DISTRICT HEATING SERVICE IN DETROIT

A History and Description of the Central Heating System of The Detroit Edison Company

by

E. Z. DUBRY

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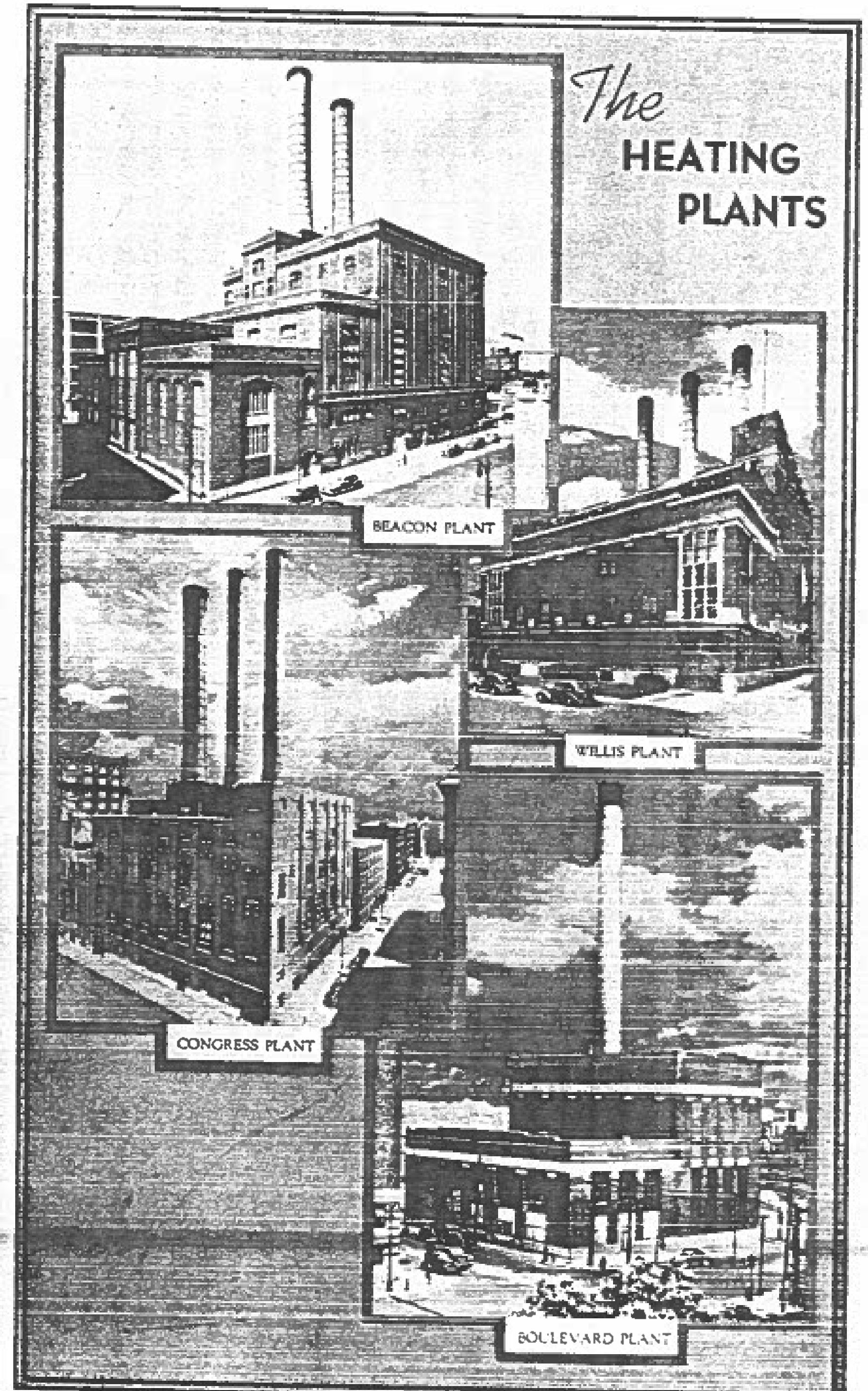
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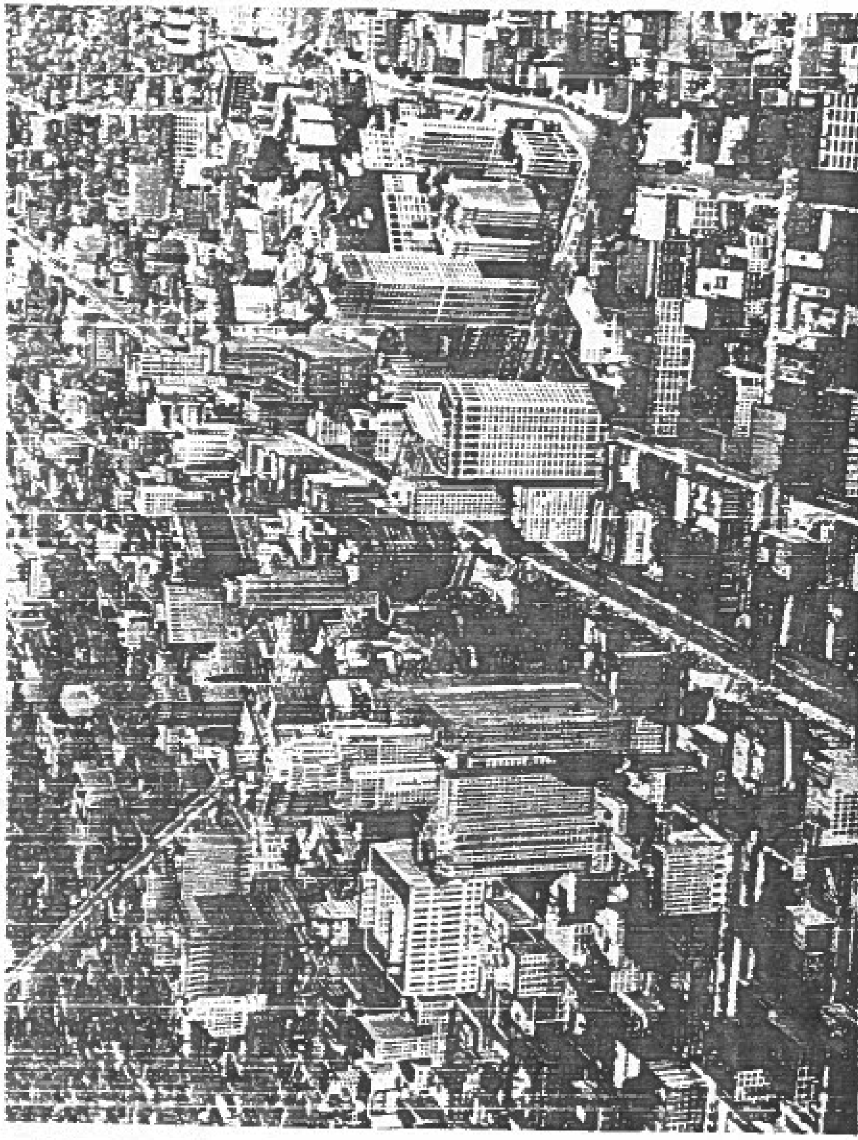

Fig. 1—Downtown District of Detroit, Showing Part of the Area Served

DISTRICT HEATING SERVICE IN DETROIT

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HISTORICAL

DISTRICT heating in Detroit dates back to 1903 if some previ unsuccessful attempts to operate similar undertakings are except In that year The Detroit Edison Company was organized for purpose of building and operating an electric power plant to supply c rent to the two electric companies which were then operating in Detr and the several small generating stations of those companies were rec structed into substations from which was distributed the current recei from the new main generating station. In the case of one of the statio the Willis Avenue Station of The Edison Illuminating Company Detroit, it was decided that the operation of the generating units wo be continued and the exhaust utilized for heating the buildings in neighborhood, thereby improving the overall thermal efficiency a eliminating, for as much current as might be generated locally, the c version losses involved in changing the alternating current received fr the main generating station to the direct current required for distril tion in that district. The station was situated in what was at that ti a high-class residential section which offered a promising field for development of the business.

Accordingly, in 1903, a separate corporation, the Central Heat Company, was organized, and a franchise was obtained from the City Detroit, permitting the company to install distribution lines in streets and alleys. The Central Heating Company was to own a operate the heating system and purchase the exhaust steam from T Edison Illuminating Company of Detroit.

Steam was chosen as the medium for distributing the heat ratl than hot water, and it is interesting to note that most of the reasons wh led to this decision have been proven valid by subsequent experien These reasons were many:

1. Steam lines are cheaper to install, there being but a single pi whereas hot water usually requires a double set of mains.
2. There is a saving in station equipment, as there are no circul ing pumps required.
3. Buildings piped for hot water heat can be served by ste: through the use of a surface heater.
4. Steam service can be metered.

5. Steam will circulate to any elevation, whereas with hot water, it is necessary to carry enough pressure on the entire system to lift the water to the tops of tall buildings.

6. The customer can control his own heat supply with steam, while hot water service must be regulated from the central station.

7. The cost of equipping a building for steam heat is less.

8. Cooking apparatus and water heaters can be served by steam, but not by hot water.

With 3000 feet of mains and 12 customers the company commenced operation on December 10, 1903. During the next summer 9865 feet of mains were added and the distribution system was steadily extended from year to year.

In 1904, the Central Heating Company began the construction of a boiler plant, known as the Farmer Street Plant, and a distribution system in the downtown business district of the city to distribute live steam. There were at this time many isolated electric plants in downtown buildings whose owners were unwilling to purchase current from the Edison

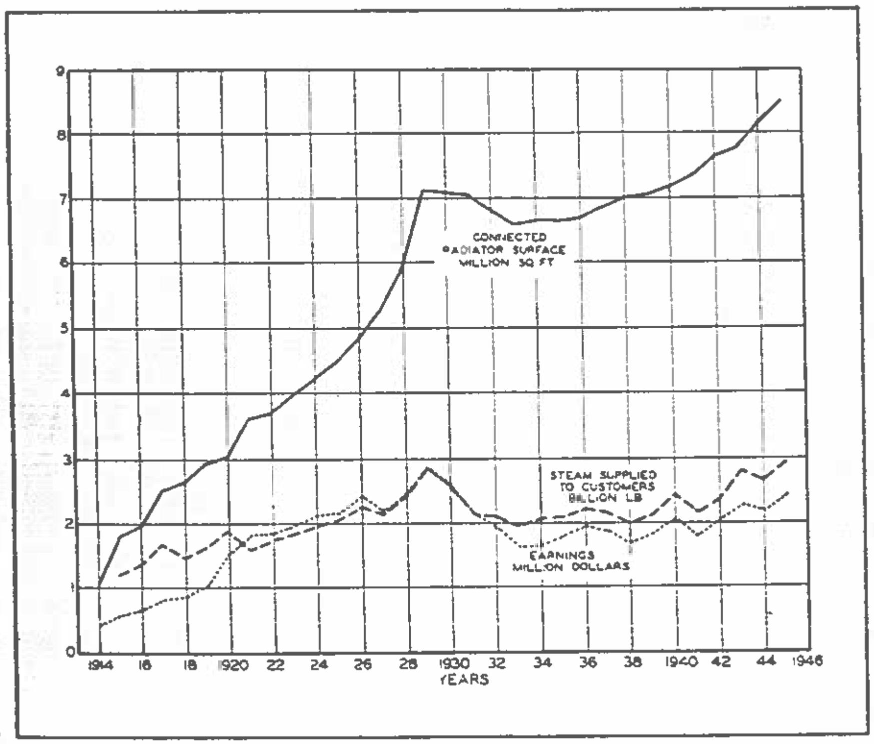


Fig. 2—Growth of the Heating Service

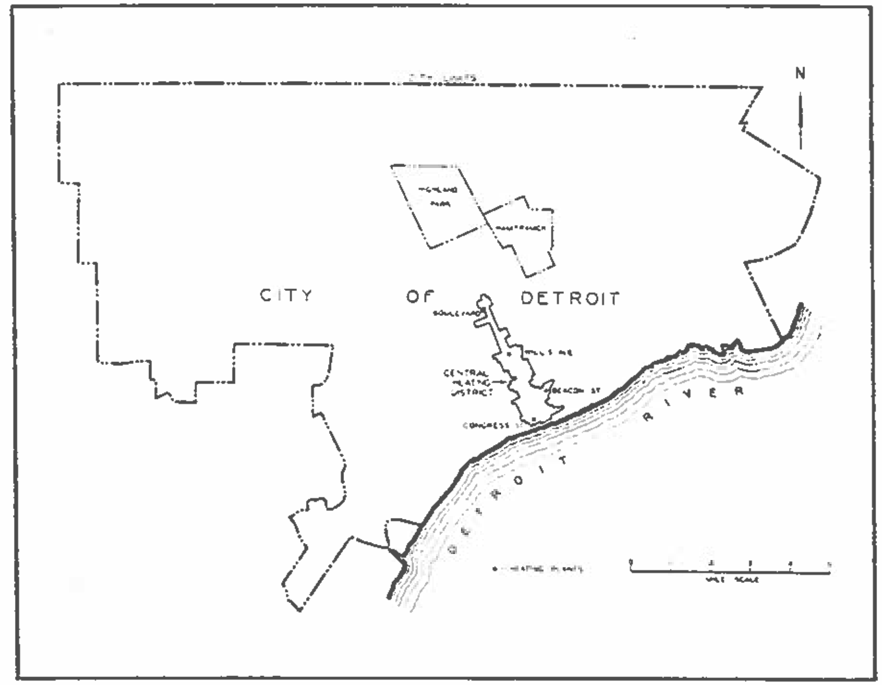


Fig. 3—Location of District Served

Company, partly because the necessity would still remain of operating their boiler plants for heating, and partly because of the expense involved in substituting electric-driven equipment for their steam-driven pumps, etc. The Edison Company's assistance in the construction of the heating plant was believed to be justified by the possibility of obtaining electrical business, and experience demonstrated the correctness of this idea. In order to serve the steam-driven pumps and cooking apparatus, it was decided to install in the central part of the district, a high pressure (100 pounds per square inch) power main as well as the lower pressure (15 pounds per square inch) heating main. The Farmer Street Plant was operated until 1926, when it was torn down to make way for an electrical substation, its load being taken by the newer heating plants. The high pressure steam for power had been discontinued several years previously.

In 1912, owing to extensions of the distribution system and the connecting of new business, it became necessary to increase the boiler capacity in the downtown district and accordingly the construction of a new plant on Park Place, near Grand River Avenue, was begun and the first boiler unit was put into service in December of that year. The Park Place Plant was shut down in 1927, and its load transferred to other plants, because of the proximity of tall buildings which extended above its stacks.

