1905

IMPROVED HOLLY SYSTEM

OF

DIRECT AND EXHAUST

District Steam Heating

FOR CITIES AND
VILLAGES, THROUGH
UNDERGROUND MAINS

250 PLANTS NOW IN OPERATION

American District Steam Co.

Executive Offices
LOCKPORT, N.Y.

Western Offices
CHICAGO

Eastern Factories
LOCKPORT and NO. TONAWANDA, N.Y.
Introduction

In introducing the subject of steam distribution through long lines of underground mains, perhaps it would not be amiss to give a brief history or story of the first district system installed. The plant, at the time of its installation, was largely experimental, and has since been utilized to develop improvements in the construction of devices to take care of expansion and contraction, anchorage, etc.; to test efficiencies and adaptability of nearly thirty different methods and materials for insulation against radiation, and condensation losses in the street mains and service pipes; also in ascertaining the life of wrought iron pipe, and of steel pipe, both with reference to the mains for supplying steam and the one for returning the water of condensation to the station.

Although Mr. Birdsall Holly, the original inventor of the system of underground steam distribution which bore his name, was an engineer of worldwide reputation, to whom was due the invention of pumping machinery for direct distribution of water and the solution of many difficult engineering problems, still to-day, practically the beginning of the twentieth century, the original methods have been greatly improved and modified, and not a SINGLE device is now in use in the construction of central station heating plants which was in use in his time.

In 1877 about a mile of underground mains was installed at Lockport, a city of about 20,000 population, situated adjacent to Buffalo, N. Y., to which mains were connected that year, five stores, seven residences and two churches. Nearly every year since that time
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either a few hundred or a thousand feet of experimental mains have been added to the first installation, in which every known method of insulation and device worthy of trial have been put to practical test. A great many of these seemed theoretically correct, but were proven failures, and have been replaced with improved and modern construction. During these twenty-eight years the number of customers has been steadily increasing, so that at the present time steam is being furnished to more than 350 consumers in both the residence and business blocks who are connected with the six miles of street and service mains, and at no time during the heating season, even for so short a period as an hour, has there been failure to supply a sufficient amount of steam to every consumer, or is there a single building not now connected with the mains that once took the steam for heating. Enough was demonstrated to show that steam can be economically supplied over long distances, with sizes of pipe properly proportioned, and some of the larger plants are now operating as much as from ten to twelve miles of steam mains, and, in addition, from two to four miles of service mains.

Mr. Holly died a number of years ago and other eminent engineers have been employed in his place. Many inventions and improvements of engineers not connected with the company have been tested and the successful ones adopted. The American District Steam Company, the successor of the Holly Steam Combination Company, Ltd., comes to-day before the public with the experience of more than a quarter of a century, and while the original plant constructed by Mr. Holly in 1877 is still in successful mechanical and financial operation, yet the constructing company has not stood still in its methods of installation, but has made constant improvements in general and in detail, and has devised new methods and appliances that conditions have made necessary or desirable.

Steam Heating as a Business Enterprise

Essentially, district steam heating is a simple manufacturing enterprise. Like any other commodity, steam may be manufactured in large quantities at a low cost and sold in small amounts at an increased price. The ultimate extent to which a district heating plant will be profitable depends on chiefly:

1st. Volume of business.
2d. Properly constructed plant.
3d. Efficient management.
4th. Methods of charging for steam supplied.

Dividends do not depend on the amount of money invested regardless of conditions, but by reason of a minimum cost of production and delivery, both attained by construction as perfect as may be, and a reasonable difference between the generating and delivery cost, and the selling price.

The main factors which contribute to the success of a district plant have associated with them others, such as the ability to serve all classes of buildings, piped for one or two-pipe steam systems, hot water systems, or other systems, without requiring change of radiation and attendant expenses, as well as to have a system that does not require expensive fitting up of buildings not now heated by either steam or water.

Cost of Maintenance

The system must be free from devices which require frequent attention and repair. A constantly steam-tight line is an absolute necessity.
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#### Economy of Operation

The economy of operation derived from the centralization of many small and inefficient plants is so thoroughly established as to make it unnecessary to enlarge upon this feature further than to point out that this law is particularly applicable to the furnishing of an adequate and satisfactory supply of heat to a community.

#### Durability of Plant

The present insulation and devices in use by the American District Steam Company have been proven to be the best for durability of any known, and leave no weak points to impair the life of the plant.

#### Advantages to the Consumer

Among the advantages to the consumer of having steam delivered to him instead of making his own are:

- Increased cleanliness due to the absence of coal, ashes and smoke about the building.
- A more steady supply of heat than is the case when individual boilers are operated.
- Heat ready for use at all times during the heating season, both day and night.
- No boiler to be installed.
- Increased safety from fire loss.
- Increased amount of available space in buildings, due to the absence of boilers, coal bins, ash piles, etc.
- No depreciation of apparatus.
- No ashes to be removed.
- A simple means always at hand for heating water for laundry, baths and other purposes.
- No fires to build and look after.

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#### As an Investment

As an investment, district steam heating presents a splendid opportunity. The financial history of the enterprise bears out this assertion, and of a few plants which may not have attained a marked degree of success the principal underlying causes have been a lack of proper management, proper methods of charging, and a character of construction, which, compared with that of the present, is imperfect and experimental.

