connections are made so that water travels from top to bottom in one coil and from bottom to top in the other.

The design of a two-pipe reversed-return system will be illustrated by *Example 1*.

Example 1: Design a two-pipe reversed-return hot water heating system for a 37 x 29 ft one-story residence with basement having a heat loss of 50 MBh (50,000 Btu per hr). The heating units are to be convectors operating with a supply water temperature of 210 F and a 20-deg temperature drop. The piping layout and location of convectors are shown in Fig. 8.

Solution: A 50 MBh load with a 20-deg drop requires a water circulation of 5 gpm. The length of the reversed-return circuit is determined as 138 ft of pipe, by following the supply from the boiler to point *G* Fig. 8 and the return from point *N* back to the boiler. The estimated total equivalent length is 138 × 1.5 = 207 ft. This, plus an allowance of the equivalent of 25 ft of pipe for one convector circuit results in a total equivalent length of pipe of 232 ft. Fig. 9 shows that a 1-in. pump has a capacity of 5 gpm at 4.7 ft available head. The preliminary average design friction loss is then 4.7 × 100/232 or 2 ft per 100 ft of pipe (240 milinches per ft). This value can also be determined by reference to Table 1, where, using the vertical column under 5 ft, the next larger equivalent length to 232 ft is 250 ft. To the right in this line read the average design friction loss as 2 ft per 100 ft or 240 milinches per foot.

The piping may be sized initially from Table 1 as follows: In the friction loss column find the value 2 ft per 100 ft. Proceed to right in the same line to the nearest gpm value and then read the pipe size at the top of the column.

The pipe sizes found by this method for the various sections of Fig. 8 are shown in the following table:

Section	MBh	Gpm	Pipe Size Inches
Supply			
A–B	50	5.0	1
B–C	43.5	4.35	1
C–D	36	3.6	¾
D–E	30	3.0	¾
E–F	25	2.5	¾
F–G	18	1.8	¾
G–H	8.2	0.82	½
Return			
I–J	6.5	0.65	½
J–K	14	1.4	½
K–L	20	2.0	¾
L–M	25	2.5	¾
M–N	32	3.2	¾
N–O	41.8	4.18	1
O–A	50	5.0	1

The risers to the convectors may also be sized for the same average friction loss, 2 ft/100 ft or 240 milinches per foot, as follows:

Convector No.	1	2	3	4	5	6	7
Load MBh	6.5	7.5	6.0	5.0	7.0	9.8	8.2
Gpm	0.65	0.75	0.60	0.5	0.7	0.98	0.82
Pipe size	½	½	½	½	½	½	½

After the initial pipe sizes have been selected the friction loss in the system should be recalculated as indicated in the following table. The highest pressure drop circuit should be marked off into sections; each of a different flow rate. The total equivalent length of each section should then be determined by adding its elbow equivalent length (see Tables 2 and 3 and Fig. 7) to its actual measured length. Total friction loss is established from

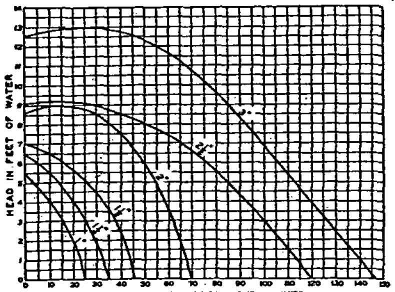

Fig. 9....Performance Chart for Circulating Pump

charts or tables for each section by multiplying its total equivalent length by the actual friction loss per foot at design flow. The circuit friction pressure drop is the summation of individual section pressure drops as shown in Table 4.

If the total friction loss as determined does not agree with the pump head, some pipe size changes will be necessary to obtain closer agreement. The slight difference in head calculated by milinches and by feet of head is due to use of only 2 significant figures for the latter. This is well within the accuracy required.

As would be expected the calculated head of 4.02 ft is different from the 4.7 ft estimated. This is due to two factors: (1) the difference between the actual and estimated number of fittings and (2) the differences between actual and estimated losses in the different sections as the friction losses were generally below the average friction loss assumed.

The 1-in. pump initially selected would be entirely satisfactory for the installation and would produce a flow slightly in excess of 5 gpm. A procedure to determine the actual flow and head capacity of the pump and system is discussed under Circulating Pumps.