In June, 1914, The Detroit Edison Company purchased the mains and business of the Murphy Power Company which had been engaged

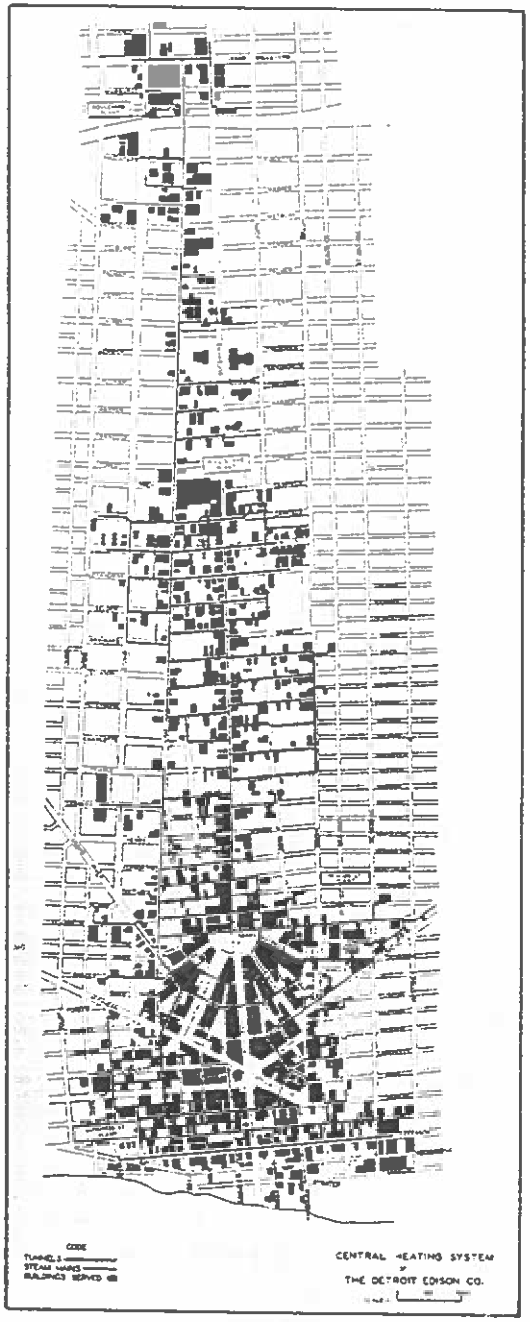


Fig. 4—Map of Heating System Area Showing Buildings Served

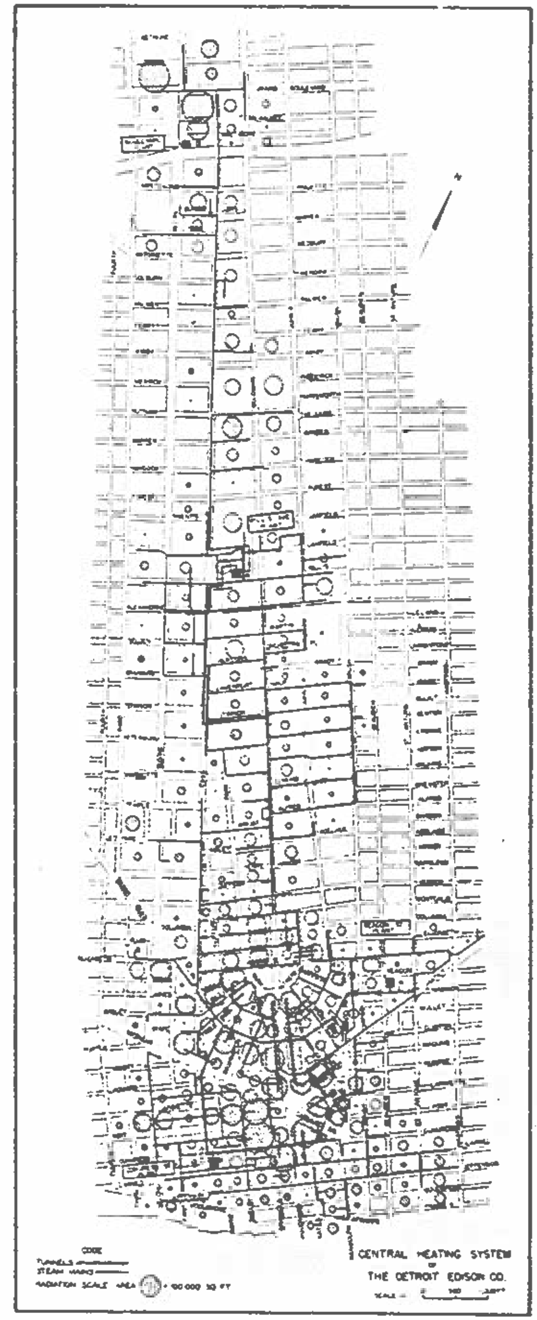


Fig. 5—Map of Heating System Area Showing Distribution of Connected Radiator Surface

since 1904 in the supply of steam heat in the southern part of the central business district of the city. This company operated an electric generating plant, the turbines exhausting into the heating system. The Murphy Company's power plant was leased and operated during the season of 1914-1915, after which steam was supplied from the Central Heating Company's existing plants.

As of July 1, 1915, all the plants and business of the Central Heating Company were bought by The Detroit Edison Company, and since then the steam heating business has been carried on directly by the latter company.

In 1916, reconstruction of the Willis Avenue Plant, made necessary by the increasing steam demand, was begun and the engine-driven generators were removed and replaced by a separate, converting substation. This district has thereafter been supplied for the most part with live steam from a boiler plant devoted exclusively to this purpose.

In 1917, the first boiler units were installed in a new plant at the corner of Congress Street and Cass Avenue. Additional boilers were added and in 1923 the final unit was installed.

To take care of the continually increasing demand for heating steam, the Beacon Street Plant was designed and the first two boiler units were put into service in the fall of 1926. A third boiler was added in 1927 and a fourth in 1929. The Beacon Street Plant is designed to care for large increases in steam requirements for some time to come.

In 1928, the boiler plant supplying heat to the large office building of the General Motors Corporation was purchased and the distribution system was extended northward to connect with it and to serve the then rapidly growing business center in the Grand Boulevard district. Thus there are now four boiler plants serving the entire heating system.

Figure 2 shows the growth of the heating service in Detroit.

The distribution system has been extended and reconstructed from time to time to meet the demands of the growing business. At present it contains 42 miles of underground mains and 2½ miles of tunnels and serves approximately 1650 customers. It covers an area about 3¼ miles long, varying in width from one block to nearly one mile, in the heart of the city, as shown in Figure 3. The entire central shopping, business, and financial districts of the city are located within the lower part of this area. North of this, occupying the middle part of the area, is the Willis Avenue district, at first exclusively residential, but now changing to a district of apartment houses and small stores, and in the upper part of the area is the Boulevard business district in which are located three of the city's largest office buildings. Fig. 4 shows the distribution system and the location of the buildings which are served. A number of the larger buildings served by the system are shown in Figs. 6, 7, and 8.

The connected demand in terms of equivalent steam radiator surface was 8,526,500 square feet as of January 1, 1946. The distribution of the connected radiator surface is shown in Fig. 5, the area of each of the shaded circles representing the connected radiator surface in the corresponding city block. The four boiler plants delivering steam to the system are to some extent interconnected so that the steam requirements can be divided between them.