Heat being a prime necessity and indispensable in domestic and public life has an assured market always, even more so than gas, electric light or water.

The income per mile from a system of steam mains is far in excess of either gas, electric light or water, and most buildings pay more for heat per year than they do for gas, electricity and water combined.

#### Profit

O enumerate some of the sources of the margin of profit derived from the operation of district direct steam heating plants, the following points may be considered:

BOILER DUTIES.—With a battery of boilers installed, sufficient in capacity to meet the maximum
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Demand for heat, only such a number of them will be in use, when demand for heat is lessened, as will allow their operation under the most favorable conditions, working within the range of the most economical duty; while in the case of an individual boiler in any building, which boiler has to be large enough for satisfactory service in the coldest weather, is many times, during the season, operated only under a load of from ten to twenty per cent. of what it should be in order to get the most economical results. This difference in service to be obtained from the boilers alone is a cause sufficient in itself to put a steam heating plant on a good, dividend-paying basis.

Saving in Cost of Labor.—The expense of firemen operating individual boilers in many separate buildings can be largely reduced by combining the needed boiler capacity in large units in one plant, which can be operated by a few men, and such cost of firing can be still further lessened by automatic stokers and machinery for handling fuel, ashes, etc.

Cost and Kind of Fuel.—The cheapest grade of fuel is used, and the boiler house of a central station heating plant is generally located where fuel can be obtained with the least expense in handling. In the smaller boilers, such as are found in houses and medium-sized blocks, the average rate of evaporative duty is less than one-half that in a large boiler using exactly the same kind of fuel. In the vast majority of cases, the individual user of fuel burns a higher grade, with its increased cost, than a central station would use.

Reduced Cost of Fire Insurance.—In many cities now enjoying the benefits of a district steam heating plant, the board of fire underwriters have materially reduced the rate of insurance in buildings heated by steam taken from the street mains, and even where a reduction in premium rates is not af-

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fected, a reduced amount of insurance can be safely carried, on account of a reduced hazard from fire.

Saving in Aggregate Cost of Boiler Insurance.—This is quite a considerable item where a large number of individual boilers are at present installed along the line of the steam main.

In Natural Gas Fields.—People are educated to the luxury of having their building heated by a public-serving corporation. The natural gas supply is uncertain, and in many places is rapidly giving out, with a corresponding increase in cost to the consumer. Direct heating by natural gas is very unhealthful, as it burns up the oxygen in the air. Steam heating companies are now rapidly entering cities located in the gas belts, and results from those already in operation indicate that this field is proving a very attractive one to investors.

Exhaust Steam Heating

The steam engine of to-day has reached a degree of perfection beyond which it seems improbable that any material advance in efficiency will be made, except by some radical change in the thermal cycle.

The knowledge and skill which have been given to the design and construction of the modern steam engine are apparent, yet the principal object of the mechanism, the conversion of heat into mechanical energy, is almost defeated by the low efficiency of the device. Under the best conditions possible, a maximum of only twenty per cent. of the heat delivered to the engine in the form of steam is transformed from thermal to mechanical energy, and under commercial conditions of variable load the efficiency seldom exceeds ten per cent. Compared with the water turbine, or with electrical machinery, the steam engine as a transformation device, falls far below other machines similarly employed.
The advisability of using exhaust steam as a heating agent has long been recognized, yet there are many who have the false impression that the steam that has passed through the engine possesses but little heat compared with what it had when it entered the cylinder. But steam manufactured at high pressures and reduced to a heating pressure is, in fact, drier, and thus more effective than if sent out at heating pressure. Steam exhausted from the engine answers this condition and is thus in the line of economical duty. This misapprehension should be entirely cleared away by reference to the eminently satisfactory results as obtained by the companies using exhaust steam for heating purposes, of which there are more than one hundred. When exhaust steam is sold, the price fixed should be based upon the cost of manufacture in exactly the same manner as though it was manufactured for no other purpose than heating, and the experience of companies now in operation shows that business can be secured at prices determined in that manner in competition with individual heating plants.

The conditions of operation that are necessary, in order that exhaust steam may be utilized in a heating system, vary through wide limits, depending upon the local conditions, class of engines operated, maximum and minimum demand for heat, and the maximum and minimum output of the plant in electrical or power load during the heating and non-heating season.

The use of exhaust steam for heating furnishes a source of income which cannot well be ignored. There are many manufacturing companies which derive the principal part of their profits from the utilization of their waste products. Quoting from a recent report of a manager who has an exhaust steam heating system in connection with his electric light and power plant, he says: “The bugbear, BACK PRESSURE, on our engines is the most profitable load the engines carry.”
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duced into the mains at the same pressure as the exhaust steam, thus supplying the deficiency. That this can be done at a profit is illustrated not only by the financial success of live steam heating companies, but in a preceding paragraph is set forth the fact that the price charged for exhaust steam should be based upon the cost of production, irrespective of the fact that it is possible for the steam to serve a double purpose.

Competent engineers assert that during the hours when the electric plant is idle and the fires are banked, it costs, approximately, ten per cent. of what the fuel and labor expense would be to run at full working capacity, which, of course, brings no return, but by the addition of a steam heating plant continuous work is given to boilers and men, and a profit secured in place of this loss.

