TABLE 2. CALCULATION OF UMRT

SURFACE		AREA SQ FT	INSIDE SURFACE[a] TEMPERATURE F	PRODUCT (AREA x TEMPERATURE)
Outside walls	0.10	272	65	17,680
Adjacent inside walls	—	352	70	24,640
Ceiling	0.08	480	66	31,680
Glass	0.55	80	43	3,440
Total		1,184		77,440

$$\text{UMRT} = \frac{\text{Total of products}}{\text{Total area}} = \frac{77{,}440}{1{,}184} = 65.4\text{ F}$$

[a] Values of inside wall surface temperature for various U values and outside design temperatures found in Fig. 12.

4. *Determination of Panel Output*

Values of total panel output for various panel positions, panel surface temperatures and unheated MRT are given in Fig. 11. From Fig. 11, with a floor panel surface temperature of 85 F and a UMRT of 65.4 F, the total panel output is 34 Btu per (hr) (sq ft of panel surface).

Panel area = 24 x 20 = 480 sq ft
Panel output = 480 x 34 = 16,320 Btu per hr

This panel output of 16,320 Btu per hr is reasonably close to the calculated room loss of 17,063, and is satisfactory. If this value of total heat output from panel to the room were much less, *i.e.*, 10 or more percent less, than the calculated heat loss from the room, some method of supplementary heating would be needed. Floor panel surface temperatures exceeding 85 F are not recommended.

5. *Determination of Panel Input and Water Temperature*

Fig. 15 presents a graphical method of determining the required water temperature and total heat input to a panel for various cover depths, tube or pipe sizes and spacings, and rate of heat output to the room.

The panel output for this example has previously been found to be 34 Btu per (hr) (sq ft). Since some of the heat input to the panel is lost to the ground, it is necessary to supply more than 34 Btu per (hr) (sq ft) to the panel by means of the hot water heating medium. The amount of heat which must be supplied to the panel to give the required output may be determined graphically from Fig. 15. Assume that the panel has $\frac{3}{4}$ in. pipes, spaced on 12 in. centers, and that the depth of cover from top of panel surface to top of pipes is 2.5 in. The four sections of Fig. 15 are marked Part 1 to Part 4 and, as will be evident by following the dashed line on the chart, are used as follows:

Part 1. Starting from the depth of cover (2.5 in.), proceed vertically to the line representing pipe spacing on centers (12 in.), and then horizontally to the first ordinate of Part 2.

Part 2. Move parallel to the nearest upward sloping line, indicating "2 in. & over" cover, to intersect the ordinate representing $\frac{3}{4}$ in. pipe, and then proceed horizontally to the first ordinate of Part 3.

Part 3. Proceed parallel to and along the nearest downward sloping line to an intersection with the ordinate representing the panel output (34 Btu per sq ft), and then move horizontally to the right hand scale of Part 3 and read a required average water temperature in the coil of 106 F.

Part 4. From the water temperature 106 F just found in Part 3, proceed horizontally into Part 4 to intersect the line representing insulation between the slab and fill. Directly below this intersection read 1.09 (on the bottom scale) as the multiplier to be used.

The required panel input is, therefore, 1.09 x panel output, or 1.09 x 34 = 37.1 Btu per (sq ft) (hr).

The total required panel input is 37.1 x panel area = 37.1 x 480 = 17800 Btuh.

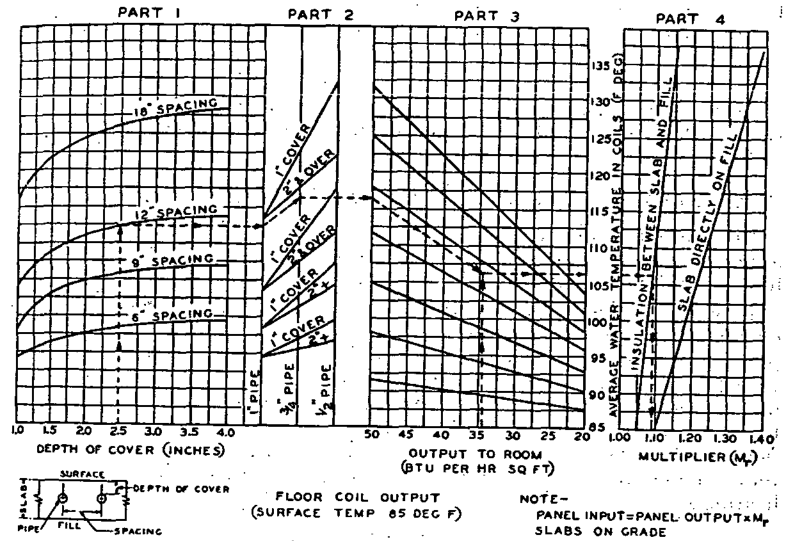

FIG. 15. RELATION OF WATER TEMPERATURES AND COIL OUTPUTS TO COIL SPACING AND DEPTH OF BURY FOR FLOOR COILS IN SLABS ON GRADE

CEILING AND WALL PANEL DESIGN

Where coils are embedded in plaster on ceilings or walls, design procedure is simplified considerably by the physical limitations of the space available. For tube fastened to the underside of lath, the largest practical size is $\frac{5}{8}$ in. O.D., while for ferrous pipes above the lath, it is 1 in. I.P.S. Therefore, the actual tube or pipe size selected is usually determined by the length of coil circuit and its flow resistance in consideration of the available circulating head.

In order to obtain a reasonably even heat distribution over the finished plaster heating surface, pipes or tubes should be spaced on about 6 in. centers, and not over 9 in. centers. Within these limitations it is found in practice that heat output rates do not vary too seriously with variations in pipe and tube size and tube spacing.

In general, for plaster ceiling panels with tubes or pipes spaced on $4\frac{1}{2}$ to 9 in. centers, the temperature of the circulating water is about 10 to 25 deg above the desired surface temperature.

The hourly heat output per square foot of panel surface may be found by means of Figs. 11, 12, and 13, and the calculations for room heat loss and UMRT, as previously illustrated in the example of floor panel design.

HOT WATER PIPING

When water is used as the heating medium, the piping layout and arrangement should be based on the design principles outlined in Chapter 22 for Two-Pipe Forced Circulation Systems. The pressure drops through the coils should be carefully calculated, and it is recommended that all branch circuits and coils be balanced to provide for uniform distribution by means of regulating valves or tees. Generally, a 15 to 20 deg total