DISTRICT HEATING SERVICE IN DETROIT

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

by

E. E. DUBRY

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June 1951

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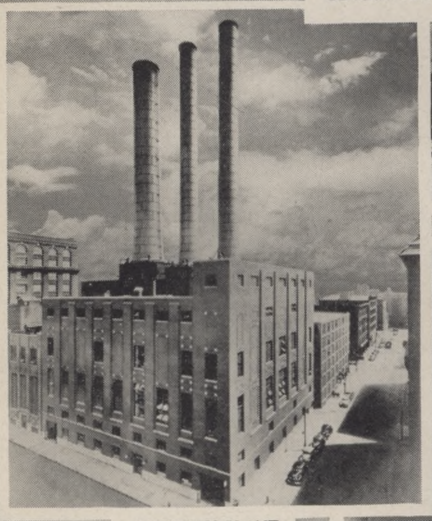

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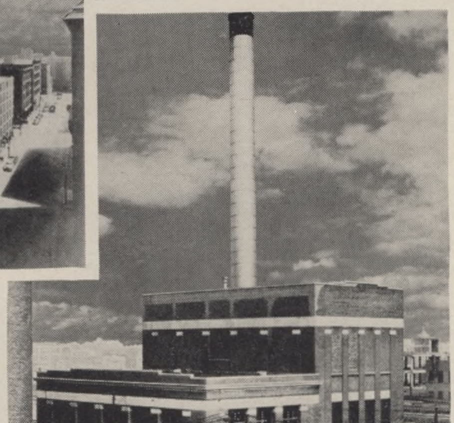

BOULEVARD PLANT

Fig. 1—Downtown District of Detroit

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HISTORICAL

DISTRICT heating in Detroit dates back to 1903 if some previous unsuccessful attempts to operate similar undertakings are excepted. In that year The Detroit Edison Company was organized for the purpose of building and operating an electric power plant to supply current to the two electric companies which were then operating in Detroit, and the several small generating stations of those companies were reconstructed into substations from which was distributed the current received from the new main generating station. In the case of one of the stations, the Willis Avenue Station of The Edison Illuminating Company of Detroit, it was decided that the operation of the generating units would be continued and the exhaust utilized for heating the buildings in the neighborhood, thereby improving the overall thermal efficiency. This also eliminated the conversion losses involved in changing the alternating current received from the main generating station to the direct current required for distribution in that district. The station was situated in what was at that time a high-class residential section which offered a promising field for the development of the business.

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

Steam was chosen as the medium for distributing the heat rather than hot water, and it is interesting to note that most of the reasons which led to this decision have been proven valid by subsequent experience. Some of the many reasons were:

1. Steam lines are cheaper to install, there being but a single pipe, whereas hot water usually requires a double set of mains.

2. There is a saving in station equipment, as there are no circulating pumps required.

3. Buildings piped for hot water heat can be served by steam through the use of a surface heater.

4. Steam service can be easily metered with a condensate meter.

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 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 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 equipment. 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

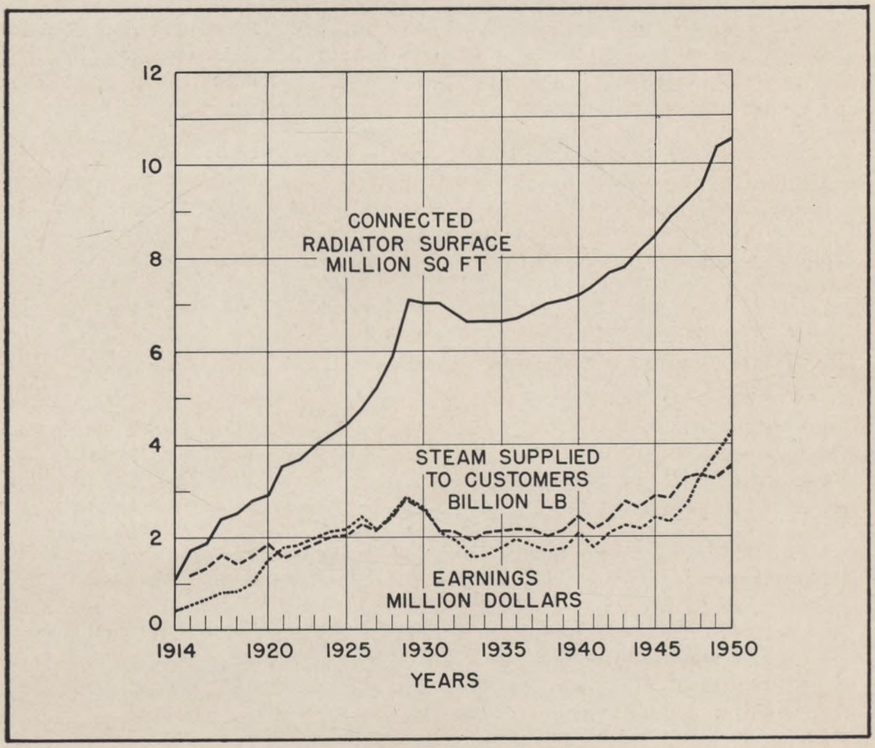


Fig. 2—Growth of the Heating Service

order to serve the customers' 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 output being supplied by the newer heating plants. The high pressure steam for power had been discontinued several years previously.

In 1912, because of 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 steam output 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 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.

On 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. 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. Other boilers were added and in 1923 the final unit was installed.

To supply 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 was designed to care for large increases in the downtown 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 help serve the then rapidly growing business in the New Center district. In 1948 a new boiler was installed in the Willis Avenue Plant to supply the steam requirements of Wayne University and the Boulevard areas. Thus there are now four boiler plants serving the entire heating system.

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

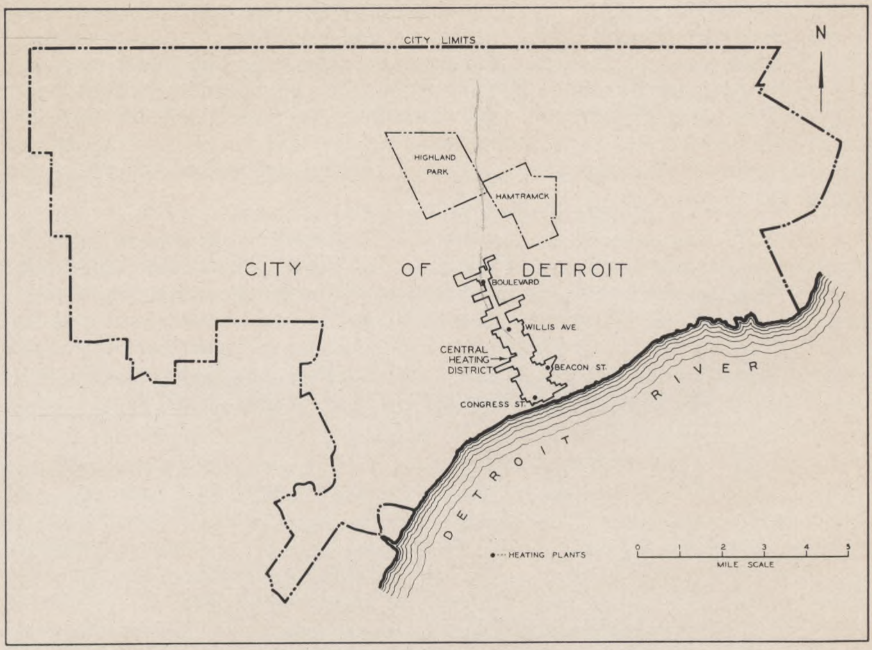


Fig. 3—Location of District Served

The distribution system has been extended and reconstructed from time to time to meet the demands of the growing business. At present it contains 47 miles of underground mains and 2½ miles of tunnels and serves approximately 1800 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, small stores, a cultural center and in the upper part of the area is the New Center 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. 5, 6, 7, 8, 9, and 10.

The connected demand in terms of equivalent steam radiator surface was 10,538,755 square feet as of January 1, 1951. The four boiler plants delivering steam to the system are to some extent interconnected so that some of the steam requirements can be exchanged between them. Pipe lines between plant areas are not now large enough to exchange the output of the largest boilers in each plant. We plan to improve this condition in the future.