Heating versus Condensing

TEAM engineering has been defined as the “Science which produces the greatest income from a pound of coal.” To this end condensers have been used for many years, and in many cases these have been operated at a positive loss in plant efficiency. In more cases, however, they have been a benefit. Where the conditions permit the installation of a heating system it may be stated, as a general proposition, capable of demonstration, that the financial return derived from the sale of exhaust steam will be far in excess of that derived from the operation of condensers.

By present methods employed by the American District Steam Company, the connections at the engines are so arranged that only a needed number of engines will be operated non-condensing when heat is required and furnish their exhaust for heating purposes; while the balance of them can be operated condensing.

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The American District Steam Company equips the station in such a manner that boiler feed water is heated, it being arranged that the steam not needed for heating the feed water does not become saturated before entering the street mains.

To illustrate the increased value of utilizing the heat in the exhaust steam from the engines instead of condensing it, without going into technical arguments, we instance that companies that are operating non-condensing when heat is needed receive an income from the sale of exhaust steam for commercial heating purposes, during the heating season of from seven to eight months, exceeding in amount the cost of fuel at the station for the entire season required to manufacture light, heat and power, plus interest on the cost of the steam heating plant. No advocate of condensing can even hope to approximate such a result.

This company has constructed a considerable number of heating plants which are operated in connection with compound condensing engines of the highest class, and is prepared to submit detailed plans and reports on similar prospective installations.

Electric companies operated by water power find it a great advantage to construct a direct steam heating plant to operate in conjunction with their electrical business, not only on account of the revenue and profit derived from the steam heating enterprise, but the advantage gained in doing away with competition of isolated plants that are forced to construct a heating plant and, naturally, furnish their own light and power as well.

Heating and Refrigeration

HE coupling of two lines of business seemingly opposed is illustrated by the successful operation of steam heating and artificial refrigerating and ice manufacturing plants in combination.

The boilers which are used in the summer months
to furnish steam for distilled water, for artificial ice, to operate ice machines for cold storage plants, and for underground anhydrous ammonia and brine lines can profitably be employed in the winter time for supplying steam for heating purposes; otherwise remaining idle, at least in part.

**General Details of Construction**

The American District Steam Company manufactures all the component parts of its construction in its own factories, with the exception of the wrought iron pipe, the latter being made for it under its own rigid specifications as to the weight, length of each pipe and chemical composition of the material. Their devices have been designed on lines suggested by experience, and are of a form and character to best perform the service for which they are used. Their fittings have been designed and made with special reference to the fact that they are to be used in a particular way and not required to fit a multiplicity of conditions. This applies not only to the various devices for taking care of expansion and contraction, supply anchorage, etc., but also applies to the return mains and station connections.

**Return Mains**

In some cases it is desirable to return the water of condensation to the station for re-evaporation, on account of its purity and also of its action in preventing the formation of scale in the boilers, or because of the high cost of water for steam-making purposes. In such cases, a wood pipe made specially for this purpose, with a special form of coupling and with special fittings, is used. This wood pipe, under proper temperatures and conditions, is quite as durable and far cheaper to install than either wrought or cast iron pipe. Steel pipe cannot be used for this purpose, on account of the pitting and corrosive action which is immediately set up by the water of condensation, thus rendering the life of the steel pipe extremely short.

Returning the water of condensation may or may not be advisable, depending wholly upon local conditions, and no uniform practice can be said to exist. The determining factors in each case will be carefully studied by the engineers of this company before any recommendation either for or against the return system is made.

As an alternative to the use of wood water pipe for returning condensation, this company is also prepared to install, where desired, a cast iron return main properly insulated, in which case pipe is used having threaded ends and with special threaded cast iron couplings, similar, in a general way, to those used for wrought iron pipe. With this type of construction, however, expansion and anchorage devices are required.

**Insulation**

At Lockport, N. Y., the American District Steam Company has installed mains using nearly every known method of insulation, for purposes of experimenting and testing efficiency and durability. Brick conduits with eight-inch walls have been constructed, and the wrought iron pipe therein cov-
ered with asbestos, with hair felt, with mineral wool, with magnesia sectional covering, with an inch of cork sectional covering, with sectional air-cell asbestos covering, etc., etc. All of the same kind of coverings have been tried in connection with the use of vitrified sewer pipe, cement casings, boxing, and round wood casing having various thicknesses of shell, and careful and elaborate radiation and condensation tests have been made. The best results by far have been obtained by covering the wrought iron pipe with sheet asbestos, and enclosing same in a round tin-lined wood casing, having a shell of four inches in thickness, with a dead air space of at least one inch between the tin and the asbestos covering the pipe. This method has been adopted and is called our STANDARD INSULATION. One of the more important improvements in the manufacture of wood steam pipe casing of the larger sizes lies in the fact of its being made of carefully selected timber, cut and thoroughly kiln dried, and then dressed into radial staves with groove and tongue running the full length of the stave, to make a given size, and placed in a banding machine, where the staves are firmly banded together by 3-16 inch galvanized steel wire being spirally wound around the casing, and but a short distance apart, the banding machine being powerful enough to fully imbed the wire into the wood. After this is done, a mortise and tenon of 3½ or 4 inches is cut on the ends. The outside of the casing is then thoroughly covered with asphaltum, pitch and sawdust, and after being lined with a specially prepared tin is ready for use. With this method of insulation, condensation and radiation losses have been reduced to about one-quarter of one per cent. to six per cent. to the mile of pipe delivering at capacity, varying according to the size of mains.