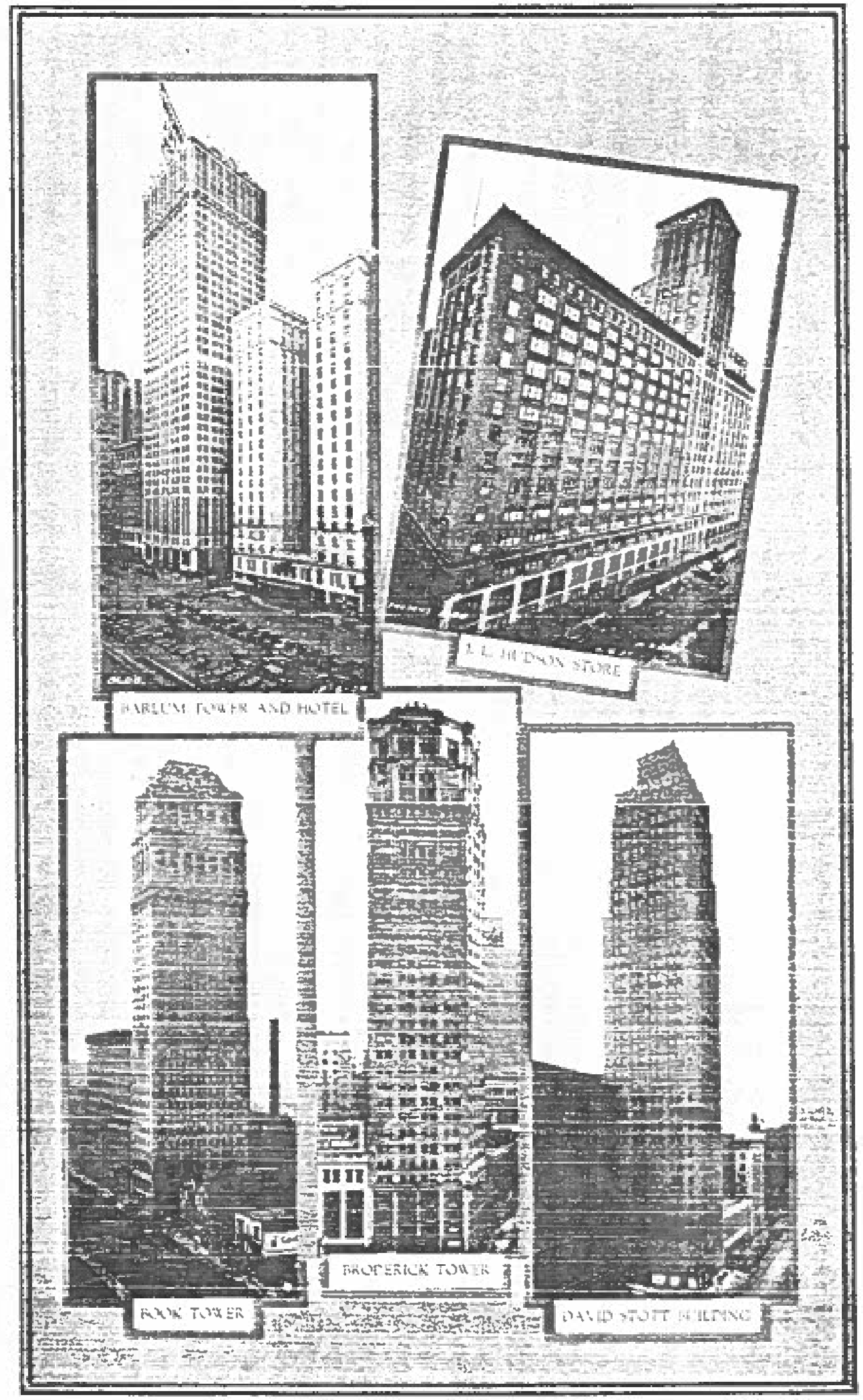


Fig. 6—Large Buildings Using Central Heating Service

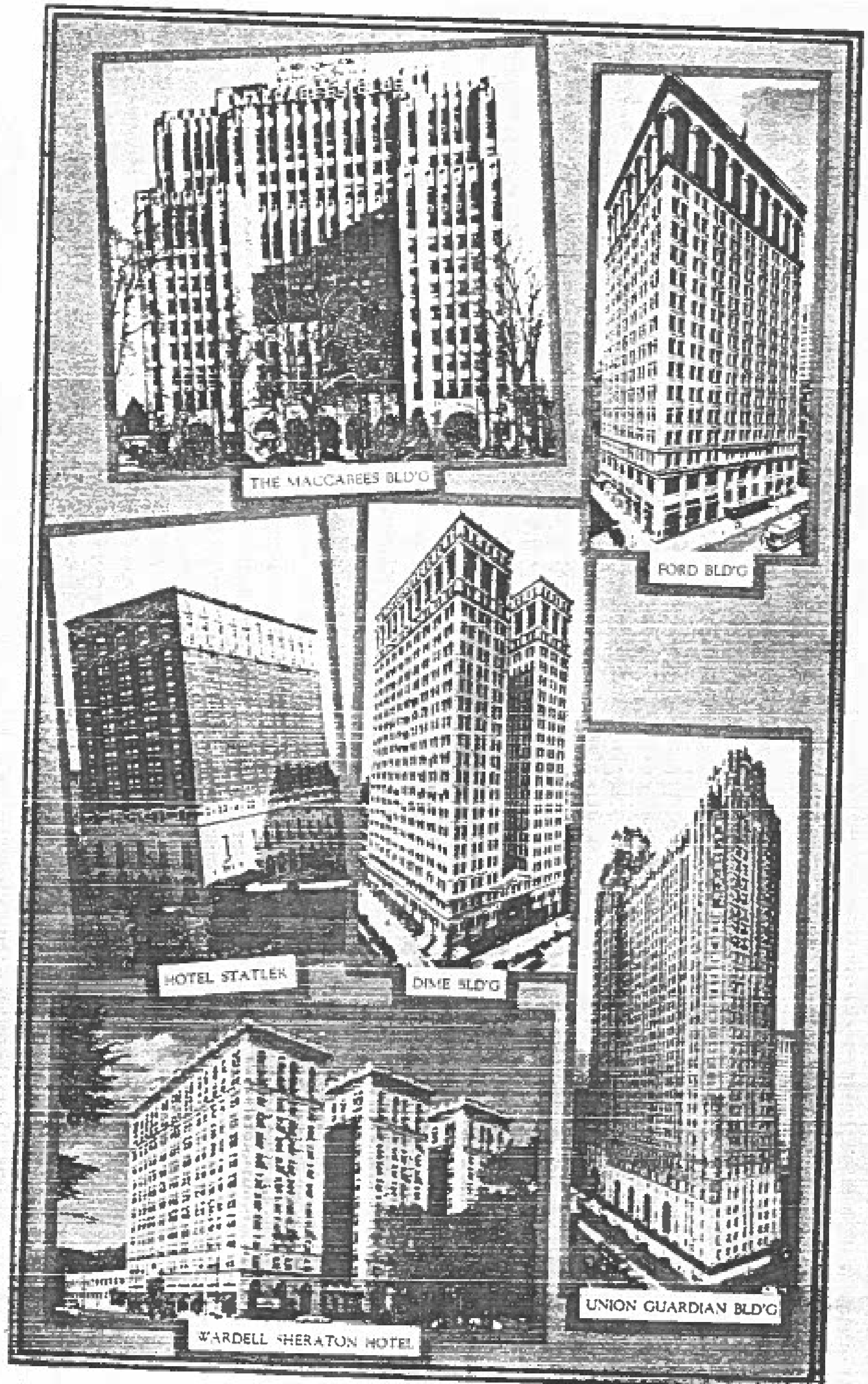


Fig. 7—Large Buildings Using Central Heating Service

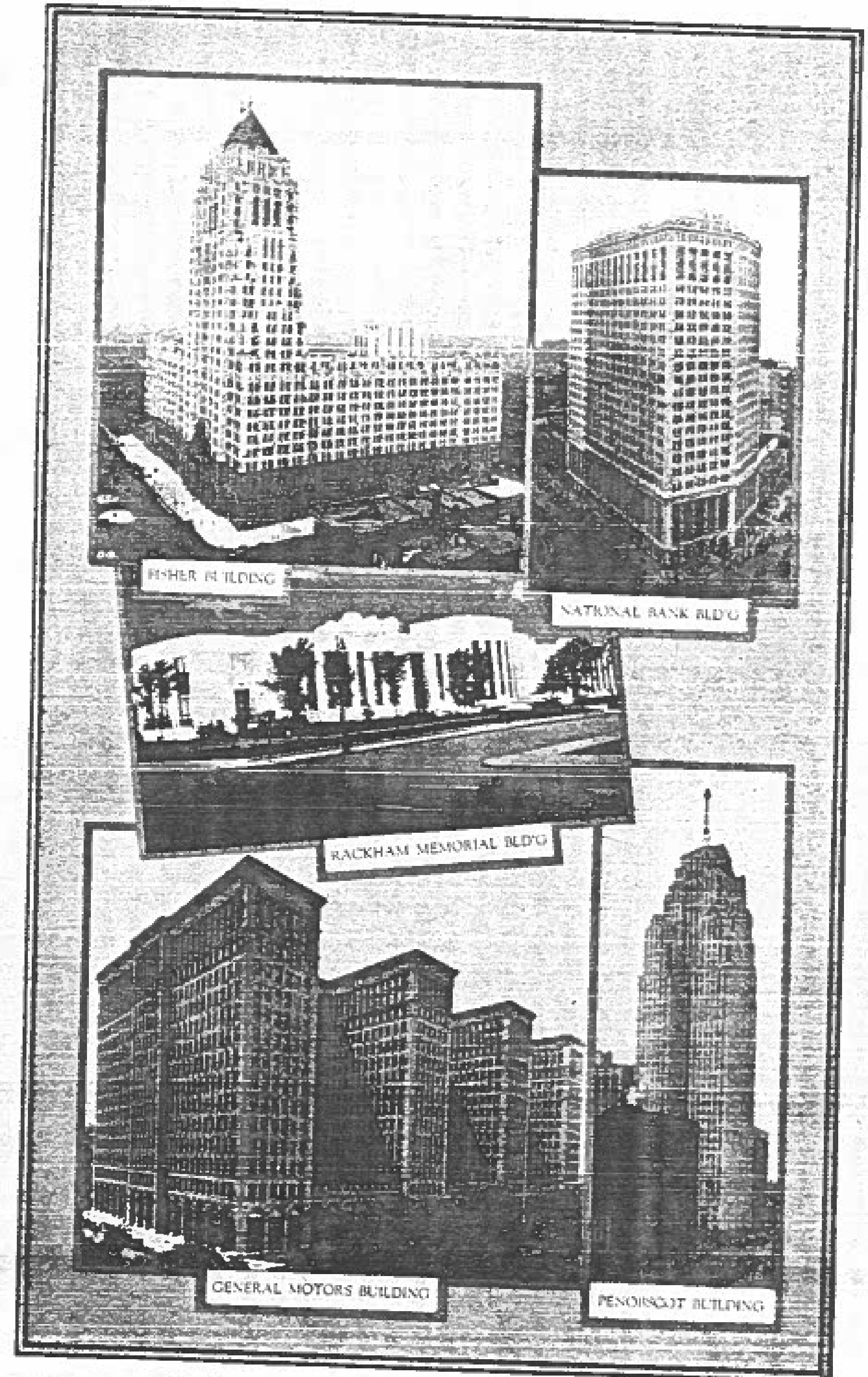


Fig. 8—Large Buildings Using Central Heating Service

THE HEATING PLANTS

The principal data concerning the four boiler plants are given in Table I. They contain bent-tube boilers, for the most part of the W type, fired by underfeed stokers. The aggregate boiler heating surface, as of January 1, 1946, was 392,355 square feet.

With the exception of the Boulevard Plant, the heating plants were designed and constructed by the Company and the design and operating practices naturally are similar to those in the Company's contemporary electrical generating plants.

Beacon Street Plant Boilers and Stokers

The Beacon Street Plant, the newest and largest of the four, is illustrated in Figs. 9, 10, 11, and 12. Each of the four boilers it contains has 41,550 square feet of heat absorbing surface. With high grade coal each boiler is capable of producing, for short periods, 530,000 pounds of steam per hour at a pressure of 150 pounds per square inch. Some additional statistics regarding three of the boilers are as follows:

Number of drums	5
Diameter of drums, inches	54
Length of tube sheet, feet, inches	27–3

Fig. 9—Boiler Room, Beacon Street Heating Plant

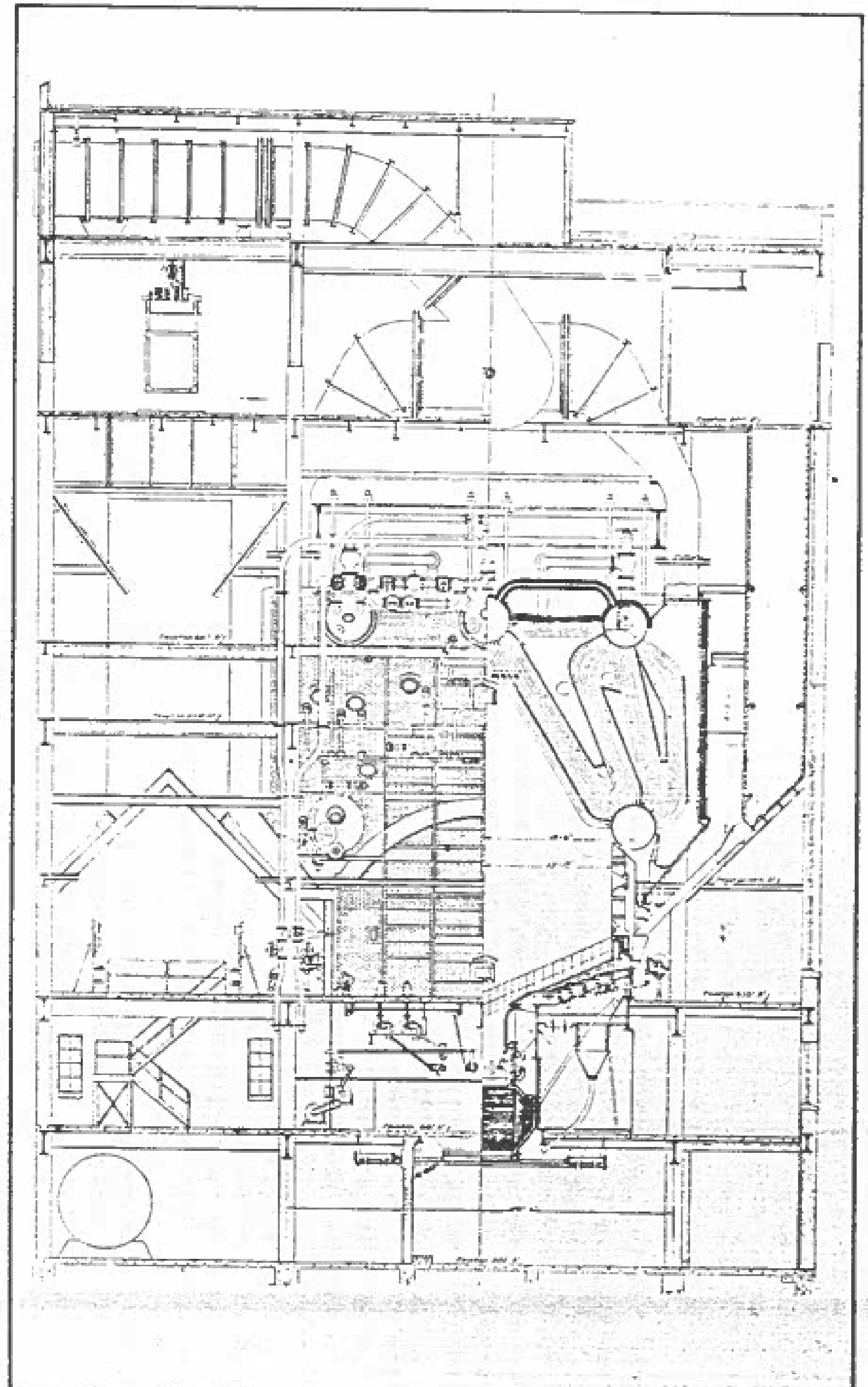


Fig. 10—Section and Elevation of 41,550 Sq. Ft. Boiler, Beacon Street Heating Plant

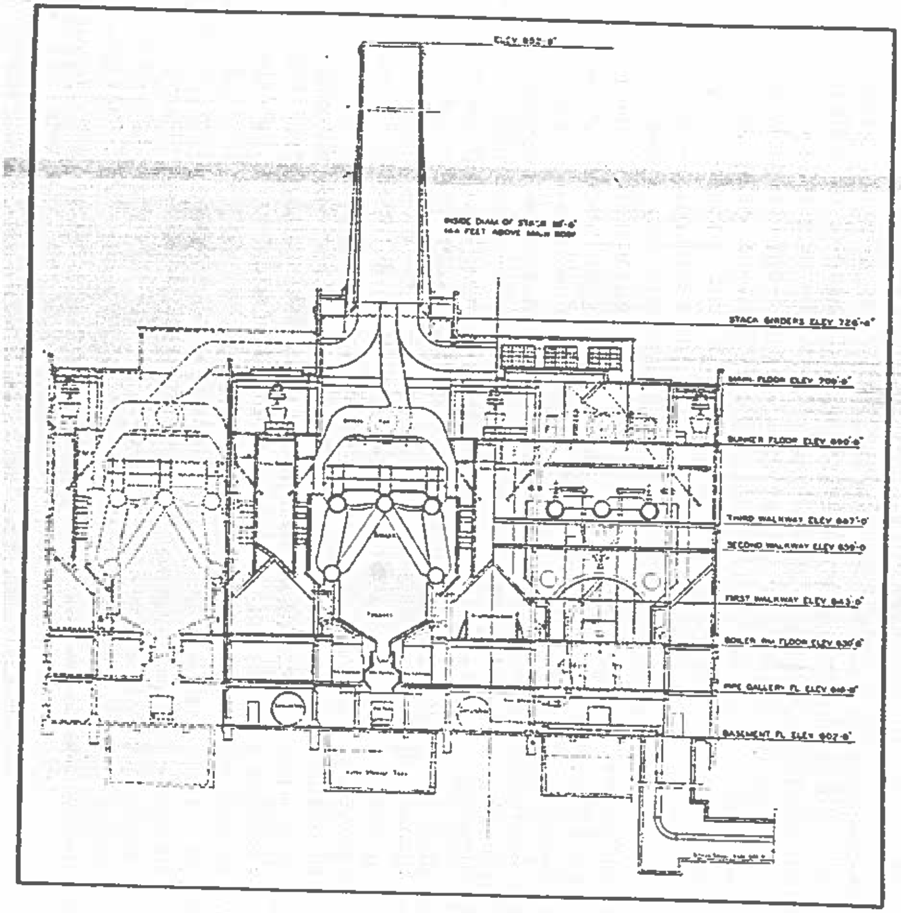


Fig. 11—Cross Section, Beacon Street Heating Plant

Number of tubes	2792
Outside diameter of tubes, inches	3¼
Projected grate area, including pit, square feet	636
Inclined grate area, including pit, square feet	679
Coal burned per square foot of inclined grate area at maximum load, pounds per hour	72.5
Btu liberated per hour per cubic foot of furnace volume	39,800

The fourth boiler differs from the others in that it has six drums, the four upper ones being 48 inches in diameter. It has 2926 tubes.

The plant is designed to contain eventually nine of these boilers, if needed, but at present it seems unlikely that it will ever reach that size.

There were two controlling reasons for the choice of stokers in preference to pulverized coal at Beacon Street. The first reason was that methods of removing the ash from flue gas were not sufficiently perfected, at the time the decision was made, to make a pulverized coal plant advisable in a downtown district. Secondly, it did not appear desirable to operate a pulverized-coal preparation plant with its accompanying dirt and noise in such a district. The alternative, that of locating the pulverized-coal preparation plant at a railroad siding some distance away, was considered but economic studies indicated that the overall investment and labor costs of a pulverized coal plant with the preparation plant thus separated would not be justified by any probable gain in thermal efficiency over a stoker plant.

The Congress Street and Willis Avenue Plants while not as modern as the Beacon Street Plant are nevertheless efficient and of good design.

Coal Supply

Except for the Boulevard Plant, the heating plants are located some distance from the railroads and coal must be hauled to them by truck.

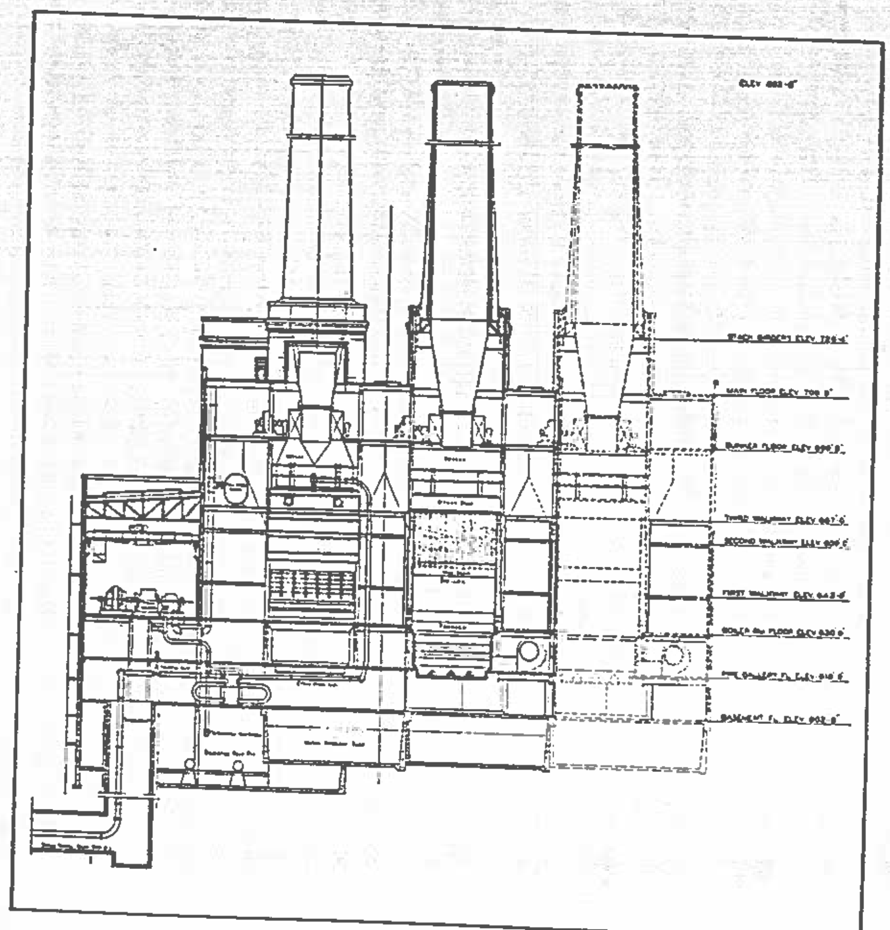
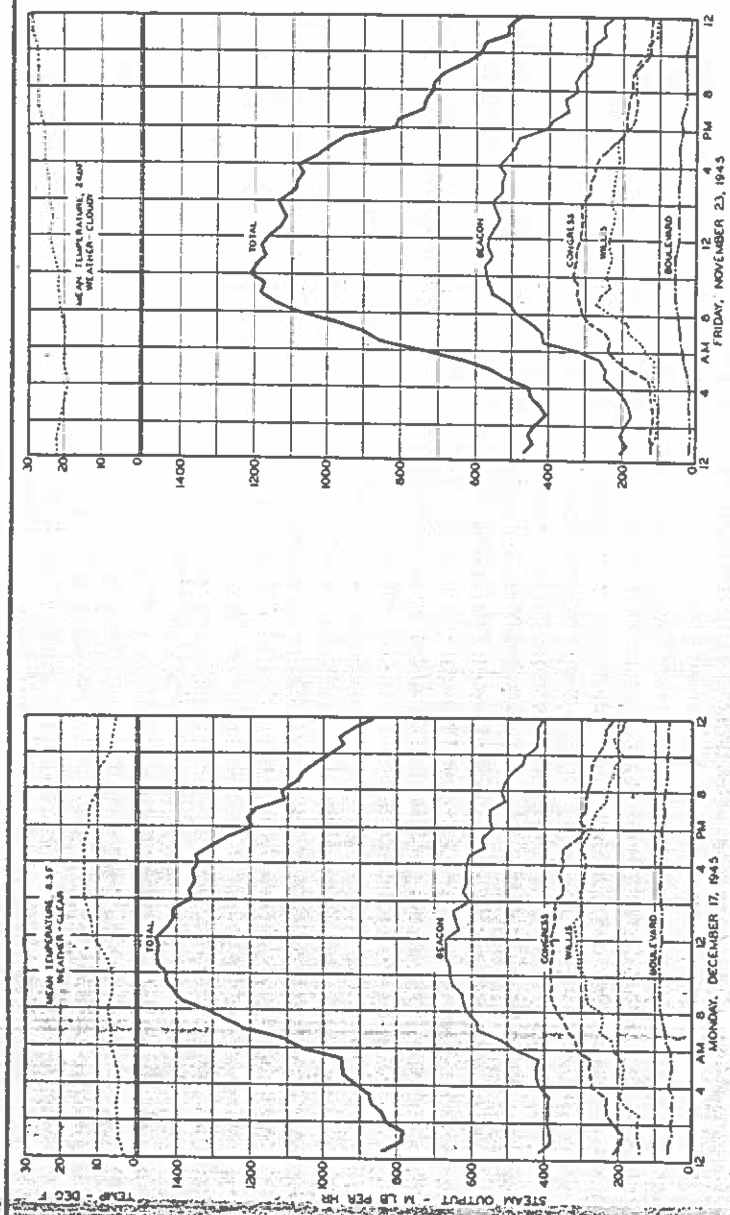