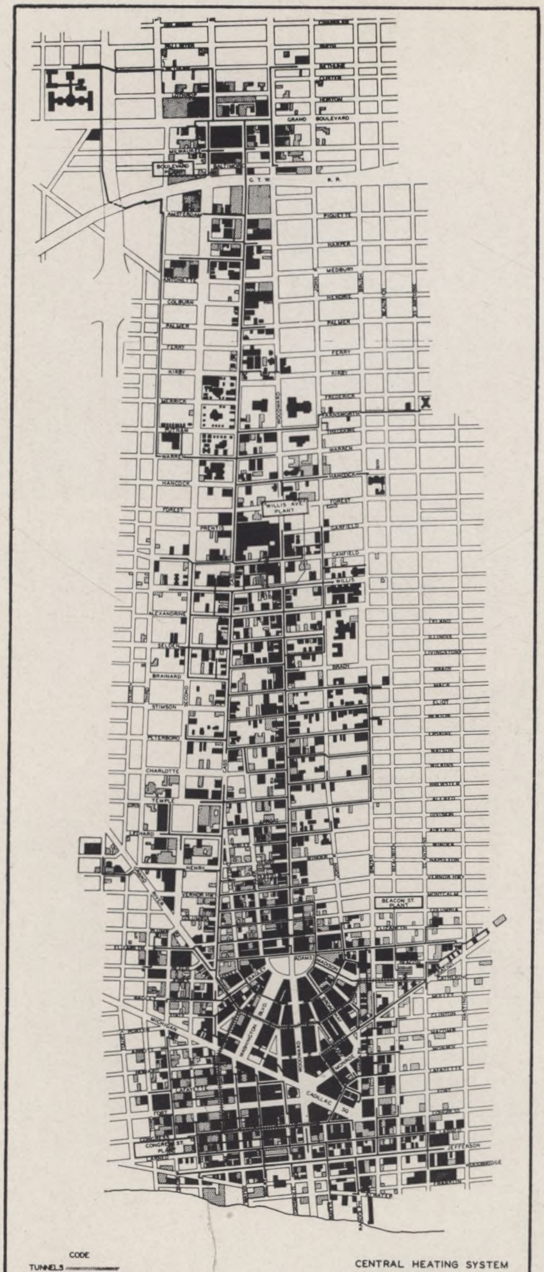


Fig. 4—Map of Heating System Area Showing Buildings Served

Fig. 5—Large Buildings Using Central Heating Service

CADILLAC TOWER and BARLUM HOTEL

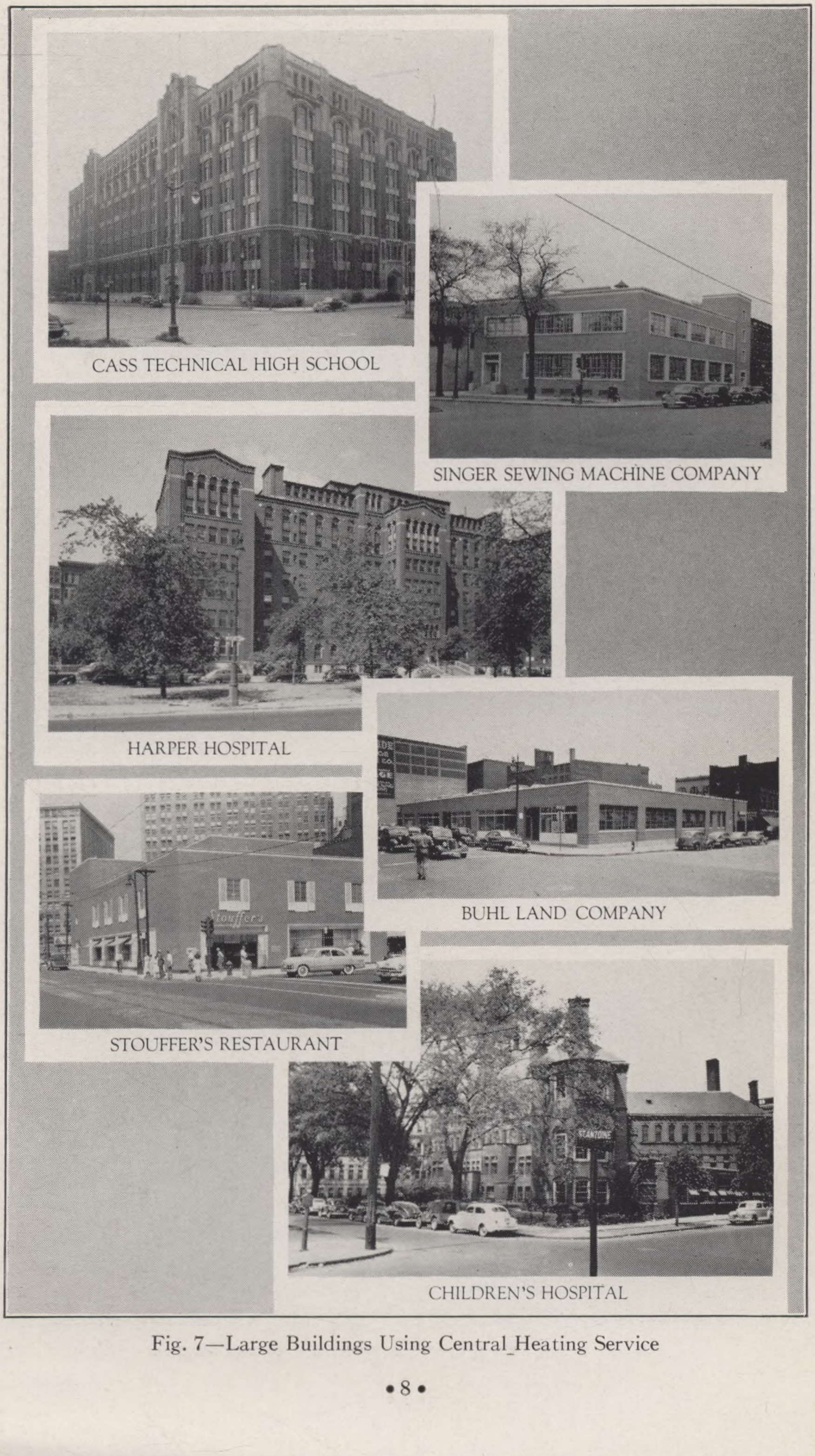
J. L. HUDSON STORE

BOOK TOWER

BRODERICK TOWER

DAVID STOTT BUILDING

Fig. 6—Large Buildings Using Central Heating Service



CASS TECHNICAL HIGH SCHOOL

SINGER SEWING MACHINE COMPANY

HARPER HOSPITAL

BUHL LAND COMPANY

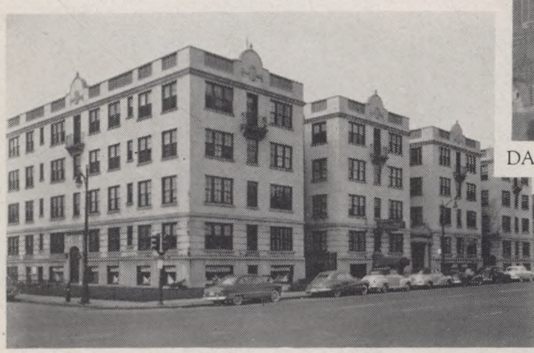
STOUFFER'S RESTAURANT

CHILDREN'S HOSPITAL

Fig. 7—Large Buildings Using Central Heating Service

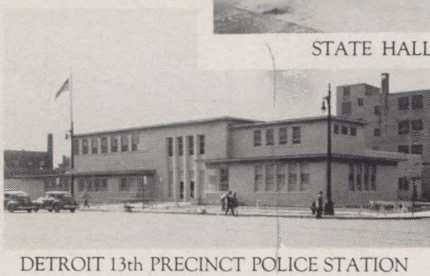
MASONIC TEMPLE

DAVID WHITNEY BUILDING



SHERIDAN COURT APTS.

STATE HALL-WAYNE UNIVERSITY



DETROIT 13th PRECINCT POLICE STATION

Fig. 8—Large Buildings Using Central Heating Service

Fig. 9—Large Buildings Using Central Heating Service

Fig. 10—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, 1951, is 411,701 square feet. See Table II for data on boilers and turbines.

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.

Heating Plant Boilers and Stokers

The Beacon Street Heating Plant, the newest and largest of the four, is illustrated in Figures 11, 12, and 13. Three of the four boilers in this plant have 41,550 square feet of heating surface each. The fourth boiler was equipped with water walls in 1950 which increased the heating surface of this unit to 41,736 square feet. Three of these units are each capable of producing about 500,000 pounds of steam per hour with a good grade of coal. The maximum output of the fourth unit was increased about 50,000 pounds per hour by installing a modern stoker. Some additional statistics regarding three of the boilers are as follows:

Fig. 11—Boiler Room, Beacon Street Heating Plant

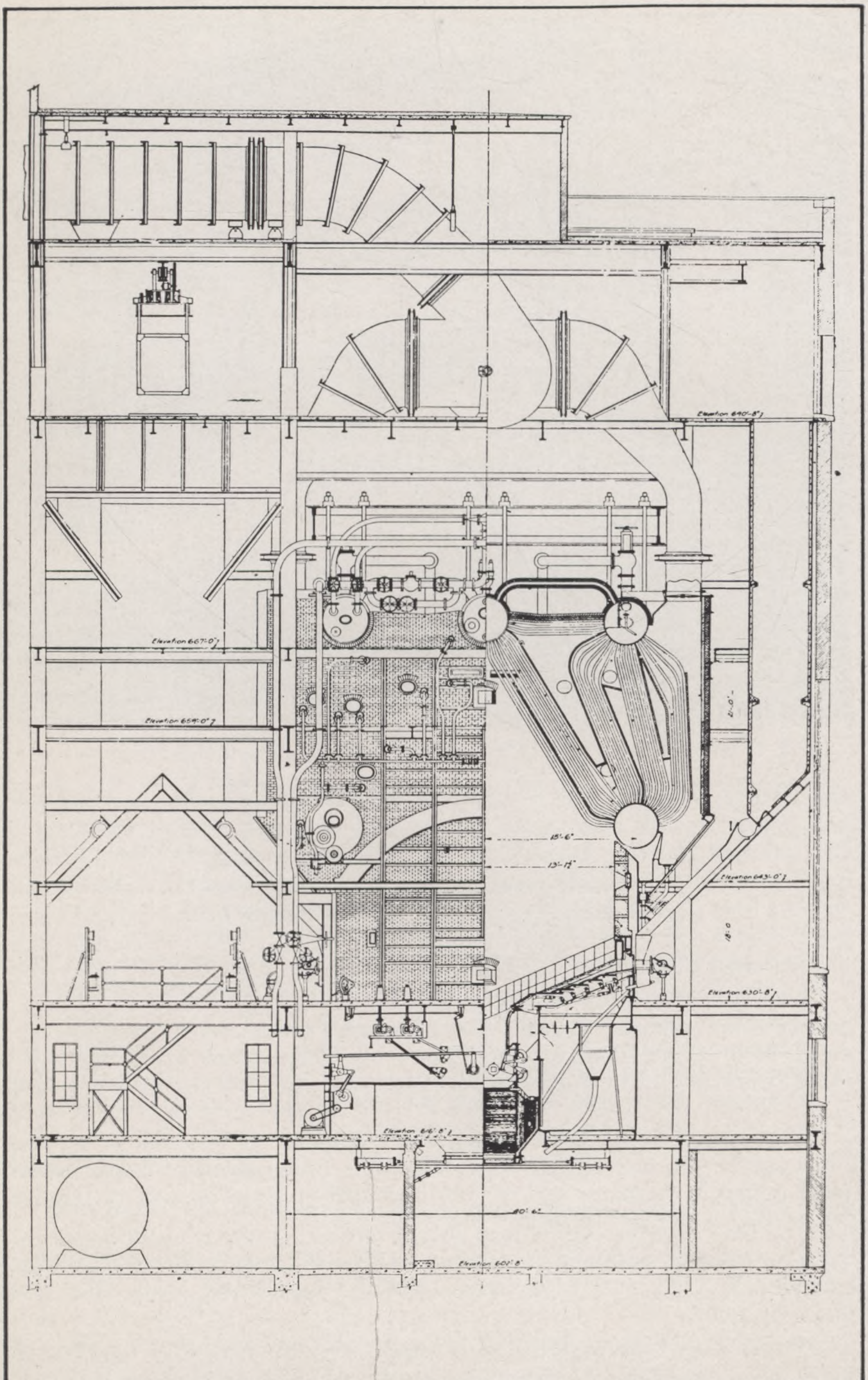


Fig. 12—Section and Elevation of 41,550 Sq. Ft. Boiler, Beacon Street Heating Plant