Table of relative value of non-conducting materials:

<table>
<thead>
<tr>
<th>Material</th>
<th>Relative Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Am. Dist. Steam Co. 4&quot; shell, tin-lined wood casing</td>
<td>456</td>
</tr>
<tr>
<td>Loose wool</td>
<td>335</td>
</tr>
<tr>
<td>Loose lamp-black</td>
<td>123</td>
</tr>
<tr>
<td>Geese feathers</td>
<td>108</td>
</tr>
<tr>
<td>Felt, hair or wool</td>
<td>100</td>
</tr>
<tr>
<td>Carded cotton</td>
<td>100</td>
</tr>
<tr>
<td>Charcoal from cork</td>
<td>87</td>
</tr>
<tr>
<td>Mineral wool</td>
<td>.68 to .83</td>
</tr>
<tr>
<td>Fossil meal</td>
<td>.65 to .79</td>
</tr>
<tr>
<td>Straw rope, wound spirally</td>
<td>.77</td>
</tr>
<tr>
<td>Carbonate magnesia</td>
<td>.57 to .76</td>
</tr>
<tr>
<td>Charcoal from wood</td>
<td>.63 to .75</td>
</tr>
<tr>
<td>Paper</td>
<td>.50 to .74</td>
</tr>
<tr>
<td>Cork</td>
<td>.71</td>
</tr>
<tr>
<td>Sawdust</td>
<td>.61 to .68</td>
</tr>
<tr>
<td>Wood ashes</td>
<td>.61</td>
</tr>
<tr>
<td>Ground chalk</td>
<td>.49</td>
</tr>
<tr>
<td>Gashouse carbon</td>
<td>.47</td>
</tr>
<tr>
<td>Asbestos paper</td>
<td>.47</td>
</tr>
<tr>
<td>Asbestos fibre</td>
<td>.36</td>
</tr>
</tbody>
</table>
though in amount less than 1-10 of one per cent. used in its manufacture, positively precludes its use at any price.

**Expansion and Contraction**

The law of expansion and contraction is fixed and positive. To provide for the same, it is necessary to place at frequent intervals an automatic device. When used in underground work in city streets, to avoid manholes, the device should be one that does not require packing or attention after installation. To attain such a device required several years of experimenting. Many engineers have, from time to time, submitted to the American District Steam Company their ideas and inventions, all of which have been given a trial.

A device called a "Variator," with several important and excellent improvements added in the past few years, is conceded to be the only perfect expansion device manufactured. In addition to its property of taking care of expansion, it also has a fixed position, from which stationary part services are taken. It is, therefore, both fixed and flexible as to its uses.

The "Variator" is made in two styles—the "Double" and the "Single." The "Double" variator has two copper diaphragms and is otherwise constructed with two movable ends, so that expansion and contraction are provided for two sections of pipe, fifty feet of pipe being allowed on either side.

The "Double" variator is installed only in sections of mains between two fixed points, one hundred feet or less apart and having no offset or deviation from a straight line between the anchor specials, which are located at fixed points.

The "Single" variator is used where slight angles or deviations from a straight line are desired, and has but one copper diaphragm and one movable end. The pipe attached to the movable end is straight from the point of beginning of expansion, or the anchor special, located fifty feet or less away; the angle which is required for the change of grade or alignment is made at the ball or fixed end of the single variator, or by means of a patented, adjustable annular wedge between flat flanges attached to the fixed end.

AN OFFSET IN PIPE, to provide for expansion, is faulty construction for many reasons—the liability of breaking fittings at bends, which is bound to occur in large-sized pipe that is too heavy to
spring between swinging and fixed points; the decreased flow of steam due to friction caused by abrupt angles, which, in effect, means a loss in capacity and efficiency; to increased length of pipes due to offsets, with consequent increased loss by radiation, and increased cost in construction, trenching, paving, etc. This construction does not allow services to be taken off at fixed points, except at infrequent intervals. Such construction is extremely crude in conception and bound to be unsatisfactory in results; it has no redeeming feature.

**SLIP JOINTS**, to provide for expansion in city streets, are objectionable in that they require repacking at frequent intervals, and to allow for this numerous manholes must be constructed. Slip joints, at their best, are liable to leak and become a nuisance generally.

The American District Steam Company, after many years of experimental work, has devised a type of expansion joint which, to a very marked degree, overcomes many of the objections of the ordinary types. Illustrations of same are shown above. These expansion joints are made with both single and double brass slips, as illustrated, and not only have the usual form of packing, but have water packing along the slips. They are also designed to permit dry steam being taken from the mains through being tapped as far as possible above the center line of the fitting in expansion joints of 12" or more in diameter, and in expansion joints of smaller diameter the tapping is done at the top and service connection brought out, as illustrated by the construction cut on page 27.

