involves the regulation of the rate of heat loss from the human body in its several forms.

The first step in the calculations for radiant heating of a given room is to determine the desired MRT; the second, to decide on the location of the heated surfaces; the third, to establish the temperature at which the heating surface shall operate; the fourth, to compute the size of the heating surfaces required to produce this MRT; the fifth, to calculate the actual heat loss from the room and to provide, if necessary, any additional convected heat beyond that given off by the radiant surfaces for the required number of air changes. If humidification is required, this must be considered similarly to a conventional air conditioning system, except that the air temperature of the room will be much lower and will therefore require less moisture.

Mean Radiant Temperature

If the entire interior surface of a room were at the same temperature, this would be the MRT. Such a condition seldom exists, because in different parts of a room, some surfaces are exposed to the outer air while others are adjacent to heated rooms. The actual surface temperature varies with the construction and exposure of different sides of the enclosures. It is therefore necessary to calculate the thermal mean of these interior surface temperatures.

This is not the same as the arithmetic average of the various actual surface temperatures, but the radiant temperature which corresponds to the average of the several rates of heat emission (Btu per square foot) from the several surfaces. The emission at any given surface temperature, for any stated emissivity factor can be obtained directly from Table 1, while the emissivity factors for many materials may be found in Table 9 of Chapter 3. For example, from Table 1 it can be determined that if the emissivity of the surface is 0.90 then 1 sq ft of surface at 50 F will emit 104.9 Btu per square foot per hour to surroundings at absolute zero.

Such a determination of the amount of radiant heating surface needed in a room (to maintain a desired MRT) requires knowledge of the type of heating, and of the temperatures of the unheated surfaces. The latter can be estimated from Fig. 6 which is based on an inside air temperature of 70 F. For other air temperatures the inside surface temperature will be proportional to the overall temperature difference. For example if the surface temperature is 60 F based on an inside air temperature of 70 F and an outside temperature of zero, the surface temperature for 65 F air will be 65 ÷ 70 times 60 or 55.7 F. There will be some variation in surface temperature with emissivity, but, except in the case of reflective materials this may be neglected, as the variation due to ordinary building surfaces will be small.

Detailed Computation Method

Assuming the mean surface temperature of the exposed part of the human body and clothing to be 80 F and the emissivity factor to be 0.95, from Table 1 it can be determined that the body surface will give off 139.4 Btu per square foot per hour to absolute zero surroundings. Since the

average human body releases approximately 12.25 Btu per square foot per hour by radiation, the mean radiant emission from the surroundings must be 127.15 Btu per hour with an average emissivity factor of 0.93 which requires an MRT of approximately 71 F. If the body is covered less so that the mean surface temperature of the body is 85 F with an emissivity factor of 0.95, the correct MRT for the room should be 74 F. Consequently, for baths and similar rooms the MRT should be slightly higher than for offices, etc. The mean radiant emission from walls, etc., to give this desired rate can be determined from Table 1. Multiplying by the total surrounding area will give the desired total radiant heat effect. Therefore the MRT for an ordinary living room, office, or similar room to give comfort conditions is 71 F.

The location of the surfaces is generally decided according to the type of building and its use. For high ceilings it is advisable to select floor

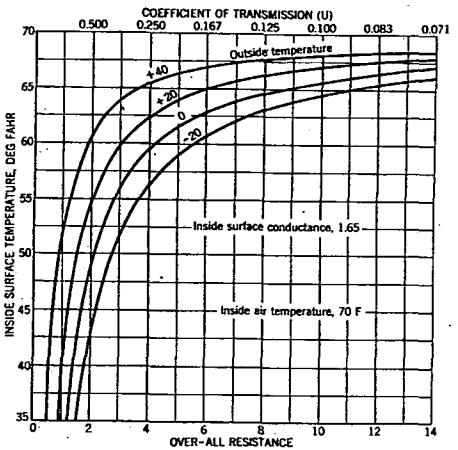

FIG. 6. CURVES FOR ESTIMATING INSIDE SURFACE TEMPERATURES OF OUTSIDE WALLS

heating or install heated panels in the walls at low level. For exposed rooms it may be necessary to have some wall or ceiling panels in addition to floor heating.

The temperature of the surface is controlled somewhat by the location. If the floor is chosen, then hot water pipes should be used as the medium; and the surface temperature should never be more than 85 F unless border heating is used. The latter comprises strips of heated surfaces where occupants will not usually rest their feet, such as portions of the floor adjacent to walls or windows, aisles of churches, halls, etc. If iron panels are used on side walls, etc., a surface temperature up to 160 F may be used with hot water as the heating medium. Vapor or low pressure steam may also be used with a maximum surface temperature of 180 F. For ceiling or other plaster heating, hot water pipes should be used with a maximum water temperature of 130 F giving a surface temperature of about 115 F.