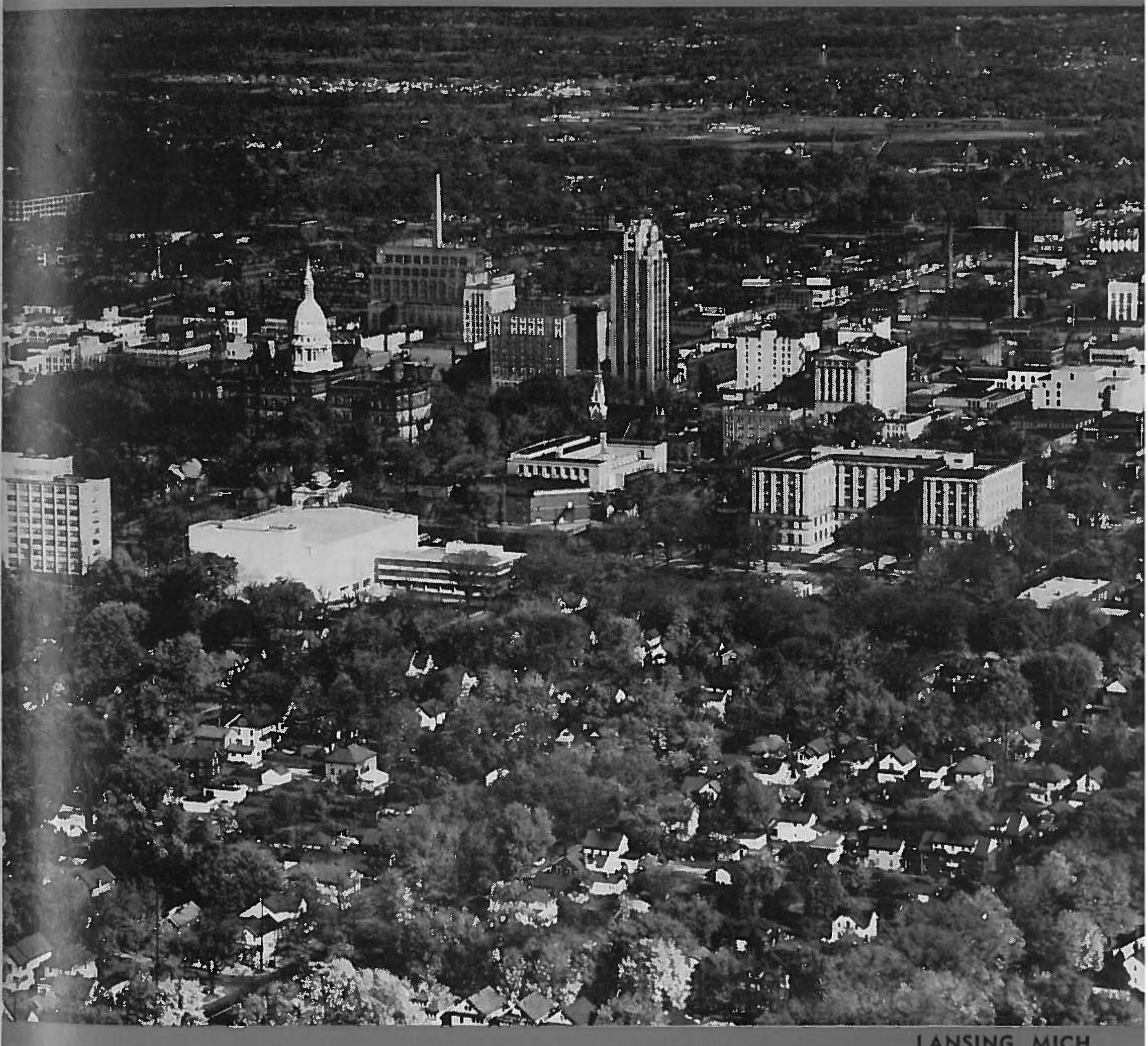
DISTRICT HEATING

Office

PUBLISHED QUARTERLY SINCE 1915

JULY 1959 — VOL. XLV, No. 1



LANSING, MICH.