**Anchor Specials**

These special fittings establish the fixed points in the mains from which expansion takes place toward the variator, and are so constructed that, if required, a deviation from a straight line, or change in grade, can be made by using our patented adjustable annular wedges between flanges. These fittings are firmly anchored by long, iron bars bolted to the fittings and running along the casing to which they are securely fastened with lag screws. The larger sizes have a cast anchorage and saddle, in addi-
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Division to the bars, and by this device there is no possibility of the pipe creeping, even on a steep grade, or in any way changing its position. The anchor specials also have openings to allow service connections. All service pipes are connected to the street mains either at anchor specials or variators which, being anchored, do not change their location, thus allowing services to be taken from fixed or immovable points, entirely eliminating any possibility of breaking off a service or causing a leak at point of connection. All openings in variators and anchor specials are arranged so that services can be taken from top or bottom of main at a sweep angle which is provided in the device and a connection can be made on either side of same above center line of pipe, or from top of anchor special. The above arrangement is a great improvement over the method in vogue a few years ago, as no water of condensation has to be lifted when steam is taken from top of main, which was not the case in the old construction, and which necessitated a pressure of about one pound for every two feet of lift to the point of discharge in the building above the bottom of the street mains, and also allowed saturated steam to enter customer's building.

Street Corner Fittings

Street corner intersections specially constructed, flanged crosses are installed, which have lateral openings for continuing the mains in other directions. These crosses are provided with a means of anchorage, and are, when reducing size of mains, made with eccentric openings, and the branches are made with sweep angles, thus reducing friction losses.

To these crosses are bolted special packingless gate valves, where desired, which are made accessible for manipulation through a double-cover manhole curb, placed in concrete or brick work.

All our street valves are flanged and are what are known as "Packingless" valves, having two brass gates and also a seat on the stem, so when valve is closed no steam enters the body of the valve, and when open the seat on the stem prevents steam from escaping around the gland.
The packingless feature of our valve is in exclusive use by us, and is admitted to be a great improvement over the valves which have heretofore been placed upon the market.

FLANGED ANGLE JOINT

These angle joints are used to meet the angles in the line of pipe, due to changes of grade or alignment, and to save the time necessary to make special fittings for that purpose; they can be set to make any angle from the slightest to the full ninety degrees.

General Construction

It is essential that great care be used in laying and grading street mains. Our engineers are educated and experienced in so establishing grades that only direct and straight thrusts into variators or expansion joints are secured when main is completed and pipe expands. All slight deviations from a straight line are made at the anchor specials, single variators and single expansion joints. More abrupt angles are made either with angle joints placed next to anchor specials, or with our patented adjustable annular wedges placed between flanges. All unavoidable pockets in the line are freed from water of condensation by means of automatic traps, specially devised for this system, and which are thoroughly reliable. At intervals not more than one hundred feet apart anchor specials are placed and, midway between, a double variator and pipe connecting them covered with asbestos, firmly secured by means of copper wire and enclosed in tin-lined, round wood casing, inside bore being from two to two and one-half inches larger than the outside diameter of the iron pipe enclosed. The iron pipe is carried and centered by means of guides and rollers which are placed in the casing about seven feet apart. The space existing between the iron pipe and the inside diameter of the wood casing is made a dead air space by means of collars and packing at intervals of about fifty feet. The anchor specials and variators are enclosed in brick or concrete boxes having eight and six-inch walls, respectively, and made watertight. These boxes are filled with dry pine shavings and dry asbestos, which act as an insulating material. The devices are anchored in the brick or concrete work by means of heavy cast-iron saddles and, in many cases, also to the wood casing by iron bars. A thickness of three-ply tar paper is placed over the wood casing the entire distance, entering brick or concrete wall and extending down below the center line of each side.

Under-drainage for the line is provided by means of drain tile surrounded by broken stone, so that casing will not at times be surrounded by water due to filtration, springs, leaky water or sewer pipes. This careful and thorough work is fully rewarded by the increased durability, efficiency and perfect operation which it insures.

Service Mains

SERVICE mains, insulated in the same manner as street mains, are taken from the top of the fittings in the street mains, and are carefully graded upwards from the connection, to the building to be heated. Where it is desirable to drip the street mains from condensation the service connection is made from
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the bottom of the street main and is laid on a slight down grade to the building, where it is dripped through a separator into a separate trap discharging through an economizing coil, the heat being fully utilized. Service nipples are put in anchor specials and varicators and extend through the brick or concrete work, thus allowing for service connections to be made at fixed points about fifty feet apart without disturbing the main line construction.

Labor

In the installation of a steam heating or power plant by the American District Steam Company, in addition to an experienced engineer there are sent skilled foremen and helpers, who set all the devices and perform the general work of construction complete and ready for operation. It takes a large and diversified amount of experience for engineers as well as helpers to properly meet all conditions that are found in underground work, especially in the crowded conditions beneath the surface of streets of large cities.

Durability

Repeated examinations of the different installations at Lockport, N. Y., and other cities have been made, with the following results as to material condition:

Full-weight, wrought-iron line pipe used as steam supply main after being twenty-three years underground did not show any effects of wear or any pitting or corrosion on the inside, or where protected against water and electrolysis, and with wood casing it was also perfect on the outside. Where pipe was incased in boxing which had almost entirely given out, the iron pipe was badly rusted on the outside, and where box had been filled with bark it had given out in even shorter time; with brick conduit filled with mineral wool, the pipe was found bare from protection. Where moisture had come in contact with the mineral wool, the moisture completely destroyed it, leaving but a residue at the bottom of the conduit or box.

