After the true heat loss is obtained, the loss per square foot of pipe surface can be calculated from the relationship:

$$q_i = q_o (r_2/r_1).$$

where

q_i = Btu per (hour) (square foot outer surface of pipe).

The heat loss through two or more thicknesses of insulation applied to a pipe can be calculated by means of the equation:

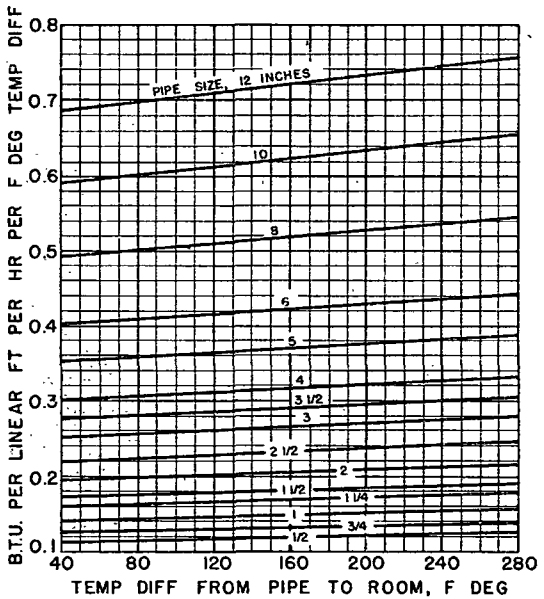

FIG. 3. HEAT LOSS THROUGH 2 IN. THICK 85 PER CENT MAGNESIA TYPE COVERING

$$q_o = \frac{t_1 - t_2}{\dfrac{r_s \log_e \dfrac{r_2}{r_1}}{k_1} + \dfrac{r_s \log_e \dfrac{r_3}{r_2}}{k_2} + \ldots} \qquad (2)$$

where

r_2 = outer radius of second layer of insulation, inches.

r_s = outer radius of last layer of insulation, inches.

The method of solving Equation 2, which is the most difficult of the two, is given in Example 3.

Example 3. Compute the heat loss per linear foot of pipe surface per hour from a 6-in. pipe, insulated with a 3-in. thickness of diatomaceous silica, and a 2-in. thickness of 85 per cent magnesia. The pipe is operating at a temperature of 1200 F and is exposed to a room temperature of 80 F.

Solution. In figuring the heat loss from Equation 2, it is necessary to first make an assumption for the outer surface temperature t_2 and the temperature between the diatomaceous silica and 85 per cent magnesia insulation, so that the mean temperature of each material can be obtained and the thermal conductivity corresponding to the mean temperature of each material substituted in the formula. First assume an outer surface temperature of 140 F and a temperature of 570 F between the two materials corresponding to a mean temperature of (1200 + 570) ÷ 2 or 885 F for the diatomaceous silica and (570 + 140) ÷ 2 or 355 F for the 85 per cent magnesia insulation. The conductivities of these two materials at mean temperatures of 885 and 355 F interpolated from Table 6 are 0.865 and 0.5 Btu respectively.

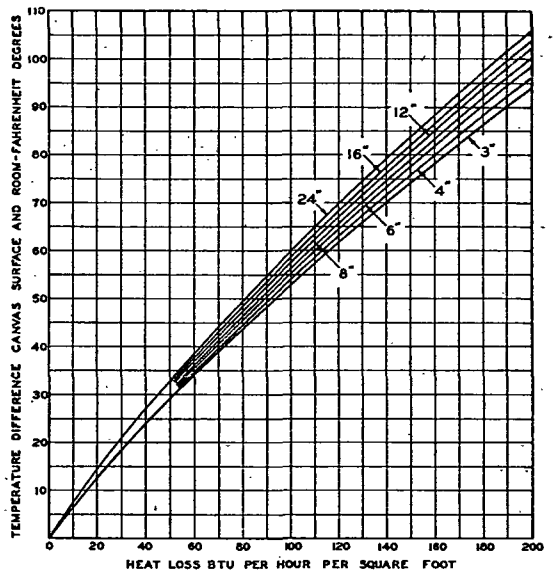

FIG. 4. HEAT LOSS FROM CANVAS-COVERED CYLINDRICAL SURFACES OF VARIOUS DIAMETERS

These values are substituted in Equation 2 and a trial calculation made. For a nominal 6-in. steel pipe $r_1 = 3.312$, $r_2 = 6.312$ and $r_3 = 8.312$ then,

$$q_o = \frac{1200 - 140}{\dfrac{8.312 \log_e \dfrac{6.312}{3.312}}{0.865} + \dfrac{8.312 \log_e \dfrac{8.312}{6.312}}{0.5}} = \frac{1060}{6.2 + 4.58} = 98.3 \text{ Btu.}$$

The temperature drop from the outer surface of the insulation to the surrounding air for a heat loss of 98.3 Btu is found from Fig. 4 to be 57 F for a 16-in. O.D. cylindrical surface, or 57 + 80 F room temperature = 137 F surface temperature. Since a surface temperature of 140 F was assumed, it is evident that a temperature closer to 137 F, or, for instance, 138 F should be used for recalculation:

$$q_o = \frac{1200 - 138}{6.2 + 4.58} = 98.4 \text{ Btu.}$$

Since the temperature drop through each material is equal to the heat flow times the actual resistance of each material the temperature drop through the diatomaceous silica is 98.4 × 6.2 = 610 F or the temperature between the two insulating materials is