

ferent. For example; a 10 deg temperature drop may be used in the main with a 20 deg drop through the radiation.

Example 2: A one-pipe system is to be designed for the residence discussed in Example 1. Fig. 10 shows the piping arrangement for the one-pipe system. The size of the convectors is determined on the basis of a 210 F design supply water temperature and a 20 deg design temperature drop as in Example 1.

Solution: For initial selection of pump use a 1-in. pump having a capacity of 5 gpm at 4.7 ft head. The measured pipe length is 140 ft which establishes an equivalent length of $140 \times 1.5 = 210$ ft. The preliminary design friction loss is then found in Table 1, as in *Example 1*, to be $2\frac{3}{4}$ ft/per 100 ft or 270 mi/ft. At this average design friction loss, see Table 1, a 1-in. main will be used for the required flow of 5 gpm.

From manufacturers' data at 5 gpm flow, the pressure drop from a 1-in. fitting is established at 3000 mi or 0.25 ft. If any heating units are located below the main

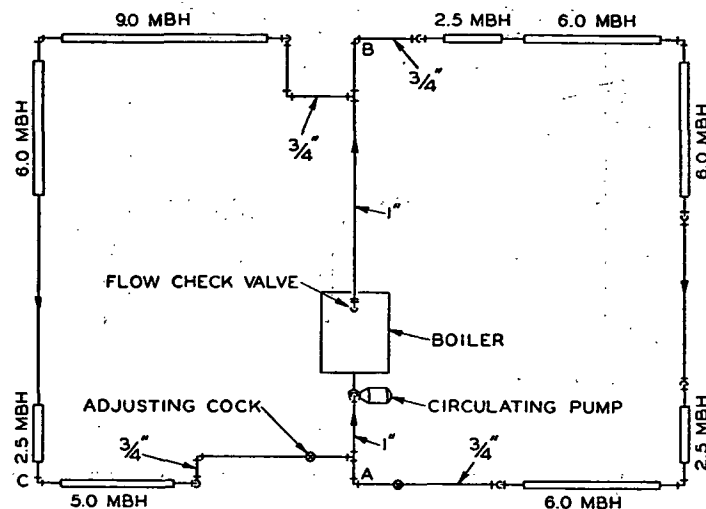


FIG. 11. A SERIES-LOOP SYSTEM

the gravity head due to temperature difference should be subtracted from available fitting pressure drop. In this example, the riser and convector friction pressure drop should not exceed 3000 mi or 0.25 ft.

The friction loss through the $\frac{1}{2}$ -in. risers to the 9.8 Mbh convector was calculated to be 0.28 ft or 3450 mi in *Example 1*. This loss plus the 0.1 ft (1200 mi) loss in the convector, equals 0.38 ft (4650 mi) which exceeds the capacity of the fitting. If $\frac{3}{4}$ -in. risers are used, however, the riser pressure drop is considerably reduced. For 9.8 Mbh flow the pipe friction drop is 0.34 ft for 100 ft (40 mi per ft). The equivalent length changes from 22 to 26 ft. The riser pressure drop is then 26×0.34 or 0.09 ft (26 $\times$ 40 or 1040 mi). The head loss through the convector circuit is then $0.09 + 0.1$ or 0.19 ft (2240 mi). Since this is below the available fitting pressure drop, the riser size is satisfactory.

Other upfeed risers are similarly sized.

The downfeed riser is sized as follows:

... The design conditions are 200 F water in the supply main and a 70 F room temperature. The centerline of the convectors is 5½ ft below the main. The thermal head initially caused by 200 F water in one riser and 70 F water in the other opposes circulation. From Chart Fig. 1 this negative gravity head is shown to be 420 mi per foot, 420 mi. $\times$ 5.5 ft = 2300 mi total negative gravity head. Subtracting this from the 3000 mi fitting pressure drop leaves 700 mi available to start circulation. The com-

bined convector and riser pressure drop equals 1380 mi even when a 1-in. riser is used. Since the convector and riser pressure drops are greater than the available fitting head; a change must be made. The total fitting pressure drop could be increased by adding a supply one-pipe fitting, or by increasing fitting pressure drop through use of a larger pump. In this case, the riser is sized on the basis of an added fitting. In accordance with the sizing procedure followed in this example, a 3/4-in. riser is adequate.

The pipe sizes selected should be recalculated at the design flow rates either in milinches as shown in the upper part of the following table or in feet per hundred feet as shown in the lower part of the table.

SECTION	PIPE SIZE IN.	LOAD MBH	LOSS PER FOOT OF PIPE MI	LINEAR PIPE LENGTH Ft	ELBOW EQUIV. LENGTH Ft	TOTAL EQUIV. LENGTH Ft	TOTAL FRICTION LOSS MI
Main . . .	1	50	240	140	87*	227	54,500
8 one-pipe fittings at 3000 mi**							24,000
Total							= 78,500 6.55 ft

SECTION	PIPE SIZE IN.	LOAD MBH	LOSS PER 100 FT OF PIPE Ft	LINEAR PIPE LENGTH Ft	ELBOW EQUIV. LENGTH Ft	TOTAL EQUIV. LENGTH Ft	TOTAL FRICTION LOSS Ft
Main ...	1	50	2.0	140	87*	227	4.54
8 one-pipe fittings at 0.25 ft head**							2.0
Total							6.54

* The elbow equivalent length is based on: 8 elbows, 2 tees, 2 gate valves, 1 flow check valve and 1 boiler.

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The pump capacity required is 5.0 gpm at 6.54 ft head. The 1½ in. pump shown in Fig. 9 would meet the requirements of the system based on the assumptions stated for the problem.

Series-Loop System—Description and Design

This system, illustrated in Fig. 11, consists of one or more loops or circuits. In each circuit, as the same water is circulated through the heating units in succession, the size of pipe should not vary materially in any portion of a circuit. The system circuit length thus becomes very important because it influences directly the water flow rate, pressure drop, and temperature drop. Since the water temperature in each successive heating unit decreases progressively, some designers consider it necessary to increase progressively the size of heating units sufficiently to compensate for the drop in temperature. If a small design temperature drop, such as 20 deg or less is used, it may not be necessary to increase the heating units toward the end of the circuit.

Various considerations affecting the design of a series-loop system are given in the following paragraphs:

1. It may be possible to eliminate all or large sections of the distribution main and thereby reduce cost. In large buildings it may be necessary to use a partial two-pipe main in combination with the series-loop system for certain sections or divisions of the building.
2. The practicability of the system will depend upon the quantity of water to be circulated through the heating units and the friction loss. Baseboard or finned-type pipe elements for series-loop systems are usually manufactured from standard steel pipe or copper tubing. The friction loss can be determined from Figs. 3 and 4.
3. If a series-loop system serves more than a single space, and if the design temperature drop for the system is in excess of 20 deg, the size of the heating unit should be determined on the basis of the temperature of the water entering the particular heating unit and the temperature drop across the unit. The temperature drop