TABLE 6. TABULATED DATA FOR EXAMPLE 7

CIRCUIT	LOAD MBH	PIPE LENGTH FT	ELBOWS NO.	EQUIVALENT LENGTH FT	SIZE IN.	UNIT FRICTION MILINCHES PER FT	TOTAL FRICTION, MILINCHES
0-1	3600	65	1.8	78	6	100	7800
1-2	3150	130	0	130	5	180	23,900
2-3	2700	130	0	130	5	150	19,500
3-4	2250	130	0	130	5	100	13,000
4-5	1800	130	2	142	4	210	29,800
5-6	1350	130	0	130	4	125	16,200
6-7	900	130	0	130	3½	113	14,700
7-8	450	130	0	130	2½	190	24,700
8-16	450	Estimated Friction Head					20,000
16-17	3600	65	1.8	78	6	100	7,800
17-18	7200	130	0	130	8	90	11,670
						Total	188,570

the water flowing through the radiator farthest from the boiler, as illustrated in Fig. 14. In a direct return system the radiators are connected so that all water returns to the boiler along the most direct path after it has passed through its radiator, as illustrated in Fig. 15.

Example 7. In Fig. 14, sixteen air conditioning units, each demanding 450 Mbh, are to be supplied with water from a central plant. The system is divided into two equal parts as shown. Each part supplies eight units and has, therefore, eight circuits. The total length of each of the eight circuits is about 1170 ft.

Solution. If the total *fh* is to be about 15 ft, the unit *fh* must be about 150 milinches per foot. With this preliminary estimate, pipe sizes may be selected from Fig. 3 and recorded with corresponding calculations as shown in Table 6 for Circuit 8, from which it appears that the *fh* of this circuit is 188,570 milinches, or 15.7 ft.

In order that each of the eight air conditioning units may receive an equal supply of water, the *fh* of each of the remaining circuits must also be 15.7 ft. Since all pipe sizes have been selected as shown in Example 6, any adjustments that may be necessary must be made in the connections from the main through the air conditioning unit and back to the main. For Circuit 8 the friction head through the air conditioning unit was assumed to be 20,000 milinches. For Circuit 4, for example, a tabular calculation like that for Circuit 8 shows that the *fh* for Section 4-12 must be 19,700 milinches in order that the total *fh* may be 15.7.

This is practically equal to the 20,000 *fh* assumed for Circuit 8 and this shows how simple it is to secure well-balanced circuits in a reversed return system.

Example 8. The direct return, forced circulation system shown in Fig. 15 is similar to Fig. 14, except that the water passing through Unit 1 returns directly to the boiler and the total length of this circuit is about 130 ft, whereas, the total length of Circuit 8 is about 1990 ft, or about 15 times as long.

Solution. The design must begin with Circuit 8. The calculations for this circuit if tabulated as shown for Circuit 8 of Fig. 14 will show that the total *fh* is 318,200 milinches, or 26.5 ft, as compared with 15.7 ft for the reversed return system.

In order that each of the eight units will receive its correct share of the water, the *fh* of each of the other seven circuits must also be 26.5 ft. For Circuit 1, for example, the total *fh* for Section 0-1 and 16-17 is 15,600 milinches; hence, the *fh* in Section 1-16 (through the air conditioning unit) must be 302,600 milinches, or 25.15 ft to prevent Unit 1 having an advantage over Unit 8.

Comparing the reversed return system of Fig. 14 with the direct return system of Fig. 15, it appears that the head against which the pump must deliver the 720 gpm is 15.7 ft as compared with 26.5 ft for the direct return and that the installation of the reversed return would require 130 ft of 8 in. pipe not necessary for the direct return system. The *fh* in the lines joining the pump to the pipe system shown in Fig. 14 and 15 is not included in this calculation.

Chapter 17

DISTRICT HEATING

Steam Distribution Piping, Selection of Pipe Sizes, Provision for Expansion, Capacity of Returns with Various Grades, Conduits for Piping, Pipe Tunnels, Inside Piping, Steam Requirements, Fluid Meters and Metering, Rates, Utilization, Automatic Temperature Control

THOSE phases of district heating which frequently fall within the province of the heating engineer are outlined here with data and information for solving incidental problems in connection with institutions and factories. Some data are included to cover the piping peculiar to heating systems which are to be supplied with purchased steam. A complete district heating installation should not be attempted without a thorough study of the entire problem by men competent and experienced in that industry.

STEAM DISTRIBUTION PIPING

The methods used in district heating work for the distribution of steam are applicable to any problem involving the supply of steam to a group of buildings. The first step is to establish the route of the pipes, and in this matter the local conditions so fully control the layout that little can be said regarding it.

Having established the route of the pipes, the next step is to calculate the pipe sizes. In district heating work it is common practice to design the piping system on the basis of pressure drop. The initial pressure and the minimum permissible terminal pressure are specified and the pipe sizes are so chosen that the required amount of steam, with suitable allowances for future increases, will be transmitted without exceeding this pressure drop. The steam velocity is therefore almost disregarded and may reach a very high figure. Velocities of 35,000 fpm are not considered high. By the use of this method the pipe sizes are kept to a minimum with consequent savings in investment.

The steam flowing through any section of the piping can be computed from a study of the requirements of the several buildings served. In general a condensation rate of 0.25 lb per hour per square foot of equivalent heating surface is a safe figure. This allows for line condensation which, however, is a small part of the total at times of maximum load. Miscellaneous steam requirements such as laundry, cooking, or process should be individually calculated.

The steam requirements for water heating should be taken into account,