Detailed Computation Method

The area in square feet of each type or temperature of surface, horizontal or vertical, is multiplied by the emission value corresponding to its actual surface temperature. These products are added together to give the total radiant heat effect, inside the room from all surfaces.

The difference between the actual average radiant heat effect and 142 Btu per hour per square foot (the radiation from a surface at 83 F, with an emissivity of 0.95) is the Btu per square foot per hour which would be lost by radiation from a body at 83 F. If the rate, at which it is desired that heat be lost from the body by radiation, be assumed, the mean radiant emission from the walls required to give this desired rate can be determined from Table 1; and multiplying by the total surrounding area will give the desired total radiant heat effect.

The difference between the desired and the actual total radiant emission represents the additional heating effect which must be supplied by the hot surfaces to be installed. The temperature of the proposed hot surface must then be selected, and its emission per square foot at that temperature determined from Table 1. The difference between this emission, and that of the unheated surface, is divided into the total amount of additional heat needed, and the quotient will be the area of the required heating surfaces.

It is evident that this method of calculation depends for its accuracy on a correct estimate of the ultimate surface temperatures naturally attained by the actual wall, window, ceiling and floor surfaces.

Unless positive ventilation with tempered air is provided, the amount of heat given off by convection from the same heating surfaces should also be determined, checked against the tempering requirements of whatever outside air can in any way enter the room, and supplemented if necessary, by additional convection heating, to maintain the desired air temperature. As this air temperature will usually be from 6 to 8 F lower (for comfort) than with purely convective heating, the relative humidity will be appreciably higher at a given dew-point, and there will be a marked saving in fuel for tempering, humidification and conductive heat loss from the building.

Example 1. The surface areas, temperatures, and emissions for a room having a volume of 5760 cu ft are given in Table 2. The figures for temperatures are fairly

TABLE 2. SURFACE AREAS, TEMPERATURES AND EMISSIONS FOR A ROOM OF 5760 CU FT

	Area Sq Ft	Assumed Surface Temperature (Deg Fahr)	Heat Emission (Btu Per Sq Ft per Hour)	Total Heat Emission from Area (Btu per Hour)
External Wall	297	50	110.6	32,850
Glass	279	45	106.5	29,710
Inner Wall	480	55	115.1	55,250
Ceiling	480	55	115.1	55,250
Floor	480	55	115.1	55,250
Total	2016			228,310

representative of American practice with well-built walls, and the heat emission is based on an emissivity of 0.95 which approximates that of most paints and building materials.

The mean radiant emission of the room is 228,310 ÷ 2016 = 113.2 Btu per square foot per hour which, as seen from Table 1 corresponds to an MRT of 53 F for an average emissivity of 0.95.

For an average individual, having a surface area of 15.5 sq ft with an average surface temperature of 83 F, the heat given off by radiation (calculated by means of Equation 1) is 217 Btu per hour, or 14 Btu per square foot per hour. This corresponds to an environmental emission of 142 (the total radiation corrected to 83 deg) −14 = 128 Btu per square foot per hour, and (according to Table 1) to an MRT of 69.2 F, both of which are higher than the actual values available in the room.

In order to determine the amount of radiating surface necessary to maintain the MRT at 69.2 F, ceiling panels are assumed with a surface temperature of 160 F, which is approximately the mean temperature for metal plates heated by hot water.

The 2016 sq ft total area of the surfaces of the room, multiplied by 128 (the emission in Btu per square feet per hour, necessary to balance a body surface temperature of 83 F) gives a total desired emission of 258,048 Btu per hour. Enough radiant heating surface must be installed to increase the total radiant heat emission from 228,310 Btu per hour to 258,048 Btu per hour. The difference between these figures is 29,738 Btu per hour. From Table 1, the emission per square foot at 160 F is 238.8 Btu per square foot, or 123.7 Btu per square foot more than for the unheated ceiling surface (at 55 F). The required radiant heating surface is, therefore, 29,738 ÷ 123.7 = 240.4 sq ft. This surface, suitably placed, would raise the MRT to the degree required for comfort, and maintain it at that value.

Such calculations may be simplified, by preparing tables showing at the usual temperatures the area of hot surface required to bring each square foot of actual wall or other surface up to one or more desired standard MRT's.

MEASUREMENT OF RADIANT HEATING

Convection heating, intended to maintain a given air temperature, is best measured by thermometric methods, which indicate the air temperature, and not the rate of heat loss from the human body. Radiant heating, on the other hand, aims to control this rate of heat loss and can be measured only by calorimetric methods, that is, by determining directly the rate of heat loss from some object, maintained at the surface temperature of the body, irrespective of air temperature. Although a definite BET is needed, the MRT and the air temperatures may both vary in opposite directions provided the sensible heat loss by radiation and convection from a surface at 83 F is maintained constant within reasonable limits.

The apparatus for this purpose consists essentially of a hollow sphere or cylinder, maintained at the accepted mean surface temperature of the human body, together with an accurate means (usually electrical) of measuring the varying rate of heat supply required to maintain this exact temperature. This instrument, the *eupatheoscope*, is readily adapted to function like a thermostat so as to turn heat on or off, when the desired temperature of 83 F, or any other predetermined surface temperature of the vessel, decreases or increases as a result of changes in the BET.

Another instrument, at present available only for British practice as it is designed for a surface temperature of 75 F, consists of a blackened copper sphere of 6 in. diameter, in which a cylindrical sump contains a volatile liquid. A small electric heating coil creates in the sphere a