The sum of these products divided by the sum of the surface areas is: 95,280/1,536 or 62.03 F, the required mean surface temperature.

In the following example, *62 F will be selected as the MRT of walls, glass and floor.*

6. *Determine the temperature of the ceiling panel.*

Determine the temperature of the ceiling so that the ceiling panel will deliver heat to the room at a rate equal to the rate at which the room is calculated to lose heat, namely, 35,117 Btuh.

When a room is heated by means of a panel, air convection currents are developed in the room similar to those which are developed when the room is heated by means of a free-standing radiator. Consequently, the heating panel delivers heat to the room partly by radiation and partly by convection. The proportion of the total heat flow delivered by convection varies with the location of the heating panel, with the height of the ceiling, and with the size, number, and location of pieces of furniture and other articles which interfere with the free flow of air along the floor and along the walls. It is generally sufficiently accurate to assume that a ceiling panel will deliver 70 per cent of its heat by radiation and 30 per cent by convection; a floor panel 55 per cent by radiation and 45 per cent by convection; and a wall panel 65 per cent by radiation and 35 per cent by convection.

In the following example, *it will be assumed that the ceiling panel must deliver 70 per cent of its heat or 24,582 Btuh by radiation*, since the total calculated heat loss is 35,117.

When two plane surfaces of infinite size are parallel to each other and their surfaces are at different temperatures, the exchange of heat between the two is proportional to the difference between the fourth powers of their absolute temperatures. This is also true when one surface is completely surrounded by another surface; for example, if one sphere is placed within another sphere, the flow of heat between the outer surface of the smaller sphere and the inner surface of the larger sphere is proportional to the fourth power of the absolute temperatures of the two surfaces.

In a panel-heated room, the heated panel may be considered to be completely enclosed by the remaining surfaces, because all heat radiated by the heated panel is intercepted by those surfaces. Consequently, the flow of heat from the heated ceiling to the room, by radiation, is proportional to the difference between the fourth powers of the absolute temperature of the ceiling and the absolute mean radiant temperature of the remaining surfaces.

The rate at which a surface emits heat varies with the temperature of the surface and with other characteristics of the surface. For ordinary heat flow calculations it is sufficiently accurate to assume that the materials which are commonly used in building construction emit heat at a rate of:

$$0.156 \left(\frac{T}{100}\right)^4 \text{ Btuh per square foot}$$

where

T is the absolute temperature of the surface in degrees Fahrenheit.

On this basis the flow of heat from the ceiling to its surrounding surfaces is at the rate of:

$$480 \times 0.156 \left[\left(\frac{T}{100}\right)^4 - \left(\frac{522}{100}\right)^4\right] \text{ Btuh.}$$

In order that this rate may be equal to 24,582 Btuh, T must be 572 and the ceiling temperature about 112 F.

Instead of calculating this temperature it may be taken from Fig. 9, as follows: The ceiling must deliver heat to the room, by radiation, at the rate of 24,582/480 or 51 Btuh per square foot. Find 51 on the left margin and move horizontally to the intersection with a 62 MRT line, and from the point of intersection to the lower margin and read about 112 F.

With a ceiling temperature of 112 F, the MRT of the room will be $480 \times 112 + 1{,}536 \times 62$; the sum divided by 2,016, or 74 F.

If an air temperature of 68 F and an MRT of 74 F should not produce satisfactory conditions, the ceiling temperature can easily be changed as necessary by changing the temperature of the circulating water.

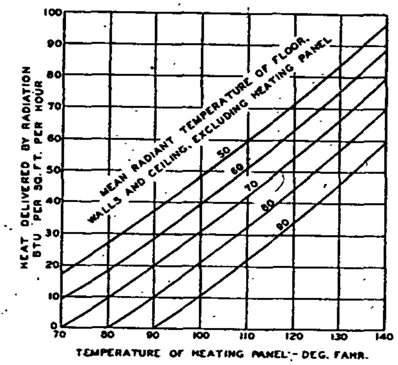

FIG. 9. HEAT DELIVERED TO ROOM BY RADIATION FROM PANEL

Calculations like the preceding may also be made with the aid of Table 2. The rate at which the ceiling must radiate heat exceeds by 51 Btuh per square foot the rate at which the ceiling receives radiant heat from its surroundings. Assuming the emissivity of the walls, floor, and ceiling to be 90 per cent of that of a *black* body, the heat radiated to the ceiling, from the surfaces whose MRT is 62 F, is (Table 2) at the rate of 115.3 Btuh per square foot; the ceiling must therefore radiate heat at the rate of 115.3 plus 51, or 166.3; its temperature must be (Table 2) between 110 F and 120 F, and, by interpolation, 112 F, as calculated.

7. *Select the medium for heating the ceiling panel.*

The medium may be electricity, steam, air, or water, but usually is air or water. If air is used it is generally heated in the basement, passed up through hollow inside walls or through ducts in those walls, allowed to flow between the ceiling and the floor above, and returned to the basement through hollow outside walls or through ducts in those walls.

If the walls and floors are constructed of hollow tile, the cells in the tile can be placed so that they will form continuous ducts through which the warm air can flow up the inside walls, then between the ceiling and