Fig. 12—Longitudinal Section, Beacon Street Heating Plant



Friday, November 23, 1945

	BEACON	CONGRESS	WILLIS	BOULEVARD	TOTAL
Steam Output (M Lb)	9,342.0	5,279.0	4,287.0	924.0	19,832.0
30 Minute Max. Load (M Lb)	571.0	330.0	272.0	60.0	1,209.0
Average Load (M Lb)	389.2	220.0	178.6	38.5	826.3
Load Factor	.682	.667	.642	.657	.683

Monday, December 17, 1945

	BEACON	CONGRESS	WILLIS	BOULEVARD	TOTAL
Steam Output (M Lb)	12,747.0	7,374.0	5,883.0	1,775.0	27,779.0
30 Minute Max. Load (M Lb)	673.0	386.0	315.0	93.0	1,454.0
Average Load (M Lb)	531.1	307.3	245.1	74.0	1,157.5
Load Factor	.789	.796	.796	.778	.796

Fig. 13—Plant Output Curves

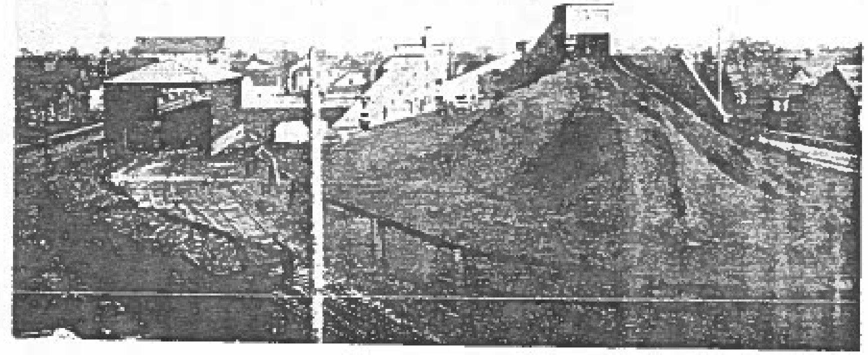


Fig. 14—Hale Street Coaling Station

At present there are two coal yards in service, the Hale Street Coaling Station (Fig. 14), bounded by Hale, St. Aubin, Mack, and Dequindre Avenues, is located on a railroad siding; the Orleans Coal Dock (Fig. 15) is located on the Detroit River at the foot of Orleans Street. Crushed or slack coal is stored in piles in the yard at both locations, neither of which is far from the Beacon Plant.

At present the combined rail and boat freight rate for water borne coal is about 38 cents per ton less than for the all-rail shipment. Because of this, the coal for all plants except the Boulevard Plant is shipped to Detroit from Toledo by boat and unloaded directly on the Orleans Dock. Some of it is then carried by common dump trucks to the Hale Street Station where approximately 25,000 tons can be stored. More than 100,000 tons can be placed on the Orleans Dock. These two stock piles

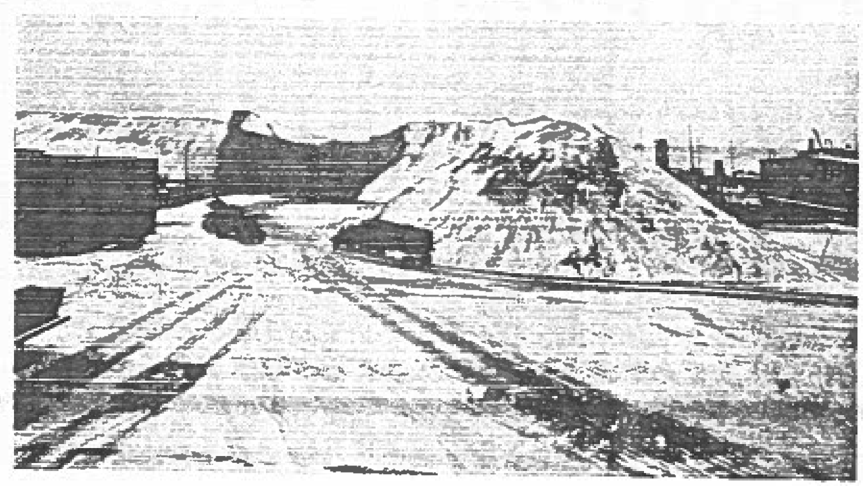


Fig. 15—Orleans Street Coal Dock

usually furnish sufficient coal to meet the requirements of the Beacon, Congress, and Willis Plants from the close of navigation in December until the reopening the following March.

The coal is hauled to the plants on semi-trailer trucks, each carrying two buckets of six to eight tons capacity each.

Water Conditioning

Because of the cost of underground return piping and its high corrosion rate, due to the presence of oxygen in a partly filled pipe, it is not economical to return to the plants the condensate formed in customers' buildings except when these buildings are adjacent to the tunnel system. Beacon, Congress, and Willis Avenue Plants, therefore, use large amounts of makeup water which is taken from the city water mains.

If no treatment is used prohibitive amounts of scale form within the boilers and the steam contains sufficient oxygen (air) and CO_2 to vigorously corrode the condensate piping in the customers' buildings.

To eliminate scale formations in the boilers, the makeup water is softened by passing it through green sand zeolite softeners. Thereafter enough acid is added to facilitate the removal of virtually all of the CO_2. Removal of the CO_2 and air is accomplished by passing the acid-treated soft water through degasifiers and deaerating type feedwater heaters. Subsequently caustic soda is added to make the water *definitely alkaline.*

A typical feedwater treating cycle is shown diagrammatically in Figure 16 and the chemical conditions at key points are shown in Table II. These data show definitely that even though acid is added to the feedwater it is completely eliminated before the water enters the boilers. Thus there is *absolutely no chance* of the steam containing any mineral acid. It is virtually devoid of air and contains not more than five parts per million of CO_2. Steam of better chemical purity is not produced, commercially, where high percentages of carbonate bearing feedwater are used.

At the Boulevard Plant, under normal conditions, no makeup water is used. The water in the boilers is kept charged with oxygen-consuming chemicals. Thus the steam produced is virtually devoid of both oxygen and CO_2. In emergencies makeup water from the city mains may be used without treatment. When this occurs sodium phosphate is introduced into the boilers to prevent scale formations.

Water conditioning is regarded as an integral and one of the more important parts of the operation of the Central Heating Plants. Daily chemical analyses of the boiler water are made, and hourly tests are made at key points in the water processing systems. The regular operators on each shift have been trained to make all water determinations. Any unusual conditions are referred to the chemist for detailed study.

Generation of Electricity in Heating Plants

The plants are operated primarily as live steam plants, delivering steam directly from the boilers into the distribution system with proper means for reducing the steam pressure to that required for distribution. There would be of course a thermal advantage in passing all of the steam through turbogenerators and thus generating electricity at a high overall thermal efficiency. The commercial justification of such a practice has not,

TABLE I

Installation Data, Heating Plants

	BEACON STREET	CONGRESS STREET	WILLIS AVENUE	BOULEVARD
No. of boilers	4	6	5	4
Type of boiler	W type	W type	W type	Stirling
Heating surface per boiler, sq ft	4— 41,550	3— 12,935 1— 15,430 2— 29,820	2— 13,000 1— 15,430 1— 25,200 1— 25,650	5,000
Total boiler heating surface, sq ft	166,200	113,875	92,280	20,000
Boiler pressure (allowable working pressure), lb per sq in.*	160	160	160	200
Furnace volume, cu ft	16,700	2— 4,370 1— 4,700 1— 4,770 2— 10,430	1— 4,370 1— 4,700 1— 4,770 2— 6,590	1,210
Type of stoker	Underfeed, two per boiler 14 retorts 29 tuyeres each	Underfeed, two per boiler 4— 7 retorts, 17 tuyeres each 1—14 retorts, 21 tuyeres each 1—14 retorts, 22 tuyeres each	Underfeed, two per boiler 3— 7 retorts, 17 tuyeres each 1—10 retorts, 22 tuyeres each 1—11 retorts, 21 tuyeres each	Underfeed, single 4— 5 retorts, 17 tuyeres each
Type of feed water treatment	Zeolite***	Zeolite***	Internal, sodium carbonate (will be Zeolite in the fall of 1946)	Internal, di-sodium phosphate, sodium sulfite
Electric generating units	1—3000 kw a-c 2—2400 kw d-c	1— 750 kw d-c 1—1000 kw d-c	1— 500 kw d-c 1—1000 kw d-c	None
Maximum continuous plant output, lb steam per hr (with the largest boiler down)	1,118,000	566,000	419,000	78,000
Area covered by plant building, sq ft	23,700	15,050	13,930	10,200
No. of men employed at 40 hrs per wk	48½**	35 9/16**	34 13/16**	14¼**

* The actual operating pressure varies in the different plants between 125 and 150 lb per sq in.

** The time of 1 clerk is divided between 3 plants. The time of 1 electrician is divided between 4 plants and the coaling stations.

*** Zeolite with after-dosage of acid.

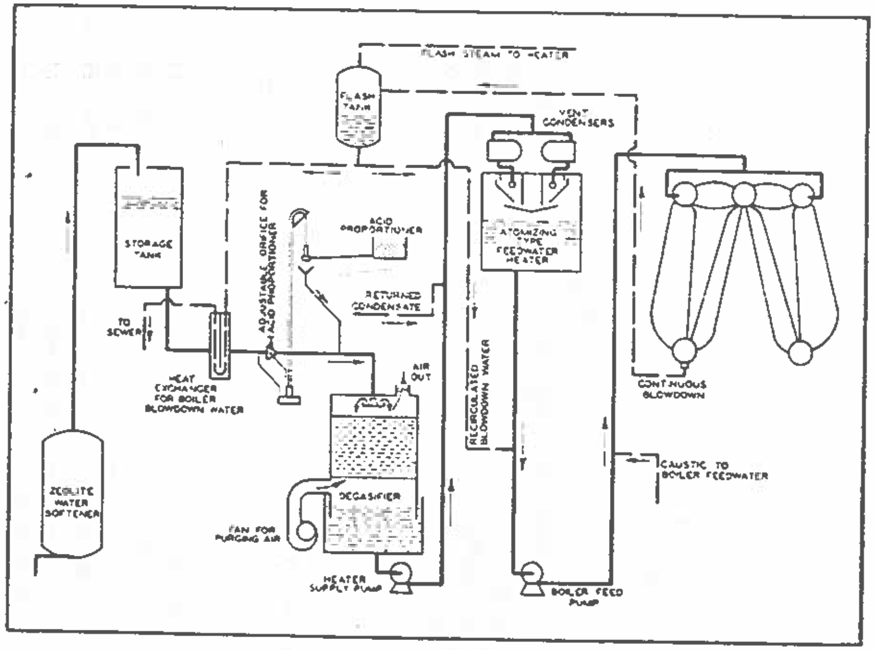


Fig. 16—Boiler Water Treating Cycle, Congress St. Heating Plant

TABLE II

Typical Chemical Conditions of Water at Various Points in the Congress Street Plant Boiler Water Treating System

All Values except pH are ppm.

	AVERAGE CITY WATER	ZEOLITE SOFTENED CITY WATER	ACID TREATED ENTERING DEGASIFIER	LEAVING DEGASIFIER	LEAVING DEAERATING HEATER*	IN BOILERS
Calcium—Ca............	25.	1.0	1.0	1.0	0.7	1.0
Magnesium—Mg.........	6.	0.2	0.2	0.2	0.2	2.0
Sodium—Na............	5.	48.0	48.0	48.0	31.0	600.0
Silica—SiO_2............	1.	4.0	4.0	4.0	2.5	39.0
Oxides—Fe_2O_3 & Al_2O_3....	1.	2.0	2.0	2.0	1.5	3.0
Bicarbonate—HCO_3.......	98.	98.0	10.0	10.0	7.0	0
Carbonate—CO_3.........	0	0	0	0	Trace	25.0
Hydroxide—OH.........	0	0	0	0	0	20-200
Phosphate—PO_4.........	0	0	4.0	4.0	2.5	10.0
Sulphate—SO_4...........	21.	21.0	100.0	100.0	64.0	1000.0
Chloride—Cl.............	6.	6.0	6.0	6.0	4.3	115.0
Dissolved Solids.........	163	180	175	175	114	2200
Hardness as $CaCO_3$......	89	3	3	3	2	—
Free CO_2 (Carb. Dioxide).	2	2	65	39	0	0
Dissolved Oxygen........	13	13	13	13	0	0
pH Value...............	7.1	7.9	5.7	6.4	8.4	11.5

*Includes returned condensate and steam condensed during heating to 218F.

however, appeared to exist. One reason is the limited season during which such an investment could be used. Another reason is the fact that turbo-generators installed in the heating plants are necessarily of relatively small capacity and can not properly be regarded as saving any investment in the Company's electrical generating stations. The thermal advantage of their use would thus be largely offset by the investment costs.