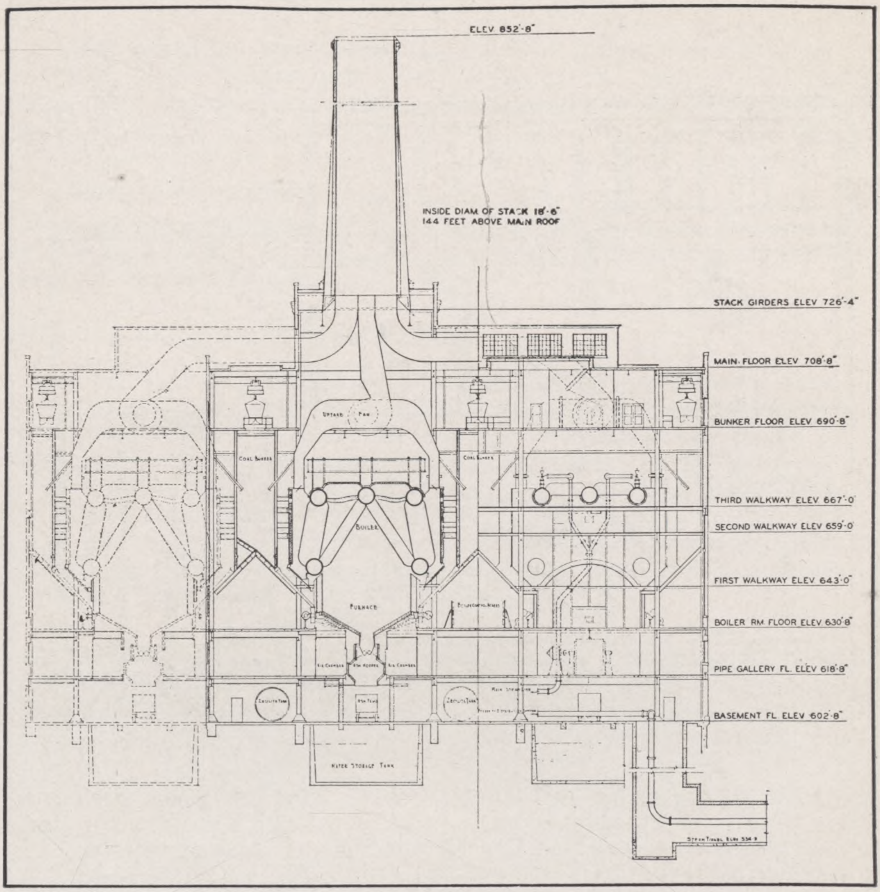


Fig. 13—Cross Section, Beacon Street Heating Plant

Number of drums	5
Diameter of drums, inches	54
Length of tube sheet, feet	27¼
Number of tubes	2792
Outside diameter of tubes, inches	3¼
Projected grate area, including pit, square feet	636

The fourth boiler differs from the others in that it has six drums and water walls over each stoker. The four upper drums on this boiler are 48 inches in diameter and the unit has 2926 tubes. The projected grate area of this boiler is 716 square feet.

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

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

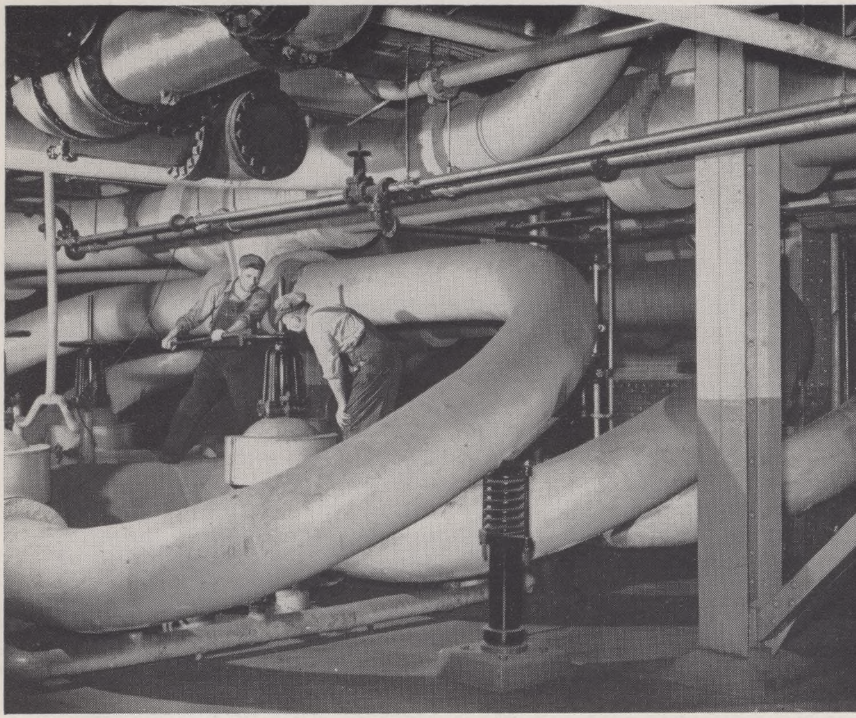


Fig. 14—Main Steam Piping From Boilers to Feeders at Beacon St. Heating Plant

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 most recent boiler installed in the Central Heating Department is No. 4 at Willis Avenue Heating Plant. This unit is equipped with water walls, economizer, and dust collector, and is capable of producing 230,000 pounds of steam per hour.

Water Conditioning

Because of the installation cost of underground return piping 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 and Congress Plants, therefore, use 75% of makeup water which is taken from the city water mains. Willis Avenue Plant uses 100% makeup while the Boulevard Plant uses practically none.

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.*

The most recently developed feedwater treating cycle is shown diagrammatically in Figure 15 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 practically devoid of air and CO_2. Steam of better chemical purity is not produced, commercially, even where only distilled water is 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 also 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 a chemical engineer for detailed study.

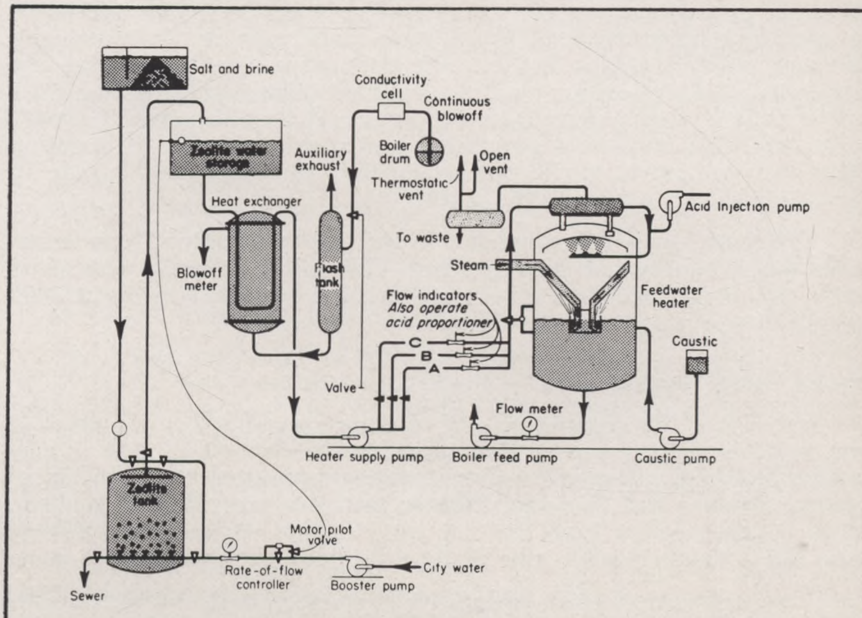


Fig. 15—Diagram of water-treating system at Willis Avenue Plant

TABLE I
Installation Data, Heating Plants

	BEACON STREET	CONGRESS STREET	WILLIS AVENUE	BOULEVARD
No. of boilers	4	6	6	4
Type of boiler	W type	W type	W type	Stirling
Heating surface per boiler, sq ft	3— 41,550 1— 41,736	3— 12,935 1— 15,430 2— 29,820	2— 13,000 1— 15,430 1— 25,200 1— 25,650 1— 19,160**	5,000
Total boiler heating surface, sq ft	166,386	113,875	111,440	20,000
Boiler pressure (allowable working pressure), lb per sq in.	160	160	160	200
Furnace volume, cu ft	3— 16,700 1— 16,000	2— 4,370 1— 4,700 1— 4,770 2— 10,130	1— 4,370 1— 4,700 1— 4,770 2— 6,590 1— 6,950	1,210
Type of stoker	Underfeed, two per boiler 4—14 retorts	Underfeed, two per boiler 4— 7 retorts 2—14 retorts	Underfeed, two per boiler 4— 7 retorts 1—10 retorts 1—11 retorts	Underfeed, single 4— 5 retorts
Type of feed water treatment	Zeolite*	Zeolite*	Zeolite*	Internal, di-sodium phosphate, sodium sulfite
Electric generating units	1—3000 kw a-c 1—2400 kw d-c 1—1700 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)	1,080,000	540,000	610,000	90,000
Area covered by plant building, sq ft	23,700	15,050	13,930	10,200
No. of men employed at 40 hrs per wk	55	39	45	14

*Zeolite with after-dosage of acid.

