in accordance with the manufacturer's specification. The engineer must evaluate carefully the economic considerations involved in the selection of an insulating material as adapted to various building constructions. Lack of proper evaluation, or improper installation may lead to unsatisfactory results. Special attention must be given to vapor barriers as outlined in Chapter 10. Water-soaked insulation loses its effectiveness as insulation.

Computed Heat Transmission Coefficients

Computed overall heat transmission coefficients of many common types of building construction are given in Tables 7 to 21, inclusive, each coefficient being identified by a serial number, except in Tables 19, 20, and 21.

TABLE 6. COEFFICIENTS OF TRANSMISSION (U) OF FRAME WALLS AND ROOFS WITH INSULATION BETWEEN FRAMING[a]

Coefficients are expressed in Btu per (hour) (square foot) (Fahrenheit degree difference in temperature between the air on the two sides), and are based on an outside wind velocity of 15 mph.

COEFFICIENT WITH *NO* INSULATION BETWEEN FRAMING	COEFFICIENT WITH INSULATION BETWEEN FRAMING				NUMBER
	MINERAL WOOL OR VEGETABLE FIBERS IN BLANKET OR BAT FORM[b] (Thickness below)			3⅝ IN. MINERAL WOOL BETWEEN FRAMING[c]	
	1 IN.	2 IN.	3 IN.		
	A	B	C	D	
0.11	0.078	0.063	0.054	0.051	33
0.13	0.088	0.070	0.058	0.055	35
0.15	0.097	0.075	0.062	0.059	37
0.17	0.10	0.080	0.066	0.062	39
0.19	0.11	0.084	0.069	0.065	41
0.21	0.12	0.088	0.072	0.067	43
0.23	0.12	0.091	0.074	0.069	45
0.25	0.13	0.094	0.076	0.071	47
0.27	0.14	0.097	0.078	0.073	49
0.29	0.14	0.10	0.080	0.075	51
0.31	0.14	0.10	0.081	0.076	53
0.33	0.15	0.10	0.083	0.077	55
0.35	0.15	0.11	0.084	0.078	57
0.37	0.16	0.11	0.085	0.080	59
0.39	0.16	0.11	0.086	0.081	61
0.41	0.16	0.11	0.087	0.082	63
0.43	0.17	0.11	0.088	0.082	65

[a] Coefficients corrected for 2 x 4 framing, 16 in. on centers—15 percent of surface area.
[b] Based on one air space between framing.
[c] No air space.

For example, the coefficient U of a brick veneer, frame wall with wood sheathing and $\frac{1}{2}$-in. of plaster on gypsum lath is 0.27 (Wall No. 28-C in Table 7) and with 2 inches of blanket or bat insulation, the coefficient would be 0.097 (No. 49-B in Table 6).

In the analysis of any wall construction for the purpose of calculating the overall coefficient of heat transmission U, it is first necessary to determine the paths of heat flow, that is, whether they are parallel or series, or a combination of both. This is in accordance with the basic laws of heat transfer which state that *in parallel flow the conductances are additive*, while *in series flow the resistances are additive*. Likewise, in order to determine the total resistance for the wall, the conductance must be known.

The importance of this analysis cannot be over-emphasized. This is especially true in wall constructions in which there are parallel paths of heat flow, and one path has a high heat transfer, while others have a low heat transfer. The method of making this calculation can best be shown by *Example 2* and Fig. 5. As this wall was tested by the hot box method at the *University of Minnesota*, a direct comparison can be made between calculated and tested values.

Example 2: Calculate the coefficient of heat transmission U for a wall shown in Fig. 5. Wall construction consists of two 4-in. concrete walls separated by a 2½-in. space filled with insulation; ¼-in. diameter metal tie rods are imbedded a distance of 1 in. in each 4-in. concrete wall, and spaced 9 in. vertically and 12 in. horizontally. Values of k are: insulation 0.30, concrete 12.00, tie rods 400.00.

Solution: In Fig. 5 the following paths of heat flow from plane A to plane F will be noted:

1. From A to B: One path through 3 in. of concrete.
2. From B to C: Two paths, (a) through 1 in. of tie rod, and (b) through 1 in. of concrete.

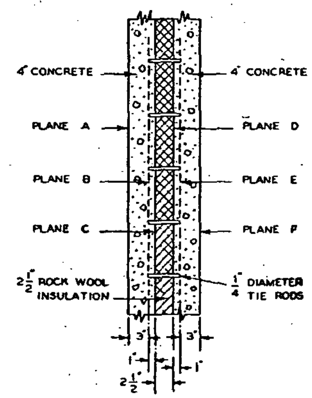

FIG. 5. SECTION OF CONCRETE WALL HAVING STEEL TIE RODS AND INSULATION

3. From C to D: Two paths, (a) through 2½ in. of tie rod, and (b) through 2½ in. of insulation.
4. From D to E: Two paths, (a) through 1 in. of tie rod, and (b) through 1 in. of concrete.
5. From E to F: One path through 3 in. of concrete.

It will be noted that items 2 and 4 are paths of similar flow, and could be treated as one. If equilibrium or steady state heat transfer is assumed, there will exist a temperature difference between the metal tie rod and the concrete, and also between the metal tie rod and the insulating material. The rate of heat transfer between these materials is dependent upon their conductivity values and the temperature difference. As the conductivity of the metal tie rods is considerably higher than that of the concrete or insulating material, it cannot be assumed that the same rate of heat transfer takes place for all parallel paths. Likewise, an appreciable error would be made by assuming that no heat transfer takes place between the metal tie rod and the surrounding materials. Although the pattern of the isotherms is unknown, the following method of calculation does partially take into account the heat flow between the metal tie rods and its bounding materials.

Parallel Flow. The conductances through the areas of parallel heat flow may be determined as follows:

1. The area of each ¼-in. diameter tie rod is 0.00036 sq ft, and as the tie rods are