Cork coverings were found disintegrated. Other sectional coverings were found to be in good or bad condition, according to whether or not they had been in contact with water. Sewer pipe used as a jacket around pipe and coverings was found to be in a very unsatisfactory condition. In a distance of three hundred feet nearly every piece was badly cracked or broken, and thus worthless; its properties as a non-conductor ranking extremely low, even under most favorable conditions.

The round, wood casing with four-inch shell was found in splendid condition, the fibre of the wood being as strong as when installed. Where there was no tin lining, the casing was somewhat checked and discolored. In 1888 the first tin-lined casing was installed, and has been successful both in decreasing radiation losses and in preventing damage to the wood casing; after twelve years' use, the wood casing was in absolutely perfect condition and the tin was found bright.

Inside Piping

Where service from a central plant is to be supplied to buildings already equipped with steam radiation but a few minor and inexpensive changes are required, and those only of a character made necessary by a different source of supply.

In buildings not piped for steam or hot water, the first cost of the equipment necessary is materially less than the cost of installation when similar service is to be given by an isolated plant, due to the fact that a
boiler is not required and also because less radiation is needed. The continuous service rendered from a central plant increases the efficiency of radiation to such an extent that from twenty-five to forty per cent less is required than under the varying conditions almost invariably present in all but the largest isolated plants.

Where hot-water radiation is installed, steam service may be supplied without any changes being necessary other than those before referred to.

In the event that the customer desires to continue heating by water, it may readily be done by supplying steam from the street mains to a special form of water heater illustrated below, manufactured by the American District Steam Company, through which the circulating water flows, and the steam thus condensed can be utilized and measured by meter, as in a building heated by steam. In other words, the steam is the fuel used to heat the water.

In giving up its heat to the surrounding water through the tubes in the heater the steam is condensed and this condensation discharged from the trap has a temperature very near the boiling point.

The quantity of steam required to heat in this manner is no greater than the quantity required to heat directly by steam. The condensation from the radiation in the heater, after passing through the trap, is allowed to flow through a continuous cast-iron economizing coil placed in each building. This coil is placed in a tin-lined box having an inlet for fresh air and an outlet through a register placed in the floor above for heated air, so that in passing through the economizing coil the condensation transmits its heat to the air, which circulates through and around the coil. In this manner the condensation contributes its share of the heat required and at the same time offers a ready means for securing an ample supply of warm, pure air, assisting materially in providing sufficient ventilation.

Used in connection with direct steam radiation in the building, this coil does not increase the cost of piping, because a less amount of direct radiation is needed. Although it is not so effective per square foot as steam radiation, and therefore requires additional heating surface, yet the extra amount of heating surface is compensated for by the lessened cost.
per square foot of economizing coil over direct radiation, lessened cost of decorating, valving, etc., and at the same time a great benefit is given the customer in having an indirect radiator in his building for purposes of ventilation, and convenience of being able to stand over the incoming supply of heat. The water leaves this coil a few degrees only above the temperature of the air and may be used for laundry and domestic purposes.

By the use of these economizing coils, the full value of the heat in the water of condensation is obtained and about twenty per cent. less steam is required to perfectly heat the building so piped. The value of the heat in the water from each one thousand pounds of steam delivered is one-fifth of the price charged for steam; thus, by the use of economizing coils, the heat in each one thousand pounds of condensation is sold at from ten to twenty cents, varying as to the cost of fuel in different localities.

After passing through the coil, the water is conducted to the Condensation meter, weighed and registered by it and then allowed to be utilized by the consumer, returned to the station, or passed to the sewer.
NEW method of piping up buildings, which is coming into prominence at the present time and which is proving very economical to the consumer, is known as our Atmospheric System. With this system water radiation is used, the steam being fed at the top through patented ported valves, by means of which only such portion of any or each radiator is heated as is required to maintain a uniform
District Steam Heating

temperature in the room heated. All heat units are extracted from the steam and hot water before discharging to the returns, thus enabling the consumer to utilize the heat in the most advantageous manner and at a point where it will be of the most value; the water of condensation passing from the radiators practically cold.

This system is operated under a pressure of from five to eight ounces, and when subjected to a higher pressure it is to the detriment of the system and against the economical use of steam by the customer; thus the system requires an extremely sensitive and accurate regulating steam valve at the point where the service enters the building.

Methods of Charging for Heat Service

A NUMBER of different methods of charging for heating service have been proposed and are in use, the three most commonly used being: First, a fixed annual charge for each square foot of radiation installed, a different charge being made for direct, indirect and economizing coil radiation; second, a fixed annual charge per 1,000 cubic feet of space heated, depending on character and exposure of building and amount of space heated; third, by meter.