**This boiler equipped with a Multiclone type precipitator and an economizer.

TABLE II

Typical Chemical Conditions of Water at Various Points in the Willis Avenue Heating Plant Boiler Water Treating System

All Values except pH are ppm.

	AVERAGE CITY WATER	ZEOLITE SOFTENED CITY WATER	ACID TREATED ENTERING HEATER	LEAVING DEAERATING HEATER*	IN BOILERS
Calcium—Ca	25.	1.0	1.0	0.9	1.0
Magnesium—Mg	6.	0.2	0.2	0.2	2.0
Sodium—Na	5.	48.0	48.0	45.	600.0
Silica—SiO	1.	4.0	4.0	4.0	39.0
Oxides—Fe_2O_3 & Al_2O_3	1.	2.0	2.0	1.5	3.0
Bicarbonate—HCO_3	98.	98.0	10.0**	0	0
Carbonate—CO_3	0	0	0	0	25.0
Hydroxide—OH	0	0	0	20	20-200
Phosphate—PO_4	0	0	0	0	10.0
Sulphate—SO_4	21.	21.0	100.0	106.0	1000.0
Chloride—Cl	6.	6.0	6.0	6.	115.0
Dissolved Solids	163	180	265	215	2200
Hardness as $CaCO_3$	89	3	3	2	—
Free CO_2 (Carb. Dioxide)	2	2	65	0	0
Dissolved Oxygen	13	13	13	0	0
pH Value	7.1	7.9	3.5	10.0	11.5

*Includes steam condensed during heating to 218F.
**Free mineral acid equivalent to 10 ppm of HCO_3

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, however, appeared to exist. One reason is the limited season during which such an investment could be used. Another reason is the fact that turbogenerators 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 turbogenerators 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 1950 22,478,500 kwhr were generated, of which 5,424,500 kwhr were used in the heating plants and 17,054,000 kwhr were delivered to the electrical system. Also 2,956,100 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 Detroit heating plants. The economic possibilities of combined electricity and steam production are of course more favorable with higher boiler pressures and temperatures so that the present practice may be modified in future installations.

The capacities of the turbogenerators in the various plants are shown in Table II. A picture of the Beacon Street Heating Plant turbine room is shown in Fig. 16, and a cross section view of the 3000 kilowatt A. C. turbogenerator at Beacon Plant is shown in Fig. 17.

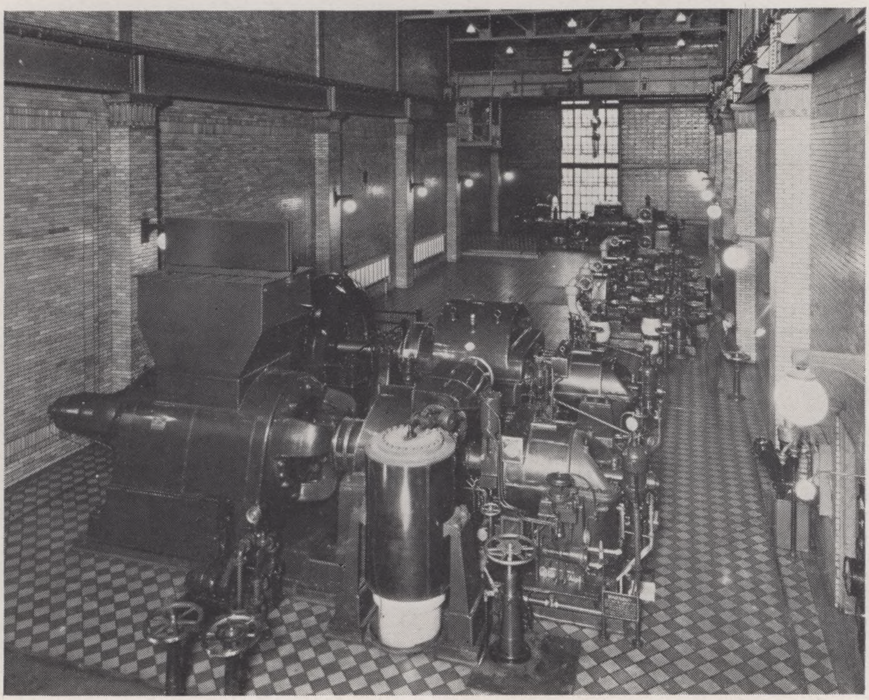


Fig. 16—Turbine Room, Beacon Street Heating Plant

Heating Plant Efficiencies

The original heating plant boilers were not equipped with economizers or air preheaters because the poor annual load factor did not justify these or any other coal saving devices. With present coal prices these devices no doubt are justified but space limitations do not now make such installations possible. The Willis Avenue boiler installed in 1948 has an economizer. The plant output curves in Figure 18 indicate the relation of the plant output on a cold winter day as compared to a summer day. 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 and after the war years when using a high ash coal are very evident.

YEAR	LB STEAM DELIVERED TO THE DISTRIBUTION SYSTEM PER LB COAL BURNED	YEAR	LB STEAM DELIVERED TO THE DISTRIBUTION SYSTEM PER LB COAL BURNED
1915	7.4	1933	9.0
1916	7.8	1934	8.9
1917	7.5	1935	9.1
1918	7.4	1936	9.0
1919	7.4	1937	9.0
1920	7.2	1938	9.1
1921	7.7	1939	9.0
1922	8.0	1940	9.0
1923	8.2	1941	8.9
1924	8.4	1942	8.9
1925	8.7	1943	8.8
1926	8.6	1944	8.6
1927	8.9	1945	8.5
1928	8.9	1946	8.5
1929	9.0	1947	8.5
1930	8.9	1948	8.5
1931	8.9	1949	8.6
1932	9.0	1950	8.8

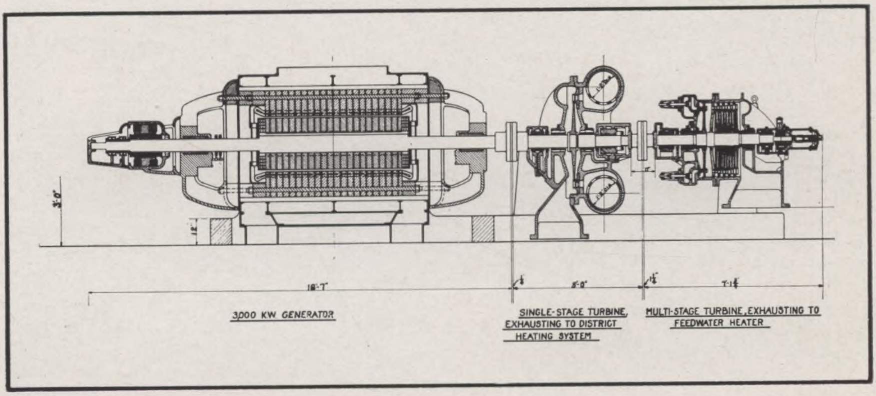
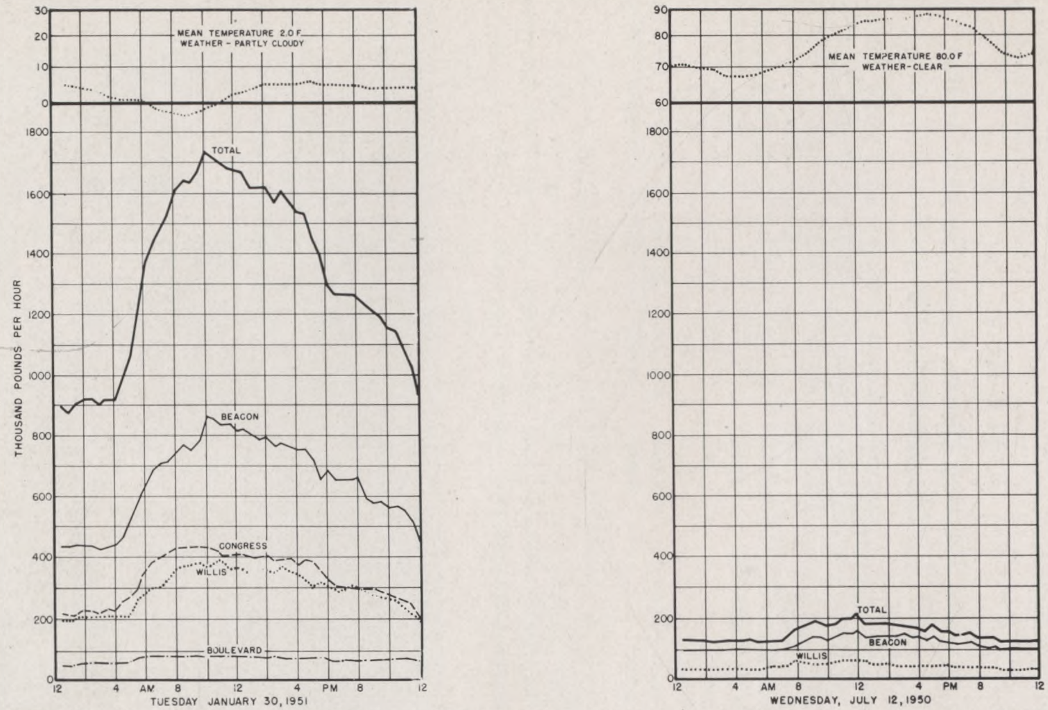


Fig. 17—Cross Section of 3000 Kilowatt Turbo Generator, Beacon St. Heating Plant



BEACON	CONGRESS	WILLIS	BOULEVARD	TOTAL
15,459.0	7,851.0	7,060.0	1,597.0	31,967.0
863.0	431.0	365.0	77.0	1,736.0
644.1	327.1	294.2	66.5	1,331.9
.746	.759	.806	.864	.7672

	BEACON	WILLIS	TOTAL
Steam output (M lb)	2,495.0	844.0	3,339.0
30 min max output (M lb/Hr)	147.0	56.0	203.0
Average output (M lb/Hr)	104.0	35.1	139.1
Daily Load factor	.707	.627	.685

Fig. 18—Plant Output Curves

Table III shows the operating results for the twelve months' period ending December 31, 1950. It will be noted that the steam output per pound of coal for the Boulevard Heating Plant is high compared with its boiler efficiency. This is because the water used by this plant is for the most part warm condensate return water from the large nearby buildings, whereas about 75% 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, 1950

	BEACON	CONGRESS	WILLIS	BOULEVARD	TOTAL
Output M lb.	2,137,950	956,010	1,031,936	171,984	4,297,880
Coal Burned—Tons	121,103	55,069	58,510	9,734	244,416
Steam Output—lb/lb coal	8.8	8.7	8.8	8.8	8.8
Btu/lb Coal as Fired	12,770	12,590	12,700	12,770	12,720
Moisture in Coal as Fired—%	6.08	6.91	6.22	6.25	6.31
Ash in Dry Coal—%	9.7	10.0	9.9	8.6	9.8
Boiler Efficiency—%	81.0	80.7	81.6	78.8	81.0
30 min. max. output—lb/hr.	818,000	405,000	384,000	69,000	1,676,000
Annual Load Factor	0.298	0.269	0.307	0.284	0.293

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 trucks.

