4660}{126} = 37 \text{ F.}$$

The temperature in unheated spaces having large glass areas and with two or more surfaces exposed to the outside (such as sleeping porches and sun parlors), are generally assumed to be the same as the outside temperature.

GROUND TEMPERATURES

Ground temperatures to be assumed for estimating basement heat losses will usually differ in the case of basement walls and floors, the temperatures under the floors being generally higher than those adjacent to walls.

Temperatures Adjacent to Basement Walls

Ground temperatures near the surface and under open spaces vary with the climate, the season of the year and the depth below the surface. The nearer the surface (during the cold weather) the lower the temperature. Frost will penetrate to a depth of over 4 ft in some localities if not protected by snow. A thick blanket of snow will result in a higher ground temperature near the surface. Consequently ground temperatures near the surface may be higher in cold climates where the snow remains on the ground for a greater length of time than in more moderate climates where the snow melts away periodically during the winter.

Complete data[3] for various localities are not as yet available but in estimating heat losses through vertical walls below grade, it is advisable not to assume average ground temperatures above 32 F in northern climates when estimating heat losses from heated basements. This is for the mean height of the basement wall. Since the recommended wall coefficient for basement walls in contact with the soil is only 0.10, any small variation in the assumed ground temperature will not materially affect the calculated heat loss.

Temperatures Under Basement Floors

The temperature under basement floors[4] is influenced by the heat from the basement or protected from the influence of atmospheric conditions by the basement. In computing losses through basement floors the ground temperatures may be assumed the same as the approximate water temperature at depths of 30 to 60 ft given in Fig. 3, Chapter 27. It should be remembered however that the distance of the basement floor below grade may have some effect upon the temperature of the ground under basement floors, the nearer the surface the higher the temperature.

BASEMENT TEMPERATURES AND HEAT LOSSES

The allowance to be made for basement heat losses depends on whether the basement is to be heated or not.

Unheated basements

If a basement is completely below grade and is *not heated*, the temperature in the basement will normally range between that in the rooms above and the ground temperature. Basement windows will of course lower the basement temperature when it is colder outside and any heat given off by the heating plant will increase the basement temperature. In any case, the exact basement temperature is likely to be a somewhat indeterminate quantity, if the basement is not heated. Since the basement temperature will generally be lower than that of the rooms above, an allowance should theoretically be made for the loss from the rooms above through the floor over the basement.

Heated basements

If the basement is *heated* and a specified temperature is to be maintained, the heat loss should be estimated in the usual manner, based on the proper wall and floor coefficients (see Chapter 4) and the outside air and the ground temperatures. Heat losses through windows and walls above grade should be based on outside temperatures and the proper air-

[3]The temperatures listed were obtained on February 11, 1941, in Pittsburgh, Pa., at the depths indicated at a location 21 ft from the walls of a heated basement.

Depth below surface, In.	Temperature, Deg Fahr
0	23.2
3	23.5
21	30.0
42	39.4
72	44.0
Average	32.0

[4]A.S.H.V.E. Research Paper—Heat Loss Through Basement Walls and Floors, by F. C. Houghten, S. I. Taimuty, Carl Gutberlet and C. J. Brown (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, January, 1942, p. 69).