Under the first method the tendency of the consumer is to install less radiation than is actually necessary for properly heating his building in the coldest weather, thus giving an opportunity for unjustified complaint of insufficient service. A further objection and perhaps a more important one to this method of charging is that the rate of condensation per square foot of radiation per hour varies through exceedingly wide limits, depending upon many conditions. The passage of heat through the walls of the radiator to the surrounding air is governed by the temperature of the steam inside the radiator, the temperature of the surrounding air, thickness of the wall, and kind of material of which the radiator is made. Assuming that the composition of the material and thickness of the wall of the radiator be of tolerably constant character, it follows that the constant temperature of the steam contained in the radiator, the quantity of steam condensed per square foot of radiation, per hour, would vary with the temperature of the surrounding air. It is practically impossible, therefore, to determine what a fair price would be per square foot of radiation per heating season, because it cannot be ascertained in advance what the minimum, maximum and average rate of condensation extending over the entire season would be, further influenced as it is by changing outside temperatures, wind velocities and humidity from time to time.

A determination of the proper rate to be charged is made still more difficult by the tendency of the consumer to open windows and otherwise waste the steam, which tendency is common where a fixed rate is charged, and there is no incentive to economize.

When charge is made upon the second basis, viz., that of a fixed charge per season of each 1,000 cubic feet of space heated, the same general objections hold as have been set forth in the preceding paragraph. This, however, is, we believe, a better method than the one previously outlined, in so far that it does away with any incentive which there might be to overrate the capacity of radiation. This method of charge also lends itself more readily to differential rate between large buildings which are not exposed on all sides and smaller buildings, such as residences which are wholly exposed, and also between buildings of different construction.

The third method of charging is the only fair and equitable basis for the consumer and the company supplying the heat. It offers an opportunity to the con-
sumer to utilize heat to just the required degree at a minimum of expense, and invariably results in a lower average rate of condensation per square foot of radia-

This method of charging also automatically adjusts itself to the different classes of buildings with varying conditions of exposure and construction, as well as to the many conditions of occupancy. Two residences similar in every way will often be found to require heat in widely varying amounts, due to the personal habits and characteristics of the occupants. The varying demand which exists from day to day is clearly shown by the curve sheet herewith, which has been plotted from a plant furnishing steam exclusively by meter. Note the effects of wind and humidity, as well as outside temperatures.

The price which should be charged for steam heat on the meter basis varies with the locality, cost of domestic and steam coal and other conditions, and lends itself very readily to the fixing of a reasonable, exact margin of profit between the cost of production and the selling price. The cost of evaporating 1,000 pounds of water at the station can readily be obtained, including the cost of coal, labor, fixed charges, etc., and this serves as a correct basis by which the selling price can be determined.
THE question of devising some reliable method of determining the amount of steam used by individual patrons has been a subject that the American District Steam Company has had experienced men at work on for years. Several kinds of meters built on the velocity principle have been used with a fair degree of success, depending, in a large part, upon the care and attention given to them. These have practically been superseded by a condensation meter, an improved device manufactured by the American District Steam Company. This meter measures the water of condensation, which passes from each building, or any portion of a building, which may be heated. If 1,000 pounds of water is evaporated into steam the volume will be increased about 1,700 times, but the weight will remain the same, and when this steam is condensed in the radiation of the consumer the water of condensation will weigh 1,000 pounds; consequently, if this water is weighed, as it passes from the building, an accurate record will be had of the steam furnished to the premises. Knowing the evaporative duty of fuel and the price of same, together with the cost of firing and other expenses incidental to the station, a basis is obtained for the proper charge to the consumers.

Frequent tests have been made of the meter under actual working conditions, and at the end of the season's run the meters have been found to be in perfect adjustment and working within one per cent. of accuracy.

**Résumé**

As a result of the experience obtained by the American District Steam Company in the operation of its own plant and in the observance of the operation of other plants, the following essential features have been adopted in the present construction of its underground heating system.

- To have the plant and system planned and installed by its own engineers and skilled workmen, who have become qualified for the work through years of experience with the company.
- The accurate grading of the underground mains.
- The use of only strictly wrought-iron pipe, full weight and ample capacity.
- The use of a perfected packingless device for taking care of expansion and contraction.
- The use of sweep angle fittings to reduce friction to a minimum, eccentric street corner specials, crosses and positive methods of anchorage.
- The use of thoroughly seasoned, round, tin-lined wood stave casing of not less than four-inch shell.
- The perfect under-drainage of mains.
- The taking of services from only fixed points in the street mains, and from top of mains, except where it is necessary to drip same.
- The utilization of the water of condensation by continuous cast-iron economizing coils.
- The use of a meter as a basis of charging for steam.
In the early history of the Holly Steam Combination Co., Ltd., the custom of many companies and inventors was followed, and the company granted the use of its ideas and patent rights to its devices and system, resulting in engineers skilled in other work undertaking to install the Holly System without any special experience in that particular branch of engineering. In most of the plants constructed by outside engineers some serious errors were made which resulted in the plants being, to a large extent, mechanical failures, making it practically impossible to give satisfaction to both the consumer and the stockholder. To avoid a repetition of these errors, and to give the local company the benefit of its experience, the American District Steam Company to-day will not sell any of its devices or rights, for its plant to be installed by anyone uneducated or inexperienced in its special system.

The American District Steam Company, during the past few years, has followed the example of the largest electrical manufacturing and constructing companies in not burdening the new enterprise with a large outlay for royalties, and therefore does not now make any charge for the use of the many patents on its system and devices.