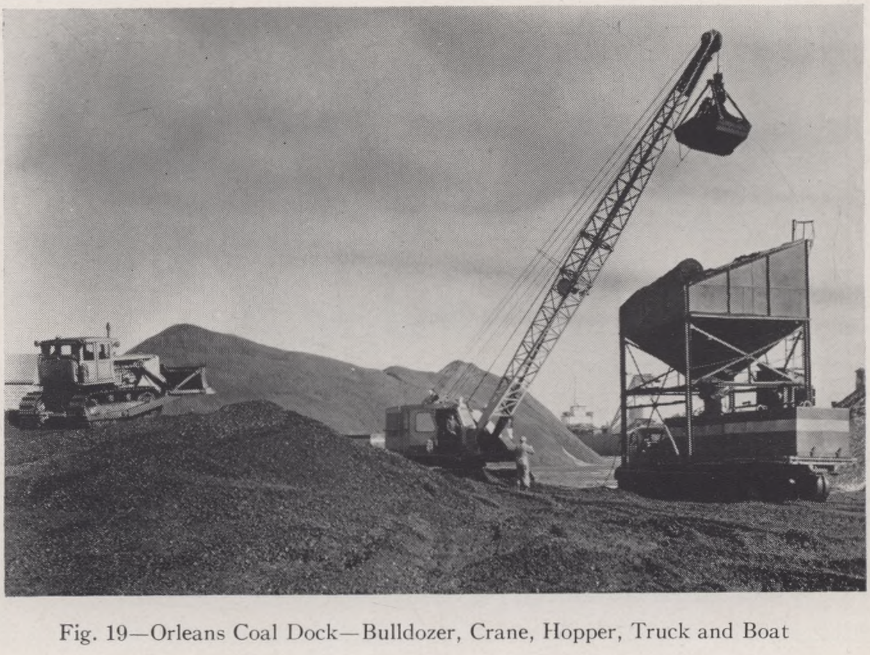


Fig. 19—Orleans Coal Dock—Bulldozer, Crane, Hopper, Truck and Boat

At the present time, the coal for all the heating plants, except the Boulevard Plant is hauled by trucks from the Orleans Coal Dock located at the foot of Orleans Street. The coal is brought to the dock by boat and stored during the navigation season. Nut and slack coal is purchased so that no coal crushing equipment is required. Bulldozer packing of the coal prevents fires in the stock piles that are 50 feet high. The present storage capacity of 150,000 tons is ample for the winter period when the boats cannot operate.

THE DISTRIBUTION SYSTEM

Steam is distributed from the plant to the consumers by a system of underground piping varying in size from 20 inches to 4 inches. 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 and protected to withstand floods caused by flash rainstorms. For the first six years until 1909, a segmental wood casing 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 is being used at 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. 20). The pipe is supported by stainless steel brackets and saddles.

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 uncharted underground obstructions. New services are easily added.

At present the specifications for the materials used are:

Pipe: Steel, black, open hearth electric resistance welded, schedule 40 (standard weight) 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, tunnel mains, surface feeders, and tunnel feeders subject to pressures up to 150 psi.

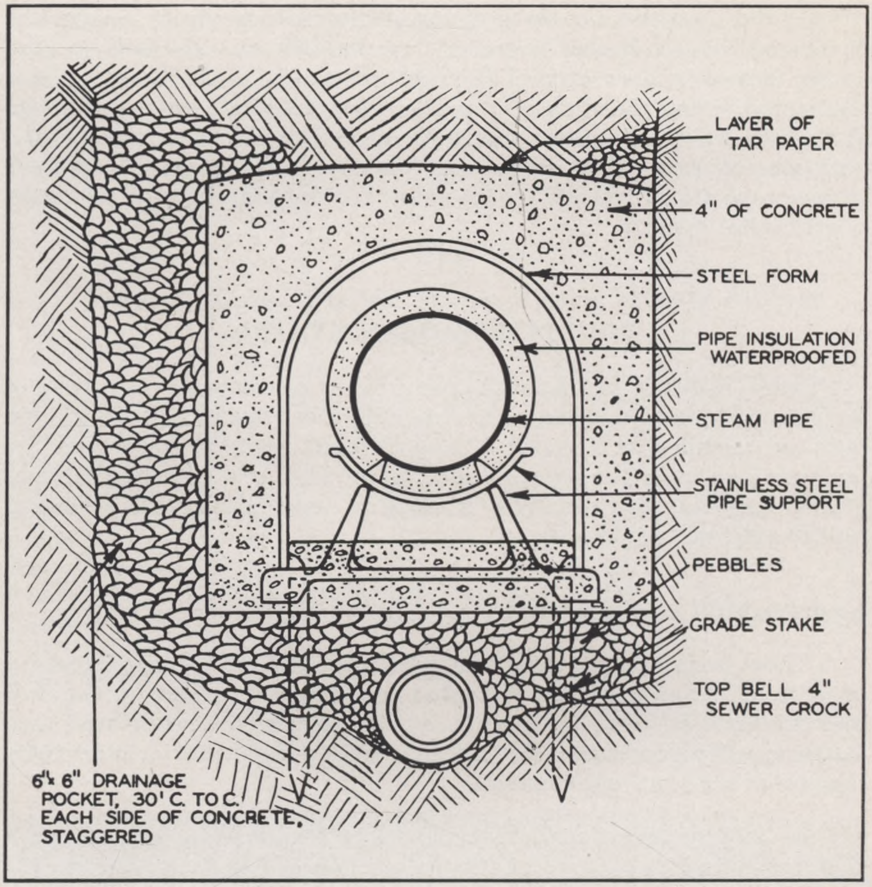


Fig. 20—Concrete Construction for Underground Steam Lines

Style of Joint: All joints acetylene-welded with welding flanges used at valves and expansion joints in manholes. Gas welding is more convenient to use in congested street trenches.

Valves: Solid wedge, inside screw non-rising stem, flanged, faced and drilled, cast steel American Std 150 lb SSP for surface mains, surface feeders, tunnel mains, and tunnel feeders.

Expansion Joints: Slip-type cast steel body and gland. The sleeve is plated with chromium over nickel and polished with anchor lugs on body; American Std 150 lb SSP for mains and feeders.

Pipe Insulation: Sectional insulation made from long fibre asbestos or equal with asbestos-base waterproof jacket cemented and wired on. The insulation thickness schedule for steam mains in conduits is:

SIZE OF PIPE	INSULATION THICKNESS	SIZE OF PIPE	INSULATION THICKNESS
3″	1½″	10″	2″
4″	1½″	12″	2″
6″	1½″	16″	2″
8″	2″	20″	2½″

In the tunnels two layers of sectional or block insulation, each layer 1½″ thick, are used. The joints are staggered. All insulation is covered with an asbestos-base waterproof jacket cemented and wired on.

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, 46 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 100 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 (1951) cost of underground piping installed complete in concrete conduit is as follows:

NOMINAL PIPE SIZE, IN.	APPROXIMATE COST PER FT DOLLARS
6	42
8	44
10	48
12	53
16	63

Distribution Losses

Distribution losses as indicated by the difference between the steam delivered by the plants to the distribution system and the condensate metered on the customers' premises, consist of condensate drained from

