OFFICIAL PROCEEDINGS

FORTY-SIXTH ANNUAL MEETING

OF THE

National District Heating Association

HELD AT THE

EDGEWATER BEACH HOTEL

CHICAGO, ILLINOIS

MAY 23, 24, 25, and 26, 1955

VOLUME XLVI

Price $10.00

PUBLISHED BY THE NATIONAL
DISTRICT HEATING ASSOCIATION
827 NORTH EUCLID AVENUE, PITTSBURGH 6, PA.

M lb capacity costs $233,000—that would be about $3.31 per M lb. How does that compare with the cost of a coal-fired boiler?

Leven D. Gray: I do not have the comparison here, however it is an unusually low cost per M lb for a boiler.

These are quoted prices from the Engineering and Construction Department.

Chairman Hatfield: Thank you, Mr. Gray and gentlemen.

We now have the pleasure of having with us M. Salmon-Legagneur, Director of Compagnie Parisienne de Chauffage Urbain in Paris, France, one of the large district heating utilities of the world. Mr. Salmon-Legagneur will now present his paper on recent developments in his company.

RECENT DEVELOPMENTS OF DISTRICT HEATING IN PARIS

M. Salmon-Legagneur [1]

(In this paper the author describes the district-heating system in Paris, France, as of 1955 and gives a very clear picture of the contemplated new steam plants and distribution extensions.)

District steam in Paris, in general, is furnished through big mains, smaller return mains taking back the condensate to the three steam plants.

HEATING STATIONS

The plants are:

1. The station of Bercy which is located near the Gare de Lyon and has four Babcock & Wilcox boilers, two of 50 tons (100,000 lb) per hr and two of 25 tons (50,000 lb) per hr. They actually burn fuel oil but could be transformed for burning coal on mechanical grates. Their pressure is 20 hpz, that is about 300 psi.
2. The station of Ivry belonging to Electricite de France, which can supply steam either with low-pressure boilers (23 hpz) of which the maximum output is 340 tons per hr or from the exhaust of a counter-pressure electric generator of 40,000 kwh capacity which gets its steam from high-pressure boilers.
3. The domestic refuse incinerator in Ivry which belongs also to a division of Electricite de France and which has six ovens producing at maximum 40 tons of steam per hr.

The contract which exists between Compagnie Parisienne de Chauffage Urbain and Electricite de France provides that these two stations shall give a maximum of 300 tons of steam per hr and 450,000 tons in the whole year.

Altogether, the district heating network of Paris thus can get a maximum output of about 425 tons per hr and 900,000 tons of steam in the whole year.

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[1] Engineer in Chief of the French Navy (reserve). General Manager of the Compagnie Parisienne de Chauffage Urbain.

DISTRIBUTION SYSTEM

The pressure of steam in the distribution system can vary with the demand from 75 to 300 psi (5 to 20 Kgs per cm^2). It actually covers 10 districts in Paris of a total of 20 but in these districts a very limited number of streets actually have steam distribution.

The total length of pipes under public ways is about 25 miles (40 Kms), the number of buildings which can be fed with steam being a little over 700 and the total calorific power which is connected being about 320 millions K calories per hr.

The portion of the network which is near the heating station of Bercy gets its steam at any time at a pressure of 75 psi (5 Kg per cm^2), a part of which is bled from auxiliary electric generators in this station.

The total amount of steam which was provided to customers during 1954 was a little over 600,000 tons, which corresponds to a load factor of about 17 to 18 per cent and represents an increase respectively of 18 per cent and 55 per cent on the amounts of steam sold in 1953 and 1950.

In February 1954, when the weather was the coldest +14F (—10° centigrade), the record of daily total output from the various stations was about 8,200 tons.

Fig. 1 shows how the distribution system in Paris compares with those of Hamburg and New York.

EXTENSIONS CONTEMPLATED

With the district-heating system now getting steam only from stations located in the southeast of Paris, the plans for extensions contemplate connections to two other heating stations, one in the southwest and one in the north of the capital.

For various reasons, there is no question of connecting the Issy-les-Moulineaux Station which is located in the southwest and the connection actually is being made to a new heating station which is located near Quai de Grenelle in the rue du Theatre on ground which was recently purchased. This heating station will in the beginning be a peak-load station. A boiler of 75 tons per output is under construction.

