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. t_m is approximately = $t_s - \left[\frac{(t_o + t_i)}{2}\right]$
t_s = temperature of the coil surface, degrees Fahrenheit.

Equation 1 may be used to check the heating coil ratings under temperature conditions differing from those stated in the manufacturer's published ratings.

Example 9. 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?

$$t_m = \left[220 - \frac{(180 + 40)}{2}\right] = 110$$

$$A = \frac{70 \times 8.33\ (180 - 40)}{100 \times 110} = 7.39 \text{ sq ft.}$$

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 is 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 when steam is used with gravity circulation from the boiler and 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. 8. Ordinarily in steam boilers of this type the top connecting nipples between the sections are in the steam space and thus no full internal circulation of water can occur. If a connection to any section is omitted, steaming may take place in that section during summer operation when steam generation is undesirable. Water heating capacity would also be reduced.

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 10. 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?

Substituting: $G = \frac{100 \times 8.3 \times (180 - 50) \times 100}{12{,}500 \times 60 \times 4.5} = 3.2$ 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 respectively. The heating value of the fuel and the temperature rise should be determined to suit local conditions.

CONTROL OF SERVICE WATER TEMPERATURE

Coal-fired boilers are usually controlled by an aquastat located in the heated water, which opens or closes draft dampers at the boiler to adjust the rate of fuel combustion. With oil- or gas-fired boilers the aquastat controls the oil burner motor or the magnetic gas valve. The gas pilot flame usually burns continuously. With electric heaters the aquastat operates a switch on the source of energy.

When steam or hot water is the medium for heating the water in the