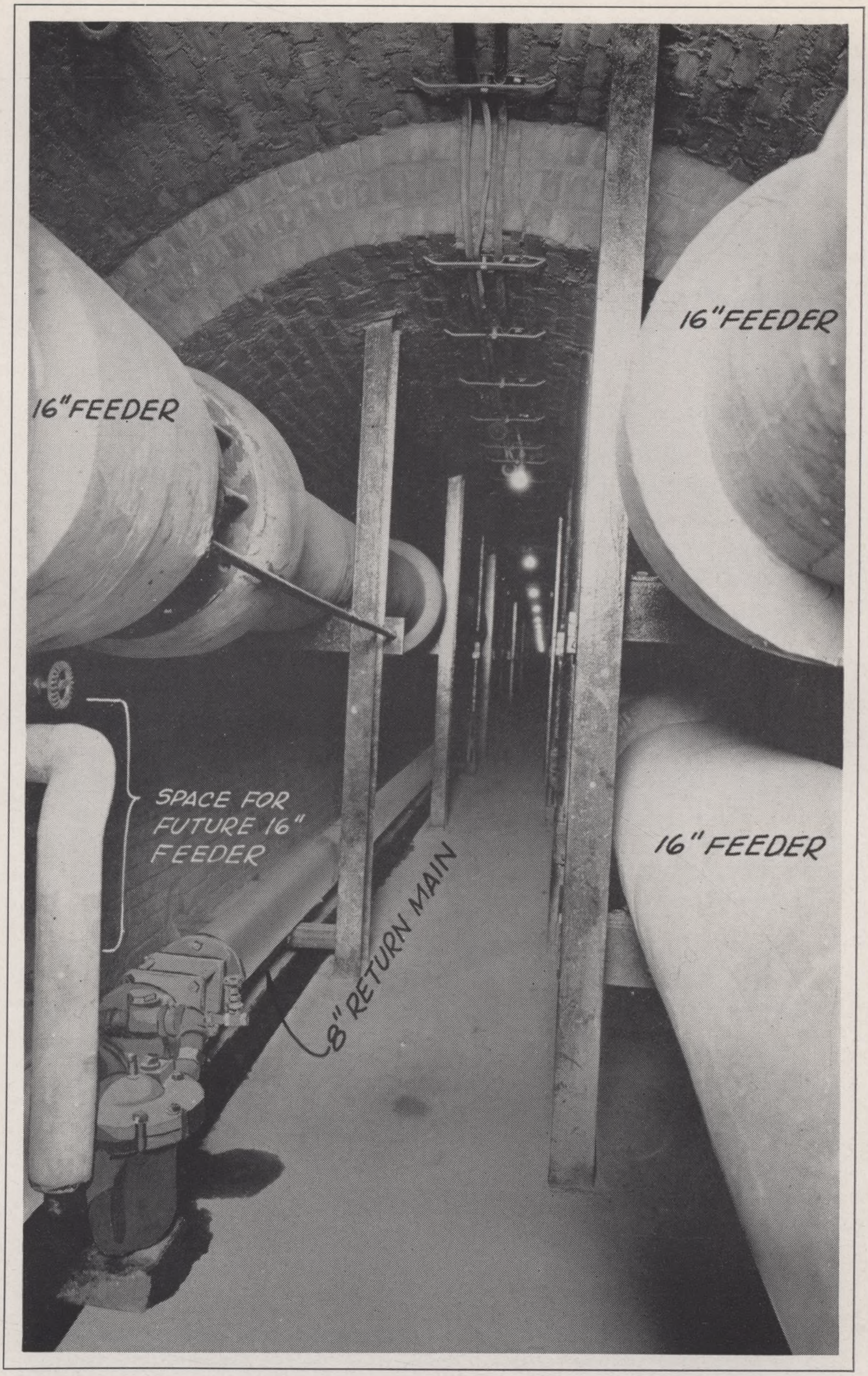


Fig. 21—Beacon-Woodward Tunnel

the mains, leakage of steam from the mains and from customers' piping, leakage of condensate and slowness of meters. For the past twenty-one years the loss in per cent of output has been as follows:

	STEAM OUTPUT M LB	STEAM SOLD TO CUSTOMERS AND USED BY COMPANY BUILDINGS M LB	LOSS PER CENT
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	17.12
1942	2,938,956	2,434,611	17.16
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
1946	3,350,237	2,800.441	16.41
1947	4,019,713	3,294,738	18.03
1948	4,002,925	3,378,733	15.59
1949	3,823,373	3,291,943	13.90
1950	4,297,880	3,646,454	15.16

Tunnels

There are about 2½ miles of horseshoe shaped tunnels, lying from 25 to 60 feet below the street level. The walls are of brick, and the floors of concrete. They are, for the most part, about 6 feet in height and about 6 feet wide and contain two or more steam pipes and a condensate return line as shown by Fig. 21.

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

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

In the past when two or more pipes were to be installed under a street, particularly in a congested district, it was regarded as desirable to build a tunnel 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. With present high construction costs, tunnels appear to be a luxury and only trench type of construction is being used.

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. When possible buildings are not 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 peak demand 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, where it ties into the distribution system, 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 foreman 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 pressure recording gages are used. Pressures at the feeding points are usually carried at from 28 to 35 psi.

Condensate Return Lines

The condensate 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 condensate 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 condensate would more than offset the value of the water which would be salvaged.

In the districts not served from tunnels the condensate is drained to the sewers, except in the case of the three large buildings in the Boulevard district. With the present cost of coal, short return lines would usually be a profitable investment, but, 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 condensate is that the customer should install an economizer to extract the heat from the condensate 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 thirty per cent is returned, and at Beacon Street sixteen per cent is returned. The amount of condensate returned to all the plants averages about eighteen 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 steam demand 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.

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 assured the customer. There is thus available a pressure drop of about 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 during the coldest days.

This range of pressure appears to be a desirable one 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 to cast iron radiators in case of the failure of a customer's pressure regulating valve to maintain the pressure limits for which it is set.

Summer Service

During the summer months approximately 10% 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, especially air conditioning, 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 required.

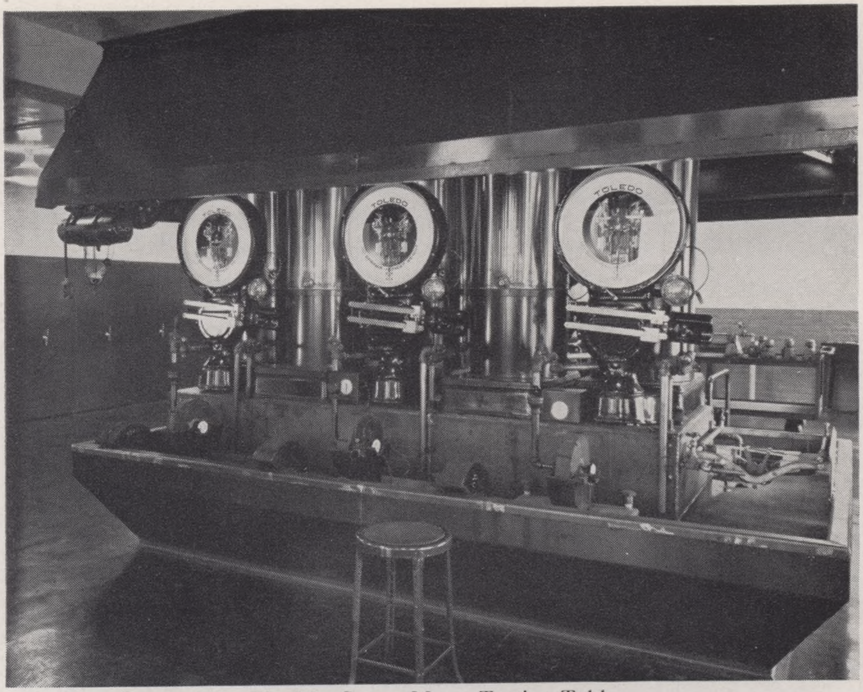
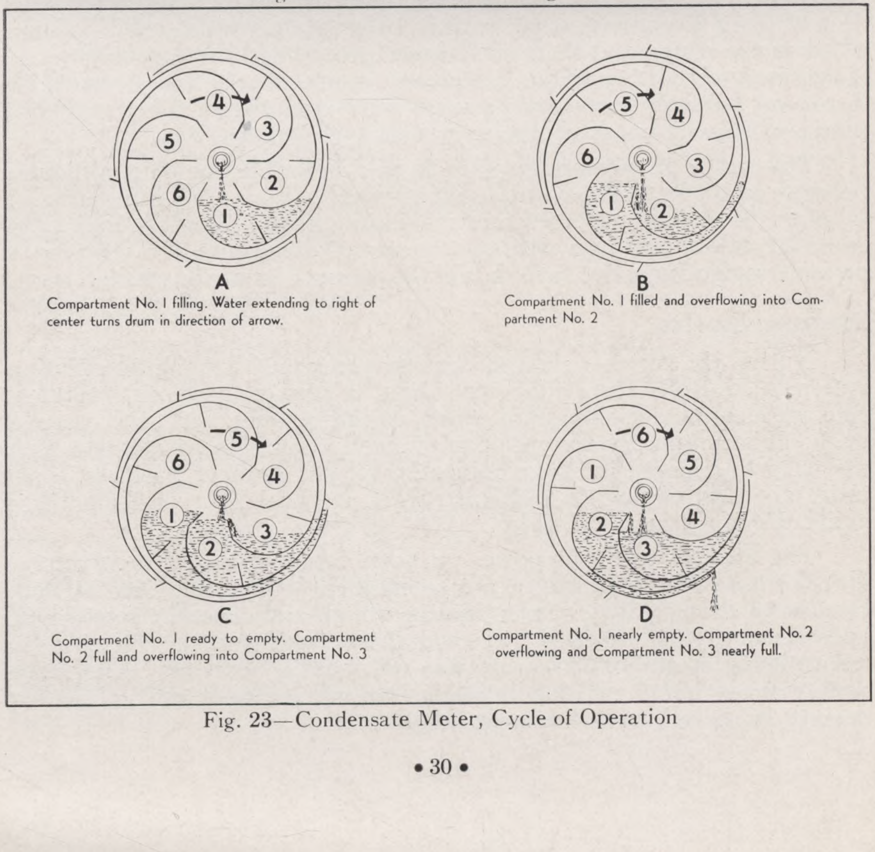


Fig. 22—Steam Meter Testing Table



A
Compartment No. 1 filling. Water extending to right of center turns drum in direction of arrow.

B
Compartment No. 1 filled and overflowing into Compartment No. 2

C
Compartment No. 1 ready to empty. Compartment No. 2 full and overflowing into Compartment No. 3

D
Compartment No. 1 nearly empty. Compartment No. 2 overflowing and Compartment No. 3 nearly full.

Fig. 23—Condensate Meter, Cycle of Operation

METERS

There are two acceptable methods for measuring the amount of steam used by customers supplied from a district heating system. These are flow meters which measure the steam in its gaseous state before use and condensate meters which measure the condensed steam, in the liquid state, after it is used.

Since the condensate meter measures the steam used in a liquid state, it is a volumetric meter, the measuring chamber of which is shown in Fig. 23. The meter is of the revolving drum type and as the drum revolves, its revolutions, by means of proper gearing and a pointer type register, are translated into pounds of steam used. Fig. 24 shows a condensate meter to which an electrically operated demand meter is connected. These demand attachments are used on demand rate customer meters.

Experience in metering steam service has shown that for metering variable quantities of steam, particularly low use service, a characteristic of strictly space heating, a more accurate measurement is obtained by using condensate meters.

In general, on those services which use process steam and where the condensed steam cannot be returned, flow meters are used. There were in service 1,963 condensate meters and 23 flow meters as of December 31, 1950.