The practice which has been followed has therefore been to install, *primarily*, sufficient electrical generating capacity to supply the motor-driven auxiliary machinery in the plants, using the exhaust steam to heat the boiler feedwater and delivering such excess electricity as is generated into the Company's electrical system. *Secondarily*, some small turbo-generators have been installed to deliver electricity solely to the electrical system, while exhausting to the steam heating mains. Those machines are of such sizes that they can operate at full output through most of the heating season and in some cases they are machines salvaged from dismantled plants. Thus the cream of the thermodynamic possibilities has been utilized without a large offsetting investment. During the year 1945 24,185,700 kwhr were generated, of which 4,226,200 kwhr were used in the heating plants and 19,959,500 kwhr were delivered to the electrical system. Also 2,020,700 kwhr were drawn from the electrical system at times when the output of the heating plant generators was insufficient.

The development of boilers and turbines using high steam pressures and temperatures took place subsequent to the building of the present

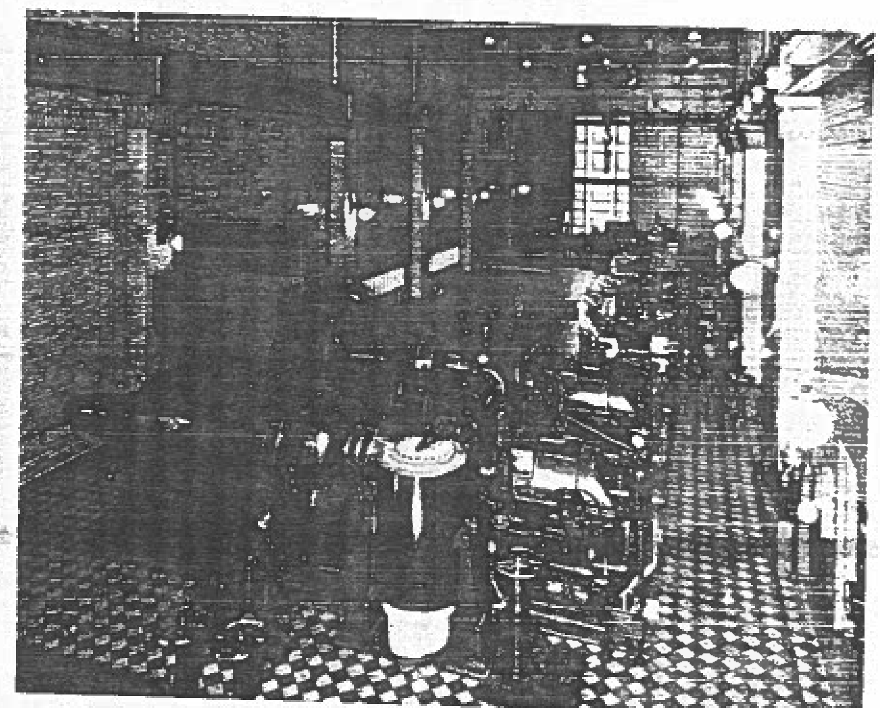


Fig. 17—Turbine Room, Beacon Street Heating Plant

Detroit heating plants. The economic possibilities of combined electricity and steam production are of course more favorable with higher boiler pressures and the present practice may be modified in future plants.

The capacities of the turbogenerators in the various plants is shown in Table I. A picture of the Beacon Plant turbine room is shown in Fig. 17, and a cross section view of the 3000 kilowatt A. C. turbogenerator at Beacon Plant is shown in Fig. 18.

Heating Plant Efficiencies

None of the heating plants is equipped with economizers or air preheaters because the poor annual load factor does not justify these or many other coal saving devices. The plants are carefully operated, however, and the efficiency is good. The best index of this efficiency as a whole is the yearly figure for the pounds of steam delivered to the distribution system per pound of coal burned. The less favorable results obtained during the war years when using a high ash coal are very evident.

YEAR	LB STEAM DELIVERED TO THE DISTRIBUTION SYSTEM PER LB COAL BURNED
1915	7.4
1916	7.8
1917	7.5
1918	7.4
1919	7.4
1920	7.2
1921	7.7
1922	8.0
1923	8.2
1924	8.4
1925	8.7
1926	8.6
1927	8.9
1928	8.9
1929	9.0
1930	8.9
1931	8.9
1932	9.0
1933	9.0
1934	8.9
1935	9.1
1936	9.0
1937	9.0
1938	9.1
1939	9.0
1940	9.0
1941	8.9
1942	8.9
1943	8.8
1944	8.6
1945	8.5

Table III shows the operating results for the twelve months' period ending December 31, 1945. It will be noted that the steam output per pound of coal for the Boulevard Plant is high compared with its boiler efficiency. This is because the water used by this plant is for the most part warm return water from the large nearby buildings, whereas most of the water used by the other plants is cold water from the city mains.

TABLE III

Operating Data, Heating Plants, Twelve Months Ending December 31, 1945

	BEACON	CONGRESS	WILLIS	BOULEVARD	TOTAL
Output M lb.	1,537,054	1,012,856	774,142	142,193	3,466,245
Coal Burned—Tons	89,416	59,713	47,352	8,241	204,722
Steam Output—lb/lb coal	8.6	8.5	8.2	8.6	8.5
Btu/lb Coal as Fired	12,820	12,650	12,630	12,370	12,710
Moisture in Coal as Fired—%	4.85	5.50	5.72	6.55	5.31
Ash in Dry Coal—%	11.3	11.5	11.4	9.5	11.3
Boiler Efficiency—%	80.0	78.8	76.7	78.0	78.8
30 min. max. load—lb/hr.	673,000	382,000	312,000	87,000	1,454,000
Annual Load Factor	0.260	0.302	0.283	0.186	0.272

THE DISTRIBUTION SYSTEM

Steam is distributed from the plant to the consumers by a system of underground piping varying in size from 20 inches near the plants to 4 inches in the outskirts of the system. These pipe lines are installed at a depth of approximately 6 feet. In general the piping is laid under the streets instead of alleys due to the fact that congestion in the alleys is usually so great as to make both construction and repairs extremely expensive.

Underground Construction

Underground piping must be well insulated to prevent excessive heat losses. For the first six years until 1909, a segmental wood casing

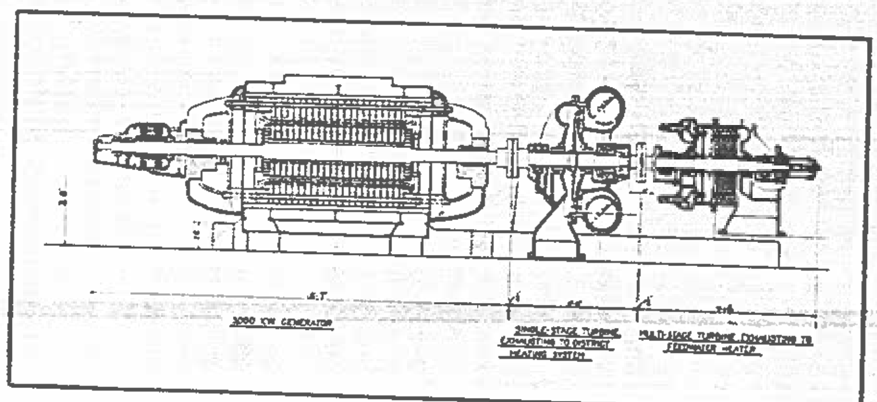


Fig. 18—Cross Section of 3000 Kilowatt Turbo Generator, Beacon St. Heating Plant

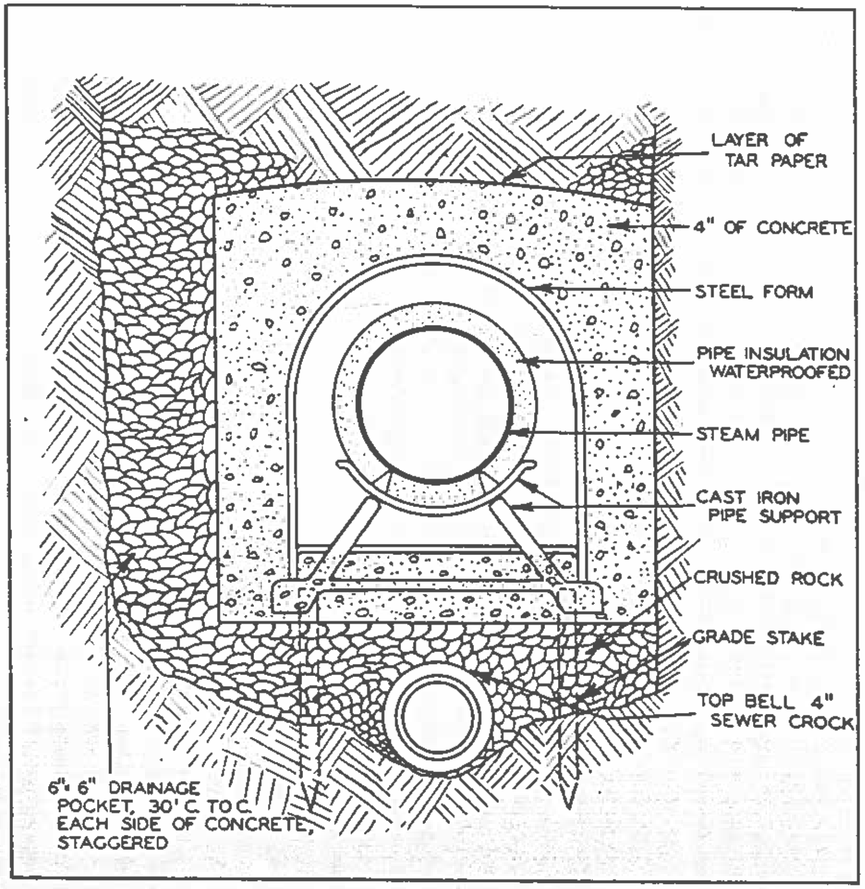


Fig. 19—Concrete Construction for Underground Steam Lines

was used exclusively. This construction, although initially satisfactory, deteriorates because of the heat and moisture.

In 1909 a concrete conduit was developed by the Company and with slight changes has been since used to the present time. In this construction the pipe is covered with insulation waterproofed by a jacket of roofing felt with the joints well lapped and mopped with hot asphaltum. A concrete envelope encloses the pipe, leaving an air space between the covered pipe and the concrete (Fig. 19).

This construction is sufficiently waterproof for the purpose and is underdrained to dispose of any seepage. It possesses the advantage of being constructed of common materials and of being easily adapted to special underground conditions.

Specifications for the materials used at the present time are:

Pipe: Steel, black, open hearth electric resistance welded, schedule 40 for nominal pipe size 2½" to 12"; for sizes 12" and larger, ⅜" wall thickness.

Flanges: Welding neck, forged steel, American Std 150 lb SSP for surface mains subject to pressures up to 35 psi. American Std 300 lb SSP for tunnel mains, surface feeders, and tunnel feeders subject to pressures up to 150 psi.

Style of Joint: All joints acetylene-welded with welding flanges used at valves and expansion joints in manholes.

Valves: Solid wedge, inside screw non-rising stem, flanged, faced and drilled, cast iron American Std 125 lb SSP for surface mains, pressures same as above; cast iron American Std 250 lb SSP for surface feeders and tunnel mains; cast steel American Std 300 lb SSP for tunnel feeders.

Expansion Joints: Slip-type, cast iron body and gland, square lap steel Van Stone sleeve, plated with polished chromium over nickel, with anchor lugs on body; American Std 125 lb SSP for surface mains with pressures as above; American Std 250 lb SSP for feeders and for tunnel mains.

Pipe Insulation: Sectional insulation made from long fibre unibestos or equal with asbestos-base waterproof jacket attached, one inch thickness is used on surface mains and feeders up to 10" pipe, one and one-half inch is used over 10". A double layer of one inch sectional insulation is used on tunnel mains and feeders up to 10" pipe. A double layer of one and one half inches segmental block insulation is used for over 10". All block insulation is covered with asbestos cement and all tunnel insulation is wrapped with a 10 ounce canvas jacket.

Gaskets: Asbestos composition.

The probable length of life of the underground steam mains is an important question. The first of the mains installed in wood casing are, at this writing, 42 years old. Much of that type of construction, installed in the first year and in subsequent years, has been replaced. Other portions are still in usable condition, but of limited further life, and replacements are steadily being made.

The concrete construction should have a much longer life than the wood casing but because almost no replacements of any mains of that type, dating from as far back as 1909, have been necessary, there is no experience to serve as a basis for life predictions. Certainly an average life of 40 years for the concrete construction would be a conservative guess, leaving out of course the possibility of replacements due to inadequacy of capacity. The life of such buried structures depends greatly upon soil conditions and experience in Detroit would not necessarily apply elsewhere.

The present (1945) cost of underground piping installed complete in concrete conduit is as follows:

NOMINAL PIPE SIZE, IN.	APPROXIMATE COST PER FT-DOLLARS
6	25
8	26
10	32
12	40
16	47

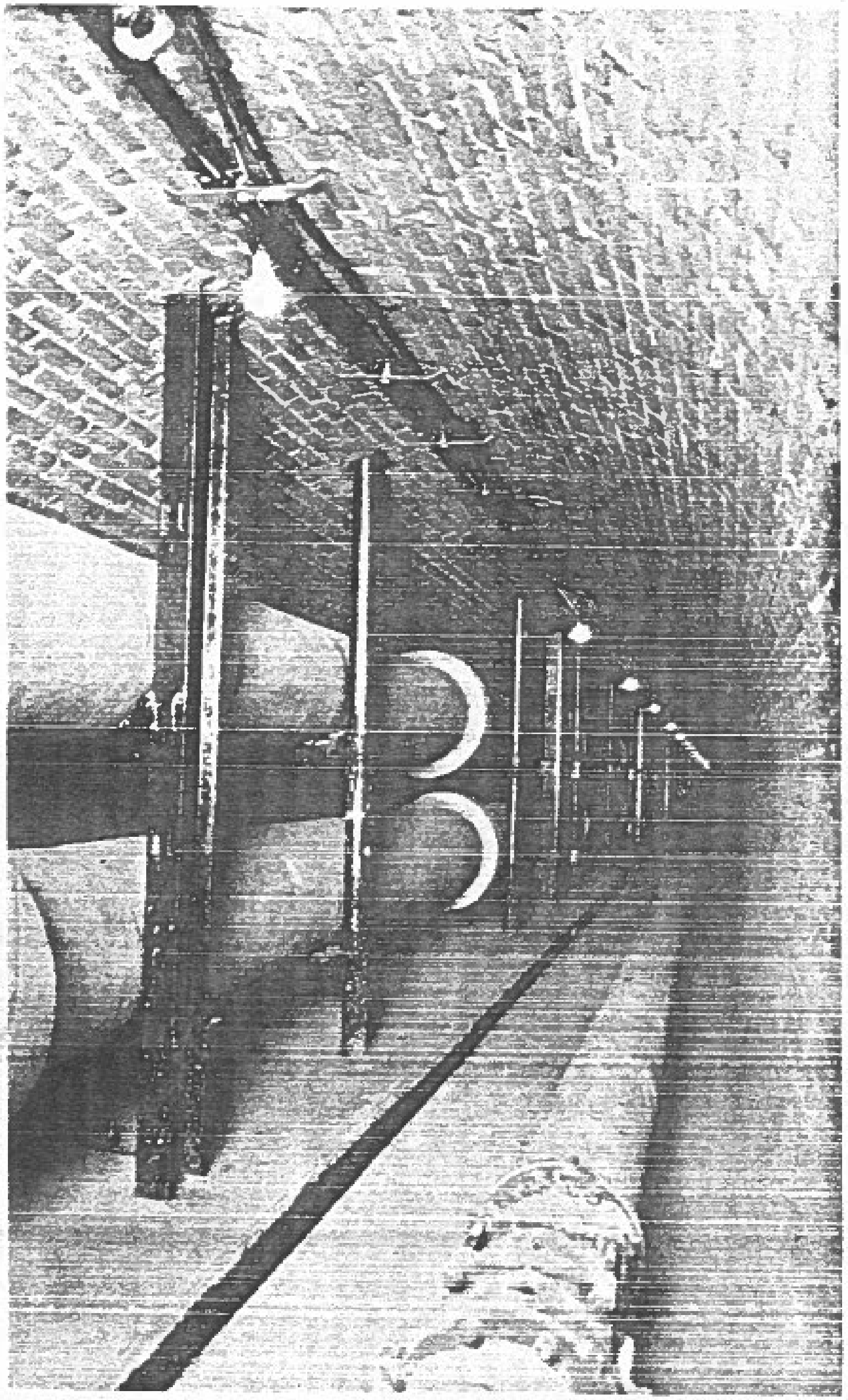


Fig. 20—Beacon-Woodward Tunnel

Distribution Losses

Distribution losses as indicated by the difference between the stea delivered by the plants to the distribution system and the condensatic metered, consists of condensation drained from the mains, leakage steam from the mains and from customers' piping, leakage of condens tion and slowness of meters. For the past sixteen years the loss in p cent of output has been as follows:

	STEAM OUTPUT M LB	CONDENSATION METERED M LB	LOSS PER CEN
1930	3,082,214	2,628,698	14.71
1931	2,613,882	2,172,945	16.87
1932	2,628,040	2,170,216	17.42
1933	2,468,850	2,009,068	18.62
1934	2,553,102	2,123,173	16.84
1935	2,596,790	2,137,655	17.68
1936	2,778,532	2,338,715	15.83
1937	2,754,302	2,262,439	17.86
1938	2,533,300	2,052,452	18.98
1939	2,635,596	2,211,873	16.08
1940	2,903,444	2,461,142	15.23
1941	2,630,893	2,180,560	17.01
1942	2,938,956	2,434,609	17.17
1943	3,283,862	2,821,548	14.08
1944	3,172,374	2,702,410	14.81
1945	3,466,245	2,959,742	14.61

Tunnels

There are about 2½ miles of horseshoe shaped tunnels, lying fro 25 to 60 feet below the street level. The walls are of brick, and the floo of concrete. They are, for the most part, about 6 feet in height and abo 6 feet wide and contain two or more steam pipes and a condensatic return line as shown by Fig. 20.

The tunnels are ventilated by suction fans which draw air throug them continuously. The temperature in the tunnels ordinarily rang from 90 to 130 degrees, but when work is being done in the tunnels, tl nearest shaft cover is raised or a ventilating cover installed, therel increasing the amount of ventilation and lowering the temperature.

All tunnels are equipped with a lighting and a telephone system. Tl lighting cables are racked on the inside of the tunnel roof and the ligh are placed at about 20 foot intervals. The telephones, of a type resista to heat and moisture, are installed at convenient points throughout tl tunnel system.

When two or more pipes are to be installed under a street, particularl in a congested district, it has been regarded as desirable to build a tunn to avoid tearing up the street, either for the original construction work or for subsequent repairs; and the tunnel permits of ready access to the pipes at any time. This may not be the case where the subsoil is of a different character, but has been demonstrated to be quite feasible for the Detroit subsoil, a blue clay, nearly impervious to water.

Feeders

The original distribution mains soon became inadequate to handle the quantities of steam required by the many new buildings erected. Instead of replacing considerable sections of the existing mains with larger pipes, the less expensive plan was adopted of installing "feeders," which extend from the plants to important centers in the distribution network. No buildings are served from them, their function being to transmit the steam to the feeding points of the system. A large pressure drop is allowed to take place in the feeders, and the pipes are consequently of relatively small diameter, which reduces the cost of construction considerably.

The velocity of the steam flow in the feeders at times of heavy load is very high. Velocities up to 75,000 feet per minute have been measured and velocities of 30,000 to 50,000 feet per minute are common. Such high velocities do not appear to be at all objectionable. There is no apparent erosion of the pipe and no objectionable vibration. The fact that the steam is in a superheated state, because of the pressure drop, is no doubt an advantage in these respects. Feeders are constructed with long radius bends wherever possible and where the connections are made to the distribution mains the diameter of the pipe is gradually increased by special taper fittings so as to re-convert some of the velocity head to static pressure.

The pressure at the remote end of the feeder is maintained nearly constant and the pressure of delivery to the feeder at the plant is raised as the demand for steam increases. In order to furnish the operating engineers at the plants with a record of the pressures existing at feeding points and at remote portions of the distribution system, electrically-operated long distance gages are used.

Condensation Return Lines

The condensation from the buildings heated is returned to the plants only to a limited extent. In the tunnels it is necessary to install a return line to receive the discharge from the traps on the steam lines, and wherever possible the condensation is drained from the adjacent buildings to this line. It is difficult and costly, however, in many cases, to arrange a gravity discharge from the building basement to the tunnel, and the cost of installing and operating pumps to handle the condensation would more than offset the value of the water which would be salvaged.

In the districts not served from tunnels the condensation is drained to the sewers, except in the case of the three large buildings in the Boulevard district. With the present cost of coal, return lines would not

usually be a profitable investment. Furthermore, they are short lived due to oxygen corrosion, and leakage from them is disastrous to the steam lines which may have been laid in the same trench.

The proper answer to the question of salvaging the heat in the condensation is that the customer should install an economizer to extract the heat from the condensation before it is discharged to the sewer. This device acts as a preheater for the hot water supply of the building.

At the Boulevard Plant nearly one hundred per cent of the condensate is returned, at Willis Avenue no condensate is returned, at Congress Street twenty-five per cent is returned, and at Beacon Street fourteen per cent is returned. The amount of condensate returned to all the plants averages about sixteen per cent of all the steam delivered by the four plants.

Operation of the Distribution System

Most of the Detroit system, like many similar ones, was originally designed to distribute exhaust steam at pressures below 10 pounds per square inch. In a system of moderate size this method is perfectly practicable, but in a large system the conveying of the quantities of steam required, at such low pressures, is very difficult if not impossible, because of the large specific volume of the steam at this pressure. The unusually great increases in load which accompanied the rapid development of the city's central district, during the period 1915-1930, made it necessary to change radically the method of distribution. The distribution pressure was raised and the feeder method, which was described in a preceding section was established.

In the downtown section known as the Beacon Street District (formerly the old Central Heating Company system) the nominal pressure on the mains is maintained between 28 and 35 pounds per square inch, but in the coldest weather the pressure at many points drops considerably, and a minimum pressure of only 10 pounds per square inch is guaranteed to the customer. There is thus available a pressure drop of 20 pounds per square inch between the points at which steam is fed to the mains and the more remote points, and the capacity of the mains for transmitting steam is therefore much greater than it would be if a lower and more uniform pressure were maintained. The maximum pressure drop occurs, of course, only upon the coldest days.

This range of pressure appears to be a desirable one and it is probable that the entire system will eventually be so operated. The minimum pressure of 10 pounds per square inch (which occurs very infrequently) is ample for cooking purposes. The maximum pressure is not so high as to be dangerous in case of the failure of a customer's reducing valve to function.

The pressure on the mains in the Congress Street District is maintained between 12 and 20 pounds per square inch with the guarantee to the customer of 5 pounds, and in the Willis District the pressure in the system is maintained between 10 and 15 pounds per square inch with the guarantee to the customer of 3 pounds. Both of these districts were originally designed as exhaust steam systems, and the underground fittings are of low pressure pattern. In the Willis-Boulevard District which is practically entirely new construction, the pressures are maintained between 32 and 50 pounds per square inch with a 10 pounds guarantee to the customers.

Summer Service

During the summer months approximately 30% of the distribution system is shut off. The remainder is kept in service for those customers who use steam for cooking, hot water, clothes presses, and other process work. This summer service, though of small volume in comparison with the fixed line losses, is unavoidable. Additional summer business is welcomed when it can be served from those mains which are kept in service.

The sale of steam for power purposes has not proved satisfactory, first, because of the lack of a proper method of metering, and second, because of the necessity of maintaining a high and constant pressure on lines serving such business, which greatly reduces their capacity for transmitting steam. This feature was no doubt a necessary part of the service when many existing buildings having steam-driven equipment were to be served, but is no longer demanded. No power business is accepted.

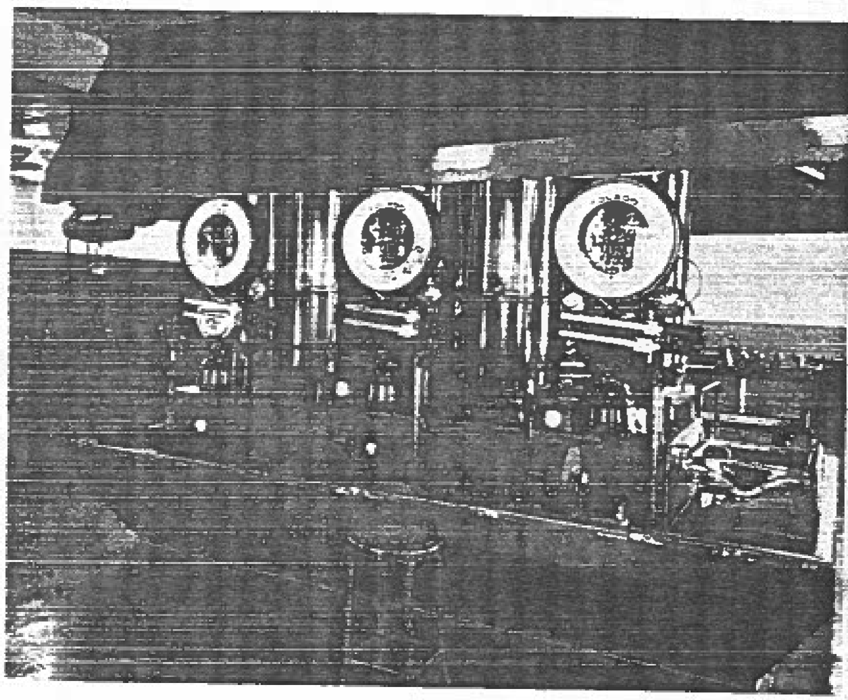


Fig. 21—Steam Meter Testing Table

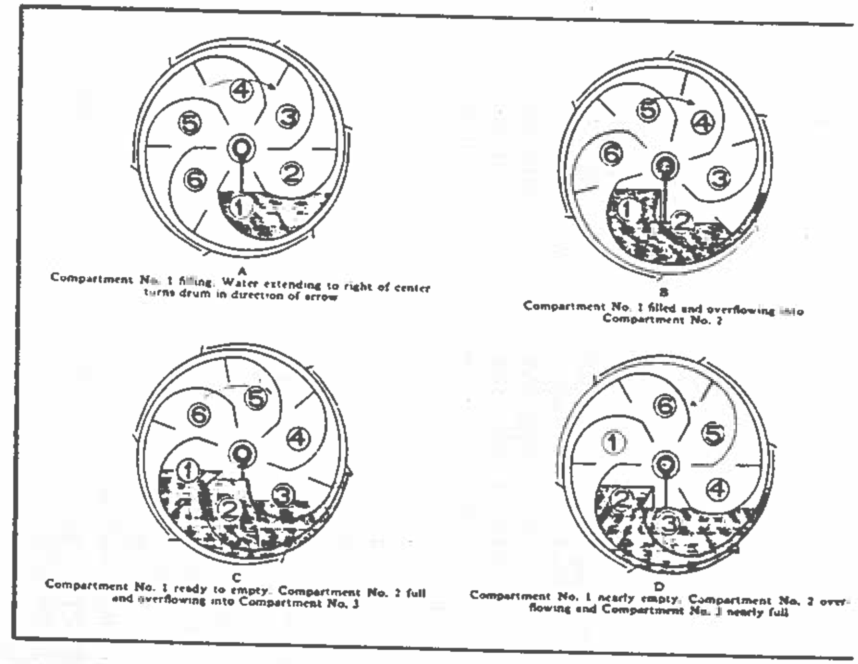


Fig. 22—Condensation Meter, Cycle of Operation

METERS

The steam service is charged for on the basis of the quantity c steam condensed in the customer's heating system. The art of meterin condensation was a comparatively new one when the Company com menced operations and many advances have been made in it, but it ha not yet reached, and probably never will reach, the standards of relia bility and accuracy of electrical metering. The troubles experienced ar largely mechanical; but there are certain fundamental obstacles in th way of their entire elimination. The conditions of temperature, moisture and dirt are severe, and the allowable weight and cost of the meter ar limited.

A volumetric, revolving drum meter is used. The principle of opera tion is shown in Fig. 22 and a meter of the largest size is shown in Fig 23. To record the hourly demand, of certain customers, a mechanicall driven chart attachment is provided.

Meters are tested at any time upon request of the customer but ir any case at intervals of *two years or less.* Inspections in service are made at intervals varying from four to ten weeks, depending upon the size o the meter, and readings are taken weekly or oftener in order that stop pages or excessive consumption may be detected. When tested on a customer's premises the allowable limits of accuracy are 4 per cent ir either direction, but no meter is installed unless the shop test shows it tc be within 2½ per cent of being correct. Meter tests are rarely demandec

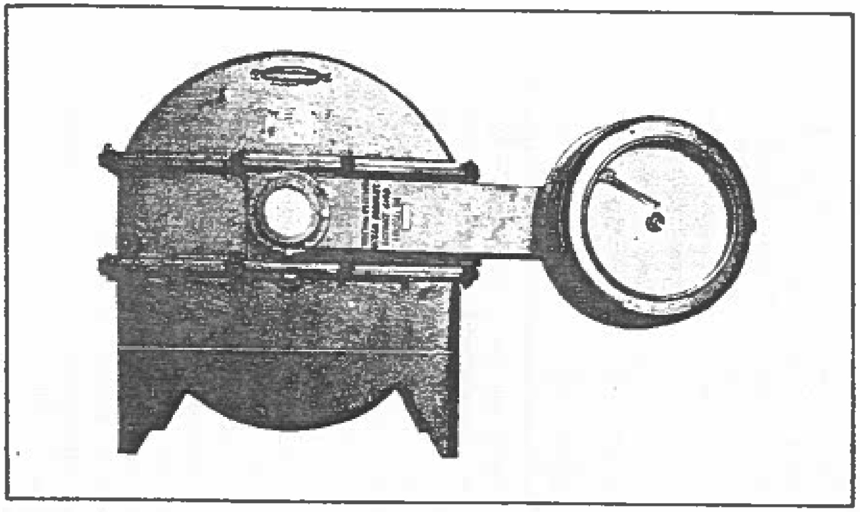


Fig. 23—Condensation Meter with Demand Meter Attached

by customers. Improved knowledge of the characteristics of heating systems has made it possible to explain abnormally high consumption and to instruct the customer as to methods of controlling it. As a result, customers in general are not suspicious of the accuracy of their meters. On the whole it might be said that the art of metering is in a fairly satisfactory state.

