companies are doing this at the present time and others are building properties to operate along this plan.

Regarding the second point, distribution, in waterworks or in gas properties the losses from distribution consist of leaks and pressure drops due to friction which is caused by insufficient pipe capacities. In central heating there are these two losses to contend with, and in addition the loss from radiation, called "line loss" by central heating engineers. Leaks are a decided detriment to heating pipe line, and the loss from this source is probably more serious than was at first supposed. Assume, for example, a hole ¾ in. in diameter in a pipe line containing steam at 5 lb. pressure. With an evaporation of 7 lb. of water per lb. of coal, this leak will cost 23 tons of coal per month. A leak of this size is equally as detrimental in a hot-water heating system. The loss from friction affects, of course, the initial pressure to be carried on the heating mains, and consequently affects the back pressure to be carried on the engines.

As to the detriment of too high a friction loss, in a 3-in. steam line 1,000 ft. long, carrying 1,000 lb. of steam per hour, the friction loss will be equal under average conditions approximately to 1,460 B.t.u. per hour. This same load carried 1,000 ft. in a 3½-in. line will show a friction loss equal approximately to 500 B.t.u. and a 4-in. line under the same conditions will lose only 240 B.t.u. from friction.

The radiation loss from central heating is even more important than friction loss, from the B.t.u. standpoint. There is a number of styles of underground insulation in use to-day, which lose anywhere from 0.03 lb. to 0.38 lb. of steam per sq. ft. of underground surface per hour.

In order to determine the most economical line to install it is necessary to combine the friction and radiation losses. Take, for example, a demand of 1,000 lb. of steam per hour which must be carried 1,000 ft. A 3-in., 3½-in., 4-in. or 4½-in. pipe will do this work, but the most economical size must be determined. The loss from friction would be 1,460 B.t.u. per hour on the 3-in. line; 500 B.t.u. on the 3½-in. line; 250 B.t.u. on the 4-in. line and 130 B.t.u. on the 4½-in. line.

Assume a radiation loss of 0.05 lb. of steam per sq. ft. of underground surface per hour; the radiation loss from the 3-in. line will be approximately 45,000 B.t.u. per hour; 3½-in. line approximately 52,000 B.t.u.; 4-in. line approximately 58,000 B.t.u.; 4½-in. line approximately 65,000 B.t.u. Combining these two losses, it is seen that the 3-in. line is the most economical to install, provided it does not affect the heating station conditions by causing excessive back pressure on the engine.

Experience has shown that a 3-in. line carrying this load the given distance will have a drop in pressure of about 7 lb., and as it is necessary to have 1 lb. pressure at the end of the line, it means that the back pressure at the station would be approximately 8 lb. If this pressure is excessive it would be necessary to run a 3½-in. line, which would give a back pressure of less than 5 lb. The difference in cost between a 3-in. and a 3½-in. line is comparatively small. The cost of material is somewhat less for a 3-in. line; the cost of labor is approximately the same.

To show the value in dollars and cents of efficiency in underground insulation, a piece of line insulated with a construction that will lose 0.05 lb. of steam per sq. ft. of underground surface per hour may be compared with a line insulated with a construction that will lose 0.14 lb. per sq. ft. per hour. Both constructions are found in everyday practice. For this purpose an 8-in. line 1,000 ft. long will be considered. Such a pipe has 2.25 sq. ft. of surface per lineal foot. In the first case the line loss will amount to 112 lb. of steam per hour; in the second case to 215 ft. Assuming a generation cost of 30 cents per 1,000 lb., in a season's operation (from October 1 to June 1, or 5,832 hours) a line loss in the first case will equal $195 per year and in the second case $550 per year.

The money saved, therefore, will be the difference between these two figures, or $355 per year. This is 10 per cent. on $3,550, an amount which can be spent to install the more efficient construction. Since the difference between these line losses is 0.09 lb. of steam per sq. ft. of underground surface per hour, and since the example assumed consisted of 1,000 ft. of 8-in. line, which is 2,250 sq. ft. of surface, it is seen that for every 0.01 lb. of steam saved on this 8-in. line, approximately $400, or 20 cents per sq. ft. of underground surface, can be spent.

Another interesting example is the comparison of two insulations on an entire underground heating installation. This installation consists of approximately 800 ft. of 12-in. pipe line, 1,200 ft. of 10-in. pipe line, 3,600 ft. of 8-in. pipe line, 4,200 ft. of 6-in. pipe line, and 7,300 ft. of 4-in. line and surface. The number of square feet of underground surface in this system is equal approximately to 30,000 sq. ft. Comparing two insulations, one with 0.04 loss and one with 0.09 loss (difference 0.05) by the following formula which the author has derived, the more efficient insulation in this case will be worth $30,000 more than the less efficient:

$$N \times S \times L \times C$$

where N = the difference between the two insulations in hundredths of a pound of steam lost per hour

S = the number of square feet of surface per lineal foot of pipe

L = the length of pipe

C = a constant based upon the cost of steam per thousand pounds and the number or hours in the heating season.

Where the steam costs 30 cents per 1,000 lb. and the heating season is 5,900 hours, the value of C is 21 cents.

Regarding the third point, making the service attractive to the consumer, it is not necessary, perhaps, to wrap it up in a good looking package, but it is necessary to have it attractive in price and quality. That this class of service is attractive is shown by the fact that central heating plants, with few exceptions, have had no trouble holding their consumers. It is this one fact, as much as anything else, that has put many heating plants into trouble. They have been tempted to serve a larger territory or more consumers than their plants could economically handle, and they have been tempted also to extend their service without due regard to the economics of the proposition.

As to the best method of selling the heating service, experience has shown that the meter basis is the most equitable. The rate will depend upon local conditions. A number of companies are selling steam on the meter basis, with a sliding scale rate; others have devised a maximum demand or readiness to serve rate, both of which work out admirably in practice. The quality of the service is always sufficiently attractive to obtain a large percentage of the possible consumers.