One-Pipe System, Description and Design

The one-pipe system, Fig. 10, has a single main for both supply and return. Special fittings installed at the connections to radiation risers or runouts generate the head necessary to produce flow through the heating unit. In this system the main or circuit loop does not change size from the first to the last radiation unit. The amount of water flowing in the main is constant, except at points where some of it is bypassed through radiation. Since the water temperature in the main drops progressively, some designers consider it necessary to increase the size of heat-transmitting surface accordingly by using a progressively lower design water temperature in sizing the heating units. Most one-pipe heating systems are designed, however, on the basis of a single design water temperature. Generally, the theoretical increase in heat-transmitting surface is needed only when the system is operating at full design output. A water temperature drop in the main of 20 deg or less minimizes the capacity reduction effect.

In comparison with a two-pipe system, the one-pipe system:

1. Permits simpler piping due to the use of one main of uniform size.
2. May be more acceptable when pipe is exposed in occupied spaces.
3. Is very adaptable to small systems or to individual loops in large systems, either horizontal or vertical, as a part of a two-pipe system, or to obtain zone control in large combination systems.
4. May be lower in installation cost.
5. Has a simpler problem in regard to water-flow adjustment.

Table 4....Calculation of Actual Friction Loss for *Example 1*

Section	Flow MBh	Flow Gpm	Friction Loss (Fig. 3) Ft/100 Ft	Friction Loss (Fig. 3) Mi/Ft	Pipe Size In. (Fig. 3)	Fittings Type	Fittings Equiv Ft[b]	Pipe Length Ft	Total Equiv Length of Pipe Ft	Friction Loss Calculation	Friction Loss Mi[c]	Friction Loss Ft
BC	43.5	4.35	1.5	180	1	1 ell	2.4	14	16	0.16 × 1.5 16 × 180	2880	0.24
CD	36.0	3.6	1.0	120	1	—	—	15	15	0.15 × 1.0 15 × 120	1800	0.15
DE	30.0	3.0	2.5	300	¾	1 ell	1.9	8	10	0.10 × 2.5 10 × 300	3000	0.25
EF	25.0	2.5	1.8	210	¾	—	—	10	10	0.10 × 1.8 10 × 210	2100	0.18
FG	18.0	1.8	1.0	120	¾	—	—	14	14	0.14 × 1.0 14 × 120	1680	0.14
GN	9.8	0.98	1.2	150	½	3 ells 1 ¾ in. tee 1 1 in. tee 1 Rad. V	3.6 3.4 4.8 3.6	8	23	0.23 × 1.2 23 × 150	3500	0.26
NO	41.8	4.18	1.4	170	1	1 ell	2.5	31	34	0.34 × 1.4 34 × 170	5780	0.48
OB	50.0	5.00	1.9	230	1	3 ells 2 tees 2 Gate valve 1 Flow valve 1 Boiler	7.5 10.0 2.5 50.0 7.5	38	116	1.16 × 1.9 116 × 230	26700	2.20
Convector friction loss[a]											1200	0.10
Total friction loss											48590	4.02

[a] Data obtained from manufacturers' catalogs.
[b] See also Tables 2 and 3 and Fig. 7.
[c] Mi = milinches.

Continuing the comparison with two-pipe systems some disadvantages of one-pipe systems are:

1. The amount of water which can be bypassed by a one-pipe fitting or fittings is limited by the economics of design and the head applied. The fittings are not generally used to provide the water flow necessary for large air-handling units having a high pressure drop.
2. The pump head required is slightly higher than that required for a two-pipe reversed-return system of similar flow requirements.
3. If the progressive increase of radiation size as temperature drops is taken into account, a design complication and additional cost factor are encountered.
4. The main flow design temperature drop should not exceed 20 deg.

Design of a One-Pipe System

The basic design premise of a one-pipe system is that the pressure drop of the one-pipe fitting, or fittings, at the required main flow, be equal to or greater than the radiation circuit pressure drop at its required flow. The system may be divided into two or more loops for smaller main pipe sizes and pumps. Main and radiation circuit temperature drops may be different. For example, a 10-deg temperature

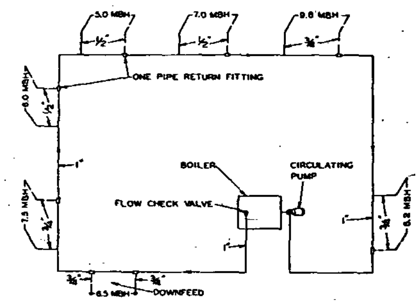

Fig. 10....A One-Pipe System

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 × 1.5 =