As of December 31, 1945, there were 1755 condensation meters in use. Six steam flow meters are installed to meet special conditions but the present policy is to meter the condensate in preference to metering the steam supply wherever feasible.

CUSTOMERS STEAM SERVICE

The district heating business exists under highly competitive conditions. It is possible for certain classes of buildings to supply their own heat at comparatively low cost. This applies in general to those small buildings in which space occupied by a boiler plant is not valuable, which do not require the employment of extra labor for operating a boiler and which burn bituminous coal or other low-cost fuel. Even in the case of the large office building, the economic advantage of district heating over the individual boiler installation is not a great one. For that reason it is necessary, in meeting the competition of the individual boiler plant, to instruct and assist the district heating customer in operating his heating system as economically as possible.

Customers' Installations

Proper installation and care of the customer's piping system has proved to be absolutely essential, particularly because of its effect upon metering conditions and to insure adequate and economical service.

TABLE IV
HEAT REQUIREMENTS OF VARIOUS TYPES OF BUILDINGS—HEATING SEASON 1944-1945
Average temperature for Heating Season (8 months) 39.5
Degree Days (8 months) 6202

Types of Buildings	Number of Buildings	Average Radiator Heating Surface Sq Ft	Average Heated Space Cu Ft	Ratio Space to Radiation	Average Steam Requirement Pounds	Heat Requirement† Lb per Sq Ft Radiator Heating Surface	Heat Requirement† Lb per Degree Day per M Cu Ft Space
Apartment	14	3,545	210,460	59	2,118,000	597	1.440
Apartment Hotel	5	14,525	931,930	64	9,544,000	657	1.710
Auto Sales	10	8,150	503,200	62	2,619,000	321	.834
Bank	17	9,890	382,130	37	1,869,000	189	.698
Bowling Alley	6	10,445	515,190	49	2,081,000	199	.656
Church	13	8,915	490,990	55	1,557,000	175	.453
Club	19	17,570	764,330	44	6,199,000	353	.984
Garages—Commercial	9	2,785	256,780	92	998,000	358	.939‡
Ramp	11	10,490	1,154,060	110	1,736,000	165	.443‡
Hospital	6	10,635	605,140	57	6,888,000	648	1.320
Hotel—Class A	6	66,070	3,005,520	45	40,072,000	606	1.210
Class B	17	10,870	735,610	68	7,551,000	694	1.250
Class C	10	2,660	192,300	72	1,501,000	564	1.040
Office Building—Class A	31	64,560	3,810,520	59	18,616,000	288	.654
Class B	30	13,910	912,480	66	4,862,000	350	.742
Class C	33	4,940	330,830	67	2,386,000	483	1.110
Printer	18	13,450	594,370	44	4,608,000	343	1.240
Recreation Center	3	15,935	907,600	57	2,248,000	141	.398
Restaurant	30	2,790	60,170	22	1,581,000	567	2.730
Store—Department	11	64,785	3,729,650	58	13,659,000	211	.440
Retail	75	3,990	251,010	63	1,556,000	390	.850
Wholesale	33	4,300	380,720	89	1,723,000	401	.671
Theatre—Class A	8	32,065	1,662,190	52	4,681,000	146	.502
Class B	19	7,965	377,530	46	1,441,000	181	.693
Warehouse	16	13,780	1,224,500	88	4,458,062	322	.466

† Includes steam used for water heating and other process.
‡ Computed on a 55-degree base.

Temperature and degree-day data from U. S. Weather Bureau

As the pressure in the street mains is considerably higher than is required for heating, a reducing valve, pressure gage, etc., are required on every new installation. The condensation is drained from the system through a common type of float trap.

Water-heating economizers utilizing the heat in the condensation are recommended by the Company. These economizers are surface heaters arranged so that the condensation, in passing through the coils, preheats the cold water supply to the building water heaters.

The heat requirements of buildings are not capable of close estimation, partly because of the lack of uniformity in building construction and the inexactness of heat loss constants, but principally because of the great difference in the degree of economy practiced by different consumers. Table IV gives the steam consumption for various classes of buildings for the season of 1944-1945.

Economical Utilization of Heat

It has been demonstrated that very marked savings in the use of heat can be accomplished in most buildings by the proper design and operation of the heating system. A permanent staff of engineers is engaged in advising customers in the selection and installation of heating equipment and in the proper operation of their heating systems. When new buildings are being designed, the engineers co-operate with the customers' architects in planning heating systems so that they can be operated with maximum economy.

Customers are urged to shut off steam at night and at other times when buildings are not in use except to the extent of using steam to prevent freezing. It has been demonstrated that this is the most effective way of reducing steam consumption. The load curves for a large office building (Fig. 24) show the savings possible by shutting off steam at night.

In the case of buildings divided into parts having different hours of use, the customer is advised to arrange and operate his heating system in such a way that steam is shut off in the mains supplying the parts not in use without interfering with the heating of the used parts. Such a method of operation is particularly adapted to office buildings having first-floor shops open in the evening and results in a marked saving of heat. This saving is due in part to the elimination of condensation in the piping. Customers are always advised to shut off steam in the building mains when heat is not needed rather than to shut off radiators.

The results of the Company's work with the customers is shown by Table V which gives the steam condensed per square foot of radiator heating surface for the entire system for the past 25 years. When corrected for variations in temperature, it shows an almost steady decrease in steam used from year to year, except for the last four years (World War II) when the economic use of steam was not given first consideration. Steam condensed per square foot of radiator surface decreased over 15 percent from 1921 to 1928. The effect of this on customers' bills is equivalent by and large to a corresponding decrease in the rates charged. The utilization work with customers is a popular and valuable feature of the service. The expense of the work and the income lost through decreased consumption are many times repaid by increased good will and this feature has become an essential and permanent part of the customers steam service.

TABLE V

Steam Condensed Per Square Foot of Radiator Heating Surface

YEAR	AVERAGE TEMPERATURE HEATING SEASON F	STEAM USED DURING THE YEAR: LB PER SQ FT RAD SURFACE	STEAM USED DURING THE YEAR: LB PER SQ FT RAD SURFACE PER DEGREE BELOW 65 F
1921	42.5	473	21.1
1922	40.8	470	19.4
1923	37.8	484	17.8
1924	38.6	484	18.4
1925	38.2	467	17.5
1926	36.1	493	17.1
1927	39.2	418	16.3
1928	39.9	436	17.4
1929	40.4	436	17.7
1930	39.4	366	14.3
1931	40.7	303	12.5
1932	43.2	308	14.2
1933	40.4	295	12.0
1934	37.2	315	11.4
1935	38.4	316	11.9
1936	37.4	372	13.5
1937	38.8	329	12.6
1938	40.0	290	12.3
1939	40.2	307	12.3
1940	37.2	338	12.0
1941	39.9	294	11.7
1942	41.7	318	13.7
1943	37.3	358	13.2
1944	39.1	332	12.8
1945	39.5	352	13.8

Based on the average of total connected radiator heating surface at the beginni and ending of each year.

Building Temperature Control Systems

A common source of steam waste, and the one which requires tl most careful supervision, is the overheating of buildings. Much of tl Company's utilization work is in connection with this item. In equippir new buildings, the customer is urged to install equipment which w enable him to control building temperatures with ease.

In recent years, there has been considerable development in aut matic temperature controls for building heating systems. There are no available several types of these controls ranging from a simple thermost to the more complicated type which automatically varies the pressure the heating system with the outside temperature.

One of the types of building temperature controls which has m with popular acceptance turns the steam on and off intermittentl in accordance with the outside temperature. The automatic change in tl length of "on" periods maintains the radiators at a temperature where tl heat emission is only sufficient to make up for the heat loss from tl

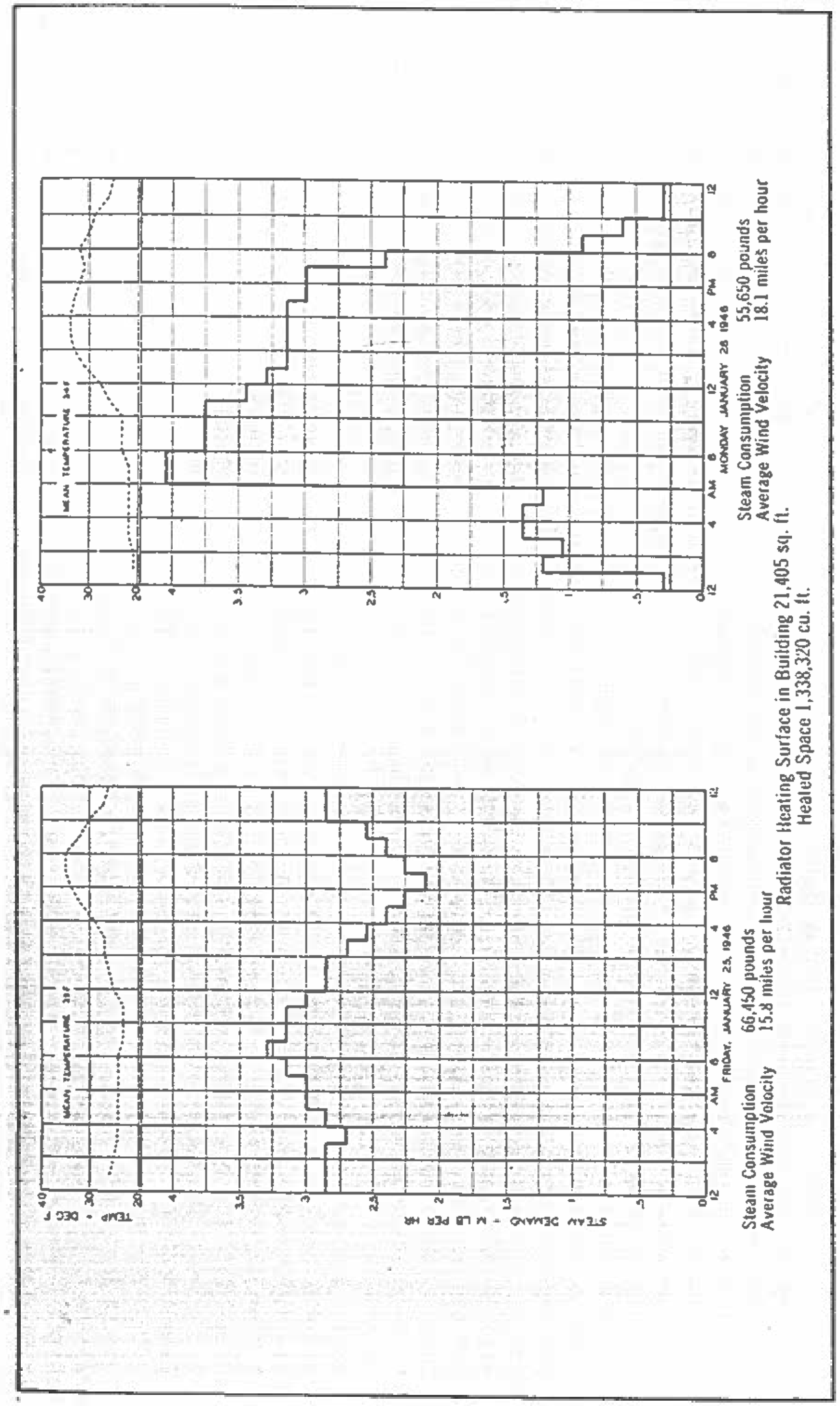


Fig. 24—Load Curves for Office Building, Showing Savings by Shutting Off Steam at Night

building. By the suitable arrangements of electric time clocks this type of control can be made entirely automatic.

The type of control recommended depends upon several factors, such as building size, type of occupancy, type of heating system, and hours of operation.

Orifice systems are recommended in conjunction with many types of controls to give a better distribution of steam throughout the system. Such a system has an orifice plate in the steam pipe at the entrance to each radiator, restricting the flow of steam to the radiator. With an orifice system, the amount of steam in the radiators is controlled by varying the steam pressure in the heating system. This can be done automatically or manually.

Steam Compressors

Although a nominal supply pressure of 30 pounds is sufficient for nearly every requirement of a customer, there are a few users for which a higher pressure (50 to 75 pounds) is desirable, such as in some clothes-pressing machines and certain laundry apparatus which has been designed for pressures higher than 30 pounds and where a higher temperature is helpful. These uses require only small quantities of steam. The cost of installing a parallel network of high pressure mains to supply these small amounts of steam would be very high when compared to the steam revenue available. A satisfactory alternative expedient has been developed. The customer installs a compressor, driven by an electric

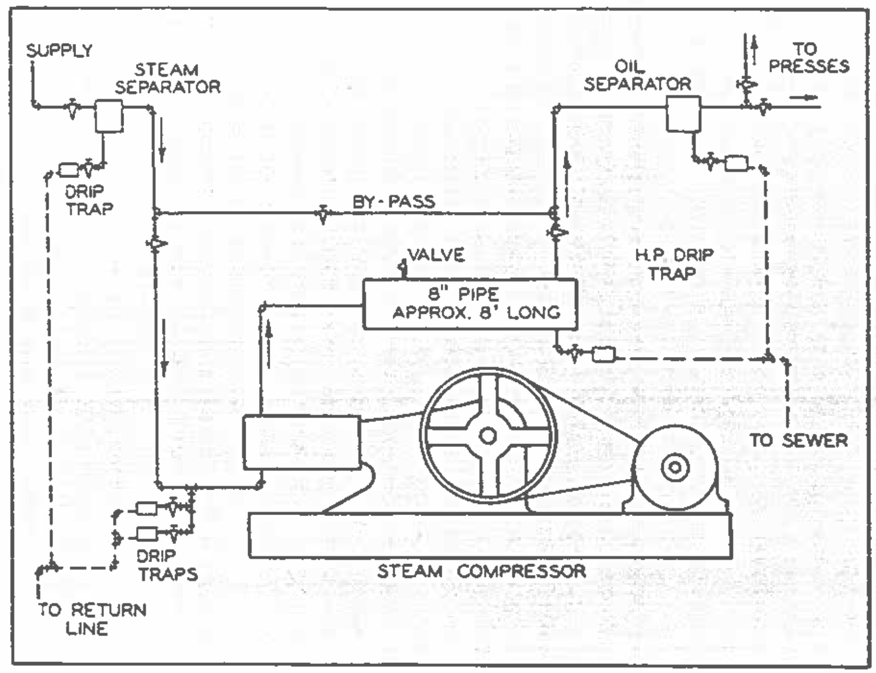


Fig. 25—Steam Compressor Piping Diagram

motor, which takes steam at the supply pressure and compresses it to the pressure desired. The cost of the installation and the cost of power appear to be more than offset by the advantages of such a supply of steam as compared with alternative methods.

To date 17 of these compressors have been placed in operation, as shown in Table VI. The compressors are ordinary reciprocating air compressors, modified in certain details. The power required to compress steam from 30 pounds to 75 pounds per square inch is about 32 kwhr per thousand pounds of steam. The installation cost is about $3000.00 for a unit having a capacity of 1000 pounds of steam per hour. Fig. 25 shows in diagram the general arrangement of the compressor installation.

TABLE VI.