The first main, running along the rue du Theatre, rue de la Croix Nivert, avenue Lowendal, boulevard des Invalides, rue de Varenne, and rue de Bellechasse, altogether about 2½ miles, will be connected to the end of the distribution network at the Ministere de la Guere.

This line is partially completed and will be finished during 1955.

It will be the main line of a new network called *Reseau de Grenelle* which will provide steam to the State Ministries which are located on the left bank of the Seine and to various buildings such as the Ecole Militaire, Hotel des Invalides and a big hospital.

The main line will be under construction beginning in November 1955.

The second power station to which the network will be connected is that of Saints Ouen, which is located quite close to the power station of E.D.F. and the domestic refuse incinerator. These two stations are less than three miles distant from the Opera. The main pipe which is contemplated will be able to supply the big office buildings near the Gare Saint-Lazare.

When these two systems will have been built, the Paris network will be supplied in a normal way and with greater security than at present.

It is contemplated also to build up a third distribution system which

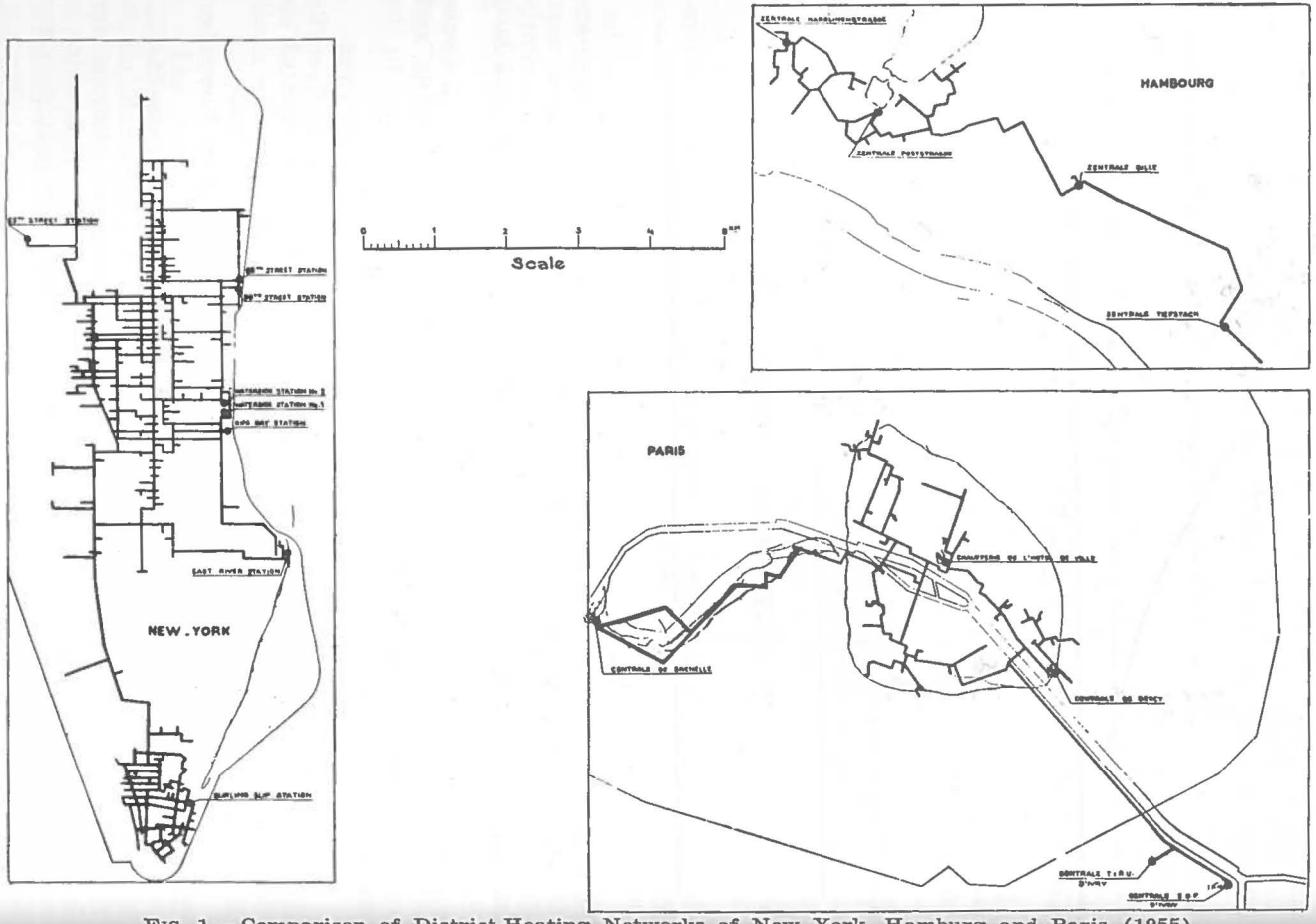

FIG. 1.—Comparison of District-Heating Networks of New York, Hamburg and Paris (1955)

would be called the *Reseau de Daumesnil* from the power station of Bercy to the buildings of the Ceinture Verte which are near the gates of Vincennes and Montreuil.

The supply of the districts of Auteuil and Passy also is being studied, steam to come either across the Seine, from the heating station of Grenelle which will be extended, or from another heating station which will be located on the right bank of the Seine.

To carry out this program it will be necessary to get large amounts of money and its total realization may take several years if only for financial reasons.

Figs. 2 and 3 show the actual distribution system and the different extensions in view.

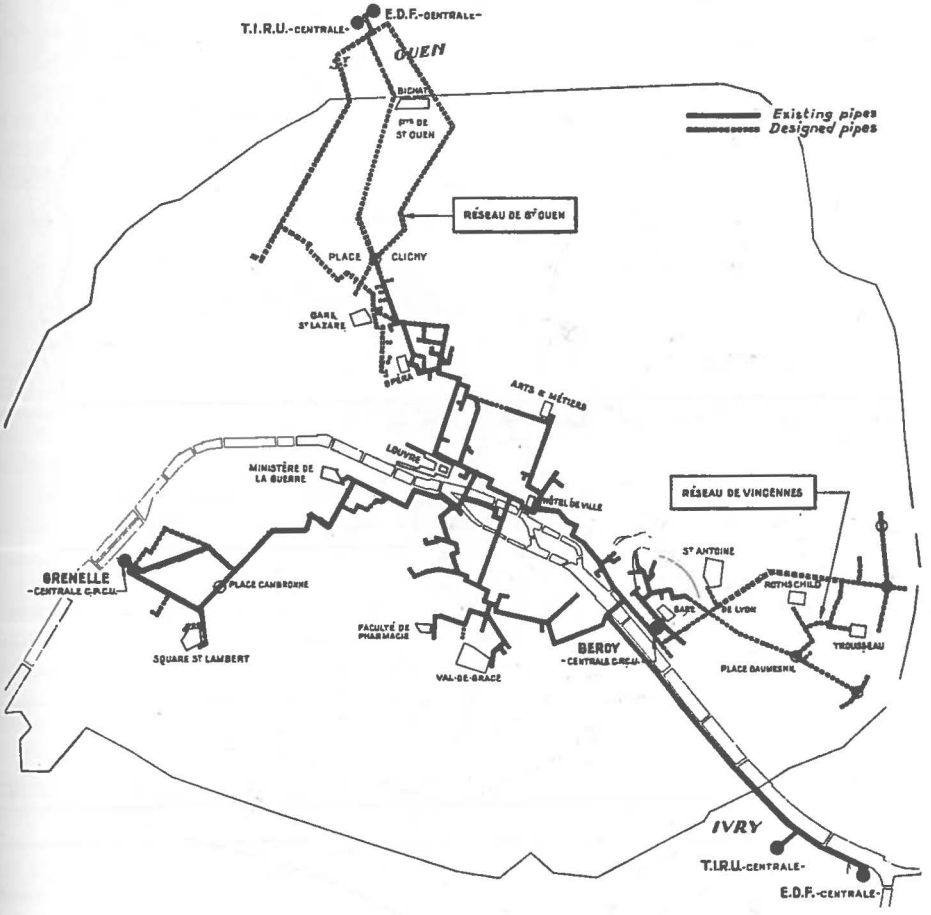

FIG. 2.—Contemplated Extensions to Paris Steam System

TECHNICAL POINT OF VIEW

The principle adopted which would allow the best efficiency according to the various sources of heat which can be used is the following:

1. Use steam from the domestic refuse incinerator in Ivry and

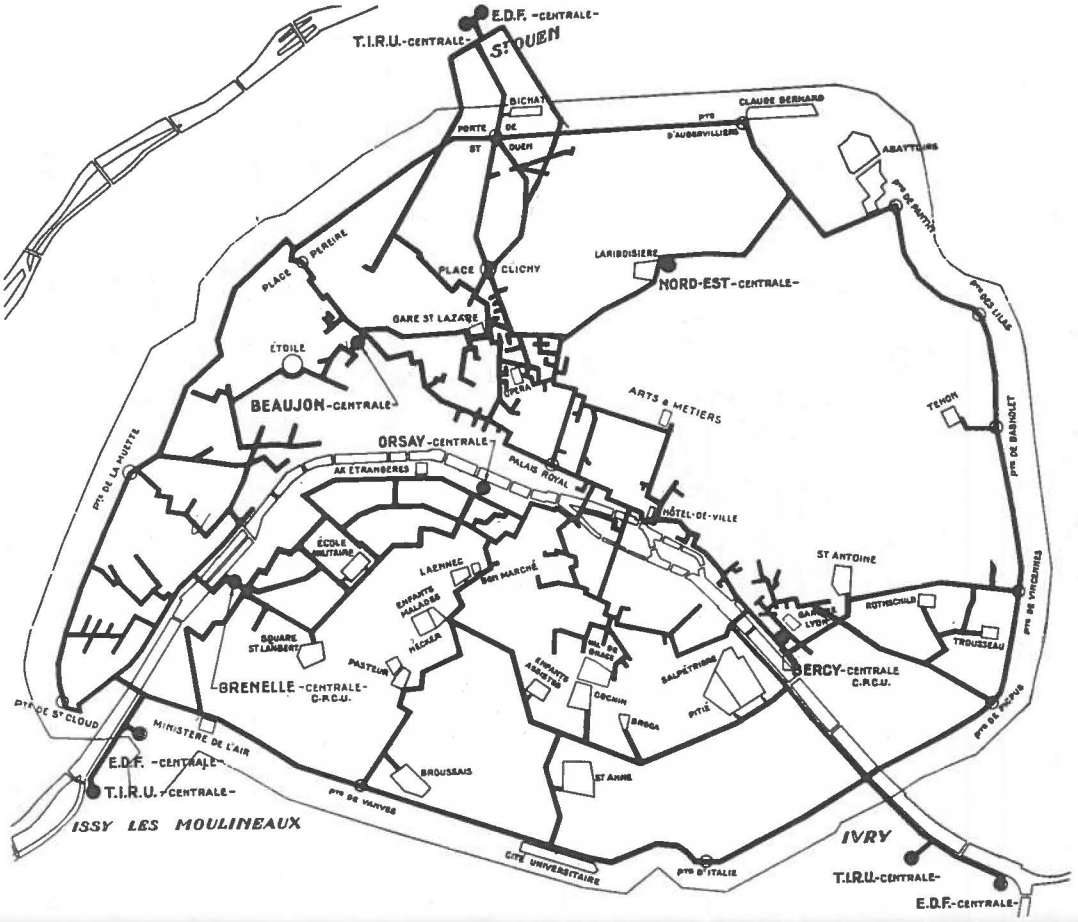

FIG. 8.—Piping Network for Heat Distribution When Completely Developed

further on in Saint Ouen when the last one will be connected to the network;
2. Use bled steam from the Bercy and Ivry plants;
3. Use steam supplied by low-pressure boilers in Bercy, burning fuel oil, and low-pressure boilers in Ivry, burning coal;
4. Use steam supplied by peak heating stations such as the Grenelle plant, which very soon will be put in operation.

As regards distribution, the tendency is to replace as far as possible the expansion loops with expansion joints either of the packed slip-tube design or of the corrugated type.

Therefore, the use of corrugated expansion joints, such as those made in America, is now contemplated. Some of these corrugated expansion joints have already been set up on the new line between the heating station of Grenelle and the War Ministry.

