division point of two sections because the Section *H-A* conveys the heat for all three radiators, whereas Section *A*-1 carries only the heat for Radiator 1.

For a similar reason *B* must be a division point. The reason for selecting 1 as a division point is that it is often necessary to select a different pipe size for Section *A*-1 than for Section 1-*B*, in order to secure the proper friction head for Radiator 1. If it were certain that the pipe size for Section *A*-1 could be the same as that for Section 1-*B* the pipe line from *A* to *B* could be called one section; since it is impossible to know in advance what the pipe sizes leading to and from the radiator must be, it is best to make the radiator the division point of two sections.

2. Having divided the several circuits into sections prepare a table, like Table 48, and record there the designations of the several sections, the quantity of heat conveyed by each section, and the number of feet of pipe and the number of elbows or elbow equivalents in each section. All of this information should be obtained from the plans for the heating system. In Fig. 35 is shown only a diagrammatic representation of the system to illustrate the general arrangement. In this case a number of elbows, valves, air valves, and the expansion tank are omitted in order to simplify the drawing. For the actual design, a complete drawing, such as that shown in Fig. 36, must be available or the designer must be sufficiently familiar with the proposed installation to be able to insert the correct pipe length and the correct number of elbows or elbow equivalents in the description of each section, as recorded in Table 48.

3. Calculate the pressure head available for the circuit by means of Fig. 32 and record it in the table.

4. Calculate the pipe sizes for the several sections by means of Figs. 33 and 34 so that the sum of the friction heads in all the sections composing any one circuit is equal, to the pressure head available for that circuit.

TABLE 48. CIRCUIT I*

Pressure head = 7 × 90 = 630 *m.s.*

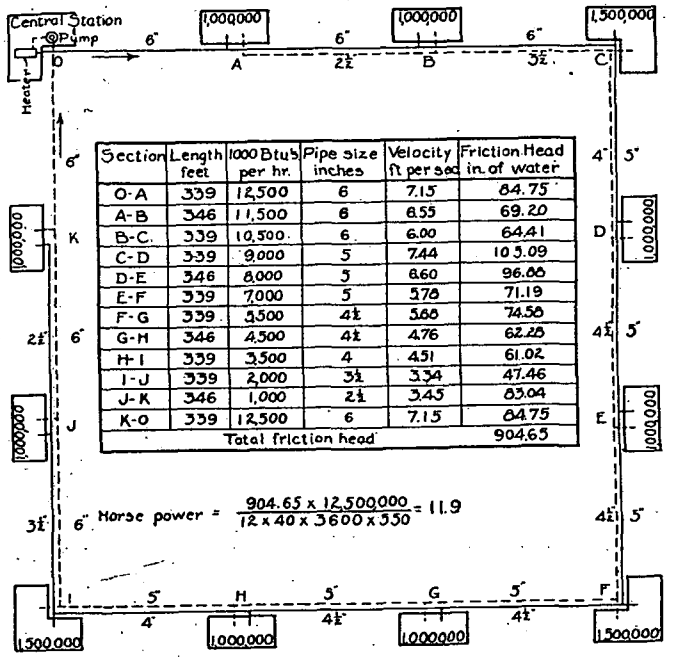
SECTION	B.T.U.	FEET ELBOWS	ASSUMED DIAMETER IN.	UNIT FRICTION	TOTAL FRICTION	SELECTED DIAMETER IN.	UNIT FRICTION	TOTAL FRICTION
H-A	30,000	8.67	1½	12	104	1½	.....	104
		3.5			122			122
A-1	10,000	1.2	1¼	35	4	1¼		4
		5.5		3.5	41			41
1-*B*	10,000	2.67	1	7.5	33	1¼	3.5	9
		7.5		12.5	183		7.5	56
B-H	30,000	10.7	1½	24.5	128	1½		128
		4.5		12	157			157
				35				
Total					772			621

*The calculations for Circuits II and III are made and recorded in a similar manner.

FORCED CIRCULATION

In designing the pipe lines for forced-circulation systems, the same methods and formulas are used to determine pressure heads and friction heads which are used in the design of gravity-flow systems, with the one exception that in forced-circulation systems the force producing the necessary pressure head is supplied partly or entirely by a pump.

The designing engineer should determine, in every case, what portion, if any, of the force necessary to produce the required pressure head will be supplied by gravity. For example, in a central heating system;



Section	Length feet	1000 Btu's per hr.	Pipe size inches	Velocity ft per sec	Friction Head in of water
O-A	339	12,500	6	7.15	84.75
A-B	346	11,500	6	6.55	69.20
B-C	339	10,500	6	6.00	64.41
C-D	339	9,000	5	7.44	105.09
D-E	346	8,000	5	8.60	96.66
E-F	339	7,000	5	5.76	71.19
F-G	339	3,500	4½	5.66	74.56
G-H	346	4,500	4½	4.76	62.26
H-I	339	3,500	4	4.51	61.02
I-J	339	2,000	3½	3.34	47.46
J-K	346	1,000	2½	3.45	63.04
K-O	339	12,500	6	7.15	84.75
Total friction head					904.65

FIG. 37. CENTRAL HOT WATER HEATING SYSTEM SUPPLYING GROUP OF ELEVEN BUILDINGS

the pump may supply the entire pressure head for the distributing mains while gravity may supply all or part of the pressure head for the service lines in the several buildings.

In forced-circulation systems, the pressure head caused by the difference in density of the water, and which maintains circulation in gravity-flow systems, is generally small when compared with the pressure head produced by the pump. It may be neglected in the design if it is less than 20 per cent of that produced by the pump.

To illustrate, let it be required to determine the pipe size for the central hot-water heating system shown in Fig. 37.