divided by 231 (total equivalent length of short branch) = 306 milinches per foot which is 66 milinches per foot more than is available in the longer circuit. Therefore approximately 12 per cent more capacity is available in the pipes which will change the pipe size only a slight amount. If it is necessary to correct this variation, a stop cock may be placed in the return line of the short branch and adjusted after installation.

However, if the variation be of sufficient magnitude, the pipes in the shorter branch should be sized accordingly. In this case the pipe size should be selected according to a frictional loss of 240 milinches per foot. Due to the fact that Section *BJ* requires a capacity of 57 Mbh, which is slightly over 1 in., use a 1 in. pipe in *BJ* and *QR*. Section

TABLE 2. CAPACITIES OF PIPES IN *Mbh* (1000 BTU PER HOUR) AND **Velocities of Water in Pipes in Inches per Second** FOR FORCED CIRCULATION SYSTEMS WITH A TOTAL FRICTION HEAD OF 2 FT AND FOR A MAXIMUM TEMPERATURE DROP OF 10 F[a]

1	2	3	4	5	6	7	8	9
Pipe Size (Inches)	Equivalent Length of Pipe (Feet[b])	Equivalent Total Length of Pipe in Feet in Longest Circuit						
		100	150	200	250	300	350	400
		Unit Friction Head, in Milinches						
		240	160	120	96	80	69	60
½	1	*6.2* **15**	*4.8* **12**	*4.1* **10**	*3.4* **9**	*2.9* **8**	*2.6* **7.5**	*2.4* **7**
¾	2	*13.2* **18**	*10.3* **14**	*8.6* **12**	*7.3* **11**	*6.2* **10**	*6.0* **9**	*5.5* **8.5**
1	2.3	*25.0* **22**	*19.2* **17**	*16.3* **15**	*14.4* **13**	*12.5* **12**	*12.0* **11**	*11.1* **10.5**
1¼	3.0	*52.8* **27**	*40.8* **21**	*34.8* **18**	*31.2* **16**	*27.8* **15**	*26.4* **14**	*24.0* **13**
1½	3.5	*79.2* **30**	*60.7* **23**	*51.2* **20**	*45.6* **18**	*40.8* **16**	*40.0* **15**	*36.0* **14**
2	4.0	*153.8* **36**	*120.0* **28**	*104.0* **24**	*93.5* **22**	*86.4* **20**	*81.5* **18**	*73.8* **17**
2½	6.0	*250.0* **41**	*192.0* **32**	*164.5* **28**	*149.0* **25**	*139.2* **22**	*135.8* **21**	*122.5* **19**
3	6.5	*444.0* **48**	*348.0* **37**	*294.0* **32**	*270.0* **29**	*254.0* **26**	*240.0* **24**	*223.0* **22**

[a]For other temperature drops the capacities of pipes are to be changed correspondingly. For example, for a temperature drop of 30 F, the capacities shown in this table are to be multiplied by 3. The velocities remain unchanged.

[b]Approximate length of pipe in feet equivalent to one elbow in friction head. This value varies with the velocity.

JK has a load of 47 Mbh which is approximately 1 in. Therefore use 1 in. in *JK* and *PQ*. *KL* carries 35 Mbh which is approximately halfway between ¾ and 1 in. Use ¾ in. in *KL* and 1 in. in *OP*. Section *LM* requires a capacity of 20 Mbh, therefore use ¾ in. in *LM* and *NO*. Size radiator branches as previously described.

Many times a ½ in. pipe will prove to be too large, but at the present time it seems to be general practice to avoid pipes smaller than this size, especially for hot water installations.

If a number of heating systems are to be designed for similar conditions, *i.e.*, for a total friction head of 6 ft and a temperature drop through the radiators of 20 F when the maximum quantity of heat is being delivered

to the building, a table such as Table 3 may be prepared from the data of Fig. 4. Having this table, the pipe sizes for the system of Example 1 can be easily selected. For example, for Sections *AB* and *RI*, each supplying 85 Mbh, the equivalent pipe length of the system is 299 ft. In the table the length shown nearest to this length is 300 ft. In the 300-ft column, a 1-in. pipe is too small and a 1¼-in. pipe is too large. The 1¼-in. pipe will therefore be selected. For other systems, it will be economical to operate with different friction heads, and tables may be prepared similar

TABLE 3. CAPACITIES OF PIPES IN *Mbh* (1000 BTU PER HOUR) AND **Velocities of Water in Pipes in Inches per Second** FOR FORCED CIRCULATION SYSTEMS WITH A TOTAL FRICTION HEAD OF 6 FT AND FOR A MAXIMUM TEMPERATURE DROP OF 10 F[a]

1	2	3	4	5	6	7	8
Pipe Size (Inches)	Equivalent Length of Pipe (Feet[b])	Equivalent Total Length of Pipe in Feet in Longest Circuit					
		200	300	400	600	800	1000
		Unit Friction Head, in Milinches					
		360	240	180	120	90	72
½	1	*7.4* **18**	*6.0* **15**	*5.0* **13**	*3.8* **10**	*3.4* **9**	*3.1* **7.5**
¾	2	*15.8* **22**	*12.7* **18**	*10.8* **16**	*8.4* **12**	*7.7* **11**	*6.7* **9**
1	2.5	*30.0* **27**	*24.0* **22**	*20.4* **19**	*15.8* **15**	*13.9* **13**	*12.5* **11**
1¼	3.3	*64.8* **33**	*52.5* **26**	*44.4* **23**	*33.6* **18**	*30.0* **16**	*26.8* **14**
1½	4.0	*96.0* **37**	*76.8* **31**	*64.8* **26**	*50.1* **20**	*44.7* **18**	*40.8* **15**
2	5.0	*192.0* **44**	*153.0* **36**	*130.0* **30**	*100.1* **24**	*90.0* **21**	*78.0* **18**
2½	6.0	*300.0* **50**	*244.0* **41**	*206.0* **35**	*161.0* **26**	*144.0* **24**	*130.0* **21**
3	7.5	*550.0* **58**	*436.0* **48**	*368.0* **42**	*287.0* **32**	*249.0* **27**	*228.0* **24**

[a]For other temperature drops the capacities of pipes are to be changed correspondingly. For example, for a temperature drop of 30 F, the capacities shown in this table are to be multiplied by 3. The velocities remain unchanged.

[b]Approximate length of pipe in feet equivalent to one elbow in friction head. This value varies with the velocity.

to Tables 2 and 4, which are based on total friction heads of 2 and 18 ft, respectively.

Example 2. Design a direct return two-pipe forced circulation system for the layout shown in Fig. 5 assuming a temperature drop of 10 F through the radiation. For this system the length of the pipe line from the boiler to the highest radiator on the farthest riser and back to the boiler is about 250 ft. There are about 16 elbow equivalents having an equivalent pipe length of about 50 ft, so the total equivalent pipe length is about 300 ft.

Solution. The same pipe size tables may be used as those developed for the reversed return system of Fig. 3, Table 3 which provides for a friction head of 6 ft.