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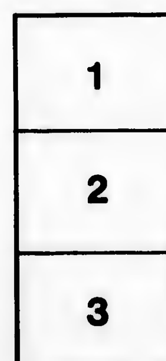
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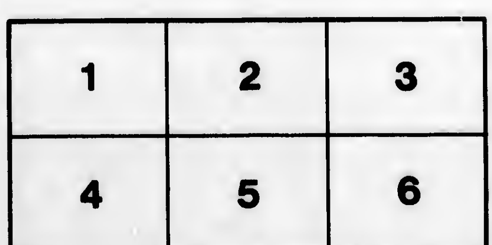
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District Steam Supply.

Heating Buildings by Steam,

FROM

A CENTRAL SOURCE.

BY

JAMES HERBERT BARTLETT,

ASSOCIATE MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS.

MEMBER OF THE INSTITUTION OF MECHANICAL ENGINEERS.

READ AT THE BRITISH ASSOCIATION,
MONTREAL, 1884.

PRINTED BY JOHN LOVELL & SON, ST. NICHOLAS STREET,
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MONTREAL.

The following is a brief abstract of the paper :

1.—Methods of Heating Houses.

2.—Origin of District, or Central Supply System.

3.—Description of the System, in Detail.

4.—Estimated Cost of Construction, and Operation, of the System, after the first Season's Experience.

5.—Developments and causes of failure.

6.—Duplex System at Lynn, Mass.

7.—The System in New York City.

8.—Tabulated List of Works Constructed, with some particulars of the same.

DISTRICT

STEAM SUPPLY.

HEATING BUILDINGS BY STEAM FROM A CENTRAL SOURCE.

The winter climate on a large portion of the United States and Canada, is so continuous and severe, that efficient means are required for raising the temperature, in all descriptions of dwelling-houses, for over two hundred days in the year.

The ordinary methods in use may be briefly stated as follows: Wood stoves, coal stoves, hot air furnaces, combination hot air and hot water apparatus, hot water, and steam.

Open fireplaces and grates, are often used as an auxiliary and as an aid to ventilation, but are not adapted for use alone. Gas stoves are seldom used, except for cooking purposes.

All stoves and furnaces are made of thin cast-iron plates. Considerable skill is required in moulding and fitting them up. After being in use for a time, and exposed to the action of the fire, the cast-iron warps and gets out of shape, allowing gas to escape, and becoming unhealthy; the air whilst being heated is burnt and vitiated by contact with the hot metal plates.

A necessary, but most unsightly feature of every stove, is the flue or stovepipe, connecting the stove and house chimney. Stove pipes are usually made of sheet iron, and of considerable length, so as to economise all the heat possible, but, as they cannot be swept or cleaned out when in position, it is necessary to take them down every year for that purpose.

Hot water and steam boilers are made of both cast and wrought iron, and of a great variety of shapes and sizes.

Anthracite coal is very generally used for household purposes; and for all small boilers, furnaces, or stoves, an expensive class of this coal is required, and in every case the fuel has first to be stored, then handled and burnt, and the ashes afterwards removed.

Prior to the year 1877 many very large buildings and blocks of buildings were heated by steam, supplied from boilers situated in some central place, and there are also many cases on record, of steam being carried very long distances in pipes.

In 1876 Mr. Birdsill Holly, a mechanical engineer of Lockport, N.Y., made a number of experiments and tests, on the condensation of steam in iron pipes, and suggested the possibility of heating towns, and cities, with steam supplied through pipes laid in the streets.

In 1877 an experiment was made by laying half a mile of three inch pipe; this was again increased to a mile and a third, and experiments carried on. Before winter set in about three miles of underground pipe had been laid, and over twenty dwelling-houses fitted up with pipes and radiators, and this number was largely increased during the winter; steam was supplied from three boilers, situated in a central position, and carrying a pressure of 25 to 30 pounds per square inch.

As all the houses, to which steam had been supplied during the winter, had been most comfortably heated, and the discomforts of the old methods done away with, the new system created a considerable amount of interest, particularly when it was claimed, that heat could be supplied at a much lower cost, than by the old methods.

DESCRIPTION OF HOLLY'S DISTRICT SYSTEM.

The system consists in the generation of steam at a central point, its transmission by well protected mains to suitable distances, and its utilization for heat, or power, by means of various mechanical devices.

Steam is supplied to the consumer in the same manner as gas, and is paid for in proportion to the amount used, as indicated by a meter, at a cost not exceeding the usual cost for coal.

As in the case of gas supply, the steam supply pipes are laid up to the curbstone, the consumer paying for all internal pipes, fittings, and radiators, which can be furnished at about half the usual charges, as a house boiler is not required.

Where buildings are already fitted up, steam is taken direct from the mains, and the house boiler cut off. Where houses are supplied with a furnace, it is only necessary to substitute steam coils in its place, for heating the air, no changes being required in the flues, or registers.

APPARATUS REQUIRED.

BOILERS.—The steam is generated in boilers centrally located with regard to minimum distance of transmission to consumers, convenience of procuring fuel, and water, and cost of site.

The form of boilers should be such, as will secure the largest possible evaporation, with the most economical description of fuel.

Those adopted at Lockport were, Seguin Boilers, flat-ended cylindrical shell, 5 feet diameter, and 16 feet long, containing 54 tubes, 3¾ diameter, arranged in vertical, and horizontal rows, in the lower half of the shell; and having a steam dome on the top.

The boilers were entirely surrounded with brickwork, and were supported by the smoke box in front, and a cast-iron belly bracket at the rear.

The grate was placed beneath the boilers, at the front, and the products of combustion returned from the back, through the flues, into the smoke box, and from thence to the chimney.

These boilers evaporated as their regular daily work, 9 pounds of water (from cold feed water) per pound of coal, with a pressure of 25 to 30 lbs. per square inch, using anthracite coal, stove and grate size.

STREET MAINS.

From the boilers, the steam passed into the mains, which are composed of American standard wrought-iron steam pipe, lap-welded, from 1¼ up, and tested to a pressure of 500 pounds per square inch, connected with tapering screw ends, and wrought-iron couplings.

For special curves, bends, and other details, cast-iron was used.

Valves were placed in various positions, in the same manner as in gas, and water works, so as to be able to turn off the supply of steam where-ever necessary.

PROTECTION AGAINST CONDENSATION.

This is the vital point of the system, and condensation was guarded against in two ways ; first, by protecting the pipes by non-conducting materials, and, secondly, by keeping them dry, when underground.

The pipes were prepared as follows : The naked pipes were held in a lathe, and were wrapped with the following materials :

1. Sheet asbestos about $\frac{1}{8}$ of an inch thick, one thickness.

2. Porous felt paper, two or three thicknesses, or hair felt $\frac{1}{2}$ inch thick.

3. Manilla paper, one thickness (sufficiently strong to stand handling covered pipes, and not to tear).

4. Wooden strips, about $\frac{3}{4}$ inch broad by $\frac{3}{8}$ inch thick.

Three or four of these strips were laid slightly spirally around the pipe, forming spacing pieces. Copper wire was used to bind the strips, and string for the other coverings.

The outside casing of all was made of solid square pine logs, bored out about two inches larger than the diameter of the pipe, the thickness of the wooden shell being in no place less than three or four inches ; the ends of the wooden pipes were made to fit into each other. When the iron pipes, duly protected, were put inside the wooden log, the spacing pieces left an air space all round, and allowed the iron pipe to expand and contract freely, by changes of temperature, while the logs were securely anchored and immovable.

(In the System at Belleville, Ill., the mains were not wrapped at all, but dependence made entirely upon air spaces inside wooden casings.)

Keeping the pipe casings dry, when underground, was effected by placing a tile drain, three or four inches in diameter, at the bottom of the trenches, which were from three to four feet deep, and conformed to the level of the streets; connections were made with the city sewers, as often as possible; broken stone was filled in at the bottom round the tile, and a covering of tarred roofing felt put over the wooden casing, and the trench filled in.

EXPANSION JOINTS.

To provide for contraction and expansion in the iron pipes, caused by differences in temperature, stuffing box joints were provided, and asbestos fibre used as packing. The expansion joints formed a part of the junction-service boxes, which were placed at convenient intervals of from 100 to 200 feet along the line of mains, and were accessible from the street, being surrounded by a brick wall, and having a man-hole and cover.

The arriving main from the boilers, had a turned and nickle-plated end, which worked through the stuffing box. The departing main was securely fastened to the junction-service box, so that, one end of each section being fast and the other moveable, free play was given for contraction and expansion. A ball and socket joint attachment was always used, so as to be able to conform to variations in the levels of the streets and to prevent injury or strain from settling.

The junction service box was a heavy casting weighing several hundred pounds for the large sizes, it was bolted to brickwork, and anchored to the wooden pipe casing. The mains were never tapped for the attachment of service pipes, these connections being only made at the junction boxes, which also served to take up the water of condensation, the bottom of the box, being placed lower than the level of the pipes.

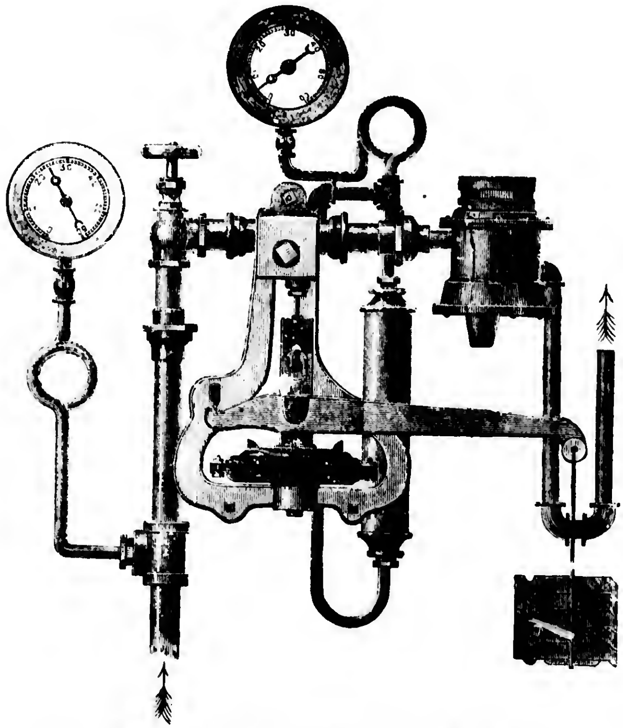
A very important improvement has recently been made by using elastic copper ends to the sections of iron mains, this allows sufficient play, and does away with all packed joints, which are now entirely discarded.

SERVICE PIPES.

The service pipe connections on the junction-service box were taken off at right angles to the main, and were provided with stop-cocks. The service pipes were protected from condensation, in the same manner as the mains.

REDUCING VALVE AND REGULATOR.

The steam on entering any building through the service pipe, at high pressure, had at once to pass through a regulator-reducing valve, by means of which the pressure was reduced to any desired amount, and the supply of steam automatically regulated.

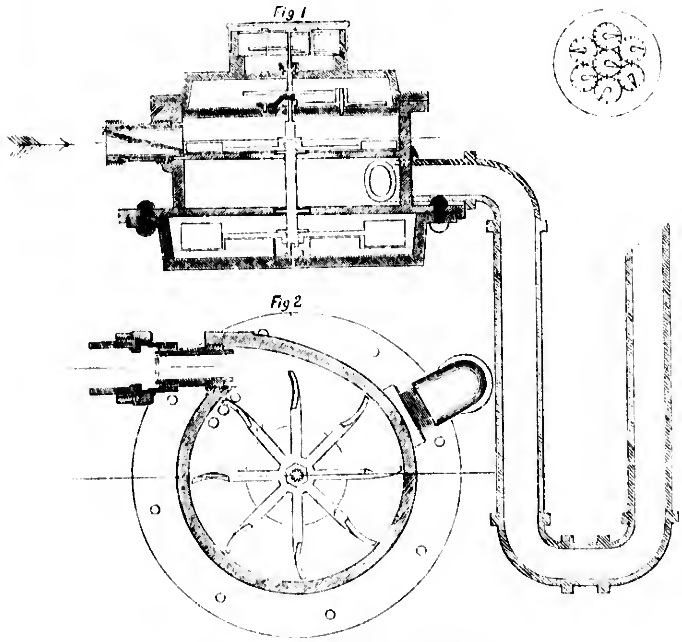


Holly's Regulating and Reducing Valve with Steam Meter in position.

This was done by means of an elastic diaphram, and a weighted lever, a small slide valve being moved, by a valve rod connected with the diaphram. Valves made on the same principal have often been used for supplying low-pressure steam engines, from high-pressure boilers.

METER.

From the reducing valve and regulator the steam, at a low and uniform pressure,—generally from 2 to 5 pounds,—passed through the meter, and into the supply pipes of the house.



HOLLY'S STEAM METER.

Figure 1.—Sectional Elevation.
Figure 2.—Sectional Plan.

A method of accurately measuring, and recording, the amount of steam supplied, has been a most difficult problem to solve, the commercial success of the system being really dependent upon it. The method at present employed is pronounced reliable and satisfactory, by several independent parties, after being in practical use for the past two years.

The meter is made of cast-iron, and in plan is circular in shape; its height and diameter are about equal; it is divided horizontally into four chambers or compartments.

On the outside, upturned face are a series of horizontal dials, which register revolutions, actuated from gear wheels inside the top chamber, they derive their motion from a central vertical shaft, passing through the other compartments, and having a bearing on the bottom of the meter.

To this shaft are fastened two miniature brass paddle-wheels, or spider frames, of eight arms each, with vane-shaped ends, curved slightly forward.

The second, or steam entry compartment, contains one paddle-wheel, which revolves almost touching the bottom. A circular opening in the bottom, connects the third, or steam exit compartment. The bottom compartment, which is closed, all but a small hole round the shaft, contains the other paddle-wheel, and is always full of condensed water, in which the paddle-wheel revolves, stationary vanes preventing the water from being bodily whirled in the direction of rotation.

Steam is admitted through a square pipe, the centre line of the opening being on the line of the inside circumference of the chamber, giving the steam a circular motion, as it enters; within, and from the top of the square pipe, is hung a long copper tongue, the same width as the pipe. The tongue rises and falls as the quantity of passing steam varies, but always directs it, upon the vane-shaped ends of the spider, which revolves in the steam, at a speed proportional to the amount and pressure of the steam admitted. The bottom spider, revolving in water, acts as a governor, and prevents the too rapid revolution of the shaft, the revolutions of which are recorded by the counters on the top. The steam passes out of the third compartment, the exit being nearly at right angles to the entrance.

The quantity of steam passing through the meter is not measured, or recorded in any ordinary terms of measurement, such as pounds, or cubic feet, but in "units," the value of which, have been determined by experiments, the amount of condensed water, resulting from steam passed through, having been accurately weighed. Charges for steam supplied through meters are made per 1,000 units. The value of the unit varies with the size of the meter, the pressure of the steam, and the cost of fuel and water, and the evaporative performance of the boilers.

DIRECT HEATING—RADIATORS.

From the meter the steam intended for heating purposes, passed through the supply pipes into the radiators. Any of the ordinary forms may be used, and all the ordinary steam fixtures. The usual American pattern of radiators are made of vertical lengths, of 1-inch iron pipe, secured into a base and cap, the steam exit and entrance both being in the base. In common with most descriptions of steam radiators, they have to be either full of steam or empty, there being no means of regulating the steam supply. Mr. Holly overcame this, by making the steam entrance at the top of the tubes, in the cap, and having an air valve at the base, to permit the air to escape. Steam, being lighter than air, displaced it to any extent that might be required, entirely, or only partially filling the tubes. In practice it was found difficult to keep the joints tight, in the base and cap, owing to unequal expansion and contraction.

INDIRECT HEATING—BY COILS IN THE BASEMENT.

The steam and water of condensation, from all the radiators, passed through coils of steam pipe, in a chamber in the basement, to which fresh air from the outside, was carried through a flue ; the air thus heated rises through flues and registers, in the ordinary way, and supplies fresh air, while assisting to heat the house.

TRAPS.

The water of condensation escaped through a steam trap, and wasted into the sewers, unless required for domestic purposes.

OTHER USES OF STEAM.

Live steam can be used for heating water, and when this is done, by direct contact, the noise can be almost entirely stopped, by first passing the steam through a small box filled with gravel or fragments of stone.

For cooking purposes, steam does well for a variety of articles, and a stove has been perfected, that with superheated steam, all sorts of cooking can be done, the superheating being done with a gas flame.

The following Report of Mr. Birdsill Holly was published at Lockport on May 18th, 1878 :

"During the past winter, an equivalent of 65 houses, * on nearly three miles of underground pipe, have been heated, and an accurate record has been kept from day to day of the amount of coal consumed.

"From well-understood facts, and from tests actually made to ascertain the amount of condensation in the houses, also 12 hour tests upon the main line with all the houses shut off, it is demonstrated what amount of condensation is due to the buildings, and how much to the pipe underground.

"The details for cost of constructing works, and the cost of fuel are applicable to this city, and will be varied somewhat, according to location and circumstances.

"The following tables show the cost of heating by this system, and the comparisons made with other systems of heating will, upon perusal, speak for themselves.

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* NOTE.—12,000 cubic feet of space being taken as an average for dwelling-houses in Lockport.

(For convenience both American and Sterling costs are given, the Dollar being taken equal to 4s. 1¼d. or Exchange at 9½ per cent. Premium.)

J. H. B.

ESTIMATED COST OF CONSTRUCTION AND OPERATION FOR A DISTRICT OF 400 DWELLINGS ON TWO MILES OF STREET-MAINS, HEATING THE SAME FOR 240 DAYS, FROM SEPT. 15TH TO MAY 15TH.

Construction of Works.

	$	£	s.	d.
Boiler house and chimney stack............	6,000 00	1,232	17	6½
Six boilers, 5 x 16 feet, set, with feed water heaters..................	12,000 00	2,465	15	1
Two miles mains, average 3 inch, at $1.40 (5s. 9d.) per ft.........	14,784 00	3,037	16	2
Superintendence and incidentals............ ..	1,216 00	249	17	3
Total..............................	$34,000 00	£6,986	6	0½

Operating Expenses for 240 Days.

	$	£	s.	d.
2,000 tons of coal, at $4.00 (16s. 5¼d.)....	8,000 00	1,643	16	8½
Two fireman and extra labor..................	800 00	164	7	8
Repairs and depreciation......................	800 00	164	7	8
Office expenses..................................	1,500 00	308	4	4½
Taxes..	400 00	82	3	10
Water bill.......................................	100 00	20	10	11½
Dividend of 20 per cent. on $34,000........	6,800 00	1,397	5	2½
Total..............................	$18,400 00	£3,780	16	5
400 Consumers at $46.00 = £9 9s. 0½d. =	$18,400 00	£3,780	16	5

COST OF A DISTRICT EQUIVALENT TO 1,000 DWELLINGS, PARTLY COMPOSED OF BUSINESS BLOCKS AND PUBLIC BUILDINGS.

Construction of Works.

	$	£	s.	d.
Boiler house and chimney stack..............	8,000 00	1,643	16	8½
Twelve boilers, 5 x 16 feet, set, with feed water heaters..............................	24,000 00	4,931	10	5
Four miles of mains, average 3 inch, at $1.40 = (5s. 9d.) per foot.................	29,568 00	6,075	12	7½
Superintendence and incidentals............	2,432 00	499	14	6
Total..............................	$64,000 00	£13,150	14	2

Yearly Expenses, Heating, 240 Days.

	$	£	s.	d.
5,000 tons of coal at $4.00 (= 16s. 5¼d.) per ton....................................	20,000 00	4,109	11	9½
Fireman and extra labor........................	2,000 00	410	19	2½
Repairs and depreciation, and sinking fund.	2,000 00	410	19	2½
Office expenses..................................	1,500 00	308	4	4½
Taxes..	1,200 00	246	11	6
Water bill.......................................	300 00	61	12	10⅓
Dividend of 20 per cent. on $64,000.........	12,800 00	2,630	2	9
Total..............................	$39,800 00	£8,178	1	8½
1,000 Consumers at $39.80 = £8 3s. 6½d..	$39,800 00	£8,178	1	8½

STATEMENT OF COST.

INDIVIDUAL FURNACE SYSTEM.

One Furnace will Cost $275=£56 10s. 1d.

	$	£	s.	d.
One consumer will use 10 tons, at $5.00	50 00	10	5	5¾
Depreciation and repairs 10 per cent. on $275	27 50	5	13	0¼
Five cents=2½d. per day for attendance	12 00	2	9	3¾
Interest, 7 per cent., on investment, $275	19 25	3	19	1¼
Unreduced insurance	5 00	1	0	6½
Total	$113 75	£23	7	5½

INDIVIDUAL STEAM SYSTEM.

One Boiler and Fixtures will Cost $800=£164 7s. 8d.

Running Expenses.

	$	£	s.	d.
Twelve tons of coal, at $5.00	60 00	12	6	7
Depreciation and repairs 5 per cent. on $800	40 00	8	4	4½
Fifteen cents=7½d. per day for attendance	36 00	7	7	11¼
Seven per cent. interest on investment	56 00	11	10	1¾
Unreduced insurance	5 00	1	0	6½
Total	$197 00	£40	9	7

District System with 400 *Consumers.*

	$	£	s.	d.
Seven per cent. interest on cost of fixtures= $200=£41 1s. 11d.	14 00	2	17	6½
Two per cent. depreciation and repairs	4 00		16	5¼
Heat bills, for steam supplied	46 00	9	9	0½
Total	$64 00	13	3	0¼

District System with 1,000 *Consumers.*

	$	£	s.	d.
Seven per cent. interest on cost of fixtures=$200	14 00	2	17	6½
Two per cent. depreciation and repairs	4 00		16	5¼
Heat bills, for steam supplied	39 80	8	3	6½
Total	$57 80	11	17	6¼

Comparison of Cost.

	$		s.	d.
Individual Furnace system	113 75	23	7	5½
Individual Steam system	197 00	40	9	7
District system with 400 consumers	64 00	13	3	0¼
District system with 1,000 consumers	57 80	11	17	6¼

This result has not as yet been realized in actual practice, but none of the systems have had so large a number of consumers on so short a main.

DEVELOPMENTS AND CAUSES OF FAILURE.

The winter's experiment, at Lockport, in 1877-78, having proved the practibility of the system, and the consumers being so well satisfied, several other towns at once took the matter up, and had systems in operation for the following winter. The first meters did not work well, and the only way of charging for heat was by bargain, based upon the previous coal bills of the consumer. The companies suffered severely in these bargains, but the greatest loss was caused by having long lines of main, with only a few consumers drawing steam,—the loss by condensation being then very great. In many cases the trenches were not properly drained; and the system was adopted before sufficient time had been given to perfect all details. The result of all this being the failure of several of the companies.

DUPLEX SYSTEM AT LYNN, MASS.

At Lynn, Mass., a duplex system was put in, for first supplying high pressure steam, through one main, to drive large mill engines—these engines, exhausting into a low pressure main, from which steam was supplied for heating, &c. The idea being to utilize the power first and leave sufficient pressure for heating purposes.

The boiler house here was situated on very low land, which was subject to inundation, during extreme high tides; the consequence being, that near the boiler house the steam mains were sometimes under water, and as few of the streets in Lynn are sewered, the ground was constantly damp in many of them, and a very large amount of condensation took place. The steam supply was discontinued, and the works sold and utilized for other purposes, although the steam works were fully paying expenses at the time of selling out.

THE SYSTEM IN NEW YORK.

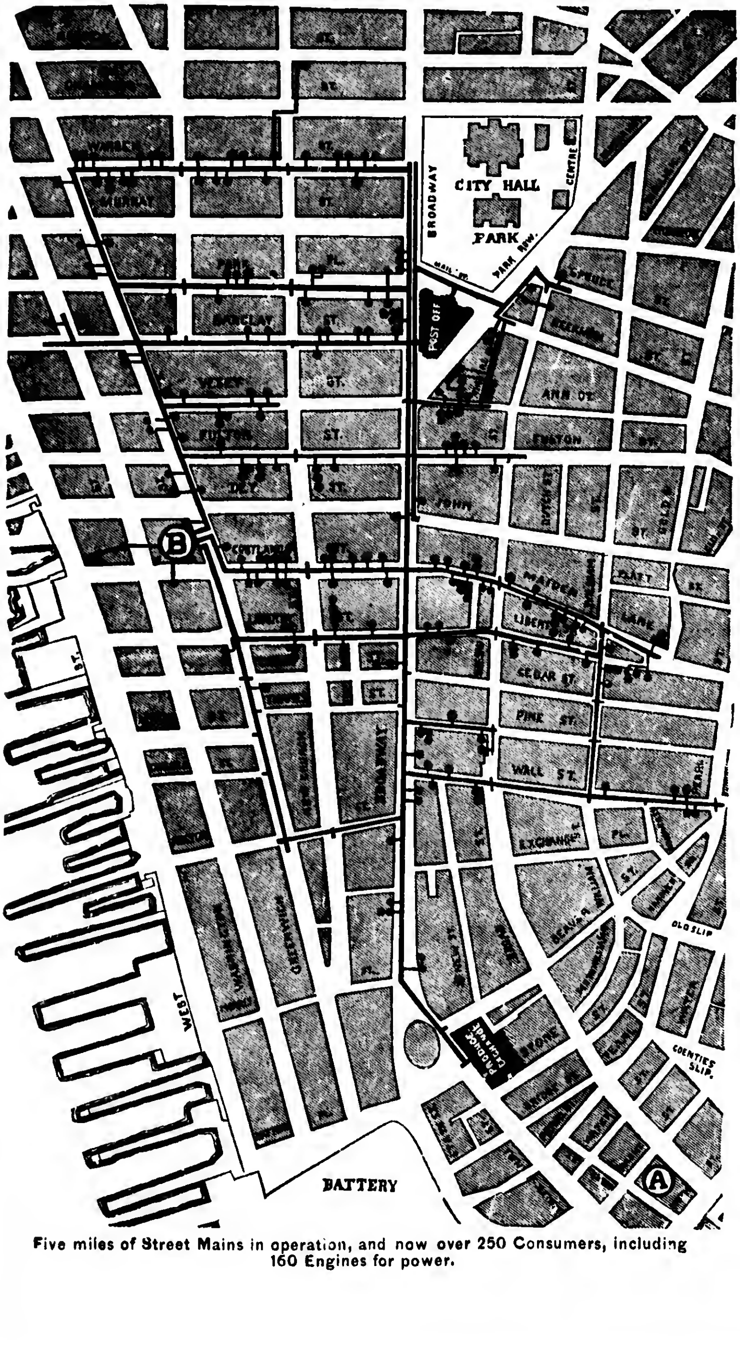
In New York, the system is being operated on a very large scale, by a Company who have selected and purchased ten sites for steam stations. The first station, (Station B,) at Nos. 172 and 176 Greenwich St., has been built, and consists of a building, 75 feet front by 120 feet in depth and 120 feet high, in which are to be placed 64, Babcock & Wilcox sectional, boilers, of 250 horse-power each, or, in all, 16,000 horse-power, distributed upon four floors, 16 boilers on each floor. The draft for the furnaces of the boilers, will be obtained by two large chimney-stacks, each about 225 feet high, supplemented by a fan blower, on each floor. The walls of the building are 36 inches thick at their base, and those of the chimneys are 4 feet thick. The dimensions of the chimneys are as follows:—Exterior dimensions at the base, 32½ by 20 feet; at bottom of flue, 32½ by 13 feet; interior area, 27 feet 10 inches by 8 feet 4 inches.

The coal supply will be elevated to the upper stories of the building, and delivered through chutes, alongside each boiler, while the ashes will be taken by chutes, from each boiler through the basement of the building.

On the 1st of January, 1884, the Company had five miles of its street steam system in active use, having increased from one mile in use on the 1st June, 1882. The mains, which are from six to ten feet underground, have been all the time under a full pressure of 80 pounds per sq. inch, and no one has been injured.

The mains are made of lap-welded tubes, and are most of of them 11, 13, 15 and 16 inches in diameter, some are shortly to be put in 20 and 24 inches in diameter. In place of being screw-coupled, they are flanged and bolted together, the end of the wrought-iron pipe being expanded into the flange, by an enormous tube-expanding machine. The condensed water is returned to the boilers by a pipe about half the size of the mains. The mains and return pipe are laid in a well-drained brick chamber, and packed all round with mineral or slag-wool as a non-conductor. Expansion and contraction is provided for, by using elastic copper ends to the pipes; and the details of the system have been very carefully worked out.

Map showing the Location of the Mains and Services of The New York Steam Co.



Five miles of Street Mains in operation, and now over 250 Consumers, including 160 Engines for power.

In a recent report the Company state that they have over 200 buildings on their line, including 160 engines for power, and that they supply the steam for running the engines of the *Times*, the *World*, *Commercial Advertiser*, the *Tribune*, and five other newspapers and a large number of printing offices, the new Produce Exchange, with nine elevators and electric lights, &c., &c., and that none of these buildings have boilers on the premises. They go on to say :—

" To mention one thing in detail, *cooking* may sound small —it is and will be, in fact, one of the very largest in its consumption of steam. * * There is one restaurant which has used our steam for eighteen months, (Messrs. Smith & McNeil, Greenwich st.,) and which buys from this Company fifteen thousand dollars' worth of steam, per annum. This is probably the largest restaurant in the world, serving about ten thousand meals per day. Messrs. Nash & Crook, in the New York *Times* building, is the next in size in the city, and one of the best known. The proprietors of both these immense establishments say they would not go back to their former mode of cooking if the coal were furnished to them for nothing."

Steam will be supplied to heat buildings, supply power, for cooking, and laundry work, for baths, and many other purposes requiring water as well as steam, for melting snow in the streets, and for extinguishing fires. Steam will be supplied by meter. The system is expected to spread all over the city, and the Company say that, although having been so short a time in operation, they have reached a paying basis.

The most recent development in connection with the New York system is that of supplying steam for electric lighting purposes. It was found that there was comparatively very little demand for steam from six o'clock at night till six o'clock in the morning, and there was consequently a waste in blowing it off every evening. To prevent this waste, the Company propose to supply steam for running electric light engines during the night, and the cost of lighting should be much reduced in consequence.

To prevent misunderstanding, it might be well to mention that there was another Company in New York, who laid pipes in the streets, on some other system, for the supply of steam, but this Company failed after having had repeated accidents and explosions in the streets.

The annexed list gives particulars of very nearly all the systems put in, the data in most cases having been kindly furnished by the companies themselves, or from published reports.

At Springfield, Mass., the Gas Company there took the matter up in 1878, and have been successful from the start, having utilized waste heat from their gas retorts, and also coke made on the premises. They put in a very short line to begin with, gradually extending it as consumers increased.

Most of the systems are in operation, for seven months, and at Denver for eight months, out of the twelve.

At first the steam mains were only laid from three feet to three feet six inches under ground, but it is now thought this is not deep enough and double this distance is recommended, so that the frost and snow will not increase the condensation.

In conclusion, it appears as if with the past experience, gained at the expense of several failures, this system of heating will in the future be adopted in many places. The two last systems reporting commercial success after being in operation only one winter.

17 Hamilton Chambers, Montreal.
August 20th, 1884.

Number.	City.	State or Province.	Year of Commencement.	Amount of Capital or Capital Stock.	BOILERS. Number.	Diameter.	Length.	Number of Tubes.	Diameter of Tubes.	Total Horse Power.	Pressure Carried.	UNDERGROUND STEAM MAINS.											AMERICAN STANDARD Wrought Iron Welded Tubes.
												1·80	2·88	4·98	7·20	11·31	19·49	30·11	42·36	70·65	96·25	166·9	Length to contain 1 cubic foot.
												78·838	50·039	28·889	19·990	12·73	7·388	4·783	3·355	2·038	1·496	0·8627	Internal area; in square inches.
												0·355	0·444	0·577	0·629	0·849	1·091	1·328	1·611	2.010	2·301	2·903	Length per sq.ft. out. sur. In. ft.
												10·750	8·625	6·625	5·563	4·5	3·5	2·875	2·375	1·90	1·660	1·315	Actual outside diam. in ins.
												10·019	7·982	6·065	5·045	4·026	3·067	2·468	2·067	1.611	1·380	1·048	" inside " "
												10"	8"	6"	5"	4"	3"	2½"	2"	1½"	1¼"	1"	Nominal Diameter.
1	Lockport.......	N.Y..	1877	$50,000	6	5	16	54	3½	480	25-30	......	Four miles 8 inches and under								.....	.....	21,120 Total Lineal Feet.
2	Detroit.........	Mich.	1878	81,750	..	5	16	..	..	1,500	" "	......	About 3 miles of all sizes, 8 inches and under								.....	.....	15,840 " " "
3	Springfield.....	Mass.	"	50,000	9	5	16	..	4	685	" "	......	300	and 18,480 lineal feet of smaller sizes							....	.....	18,780
4	Auburn.........	N.Y..	"	31.300	4	5	15	72	2½	240	" "	......	......	900,	1,200,	......	1,500,	2,000 Not counting laterals				.....	5,600
5	Milwaukee......	Wis...	1879	75,000	17	5	15	..	..	....	......	585,	2,540	5,156,	1,375,	5,195,	1,300, and 6,900 feet of smaller sizes....						23,051
6	Troy...........	N.Y..	"	75,000	6	..	..	..	..	700	25-30	......	Five miles from 8 to 3 inches					......	......	......	.....	....	26,400
7	London.........	Ont ..	"	65,000	6	.	..	..	..	......	......	......	....	1,900,	2,000,	3,000,	3,000,	1,500,	2,100,	10,000	.....	.....	23,500
8	Belleville.....	Ill....	"	45,000	10	.	..	..	..	......	......	.....	Two miles 8 inch and under					.....	......	......	......	......	10,560
9	Dubuque........	Iowa..	"	40,000	.	.	..	..	..	......	......	......	......	860,	1,960,	3,818,	4,441,	.....	205,	2,073,	2,508,	643	16,508
10	New Haven....	Ct. ..	"	50,000	6	.	.	..	..	450	25-30	......	......	......	.....	....	......	......	......	......	......	......	......
11	Lynn.........	Mass.	1880	....	..	..		..	..	....	......	......	....	....	......	......	......	......	......	......	......	......	......
12	Denver.....	Col...	"	160,000	15	5	17	48	4	1,100	25-30	......	1,540,	4,968,	....	4,094,	3,400,	500,	3,400,	1,500,	1,000,	500	20,902
13	New York City.	N.Y..	"	3,000,000	Babcock & Wilcox, 250 h.p. each.						80	Five miles mostly 11, 13, 15 and 16 inches diameter.								......	.....	.....	26,400
14	Garden City....	N.Y..	"	....	..	..	..	..	..	......	......	......	......	......	......	......	......	......	......	......	......	......	......
15	Hartford.......	Ct....	"	75,000	..	..	..	..	..	......	....	......	......	......	......	......	......	......	......	......	....	......	......
16	Burlington......	Iowa..	"	60,000	..	..	..	..	..	......	......	......	......	......	......	......	......	......	......	.. ..	......	......	......
17	Clearfield......	Pa ..	1883	15,000	2	6½	17	72	4	......	25-30	......	......	......	400,	2,200,	2,600	......	......	not counting laterals.			5,200
18	Phillipsburg....	Pa...	"	20,000	2	..	..	.	..	160	......	......	......	......	350,	4,000,	3,000	......	250	not counting laterals.			7,600

Number.	City.	Consumers. Number.	Consumers. Cubic Feet of Space Heated.	Consumers. No. of Engines.	Charges for Steam. Holly Meters per 1,000 Units. 1"	Charges for Steam. Holly Meters per 1,000 Units. 1½"	Charges for Steam. Holly Meters per 1,000 Units. 2"	Charges for Steam. Per 1000 Cubic Feet per Season.	Fuel. Description.	Fuel. Amount.	Reported Trouble from Leakages, Bad Joints, Accidents.	Reported or Estimated Loss by Condensation.	Public Opinion. Are Consumers Satisfied?	Remarks.
1	Lockport	300			c. 65	$ 2.00	$ 5.00		Soft Slack.		None.	5 per cent.	Thoroughly.	
2	Detroit				Usually			$4.00	" "		More or Less.	Very much Loss.	Yes.	Not likely to prove a good investment.
3	Springfield	194			c. 70				Pea, Dust, Coke, Buckwheat.	4,000 Gross Tons	None.	10 per cent.	Very much pleased.	Their bills are reasonable compared with Furnace Heat. The company made 12 per cent. last season.
4	Auburn	140	3,000,000		No regular rate.				Clearfield Bit.	2,300 " "	Not more than could be expec'd	Big.	Very much pleased.	Prospects good for the future.
5	Milwaukee	100	5,000,000	10	Usually			$4.00	Soft Slack.	The Company	failed during the	Second Season	and the works	were sold.
6	Troy		4,000,000	21						" "	" " "	" "	" "	" "
7	London	150							Oil and Tar.	" "	" " "	" "	" "	" "
8	Belleville	90							Soft Coal.	1,000 Bushels per day.	None.		Yes.	No dividends paid so far.
9	Dubuque	100	3,500,000									50 per cent.	"	
10	New Haven	75							Pea Coal.		Yes.	50 per cent.		"Sunk all their capital and shut down for good, in other words busted."
11	Lynn													
12	Denver	140	9,000,000						Slack Coal.	90 Tons per day.	None,	15 per cent.	Yes	Prospects for the future good.
13	New York	250		160					Hard Coal.		"	Same as Gas.	"	" " " "
14	Garden City													No information o[illegible]nable.
15	Hartford													Reported to have [illegible] money last season.
16	Burlington													Prospects improving.
17	Clearfield	62	1,500,000		c. 50	$ 1.50	$ 4.00		Soft Coal.	4 Tons per day.	None.	5 per cent.	Perfectly.	Made 6 p.c. last season, and expect 10 to 12 p.c. in future.
18	Phillipsburg	24	1,500,000		70				" "	2½ " " "	"	5 per cent.	"	Company doing well.