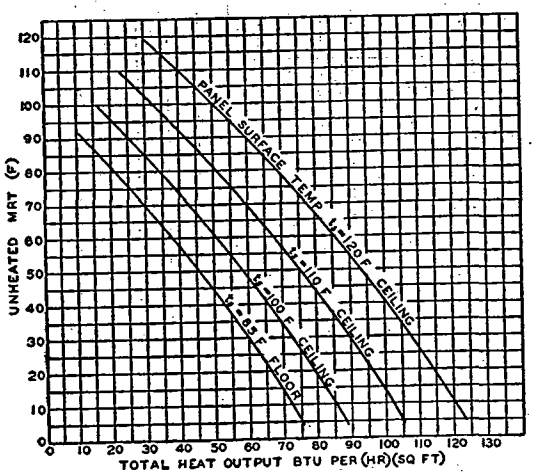
Example 2: Find the combined total useful heat transfer from a square foot of ceiling panel having a surface temperature of 100 F, when the average room air temperature is 70 F and the mean radiant temperature UMRT of the unheated room surfaces is 60 F.

Solution:

	Btu/(hr)(sq ft)
Radiation (Fig. 9 for UMRT of 60 F and t_s of 100 F)	35.3
Convection (Fig. 10, Curve B for a Δt of 30 F)	15.5
Total useful heat transfer	50.8

Since the greater number of panel installations are designed for an average room air temperature of 70 F, it is possible to present in chart form (see Fig. 11) the relationship between panel output (radiation plus convection) and the unheated mean radiant temperature for various surface temperatures and panel positions based on 70 F inside air temperature.



Output based on 70 F inside air temperature

FIG. 11. TOTAL PANEL OUTPUT RADIATION PLUS CONVECTION

From Fig. 11 the panel output for *Examples* 1 and 2 can be read directly, 38.3 and 50.8 Btu, respectively. Similarly, combined transfer rates for floor or ceiling panels operating under other conditions may be determined from Fig. 11, or from Figs. 9 and 10.

Before Figs. 9 and 11 can be used, the unheated mean radiant temperature UMRT of the room surface must be known. For the purpose of this work, the UMRT may be defined as the average temperature of the unheated surfaces of the space, weighted according to the areas of the surfaces.

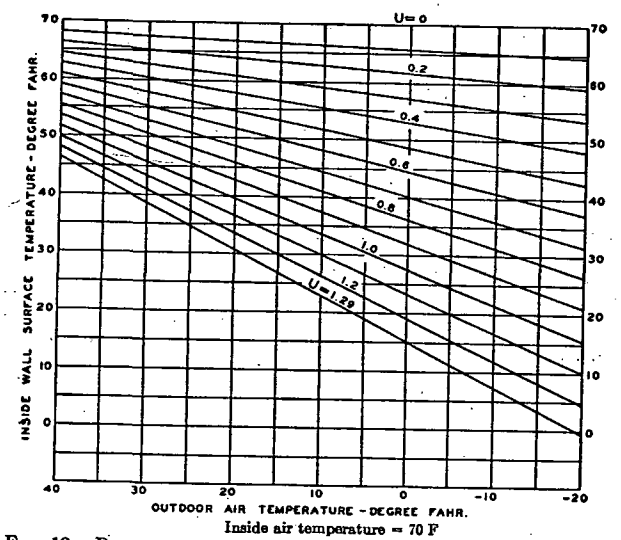
The surface temperature of the inside walls may be assumed to be the same as the inside air temperature. The surface temperatures of outside walls or exposed ceilings, for any combination of outside design temperature and transmission coefficient, may be obtained from Fig. 12. If the inside design temperature is other than 70 F, the values determined from

Fig. 12 must be corrected by values obtained from Fig. 13. The following example illustrates the use of Figs. 12 and 13.

Example 3: The outside walls of a room have a coefficient of heat transfer $U = 0.15$. Inside and outside design air conditions are 68 F and −20 F, respectively. Determine the inside surface temperature of the wall.

Solution: From Fig. 12 the inside surface temperature for 70 F and −20 F, and a U value of 0.15 is found to be 61.5 F. Then from Fig. 13, for a $\Delta t = -2$ deg and a U value of 0.15, the correction is −1.8 deg. As the correction is negative, the inside surface temperature will then be 61.5 − 1.8 = 59.7 F. The total panel output can then be determined from Figs. 9, 10, and 11.

After the various wall surface temperatures have been determined, as described, the unheated mean radiant temperature UMRT of the space



Inside air temperature = 70 F

FIG. 12. RELATION OF OVERALL COEFFICIENT OF HEAT TRANSFER TO INSIDE SURFACE TEMPERATURE

may be calculated as illustrated in Step 3 of the following section on Floor Panel Design Illustration.

FLOOR PANEL DESIGN ILLUSTRATION

The several steps in the design of a panel heating system are listed and illustrated in the following example of the design of a floor panel for the room shown in Fig. 14.

1. *Selection of Design Conditions*

   a. Outside design temperature, −10 F.
   b. Inside design room air temperature, 70 F.
   c. In this problem a floor panel heating system will be used. No basement. Insulation will be used between slab and fill.
   d. Heating medium, hot water.
   e. Floor surface temperature, 85 F (Maximum).