AN OFFICIAL PUBLICATION OF THE NATIONAL DISTRICT HEATING ASSOCIATION

District Heating in Copenhagen, Denmark

Dr. techn. A. K. Bak, Managing Director
Johannes Hansen, Engineer, District Heating Service
The Copenhagen Lighting Department

(Continued from April Issue)

Duct System

The greater part of the street mains are laid in concrete ducts of the type shown in Fig. 7. Sides and bottom of the ducts are made of 12 cm (4¾ in.) reinforced concrete. Under the bottom is a drain pipe and drainage system of pebble gravel. The steel pipes are all welded and pressure tested. Insulation is made with cell-concrete having a specific weight of not over 300 kg per m^3 (18.7 lb per cu ft). Before the cell-concrete is poured the pipes are wrapped with corrugated paper. Two or three days after pouring the cell-concrete the

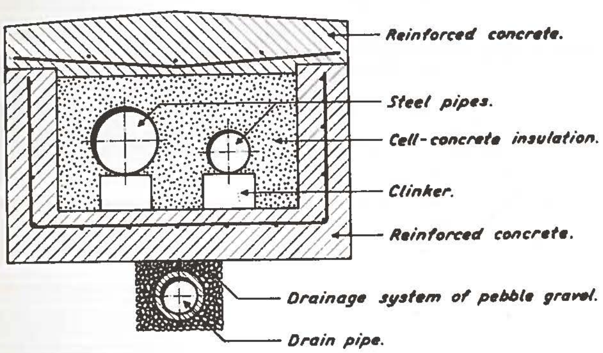


FIG. 7—Conduit Cross Section.

cover is cast in 12-15cm (4¾ in. - 6 in.) thick reinforced concrete. The cover is made in sections about 1 m (about 3 ft) long to facilitate access later in case of repair work. The thickness of the insulation depends on the diameter of the pipe and whether steam or water is circulated. On steam mains the thickness is for 400 mm (16 in.) diam. pipe 240 mm (9½ in.) and for 200 mm (8 in.) pipe 160 mm (6⅝ in.). On water mains the thickness is for the same pipe sizes 160 mm (6⅜ in.) and 125 mm (5 in.) respectively.

This type of duct has proven very satisfactory, it has the disadvantage, however, that it takes a

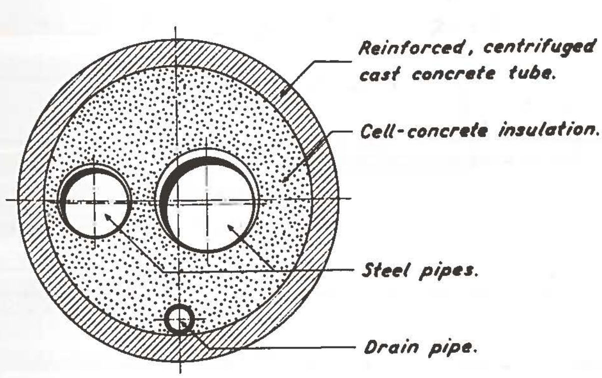


FIG 8—Prefabricated Conduit.

long time before the trench can be closed and the street remade. In recent years, therefore, a new construction with prefabricated elements has been used in streets with heavy traffic.

This design is shown in Fig. 8. The outer tube is made in a factory of reinforced, centrifuged cast concrete, each tube being about 5 m (16′) long. The tube is filled with insulating cell-concrete, holes being made for the steel pipes, to be inserted later and possibly for a drain pipe. The cell-concrete does not have sufficient strength to carry the weight of the steel pipes, it is necessary, therefore, to install bricks of a stronger concrete to take the weight of the pipes. Tubes have socket joints, tightness being obtained with rubber rings. The tubes are fabricated and ready at the factory before starting the field work. When this commences the trench is dug, the tubes installed and lined up and the trench filled again. For installing the pipe lines there must be a hole at each end of the line. At one end the pipes are welded and pressure tested, at the other end is mounted a winch for hauling the pipes through the tubes.

In special cases tunnelling has to be made.

It might be mentioned that in other places in Denmark a different type of prefabricated tubing has been used to some extent on warm-water systems. This type is shown in Fig. 9. The outer tubing is made in two halves of about 2.5 m (8 ft) length and in reinforced concrete. After mounting the steel pipes, the top half is installed, tightness for water being obtained by cement mortar. Vertical joints are socket joints with cement mortar.

The insulation here also is cell-concrete.

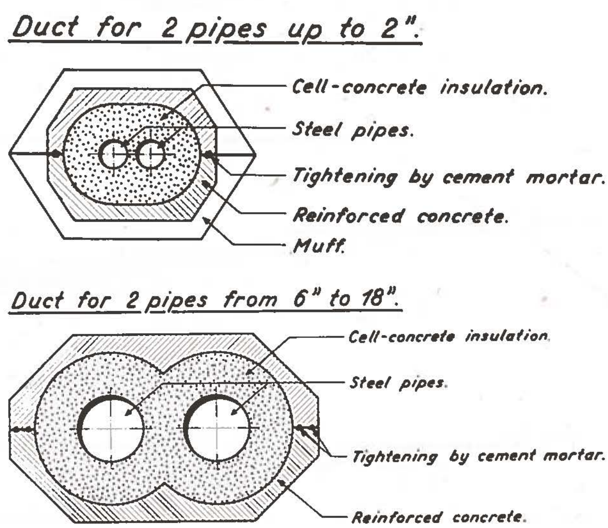


FIG. 9—Duct for Two Pipes Up to Two Inches.