Steam Booster Compressors in Detroit

LOCATION	DATE INSTALLED	BORE & STROKE	HP MOTOR	RATED CAPACITY LB/HR
Club	1928	9½ x 12	60	——
Clothing Store	1932	6 x 7	15	300
Dept. Store	1935	7 x 7	25	600
	1938	7 x 7	25	600
Hotel	1937	9 x 9	50	1000
	1938	3 x 8	5	——
Office Bldg.	1937	4 x 8	8 x 8*	——
Hotel	1938	12 x 11	75	1800
	1938	9 x 9	40	1000
	1938	4 x 4	7½	100
Dept. Store	1940	6 x 5	15	275
Dept. Store	1941	6 x 5	15	275
Spa Bath	1944	6 x 5	15	250
Hotel	1944	9 x 9	40	934
Hotel	1945	7 x 7	30	500
	1945	7 x 7	30	500
	1945	7 x 7	30	500

*Steam Engine.

Customers' Service Calls

It was learned very early that a large part of the steam customers had only a vague knowledge of steam heating systems and equipment and, therefore, they were unable to cope with even the minor difficulties which occur with their heating systems. It was found necessary, therefore, to provide a small staff of men who can service all types of heating equipment using our steam.

This staff of steam servicemen which now consists of ten men and a foreman operates in the same manner as that of the electrical system. At least one man is on duty for sixteen hours of each day during the colder part of the winter. One or more men report to the customers telephone switchboard at least once each hour and each call for assistance or complaint concerning the operation of a heating system is promptly investigated. At times when a serviceman is not on duty, one or more men are designated to be available for calls at their homes.

During the colder winter days, up to 80 calls have been received from steam customers. The difficulties in most cases are of a rather insignificant nature involving the improper operation of air vents and steam traps, plugged screens ahead of traps, frozen condensate lines, and other similar conditions.

The automatic building temperature control systems naturally are responsible for a part of the trouble calls. In some cases the equipment is not functioning properly, but a large share of the difficulty with this type of equipment results from improper adjustments made by persons not thoroughly familiar with the adjustment procedure.

During the summer months, there are very few trouble calls and the steam servicemen are then assigned to the inspection of customers heating systems. Dirty traps, plugged air vents, and other faulty conditions are detected and the customer is advised to have repairs made. This materially reduces the number of trouble calls during the heating seasons.

OPERATING STATISTICS

Year 1945

Steam to system, pounds	3,466,245,000
Steam supplied to customers (including Company buildings) pounds	2,959,742,000
Coal burned, tons	204,722
Steam to system per pound of coal, pounds	8.5
Steam supplied to customers (including Company buildings) per pound of coal, pounds	7.2
Ratio, steam sold to steam delivered to system	0.854
30-minute maximum system demand, pounds per hour	1,454,000
Annual load factor of plants	0.272
Net electrical energy generated (total minus plant use), kilowatt-hours	19,959,500
Gross earnings, dollars	2,457,312.76
Connected radiator heating surface as of Dec. 31, square feet	8,526,500
Number of customers, Dec. 31	1,634
Number of customers meters, Dec. 31	1,761
Steam condensed per square foot of connected radiator heating surface, pounds	347.12
Earnings per square foot of connected radiator heating surface, dollars	0.288
Cost of coal as burned per ton, dollars	5.49
Average temperature, heating season, degrees F	39.5
Degree days excluding July and August, 65 F base	6,497

RATES, REVENUE, AND OPERATING COSTS

For several years previous to Sept., 1920, the rates were insufficient to cover expenses and the heating business showed an annual deficit which was borne by the electrical business. In 1920 increasing production costs made this situation no longer tolerable, and a large increase in the heating rates was made. Coming at a time when the prices of most commodities were advancing, the increase met with little opposition and resulted in no appreciable loss of business. Since that time there have been several rate revisions and at present the three rates listed below are in effect.

BLOCK RATE.

RATE: $1.15 per 1000 pounds for the first 100,000 pounds per month, subject to 10% discount for prompt payment,
$ .85 net per 1000 pounds for the next 700,000 pounds per month, and
$ .75 net per 1000 pounds for the excess over 800,000 pounds per month.

MINIMUM CHARGE: $5.75 per month less 10% discount for prompt payment for the six months, November to April inclusive, except where year round service is furnished when the minimum charge shall apply for twelve months.

TERM: Until the next first day of September.

DEMAND RATE.

RATE: A demand charge of $1.00 per year per pound of steam demand, plus 45c per 1000 pounds for all steam consumed.

DISCOUNT: 5% for prompt payment.

MINIMUM DEMAND CHARGE: $1000.00 per year, subject to 5% discount for prompt payment.

TERM: Until the next first day of September.

DETERMINATION OF BILLING DEMAND:

The billing demand shall be the average of the three highest hourly demands occurring between 8:00 a.m. and 6:00 p.m. during the three month period, December, January and February, except that it shall not exceed the average of the demands so determined from the three years immediately preceding. Demands on Sundays and on nationally observed holidays are excluded from this calculation and no more than one demand shall be selected from any one day.

The annual demand charge shall be distributed over eight monthly bills from September to April, inclusive. Until the demand for the year shall be determined by meter it shall be estimated; after it has been determined the monthly billing shall be adjusted to bring the total for the year to the metered figure.

Demand Rate is optional to customer.

OPEN END RATE.

MINIMUM BILL, $5.00 net per open end per month.

The open end rate is applied to service which cannot be metered, such as kitchen service where the steam is discharged into fixtures from which the condensation cannot be recovered.

The demand rate, established in 1926, was the result of a long-standing desire for a rate which would take into account the customer's load factor, in other words his average use of heat as compared with his maximum demand. Hotels, club and apartment buildings have, as a rule, very high load factors due to their long-hour use of heat, whereas office buildings and department stores have lower load factors, and theatres with their enormous demands during the warming-up period have exceedingly poor load factors.

The investment in heating plants and underground mains is determined by the maximum demand for steam. The cost of providing equipment to serve a customer depends then on his peak load and not on the amount of steam which he uses during the year. With a simple block

rate, the long-hour user pays more than his proper share because such a rate must necessarily include fixed charges based on the average load factor. Since it is with the long-hour user, the hotel, club and apartment building, that the competition of the isolated boiler plant is the most severe, it was felt that if a rate could be established which would charge these customers more nearly their theoretical share of the cost of service it would help to meet competition. A class rate would have partially accomplished the purpose but would not have taken into account the very evident difference in load factors between individual buildings of the same class.

The use of the demand rate has decreased very considerably the bills for heating service for customers having high load factors. If applied to customers having poor load factors it would increase their bills. The use of the demand rate is made optional to the customers. The result naturally is that only those customers whose bills are reduced by its use have adopted it. At present 60 of the 1634 customers elect to use the demand rate.

Revenue and Operating Costs

The relation of gross revenue from the sale of heating service to operating expense (not including charges for depreciation) is shown in Fig. 26 for the period 1925 to 1945, and the distribution of the Central Heating costs is shown by Fig. 27. During the years preceding 1932, the margin was such as to yield a reasonably good return upon the invested capital.

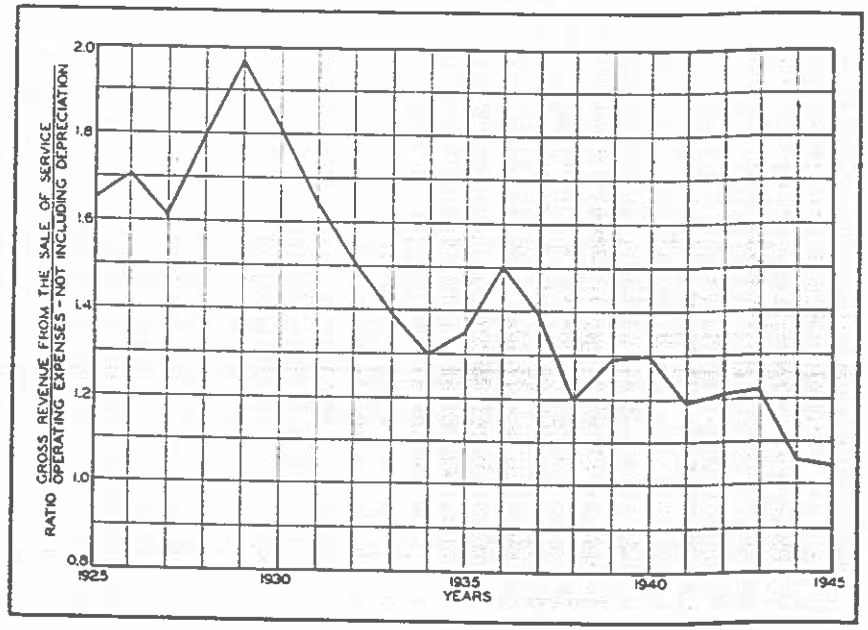


Fig. 26—Relation Between Gross Revenue from the Sale of the Heating Service to Operating Expense

Since 1932 several factors have acted to keep the ratio of revenue to costs below a satisfactory level. Because of the business depression which extended through most of the period 1930 to 1940 it was found necessary to reduce the rates considerably in 1931 in order to avoid a loss of load to other methods of heating. In spite of this rate reduction there was some loss of customers who in the time of economic stress could not afford the heating service. Simultaneously a loss of connected radiator surface took place due to the tearing down of many unprofitable small buildings. There was also a considerable degree of vacancy in rented store and office space.

During this same period beginning about 1930, the development of heat saving devices, and greater efforts toward economy by the operators of large buildings contributed to the reduction in the sale of steam. More recently, these same devices have been adapted to smaller customers. These devices have permanently reduced the requirements for heat so that the steam consumption per customer is definitely lower than it was prior to 1931. The Company has encouraged this trend, believing it to be of advantage to its customers and therefore ultimately to itself.

During the war years, all of the customers lost to other methods of heating in the early 1930's were returned to our service, and many new

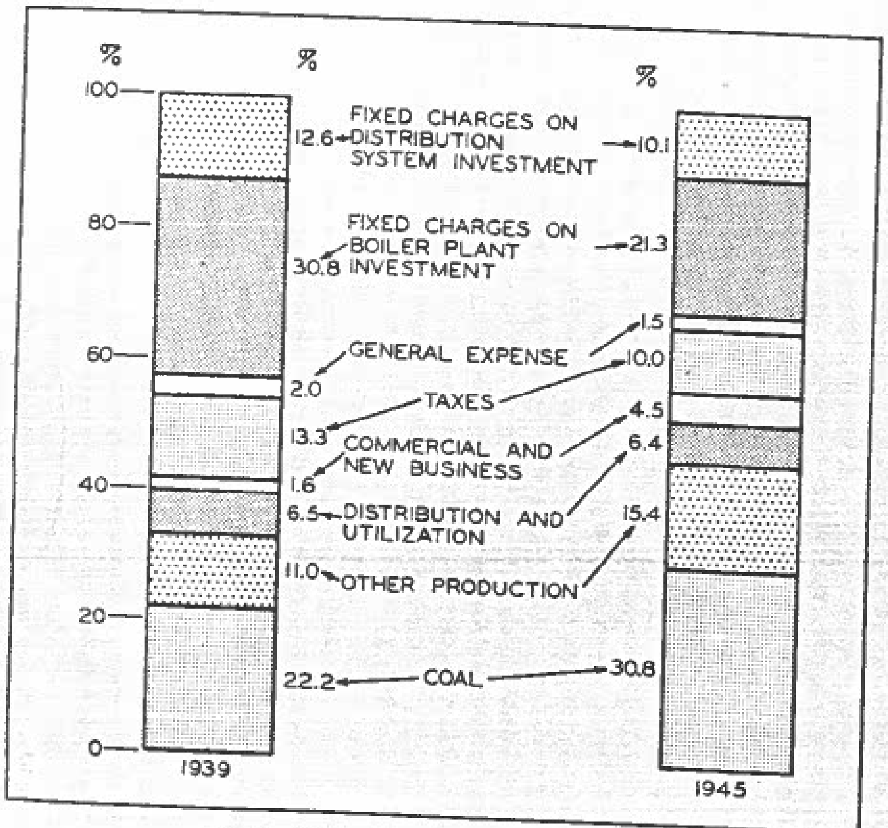


Fig. 27—Distribution of Central Heating Costs

customers in or adjacent to our service area were added. The amount of space now heated and steam sold is well above the 1929 level. There has been a continual increase in operating costs, however, and the ratio of revenue to expenses is still far below what it should be. The return on the capital invested in the heating service, therefore, continues to be inadequate.

SALES EFFORTS

In the endeavor to make fuller use of the existing capital investment in boiler plants and distribution system, much attention has been given to securing the rather small amount of unconnected business adjacent to or not far from the existing distribution mains. During the war years 1940-1945, the efforts in this direction were highly successful. In addition every effort is made to obtain as customers all new buildings erected in the steam service area.

During the depression years, 1930 to 1940, some effort was necessary to prevent inroads of competitive methods of heating. Very few large buildings discontinued the service and the majority have since resumed using it. The loss of a considerable number of small customers, however, could not be avoided. It is possible that a similar situation may develop with the return to normal peacetime conditions.

CONCLUSIONS

Early experience in Detroit made it evident that a central heating plant delivering exhaust steam at very low pressures was not as desirable from a broad economic standpoint as a live steam plant delivering steam at higher pressures. The underlying reason was the low generating cost of electricity at the main generating stations which reduces the relative value of economies which were obtainable by the operation of small combination plants.

The recent development of boilers and turbines for much higher steam pressures, however, makes it possible to generate more electricity from each pound of steam and still obtain the advantages of a fairly high distribution pressure. When replacements or extensions of the boiler plants become necessary the possibilities of combined electricity and steam generation must be re-evaluated. For the present, the generation of electricity is carried on to such an extent as is believed to give the best overall commercial economy with the boiler pressures which the present plants can carry.

As an auxiliary to a general electric light and power business the steam heating system justifies its existence. It makes it possible for the owner of a hotel, store or office building to take his entire service of light, power and heat from street mains and thus do away with occasion for a heating plant or power plant on the premises. There is practically no generation of electricity in buildings within the district we serve. The great popularity of the service has been amply evident in Detroit for the past several years. Almost all of the larger buildings, within the area served, are heated with our steam. There are few serious complaints regarding the cost of the service and practically all new buildings are connected as they are built. Few of the recently erected buildings have boiler space or chimneys and none of them have boiler plants.

The competition of the isolated boiler plant is very severe in the case of apartment buildings and hotels where the use of heat is lavish. The adoption of the demand form of rate has done much to help this situation by reducing the cost to the customer for such high load-factor service.

The service to small consumers is popular, but the cost of the underground mains is out of proportion to the amount of steam which can be sold in an area of detached residences or other small buildings, thus making the fixed (or investment) charges more than the business can ordinarily carry. In other words, the economy of the large central boiler plant, in comparison with the wastefulness of the domestic furnace or hot water boiler, does not counterbalance the greater investment cost, but may do so in a general business district where the underground investment is proportionately less and where the space and time which are saved in business buildings by the exclusion of boilers, etc., have a measurable value. Among residences of the better class there is a demand for heating comfort and convenience of the highest order with cost a secondary consideration, but because such residences are located outside of the present district heating area, the use of oil or gas for fuel appears to be the correct solution under Detroit conditions. As pointed out before, the one-time high-class residential area served by the system has changed to a business and apartment district.

The major problem for the present and for the immediate future is that of finding the rate level at which the maximum return upon the investment will be obtained, without an offsetting loss of customers to competitive means of heating.

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