COMPUTING AREA OF HEAT TRANSMITTING SURFACE

The area of the inside surface of a heating coil may be determined from Equation 1.

$$A = \frac{Q \times 8.33\ (t_2 - t_1)}{k_o \times t_m} \qquad (1)$$

where

A = surface area of coil, square feet.
Q = quantity of water heated, gallons per hour.
t_2 = hot water outlet temperature, degrees Fahrenheit.
t_1 = cold water inlet temperature, degrees Fahrenheit.
k_o = coefficient of heat transmission, Btu per hour per square foot surface. For copper or brass coils k_o = 240 (steam) and 100 (hot water). For iron coils k_o = 160 (steam) and 67 (hot water).
t_m = logarithmic mean of the difference between the temperature of the heating medium and the average water temperature and is *approximately:*

$$t_s - \left[\frac{(t_2 + t_1)}{2}\right]$$

t_s = temperature of the heating medium, degrees Fahrenheit.

Equation 1 may be used to check the heating coil ratings under tempera-

TABLE 3. COEFFICIENT OF HEAT TRANSFER OF INSTANTANEOUS WATER HEATERS
k = Btu per hr per sq ft per degree Fahrenheit logarithmic mean temperature difference

BOILER WATER TEMPERATURE	k
210	225
200	175
180	150

ture conditions differing from those stated in the manufacturer's published ratings.

Example 4. What area of copper transfer surface will be required to heat 70 gal per hour from 40 to 180 F with boiler water at 220 F?

$$t_m = \left[220 - \frac{(180 + 40)}{2}\right] = 110 \qquad A = \frac{70 \times 8.33\ (180 - 40)}{100 \times 110} = 7.39 \text{ sq ft.}$$

For instantaneous submerged heaters the surface required will depend upon (1) the velocity of water in the tubes, (2) the boiler water temperature, (3) the inlet water temperature, (4) the outlet water temperature, (5) the cleanliness of the coil surface, and (6) the condition of the boiler water surrounding the coil. If the heater is located in the water of an actively steaming part of a boiler the heat transfer may be twice as great as would be obtained if the water surrounding the coil were circulating slowly. Ratings of instantaneous water heating coils will therefore vary greatly depending upon the assumptions made regarding the conditions of operation. The values of the coefficient of heat transmission for instantaneous heaters shown in Table 3 are conservative.

For a coil in which heat is transferred from steam to water the value of $k = 300\sqrt{v}$ may be safely used (v = velocity of water in feet per second).

The rate of heat transfer between steam or water as the carrier and the domestic water is influenced by the rate of movement of both the carrier

and the water which receives the heat. For this reason, where the transfer occurs from heating system water to domestic water, it is good practice to install a circulating pump to insure rapid movement of the boiler water.

In view of the high condensation rates obtained when steam is used with gravity circulation from the boiler, as when there is a sudden demand followed by an inflow of cold water, the bottom of a steam heating transfer element always should be at least 30 in. above the boiler water line, and the steam and condensate return pipes should be of liberal size. Otherwise water hammer and reduced capacity may result due to imperfect drainage of condensate.

When connecting a transfer-type hot water heater below the water line of a cast-iron steam boiler having vertical sections, there should be a separate tapping for water circulation into every section of the boiler, as shown in Fig. 3, unless the boiler has large top nipple ports providing inter-sectional circulation. If the top nipples are entirely within the boiler steam space, no internal circulation occurs between sections and steaming may occur in any section not connected to the indirect heater and further the unconnected sections will not deliver any heat to the water heater.

COMPUTING GRATE AREA FOR COAL-FIRED HEATER

The grate area required for a small coal-fired water heater may be calculated by Equation 2.

$$G = \frac{W\ (t_2 - t_1) \times 100}{H \times E \times C} \qquad (2)$$

where

G = grate area, square feet.
W = weight of water, pounds per hour.
$t_2 - t_1$ = temperature difference between entering and leaving water, degrees Fahrenheit.
H = heating value of coal, Btu per pound.
C = weight of coal burned, pounds per hour per square foot of grate.
E = efficiency, per cent.

In a small heater 4.5 lb is a conservative value for C, and an efficiency of 60 per cent would represent excellent performance.

Example 5. What grate area is required for a coal-burning water heater warming 100 gal per hour of water from 50 to 180 F, when the combustion rate is 4.5 lb per hour per square foot of grate, if the heating value of the fuel is 12,500 Btu per pound, and the efficiency is 60 per cent?

$$\text{Substituting: } G = \frac{100 \times 8.3 \times (180 - 50) \times 100}{12{,}500 \times 60 \times 4.5} = 3.2 \text{ sq ft.}$$

The quantity of gas, oil, or other fuel required per hour for water heating may be calculated by Equation 3.

$$F = \frac{W\ (t_2 - t_1) \times 100}{H \times E} \qquad (3)$$

where

F = units of fuel (lb, cu ft, gal, etc).
H = heating value of fuel, Btu per unit.
W = weight of water, pounds per hour.
$t_2 - t_1$ = temperature difference between entering and leaving water, degrees Fahrenheit.
E = efficiency, per cent.

Efficiencies for oil and gas may be taken as 75 and 80 per cent respec-