Metering

Steam System

Where steam is supplied to heat exchangers or evaporators and all condensate is returned to a storage tank, condensate meters of the drum type are used for measuring the steam supplied.

When supplying steam to industrial undertakings, where some of the steam may be used for process work, steam flowmeters are employed. As the heating system is operated with varying steam pressure, a pressure-reducing valve is installed in the steam line to the customer to maintain the desired pressure. The steam flowmeter is installed after the pressure-reducing valve. The latest type of steam flowmeters used is equipped with automatic adjustments for pressure and temperature, the meter reading being automatically corrected for smaller variations in pressure and temperature. A charge is made for condensate not returned to the system. Steam flowmetering is, therefore, supplemented by a meter on the condensate returned.

Warm Water System

Until a few years ago heat supplied by warm water was determined for each customer by measuring through a water meter the amount of water circulated, by recording the temperature of the incoming and outgoing water, and from these data the average temperature difference was determined, and finally the heat supplied calculated. This method is rather cumbersome and requires considerable work if a reasonable degree of accuracy should be obtained and therefore is not satisfactory. Much work has been done on developing a heat meter, and different designs have been brought on the market. In recent years we have commenced using such heat meters, which from our experience so far have a satisfactory degree of accuracy and require only reasonable service and maintenance work. The meter consists of a water meter of the usual rotating type, and mounted on it what is termed a "calorimeter head" with two long-distance thermometers. The principle of one of the meters used is shown in Fig. 10. The water meter is

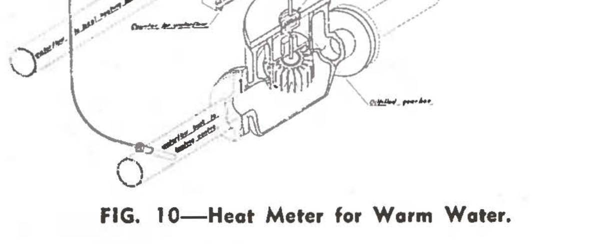


FIG. 10—Heat Meter for Warm Water.

installed in the return line from the customer to the street main. The thermometer bulbs are installed in the incoming and return pipes. The two thermometers act in such a way on a lever system that the temperature difference is obtained, and through a special mechanism this difference is multiplied by the flow of water and the result given on a counter. The meter head has two counters, one showing the water circulated in m^3 and the other the quantity of heat supplied in kcal; it has also an indicator showing the temperature difference of the water. Fig. 11 shows a photograph of the meter, and Fig 12 shows a photograph of the "calorimeter head" of another make of meter, in which not the temperature difference, but the temperatures of both incoming and return water are indicated.

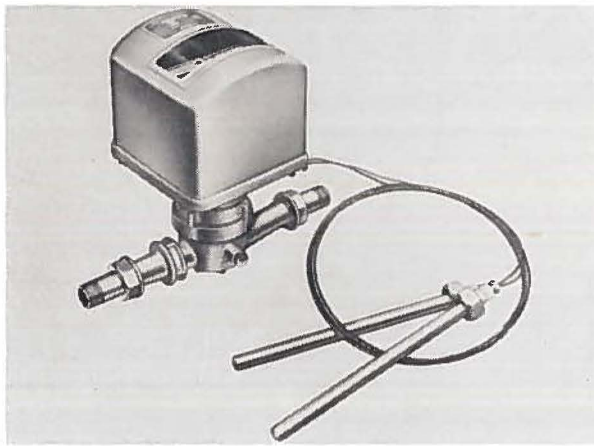


FIG. 11—Heat Meter for Warm Water.

For the water meter is specified a test pressure of 10 kg/cm^2 (142 psig) and a maximum allowable water temperature of 95 C (203 F). As for the accuracy of the heat meter, it is required that the temperature difference of the meter determined by dividing the heat recorded by the meter by the water recorded by it, must not deviate more than $\pm$0,2 C ($\pm$ 0.36 F) from the temperature difference determined by direct measurement in the incoming and outgoing pipe lines. All meters are tested for accuracy on a special test stand before being placed in service.

As the heat consumption and, therefore, the amount of water circulated is much smaller in summer than in winter usually two water meters are installed, as also indicated on the diagram Fig. 5, a small one for summer use and a larger one for the winter, thereby obtaining a more accurate determination of the heat supplied. The calorimeter head is then mounted on the large water meter in the winter season and on the smaller meter in the summer.

As mentioned before, the heat meters have proven satisfactory; they are, however, as yet somewhat expensive for smaller installations.

