For low velocities and long ducts of small cross-section, a somewhat more accurate formula may be used as follows:

$$t_2 = \frac{t_1 - t_3}{e^{\left(\frac{UPL}{14.4\,AdV}\right)}} + t_3 \qquad (7)$$

In these equations

Q = heat loss through duct walls, Btu per hour.
U = thermal transmission coefficient, Btu per square foot per hour per degree Fahrenheit.
P = perimeter of duct, feet.
L = length of duct, feet.
t_1 = temperature of air entering duct, degree Fahrenheit.
t_2 = temperature of air leaving duct, degree Fahrenheit.
t_3 = temperature of air surrounding duct, degree Fahrenheit.
M = weight of air per hour, through the duct, pounds.
A = cross-sectional area of duct, feet.
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 Equations 5, 6 and 7, one of the duct air temperatures will be unknown and will be solved for by substitution of the other known or assumed values.

Heat loss coefficients for insulated ducts with various conductivities are given in Fig. 7. The conductivities of various materials, which are based on mean temperatures, ranging from about 70 to 90 F, will be found in Table 2 of Chapter 4. For cases where the mean temperature is other than that on which the test was conducted, a correction should be made. However, in most cases the effect of this factor will be small and may be neglected.

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. Referring to Fig. 7, the overall heat transmission coefficient is found to be 0.49 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 Equation 5:

$$x = \frac{28.8 \times 6 \times 0.0749 \times 1200}{0.49 \times 10 \times 70} = 44.4$$

$$t_1 = \frac{120\,(44.4 + 1) - 80}{44.4 - 1} = 123.7$$

Substituting in Equation 3:

$$Q = 0.49 \times 10 \times 70 \left[\left(\frac{123.7 + 120}{2} \right) - 40 \right]$$

$$Q = 28.010 \text{ Btu per hour.}$$

Chapter 44

ELECTRIC HEATING

Resistors, Heating Elements, Electric Heaters, Unit Heaters, Central Fan Heating, Electric Boilers, Electric Hot Water Heating, Heating Domestic Water Supply, Radiant Drying, Reversed Cycle Refrigeration, Auxiliary Electric Heating, Control, Calculating Capacities, Power Problems

ELECTRIC heating is steadily assuming a more important place in heating, ventilating and air conditioning installations, encouraged in many localities by reduced electric rates. Electric heating is flexible, clean, safe, convenient and easy to control. It has many basic principles in common with fuel heating, but there are also important differences. When heat is delivered by wire, no combustion process is necessary, either at a central plant or at the individual room units. The output of an electric heater is a fixed constant, unaffected by the temperature of the surrounding air and it follows that the total load on an electric heating system is the total wattage of connected electric heaters, regardless of weather conditions. The main obstacle to the more general adoption of electric heating for buildings is the cost of the electricity itself.

All heat is a form of energy. Fuels hold stored chemical energy which is released into heat by combustion. Electrical power is a form of energy which can be released into heat by passing it through a resisting material. Both fuel and electric heating have two divisions: *first*, the conversion of energy into heat; *second*, the distribution and practical use of the heat after it is produced.

In converting the chemical energy of fuels into heat by combustion, there is necessarily a considerable variation in thermal efficiency. This is not true, however, when converting electric power into heat, as 100 per cent of the energy applied to the resistor is always transformed into heat. In electric heating practice no concern need be given to efficiencies of heat production, but rather to efficiencies of heat utilization. The problem is to distribute the electrically produced heat units in such manner as to obtain conditions of maximum comfort with the minimum consumption of electricity.

DEFINITIONS

Definitions of general terms used in fuel heating are given in Chapter 47. Terms which apply particularly to electric heating are: