proper share of the hot water without the use of balancing valves. However, it is desirable to divide large heating systems into sections and to install valves so that individual sections can be disconnected without interfering with the operation of the system as a whole.

Part II—Radiant Heating

The term *radiant heating* is applied in this chapter to a system in which only the heat radiated from the panel is effective as in outdoor and semi-outdoor conditions.

The outstanding example of radiant heating is the transfer of heat from the sun to the earth. The sun radiates large quantities of energy

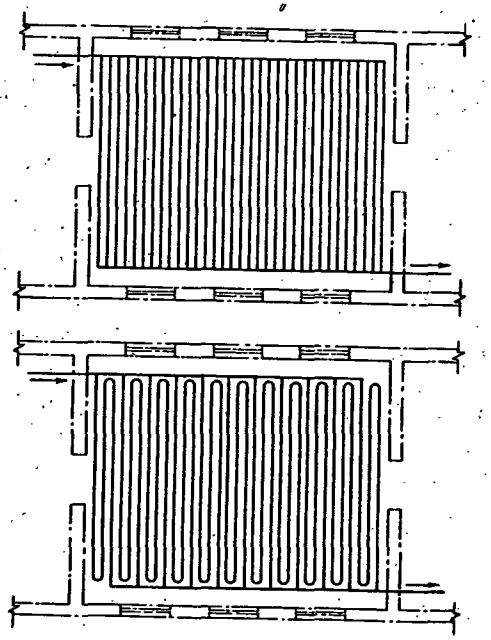


FIG. 10. ARRANGEMENT OF PIPE COIL FOR EVEN DISTRIBUTION OF PANEL TEMPERATURE

of which a very small portion is intercepted by the earth. A part of the intercepted radiation is transformed into heat when it strikes the earth's surface. In this manner *heat* is received by the earth from the sun by *radiation*.

In industry, radiant heating is employed in manufacturing processes, particularly in drying, baking, and dehydrating operations; in agriculture, it is employed to improve living and growing conditions for young plants and young animals.

The heating engineer employs radiant heat primarily in the heating of open-air schools and open-air hospitals. When a surface radiates heat, and every surface does unless its temperature is absolute zero, every point of the surface radiates heat in all directions. The total quantity of heat radiated by a point or by an elementary area is π times the quantity of heat radiated at right angles to the surface.

Thus, if in an elementary cube the upper face is the heating panel, the lower face would receive only about 32 per cent of the radiated energy and the four sides would receive each about 17 per cent.

For larger surfaces the conditions are different. If two parallel plane surfaces of considerable size are near each other, the rate of heat exchange between the two can be determined fairly accurately by means of the chart of Fig. 9. This is possible because the larger part of the heat radiated by one of the surfaces is intercepted by the other surface and only a small portion is radiated in such directions that it will not impinge upon the opposite surface.

As the distance between the two surfaces is increased, the proportion of the heat radiated by one of the parallel plane surfaces and intercepted by the other decreases almost as the square of the distance between the surfaces increases, because the intensity of heat radiation, like the intensity of light radiation, varies inversely as the square of the distance from the source of radiation.

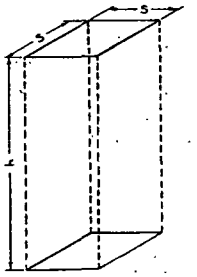


FIG. 11. EFFECT OF HEIGHT UPON RADIATION RECEIVED FROM A PANEL

For the purpose of designing radiant heating systems in which the heating panel is practically square and is radiating heat toward a parallel surface of equal size and shape, as shown in Fig. 11, the rate of heat exchange between the two surfaces will be equal to that shown in Fig. 9, multiplied by a factor, p, which depends upon the ratio of h to s (Fig. 11) as shown in the following table:

h/s =	1	2	3	4	5
p =	0.200	0.070	0.034	0.020	0.013

For example, if a panel 3 ft square is located parallel to, and 9 ft above, a bed in an open-air hospital, and if the temperature of the panel is 112 F and that of the bed is 70 F, the rate of heat transfer from the panel to a 9 sq ft section of the bed directly beneath the panel, will be 3.4 per cent of the rate shown in Fig. 9, or $0.034 \times 9 \times 44$, or 14 Btuh, approximately. The rate of heat transfer from the panel to a section of the bed other than the 9 sq ft directly beneath the panel will be lower than 14/9 Btuh per square foot.

This is a crude way of designing a radiant heating system for an open-air hospital, but it is sufficiently accurate, because the required temperature of the bed and the required rate of heat flow into it will vary with the temperature of the outdoor air, with the air movement over the bed, with the thickness and the character of the bedding, and with the physical condition of the patient.