As regards insulation, the use of the vermiculite or exploded mica has been extended; this insulation material being poured directly in the concrete box-type conduits, after the steam pipes have been placed in these conduits. This has a double advantage:

1. The insulation is improved because heat losses through convection are suppressed; and
2. The impediment is lowered in an important way compared to the formerly-used system of insulation by magnesia or glass wool coatings.

In the bends a mixture of vermiculite and of a bituminous material is used, for preventing a reduction in volume of the insulation which could be caused by the expansion of the pipes. Further experiments are now going on.

When there is a special difficulty in building the concrete box-type conduits, the pipes are placed in steel jackets which are put directly into the earth.

In Fig. 4 is compared the new arrangements and designs with the former. Experience will show if this new type insulation has drawbacks compared to the former, both from the installation and maintenance points of view.

COMMERCIAL POINT OF VIEW

The district-heating utility in Paris tries to reduce the waste of heat supplied. This is why the Company endeavors first to connect the big buildings, especially the office buildings which are equipped with old boilers requiring high consumptions of fuel, which would have been kept in operation during several years more if district-heating lines had not been built in the neighborhood.

The utility will look for new customers among buildings having high load factors, such as hospitals which were not connected until a few years ago. In this respect, two hospitals were connected recently—the Hotel-Dieu and the Val-de-Grace, for which special rates have been settled.

The Company will also connect industrial plants which may only accept very low rates, an interesting solution in several cases being to