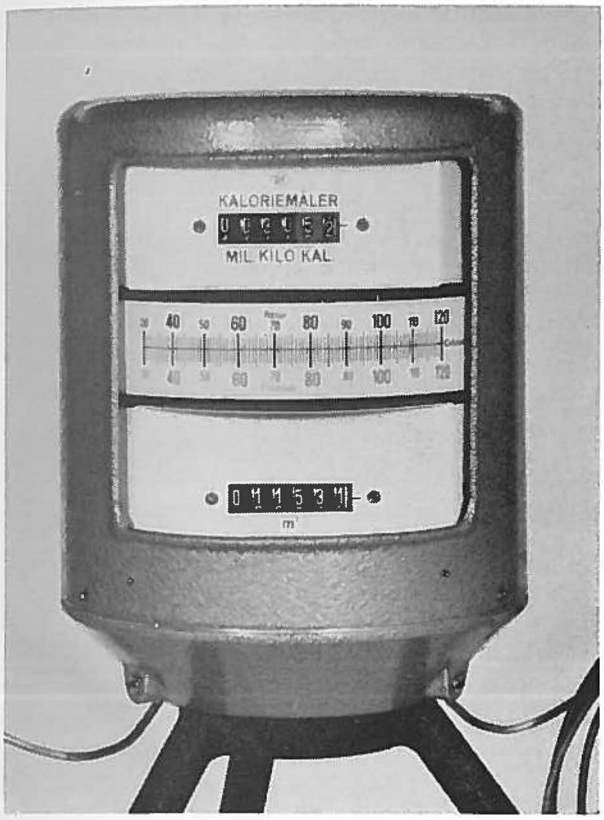


FIG. 12—Colorimeter Head for Heat Meter, Warm Water.

In several other district heating systems in the country using warm-water distribution a more simplified system of metering has been in use for many years. Here the total amount of heat supplied to the system or to a group of customers on the same mains is determined usually by a water meter and recording thermometers.

At each customer a water meter is installed for metering the quantity of water circulated, and the heat supplied is apportioned according to the water circulated. This system is, of course, simpler and cheaper; it may, however, give unreasonable differences in the customers' payments for heat unless the heating system of the various houses are designed to give about the same cooling of the water and are operated in about the same way.

Tariffs

A three-element tariff is used containing

1) a meter charge
2) a charge in proportion to connected load
3) a charge for the heat supplied.

1) The meter charge is a fixed charge of from 35 to 135 kroner ($5 to $19.6) each quarter, depending upon the size of the meter and the kind of service rendered (steam or warm water).

2) The load charge is also a fixed charge of 3.50 kroner ($0.50) each quarter for each 1,000 kcal (3,986 Btu) conected load. The connected load is determined by calculation from the size of the heat exchangers, radiators etc. installed.

3) The heat charge is payment for the heat metered to the customer. On steam supply the heat is calculated as 0.6 x 10^6 kcal (2.39 x 10^6 Btu) for each m^3 condensate. On warm-water service the heat supplied is measured as described above. The heat charge has both fuel and labor cost clauses giving automatic adjustment of the price with changes in fuel and labor costs. The total charge is now 25.20 kroner per 10^6 kcal ($0.92 per 10^6 Btu) with fuel costing 11.75 kroner per 10^6 kcal ($0.43 per 10^6 Btu).

On the steam supply a charge is also made for condensate not returned to the system. This charge is about $0.56 per ton of water.

In some of the places using the simpler metering system mentioned before a slightly different tariff system is in use. This system has also three elements, namely:

1) An annual meter charge covering the expenses of meter reading, billing, maintenance costs, etc.

2) An annual charge in proportion to the size of the building served. This charge is a fixed amount per m^3 building volume, and the size usually is such as to cover the fixed charges for interest and depreciation on the costs of the district heating system as well as the operating and maintenance costs of the system.

3) A heat charge based on the amount of water metered in the return line. This charge is to cover the cost of producing the heat, the distribution losses, pumping costs, etc. The average unit cost is calculated as the total costs divided by the total m^3 water circulated.

Conclusion

A few references have been made to district heating systems in other towns. Outside Copenhagen five of the main generating stations located at or near large towns have established combined power-heat generation and district heating supply, in all cases using warm water at maximum 100 to 110 C (212 - 230 F) for distribution. In one case the power plant is located 4 km (2.5 miles) outside the town; here the warm water is pumped with a pressure of 15 kg/cm^2 (213 psig) to a central distributing point in town. Central heating plants have also been established in a large number of smaller towns and also in villages; in some cases these plants are coupled to diesel-engine plants utilizing the heat from cylinder jackets and in the exhaust gases. It is estimated that for the year 1957/58 about 400 mill. kwh has been generated in back pressure operation in connection with district heating. This corresponds to about 10 per cent of the total electricity consumption of the country.