Meters are tested in the shop at various intervals, depending on the meter rating, up to a maximum of two years or at any time on the customer's request.

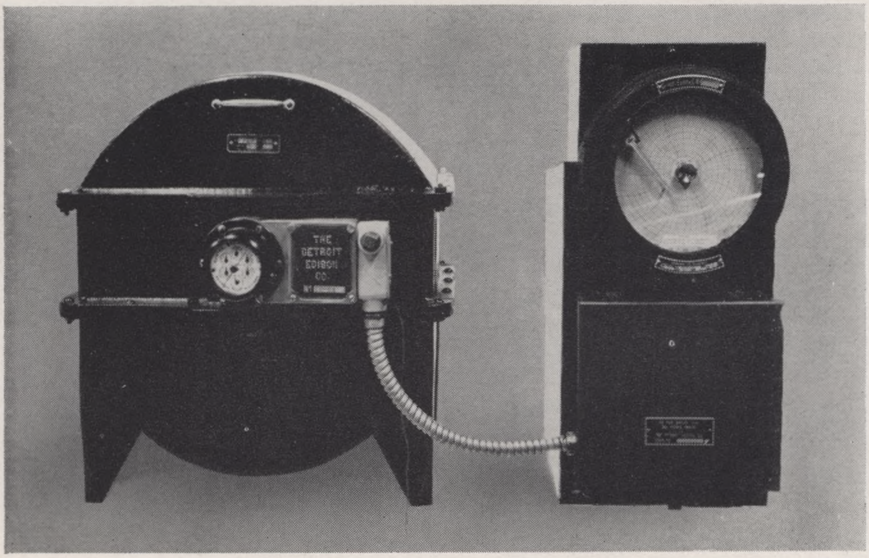


Fig. 24—Condensate Meter with Demand Meter Attached

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.

As the pressure in the street mains is considerably higher than is required for heating, a pressure regulating valve is required on every new installation. Any condensate formed in the outside service is drained from the system through a common type of float trap.

Water-heating economizers utilizing the heat in the condensate are recommended by the Company. These economizers are surface heaters arranged so that the condensate, 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, not only 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 1949-50.

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 steam use curves for a large office building (Fig. 25) show the savings possible by shutting off steam at night.

TABLE IV

HEAT REQUIREMENTS OF VARIOUS TYPES OF BUILDINGS—HEATING SEASON 1949-1950

Average temperature for Heating Season (9 months) 42.0F

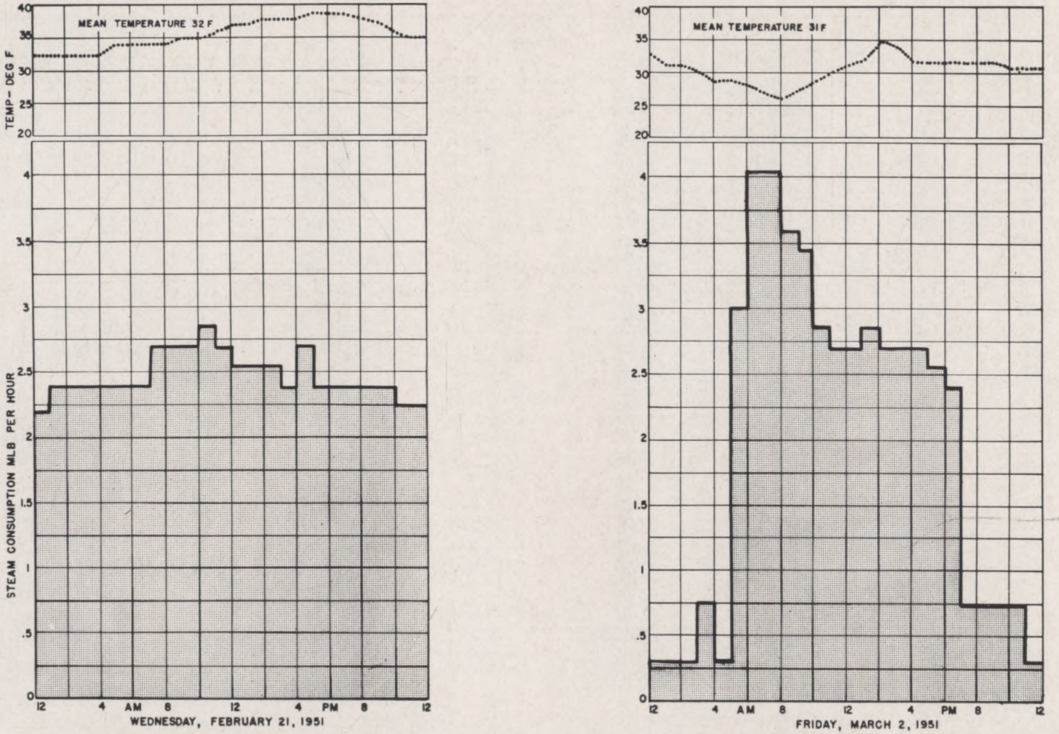
Degree Days (9 months) 6271

Types of Building	Number of Buildings	Average Radiator Heating Surface Sq Ft	Average Heated Space Cu Ft	Ratio Space to Radiation	Average Steam Requirement Pounds	Annual Steam Requirements: Process* Lb per Cu Ft	Annual Steam Requirements: Lb per Sq Ft Radiator Heating Surface	Annual Steam Requirements: Lb per Degree Day per M Cu Ft Space
Apartments	25	5,326	327,734	62	3,488,560	2.98	471	1.22
Apartment Hotels	4	17,257	749,300	43	8,024,000	3.81	299	1.10
Auto Sales	15	8,678	535,213	62	2,825,400	0.56	291	0.76
Banks	16	18,384	803,619	44	3,675,375	0.44	180	0.66
Bowling Alleys	5	10,843	262,214	24	2,274,600	0.93	187	0.57
Churches	17	8,868	502,801	57	1,889,235	0.16	204	0.57
Clubs	16	10,120	439,509	43	3,664,687	2.66	246	0.91
Garages—Commercial	8	7,037	813,225	116	2,100,125	0.07	290	0.64**
Government Buildings	23	18,193	1,021,430	56	4,690,210	0.43	233	0.66
Hospitals	7	41,151	1,914,850	59	27,541,500	6.64	455	1.24
Hotels—Class A	11	39,686	2,049,590	52	24,809,900	5.74	329	1.02
Class B	34	6,021	386,747	64	3,820,020	2.83	452	1.13
Office Buildings—Class A	22	96,200	5,211,180	54	26,001,540	0.79	227	0.67
Class B	17	24,096	1,434,488	60	7,315,880	0.84	251	0.67
Class C	27	9,891	565,206	57	3,321,920	0.79	291	0.81
Printers	22	11,506	615,960	54	5,460,700	1.44	397	1.19
Manufacturing	53	7,539	478,401	63	3,145,300	1.21	340	0.87
Restaurants	17	7,627	143,735	19	2,716,800	11.10	147	1.26
Schools	9	3,933	948,020	24	7,182,700	1.13	158	1.05
Stores—Department	14	54,480	3,037,321	56	12,232,264	1.56	138	0.39
Retail	69	6,138	323,082	52	1,447,913	0.67	201	0.61
Wholesale	15	7,068	487,902	68	2,123,700	0.69	294	0.68
Theatres—Class A	10	26,403	1,454,965	55	3,745,300	0.18	132	0.38
Class B	14	6,791	331,985	50	1,715,420	0.13	253	0.84
Warehouses	10	17,264	1,596,435	93	6,232,100	0.17	345	0.60

*Includes steam used for water heating and other process.

**Computed on a 55° F. base.

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



Steam Consumption . . . . 59,400 pounds
Average Wind Velocity . . . . 13.8 miles per hour

Steam Consumption . . . . 47,500 pounds
Average Wind Velocity . . . . 6.1 miles per hour

Radiator Heating Surface in Building 23,065 sq ft
Heated Space 1,322,220 cu ft

Fig. 25—Steam Consumption Curves for Office Building, Showing Savings 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 30 years. Steam condensed per square foot of radiator surface decreased over 35 percent from 1921 to 1950. 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 Per Year

YEAR	AVERAGE TEMPERATURE HEATING SEASON F	LB PER SQ FT RAD SURFACE	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	37.8	358	13.2
1944	39.1	332	12.8
1945	39.5	353	13.8
1946	40.3	323	13.1
1947	39.4	362	14.2
1948	39.0	360	13.8
1949	41.6	330	14.1
1950	39.8	350	13.8

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

Building Temperature Control Systems

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

In recent years, there has been considerable development in automatic temperature controls for building heating systems. There are now available several types of these controls ranging from a simple thermostat to the more complicated type which automatically varies the pressure in the heating system with the outside temperature.

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

Summer Air Conditioning

There are three types of steam-operated refrigerating machines.

1. Steam-driven compression machines, mostly turbine-driven centrifugals.
2. Steam jet machines.
3. Absorption machines.

The operating cost of the first two is high with low pressure steam.

Recent developments in the application of the absorption air conditioning machines gives some promise of increased summer steam requirements, since they can be operated economically with steam at less than 10 pounds pressure. In these units water is the refrigerant and a solution of some salt such as lithium bromide is the absorbing agent. Two of the 115-ton units are on the system. Seven 5-ton units are in use using steam from our system.

