D = diameter of round ducts, feet.
V = velocity of air in the duct, feet per minute, at specified temperature.
d = density of air, pounds per cubic foot, at the specified temperature at which V is measured.
e = naperian base of logarithms = 2.718.

In using formulae 8, 9, and 10, one of the duct air temperatures will be unknown and will be solved for by substitution of the other known or assumed values. The assumed values dependent upon the mean duct air temperature can be determined exactly by the cut-and-try method.

TABLE 15. HEAT TRANSMISSION THROUGH DUCT WALLS INSULATED WITH MATERIALS OF VARYING CONDUCTIVITIES[a]

Values are expressed in Btu per hour per square foot of flat surface per degree Fahrenheit difference in temperature between air inside and still air outside at 90 F for cold air and 50 F for warm air in ducts

Conductivity of Insulation at 86 F Mean Temp	Thickness of Insulation (Inches)	Cold Air			Warm Air			
		40 F	60 F	80 F	90 F	120 F	150 F	180 F
		Temperature Difference						
		50 F	30 F	10 F	40 F	70 F	100 F	130 F
0.200	½	0.319	0.323	0.328	0.324	0.330	0.337	0.344
	1	0.175	0.177	0.180	0.178	0.181	0.184	0.188
	1½	0.121	0.122	0.124	.....	0.125	0.127	0.129
	2	0.092	0.093	0.095	.....	.....	.....	.....
0.250	½	0.382	0.387	0.392	0.390	0.397	0.404	0.412
	1	0.214	0.217	0.220	0.218	0.221	0.225	0.229
	1½	0.149	0.151	0.153	.....	0.154	0.156	0.159
	2	0.114	0.115	0.117	.....	.....	.....	.....
0.300	½	0.440	0.445	0.450	0.448	0.457	0.466	0.475
	1	0.252	0.255	0.258	0.256	0.260	0.264	0.268
	1½	0.176	0.178	0.180	.....	0.181	0.184	0.187
	2	0.135	0.137	0.139	.....	.....	.....	.....
0.350	½	0.494	0.499	0.505	0.502	0.511	0.521	0.530
	1	0.286	0.289	0.292	0.290	0.295	0.300	0.306
	1½	0.202	0.204	0.207	.....	0.208	0.211	0.215
	2	0.156	0.158	0.160	.....	.....	.....	.....
0.450	½	.....	0.596	0.602	0.599	0.610	0.621	0.633
	1	.....	0.356	0.360	0.358	0.364	0.370	0.376
	1½	.....	0.254	0.257	.....	0.259	0.263	0.267
	2	.....	0.198	0.200	.....	.....	.....	.....
0.550	½	.....	0.682	0.688	0.685	0.699	0.714	0.730
	1	.....	0.417	0.422	0.418	0.425	0.432	0.440
	1½	.....	0.302	0.305	.....	0.307	0.312	0.317
	2	.....	0.236	0.239	.....	.....	.....	.....

[a]For round ducts less than 30 in. diameter, increase heat transmission values by the following percentages:

Thickness of Insulation (Inches)	½	1	1½	2
21 to 30 in. Duct Diameter	1%	2%	3%	4%
12 to 21 in. Duct Diameter	3%	5%	7%	9%

Heat losses for insulated ducts are given in the warm air column of Table 15. The losses are based on a uniform series of material conductivities at 86 F mean temperature and an air temperature of 50 F outside of the duct. The losses may be interpolated for odd material conductivities and temperatures. The conductivities of various materials will be found in Table 2 of Chapter 3. For cases where the surrounding air temperature is other than 50 F, the losses may be selected on the basis of temperature difference.

Recently, a new prefabricated insulated duct built entirely of asbestos has been placed on the market.

Example 4. Determine the entering air temperature and heat loss for a duct 24 × 36 in. cross-section and 70 ft in length, insulated with ½ in. of a material having a conductivity of 0.35 Btu at 86 F mean temperature, carrying air at a velocity of 1200 fpm, measured at 70 F, to deliver air at 120 F with air surrounding the duct at 40 F.

Solution. Assume the entering air temperature to be 130 F. Thus, the mean temperature difference will be 85 F. Referring to the warm air column of Table 15 and interpolating for 85 F temperature difference, the overall heat transmission coefficient is found to be 0.516 Btu. From Table 6 Chapter 1 the density of air at 70 F and 29.92 in. Hg. is found to be 0.0749 lb per cubic foot. Substituting these and the other given values in Formula 8:

$$x = \frac{28.8 \times 6 \times 0.0749 \times 1200}{0.516 \times 10 \times 70} = 42.61$$

$$t_1 = \frac{120\ (42.61 + 1) - 80}{42.61 - 1} = 123.8$$

Based on 123.8 F entering air temperature, the new mean temperature difference will be 81.9 F and the new transmission coefficient will be 0.515. Resubstituting in Formula 8, t_1 becomes 123.9 F.

Substituting in formula 6:

$$Q = 0.515 \times 10 \times 70 \left[\left(\frac{123.9 + 120}{2} \right) - 40 \right]$$

$$Q = 29.543 \text{ Btu}$$

LOW TEMPERATURE INSULATION

Surfaces maintained at temperatures lower than the surrounding air are insulated to reduce the flow of heat and to prevent condensation and frost. The insulating material should absorb a minimum amount of moisture, for one reason that the absorption of moisture substantially increases the conductivity of the material. This property is particularly important in the case of surfaces to be insulated that are below the dew-point of the surrounding air. In such cases, due to vapor pressure difference, it is necessary to seal the surface of the insulating material against the penetration of water vapor which would condense within the material, causing a serious increase in heat flow, possible breakdown of the material and corrosion of metal surfaces. An insulating material with a high degree of moisture absorption might pick up moisture before application and then, when the seal is in place and the temperature of the insulated surface reduced, release that moisture to the cold surface.

The thickness of insulation required to prevent sweating is that thickness which will raise the temperature of the outer surface of the