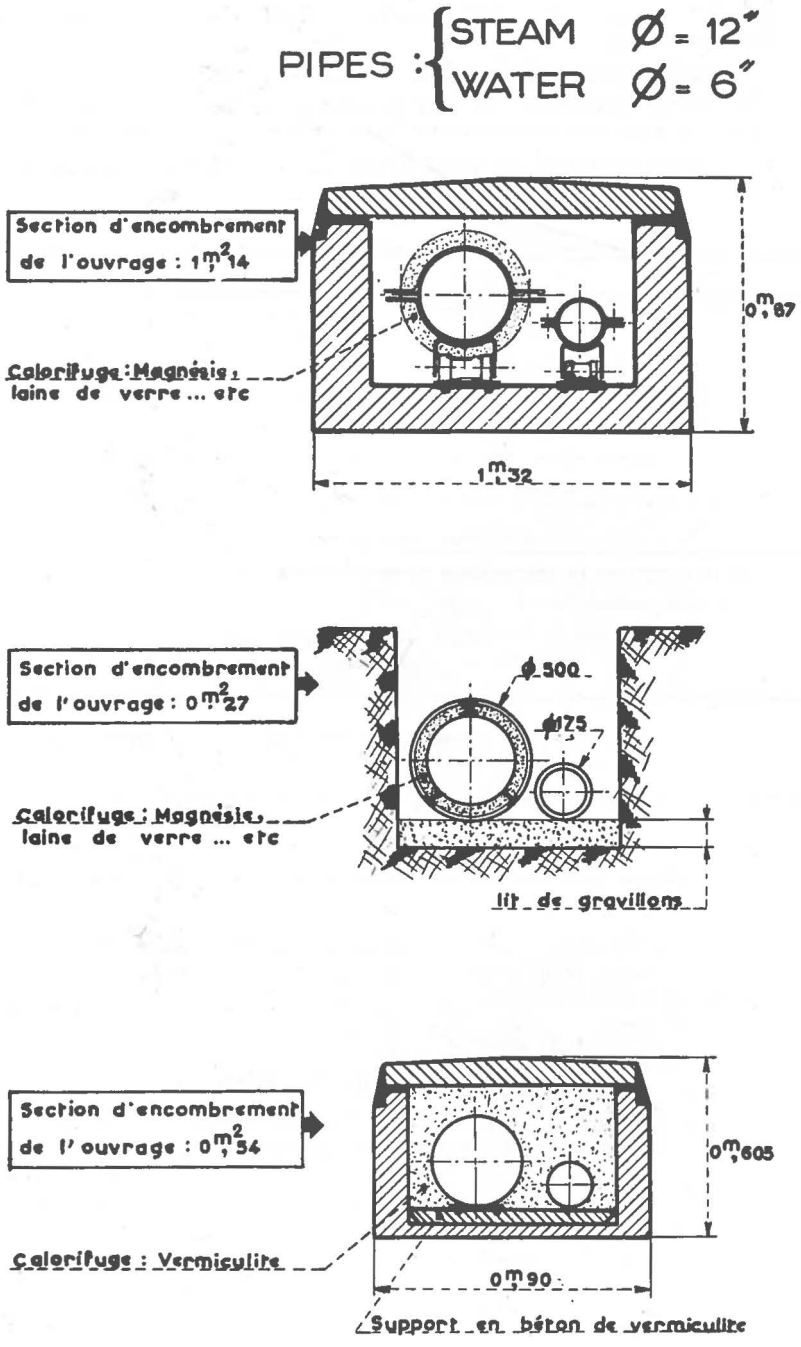

FIG. 4.—Former and New Conduit Cross Sections

supply them outside the peak hours only; heating demands during peak hours being assured by their own boilers being kept in good shape or improved. In this case, district heating needs not to foresee supplementary power for steam production and steam distribution to supply those customers, which is the reason it is possible to consent to specially low rates which are the equivalent of low-load-hour rates in the distribution of electricity.

This does not prevent the Company from connecting all the private buildings, hotels and restaurants which are located along the mains or in the neighborhood which want service. Those customers generally have a good load factor and they can use the steam which is supplied as well for heating as for water heating and even in certain cases for cooking and coffee-making. There are especially in the town of Paris several examples of very big collective kitchens which can be supplied by district heating at pressures of 20 to 45 psi.

District heating can also give cooperation in the work of reconstruction which is at present going on within the borders of Paris by supplying the heat which will be required by these very large buildings.

This extension program probably will allow reductions progressively in the cost of the heat supplied and, therefore, in the rates which already have been lowered twice; in 1950, when the new lowered rate was put in force and in 1954, when a new additional act was passed affecting the contract between the Company and Paris town. These adjustments have amounted to 8 to 15 per cent, according to the nature of the customers supplied.

Measurement is done mostly with condensate meters which are set up in each building, but in all cases where heating by means of horizontal pipes permits, the Company is in favor of individual metering in each flat. This allows substantial savings in the amount of heat used because of better supervision and closer control by the customers.

FINANCIAL POINT OF VIEW

The financial problem is perhaps simpler and yet more difficult for district heating in Paris than for district heating in smaller towns.

It is simpler because the Company is backed with investment funds given by the town of Paris, the Electricite de France and also some private stock holders; the town of Paris and Electricite de France having together more than two-thirds of the stocks. Therefore, it is clear that no extensions can be made without the agreement of these two big stockholders.

Recently a stock increase was decided on, the number of stocks being doubled. If this appears to be insufficient in the coming months, the trust which this Company has in the financial quarters would allow her to get a loan which would eventually bring in some more money.

It must also have been noticed that the Company not only gets no subsidies of any kind from the town of Paris, but gives her each year as contractor a royalty which is actually about 4.5 per cent of the total amount of her sales, as a public utility.

Furthermore, it is quite certain that the experience of past years and especially since the end of World War II has shown that this business can give to its share holders satisfactory dividends. There is no reason why this could not go on the same way in future time.

But it is also quite true to say that the financial problem creates peculiar difficulties, if one wants to contemplate an important extension of district heating in the capital. This is because no pipes are yet in place in a very great number of streets and these pipes will be very expensive to build. That is to say that the work which is to be done still is enormous and this leads to difficult financial problems.

For solving them it is to be hoped that the cost of borrowing money can be substantially lowered.

This being said, the figures which have been given in this paper and the schemes of contemplated extensions show that Paris' district heating may soon be compared to the biggest American district-heating systems. The climate in Paris is much milder than in most American towns. There is practically no need for steam for air conditioning during summer.

Actually in Paris central heating represents less than 50 per cent of the heating power and district heating 4 to 5 per cent. The first steps which have been talked about in this paper must bring this percentage progressively to 8 to 10 per cent.

Chairman Hatfield: Thank you, Mr. Salmon-Legagneur, for a very interesting report on progress in district heating in Paris.

Gentlemen: This winds up the report on this committee.

Vice President Suche: Thank you, Mr. Hatfield and gentlemen. We will now adjourn until 9:30 A.M. tomorrow.