Ever since the idea of transmission of steam heat and power through underground mains was proposed, there have been attempts to construct by parties who thought they could do just as well as a company whose every energy was thrown into district steam transmission, but such attempts have proven failures, or very unsatisfactory. The principal argument of these people for such installations has been along the line of cheap construction by the substitution of cheaper pipe, cheaper devices, cheaper insulation, cheaper workmen, etc. They argue that they can produce something "just as good" as the installations of the American District Steam Company. A single weak point or fault in the construction may be fatal to the successful working of the plant, and though a smaller amount of money has been invested, the loss may be complete.

**Methods Abandoned**

Among the apparently feasible methods and ideas abandoned which the American District Steam Company have given thorough trial and observed in the operation of other plants, and for too many reasons to detail here, but upon which they will be pleased to give full and complete data, are, principally:

- The installation of a return line, except in special cases.
- The use of sweeps or swings for taking care of expansion.
- The various kinds of pipe insulation, other than our "Standard Insulation."
- District heating by forcing hot water by the aid of pumps.
- The attempts to lift water of condensation from the street mains through service connections.

There is nothing to prevent the construction of district hot-water plants by this company, but our investigation into this branch of district heating, furnishes no reason for a belief in the present or ultimate prospects, either mechanical or financial, of a district hot-water plant.

If desired, we shall be pleased to submit in detail our reasons for the above conclusions.

**Points of Superiority**

The following are a few of the points of unquestioned superiority of the Improved Low-pressure Steam Heating over other methods, including vacuum steam and hot-water district plants:

1. Simplicity characterizes the steam system, there being but a single line of pipe with no forcing or suction process.
2. Perfect and staple insulation.
3. Perfect means for taking care of expansion and contraction.
4. Adapted for use in connection with house apparatus, whether same has been installed for hot water, vacuum steam, or one or two-pipe, low-pressure steam, and will circulate in the highest buildings.
5. There is no cause to produce circulation, on account of there being no pumps or other devices in use.
6. Allows delivery and utilization of entire number of heat units conveyed, not requiring the return of part to the station for re-heating.
7. Cost of maintenance of plant and mains less.
8. Capacity of same size mains greater.
9. Loss of heat in transmission infinitely less, through almost complete elimination of radiation and condensation losses in the street mains.
10. Any building or part of a system can be cut out without affecting the operation of the balance of the plant.
11. Less liability to leaks, on account of low-pressure steam.
12. Valves in buildings can be packed and radiators changed, without shutting off the whole building.
13. Ability to increase efficiency of radiation in building by a slight increase of pressure during excessively or unusually cold weather.
14. Can more quickly follow change of weather.
15. More easily controlled by thermostats.
16. When heat is needed allows a supply of heat more quickly throughout the entire system.
17. Having passed through more than a quarter of a century of experience and experimenting, it is now a practical and perfected system.
18. Allows the use of the meter system of charging. Thousands of meters of close accuracy are in actual use, giving an opportunity of learning the actual amount of heat used in the building when same is being heated under a contract system, thus allowing the

Specialties Manufactured

The American District Steam Company, in addition to manufacturing all its devices, insulation, etc., used in the construction of its street mains, also makes oil and water separators, reducing valves, heaters for laundries, bathrooms, barber shops, house heating, etc., steam traps, meters, valves, radiators and steam fitters' supplies. (See illustrated price list.)

Conclusion

We do not publish a list of the 250 companies for whom we have built plants in nearly as many cities of the United States, on account of the large correspondence it would place upon the companies and the annoyance it would cause them. To parties desiring such reference we would be pleased to give as large a list of names as they would care to have.

We invite correspondence, and if parties will furnish us with maps or diagrams of streets where they propose to operate, and other data in connection with their proposed enterprise, we will promptly give such information as they desire; or, if advisable, will send a representative to their city, who will prepare a prospectus which will enter into all the phases of the proposition, and furnish all necessary information to the prospective customer.
Above plan comprises a total of 14,158 linear feet of street mains and 3,475 feet of service mains. They are heating approximately 12,500,000 cubic feet of space. The plant has been in operation four years and large extensions have been added each year since the original mains were installed.

Above plant has 11,750 linear feet of street and service mains.
A-345—Approximately 7950 linear feet of street and service mains in above plant, heating 5,800,900 cubic feet of space, installed 1902.
A-390—The above plant comprises about 27,500 lineal feet of street and service mains, heating nearly 16,000,000 cubic feet of space in 350 buildings, mostly residences, containing 71,600 square feet of direct, 27,500 feet of indirect radiation and 21,000 feet of economizing coils. It is a live steam plant and charges for heat on the meter basis only.

A-319 14,000 lineal feet of street mains ranging in sizes from 8-inch to 14-inch and heating business blocks entirely, has been operated two years and at present extensive additions are being made.
A-356—This underground steam heating system includes about 11,500 lineal feet of street mains from 5 to 14 inches in diameter, and 5500 feet of service mains from 2 to 4 inches in diameter. Plant has been in operation ten years and at present is heating over 17,000,000 cubic feet of space.

A-211—7500 lineal feet of street and service mains and is operated successfully with 3½ lbs. pressure maintained at the station.