Steam Compressors

Although a nominal supply pressure of 30 pounds is sufficient for nearly every requirement of a customer, there are a few uses for which a higher pressure (50 to 75 pounds) is desirable, such as in some clothes-pressing machines and certain laundry apparatus which have 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 with the steam revenue available. A satisfactory alternative expedient has been developed. The customer installs an electric-driven compressor, which

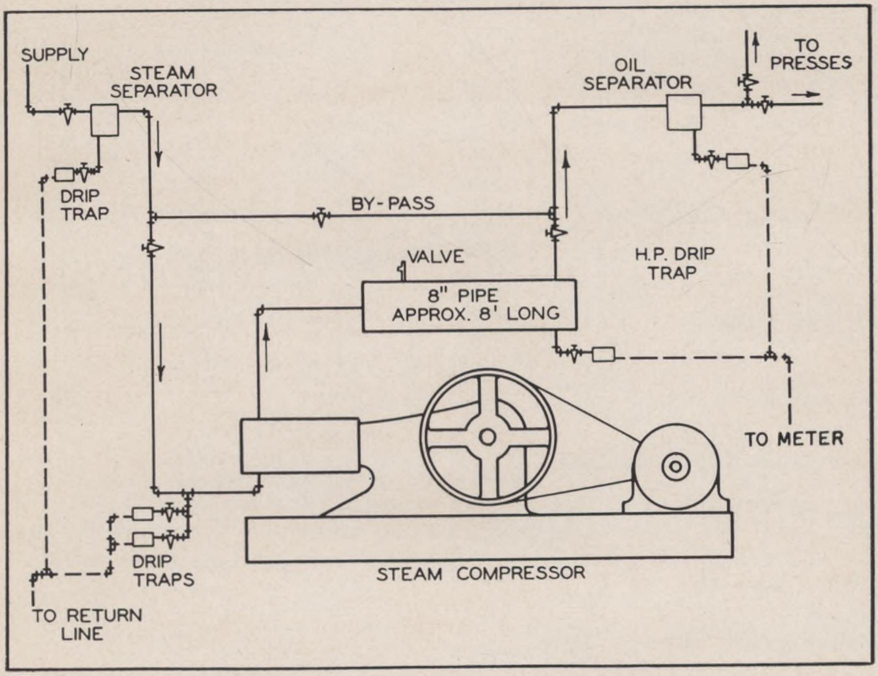


Fig. 26—Steam Compressor Piping Diagram

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 29 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. Fig. 26 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	5 x 8	10	——
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
	1945	7 x 7	30	500
Hotel	1946	7 x 7	30	400
Tire Co.	1946	6 x 5	15	275
Clothing Store	1947	6 x 7	20	100
Hospital	1947	7 x 7	30	600
Laundry	1948	14 x 13	60	1450
Hospital	1949	11 x 12	60	1200
Laundry	1949	5 x 5	5	174
Electrotype Co.	1949	6 x 5	30	400
		6 x 5	30	400
Laundry	1950	8 x 9	30	450
Clothing Store	1950	7 x 7	20	700

Sidewalk Snow Melting

Several sidewalk snow-melting systems using our steam are now in successful operation. It is an economical method of snow removal and is accomplished by circulating hot water through pipe grids installed in the sidewalk.

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 per day 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 1956	**Year 1957**
Steam to system, pounds	5,181,242,000	5,252,167,000
Steam supplied to customers (including Company buildings) pounds (as billed)	4,549,852,000	4,493,527,000
Coal burned, tons	286,089	290,551
Steam to system per pound of coal (pounds)	9.1	9.0
Steam supplied to customers (including Company buildings) per pound of coal, pounds	7.95	7.87
Ratio, steam supplied to steam delivered to system	0.878	0.856
30-minute maximum system demand, pounds per hour	1,866,000	2,070,000
Annual load factor of plants	0.316	.290
Net electrical energy generated (total minus plant use), kilowatt-hours	14,040,600	12,330,400
Gross earnings, dollars	6,441,722	7,025,647
Connected radiation heating surface as of Dec. 31, square feet	12,195,930	12,377,560
Number of customers, Dec. 31	1,751	1,704
Number of customers, meter, Dec. 31	1,915	1,915
Steam supplied per square foot of connected radiator heating surface, pounds	373	363
Earnings per square foot of connected radiator heating surface, dollars	0.5282	0.5676
Cost of coal as burned per ton, dollars	8.89	8.82
Average temperature, excluding July and August, degrees F	45.2	45.2
Degree days excluding July and August, 65 F base	6,255	6,237

Steam to system, pounds	4,297,880,000
Steam supplied to customers (including Company buildings) pounds (as billed)	3,646,454,000
Coal burned, tons	244,416
Steam to system per pound of coal (pounds)	8.8
Steam supplied to customers (including Company buildings) per pound of coal, pounds	7.45
Ratio, steam sold to steam delivered to system	0.85
30-minute maximum system demand, pounds per hour	1,676,000
Annual load factor of plants	0.293
Net electrical energy generated (total minus plant use), kilowatt-hours	17,054,000
Gross earnings, dollars	4,232,137.68
Connected radiator heating surface as of Dec. 31, square feet	10,538,755
Number of customers, Dec. 31	1,771
Number of customers meters, Dec. 31	1,963
Steam condensed per square foot of connected radiator heating surface, pounds	350
Earnings per square foot of connected radiator heating surface, dollars	0.4015
Cost of coal as burned per ton, dollars	8.54
Average temperature, heating season, degrees F	39.8
Degree days excluding July and August, 65 F base	6,547

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 electric 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.

During the depression both the demand rate and the block rate were reduced four times to meet the economic conditions. In 1934 the rates were as follows:

The block rate was $1.15 per 1000 pounds for the first 100,000 pounds per month, subject to 10 per cent 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.

The demand rate was a demand charge of $1.00 per year per pound of steam demand, plus 45c per 1000 pounds for all steam consumed. Discount, 5 per cent for prompt payment. Minimum demand charge: $1000.00 per year, subject to 5 per cent discount for prompt payment.

These rates remained in effect until September, 1946 when a coal clause was added to both the standard and demand rates. In September, 1948, rates were increased approximately 20 per cent. At present the rates listed below are in effect:

REVISED STEAM RATES

Both the block rate and the demand rate were increased July 1, 1956. The rates listed below are now in effect.

BLOCK RATE.

RATE: $1.75 per 1000 pounds for the first 50,000 pounds per month,
$1.65 per 1000 pounds for the next 150,000 pounds per month,
$1.55 per 1000 pounds for the next 800,000 pounds per month, and
$1.30 per 1000 pounds for the excess over 1,000,000 pounds per month.

Fuel Adjustment: The charge for steam used shall be increased one-tenth cent (.1¢) per thousand pounds of steam for each full one and one-half cents (1.5¢) increase above eight dollars ($8.00) per ton in the cost to the Company of coal used by its steam heating plants. The cost of coal, per ton, shall be the total amount paid or payable by the Edison Company at the mines for all such coal on hand at the month-end, plus the actual cost of freight from the mines to the Edison Company's unloading locations for this coal, divided by the total number of tons on hand at the month-end. This cost shall include any excise or taxes placed upon the purchase of coal or upon coal freight. Costs of unloading, reloading and storage, switching within or between plants, demurrage and overhead charges, are expressly excluded from this calculation. The cost of coal as determined above shall be applied to service rendered during the next succeeding month.

NO DISCOUNT.

MINIMUM CHARGE: $10.00 per month for the six months, November to April inclusive, except where year round service is furnished when the minimum charge shall apply for twelve months.

CONTRACT TERM: Until the next first day of September and thereafter until terminated by mutual agreement or on six months' written notice by either party.

DEMAND RATE.

DEMAND CHARGE: $1.75 per year per pound for the first 5000 pounds of steam demand,

$1.50 per year per pound for the excess over 5000 pounds of steam demand.

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.

CONSUMPTION CHARGE: 65¢ per 1000 pounds for all steam used.

FUEL ADJUSTMENT: Same as for the block rate.

NO DISCOUNT.

MINIMUM DEMAND CHARGE: $1750.00 per year.

CONTRACT TERM: Until the next first day of September and thereafter until terminated by mutual agreement or on six months' written notice by either party.

DETERMINATION OF BILLING DEMAND

The measured demand for each year as used in the Demand Rate shall be determined as the average of the three highest hourly demands occurring between 8 a.m. and 6 p.m. on three different days during the period from December to February inclusive, but not less than 1,000 pounds for each account. Demands occurring on Sundays, on Christmas Day, on New Year's Day, and on Washington's Birthday are not to be included in the above calculation. If these holidays fall on Sunday and are celebrated on the following day, then demands occurring on the latter day also shall be disregarded.

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 demand 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. A customer having a load factor of 0.24 or higher will

DEMAND RATE.

DEMAND CHARGE: $1.75 per year per pound for the first 5000 pounds of steam demand,

$1.50 per year per pound for the excess over 5000 pounds of steam demand.

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.

CONSUMPTION CHARGE: 65¢ per 1000 pounds for all steam used.

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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. A customer having a load factor of 0.24 or higher will generally benefit by going on the demand rate. At present 96 customers are on the demand rate.

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 condensate cannot be recovered.

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. 27 for the period 1925 to 1950. During the years preceding 1932, the margin was such as to yield a reasonably good return upon the invested capital.

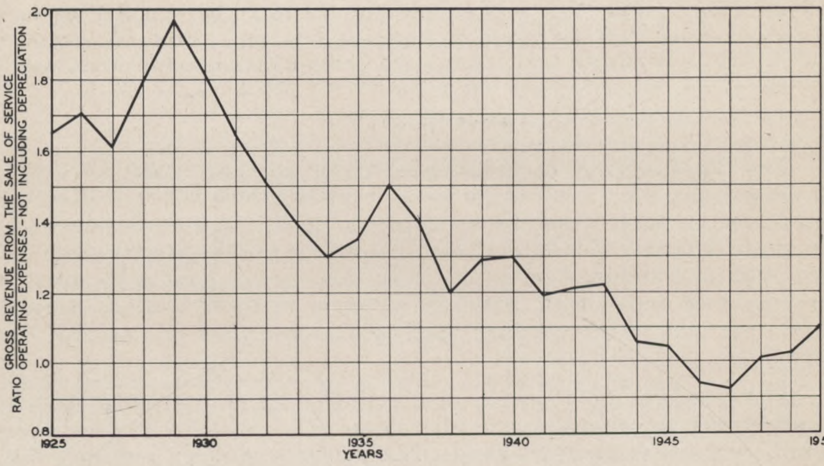

Fig. 27—Relation Between Gross Revenue from the Sale of the Heating Service to Operation Expense.

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 business 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

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 justify. 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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