Using the prices shown in Table 5, the cost of the 1,600 ft. of mains shown in Fig. 11, is $3,193. Assuming the life of the main to be 20 years and the interest rate 6 per cent, the cost of the main is $278 per year.

TABLE 5. APPROXIMATE COST OF COVERED PIPE INSTALLED IN TUNNEL

SIZES—INCHES	2	2½	3	3½	4	4½	5	6	8	10
Cost per Foot....	$0.75	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.75	$4.50	$6.25

The power required to circulate the water through the main is 150,000 × 15.9, or 2,385,000 ft. pounds per hour, or 1.2 hp. Assuming that the power required to circulate the water through the central plant is 15 per cent of the amount stated, that the efficiency of the pump is 75 per cent, and that the cost of current is 2½ cents per kilowatt-hour, the cost of circulating the water is 3.44 cents per hour, or $144 per year if the pump is to be operated 20 × 30 × 7, or 4,200 hours a year.

After completing two additional calculations similar to the one just described, for the system in which the largest pipes in the main are 4 in. and 6 in. respectively, the following results are obtained:

LARGEST MAIN, INCHES	VELOCITY IN SAME INCHES PER SECOND	TOTAL FRICTION IN FEET	ANNUAL COST	ANNUAL COST OF CIRCULATION	COMBINED COST
4	93	34.8	$221	$316	$537
5	58	15.9	278	144	422
6	40	6.47	340	59	399

This comparison assumes that the cost of the pump is practically the same in the three cases and that the cost of forcing the water through the six buildings remains constant.

Optimum Velocity of Water in Forced Circulation Systems

Based upon these assumptions, the system having the 6-in. main with a velocity of 40 in. per second in that main is the most economical to install.

For this installation the cost of circulating the water would be about 2 per cent of the cost of the heat, if the latter is estimated at 50 cents per 1,000,000 B.t.u., and if it is further assumed that the average heat demand will be one-half of the maximum, *i.e.*, that the average will be 1,500,000 for the plant which was designed for a maximum demand of 3,000,000 B.t.u. per hour.

In a manner similar to that described before, every forced circulation system should be analyzed before definite pipe sizes are adopted.

In large installations it may be found advantageous to transport the heat from the central plant to the central point of a group of buildings by means of high-pressure steam and to install at this central point a heat exchanger and a circulating pump.

Effect of Location of Expansion Tank on Pressure in Forced System

In most central heating systems it is necessary to use an expansion tank. Such a tank is generally installed near the circulating pump and on its suction side; the pump being located in the return line near the heater. With such an arrangement, the pressure in the main remains

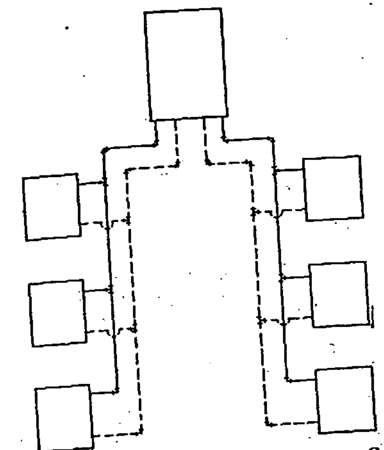

FIG. 12. TWO-PIPE, DIRECT-RETURN, FORCED CIRCULATION SYSTEM FOR SIX BUILDINGS

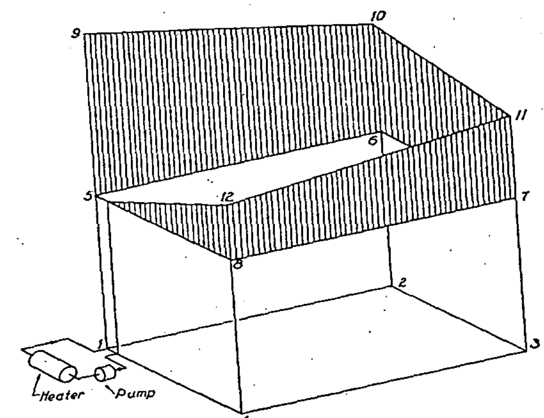

FIG. 13. INFLUENCE OF THE CIRCULATING PUMP UPON THE PRESSURE IN THE FLOW MAIN

constant at the suction side of the pump; it rises sharply in the pump and then decreases gradually along the main, as indicated in Fig. 13. In this figure, the line 1, 2, 3, 4, is a base line; the line 5, 6, 7, 8, is a line parallel to the base line drawn so that the distance 1 to 5 represents the pressure in the main when the system is not in operation. This pressure is determined by the elevation of the expansion tank and must be such that