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THE WATER WORKS OF CAMBRIDGE, MASS.

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HISTORY.

In order to clearly understand a description of the Cambridge Water Works, a brief glance at its history will be necessary.

The first public water supply was introduced into the city by the "Cambridgeport Aqueduct Company," chartered in 1837, taking water from springs on Prospect Hill, Somerville, and conducting, by means of wooden pipes, the water to the consumers in Cambridge. In 1856 another company was incorporated, called the "Cambridge Water Company," authorized to take water from Fresh Pond, and the surplus water or overflow from Spy and Little ponds, these ponds being situated near the westerly boundary of Cambridge. In 1861 the Cambridge Water Company bought out the original Aqueduct Company, and in turn the entire works were sold, in 1865, to the city of Cambridge for the sum of $291,400. At this time (1865) the population was 29,112. I may add here, that the total amount paid on account of Water Works Construction to December, 1895, has been $4,022,681.92.

Various grants for increasing the supply have been given by the Legislature of this State from time to time, the most important of which was the right granted, in 1884, to take the water of Stony Brook, a tributary of the Charles River, lying in the city of Waltham, and the towns of Weston, Lincoln, and Lexington. The water from this brook is now the chief reliance of the city, and it is in the development of this supply that the extension of the present system consists, the yield from Fresh Pond now forming a very inconsiderable portion of the Cambridge supply. Cambridge has at present a population of about eighty-four thousand, and had an average daily consumption, in 1895, of 6,000,000 gallons or 71.65 gallons per day per capita.

THE PRESENT SUPPLY AND WORKS.

Water is gathered at the Stony Brook Basin, near its junction with Charles River, — this basin holding about three hundred and fifty million gallons. This dam and basin were constructed in 1887. From here the water is conveyed by a cast-iron pipe conduit, 30 inches in diameter and nearly eight miles long, to Fresh Pond, which stores about four hundred million gallons.

A very curious fact about Fresh Pond is its extremely low elevation. When full, it is but about one foot above the level of mean high tide in Boston Harbor, and it has been pumped so low as to be about on the same elevation as mean low water, or ten feet below high tide level. The mingled waters of Fresh Pond and Stony Brook are now pumped from this low elevation to the present reservoir and standpipe in the city, and so delivered to the consumers through 125.19 miles of water pipes, and 12,681 service connections. A small part of the water is pumped by high service pumps, so as to give a pressure of about sixty pounds per square inch, but the larger portion is pumped to the reservoir, giving about thirty-five pounds per square inch pressure.

The present estimated capacity or available yield of the supply is 7,250,000 gallons daily; 1,250,000 gallons from Fresh Pond, and 6,000,000 gallons from Stony Brook. It will thus be seen that the consumption is close on to the present capacity of the works.

EXTENSION OF THE WATER WORKS.

The large and expensive extensions to the works, now being constructed, are for the purpose of accomplishing three objects: first, increasing the supply; second, increasing the pressure; third, increasing the pumping capacity.

HOBBS BROOK STORAGE BASIN.

The only way the supply could be increased was by enlarged storage. The area of the watershed of Stony Brook is 22 square miles. This should yield, with adequate storage capacity, about eighteen million gallons daily, instead of the six million gallons now obtainable. To increase the storage capacity on this watershed, about one thousand acres of land have been taken by the Water Board on Hobbs Brook, a branch of Stony Brook, and the work of construction is now well advanced. Two dams are being built: one at a narrow place in the valley, where it is crossed by Lincoln Street, and another, the main dam, at the lower end of the valley near Winter Street, in Waltham. Both dams are built mainly of earth and have concrete core walls; both carry a highway on the top.

The main dam at Winter Street is 35 feet wide on top, with slope of 1½ to 1 foot on the water side, and 2 to 1 on the loam side. The core wall, 7 feet thick, is carried to the bed rock, 16 to 18 feet below the surface; the length of the dam is about one thousand feet.

This dam is pierced by a large overflow conduit or waste way, about 7 feet in diameter, located at the bed of the brook. Flash boards in a chamber built at the end of this conduit regulate the height of the water, and, with a relief waste way or overflow in the crest of the dam at one end, provide an outlet for freshet water. The water in the basin controlled by the dam will be 165 feet above the level of the water in Fresh Pond.

It may be of interest to quote a few prices at which the work of construction at this dam is being done in quite a satisfactory manner. American concrete, of the usual proportions, is being placed, at $3.10 per cubic yard; Portland concrete, $4.75 per cubic yard; plastering of Portland cement, one half inch thick, 27 cents per square yard; excavation and construction of dam, 38 cents per cubic yard; field stone slope paving is being laid at $1.10 per square yard; brick masonry in Portland cement mortar, $10.29 per cubic yard; broken stone furnished and placed, 89 cents per cubic yard.

The dam at Lincoln Street is much the same in design as the one at Winter Street. It has a length of about six hundred feet and a width on top of 27 feet. A few of the prices paid here are as follows: American concrete, $4.00 per cubic yard; plastering, 10 cents per square yard; earth embankment construction, 27 cents per cubic yard; field stone slope paving, $1.00 per cubic yard.

WINTER STREET DAM.

The basin, when filled, will be about six hundred and fifty acres in extent and about two and one half miles in length. It will store about 2,000,000,000 gallons and give about 1,500,000,000 gallons available for use. The entire bed of the basin is to be stripped of soil and muck, necessitating the removal of about 1,900,000, cubic yards of material. Prices for the work have ruled very low, ranging from 16 to 25 cents per cubic yard — the major part being done for about twenty cents per cubic yard. The work is being done almost entirely by the old-fashioned, yet effective, machine — a one horse dump cart.

From the storage basin formed by these dams, the water is to be let down the natural bed of the brook to the lower basin at Stony Brook, and thence by the iron pipe conduit to Fresh Pond. It is proposed to eventually construct another pipe of larger dimensions, parallel with this conduit from the Stony Brook Reservoir to Fresh Pond.

PAYSON PARK RESERVOIR.

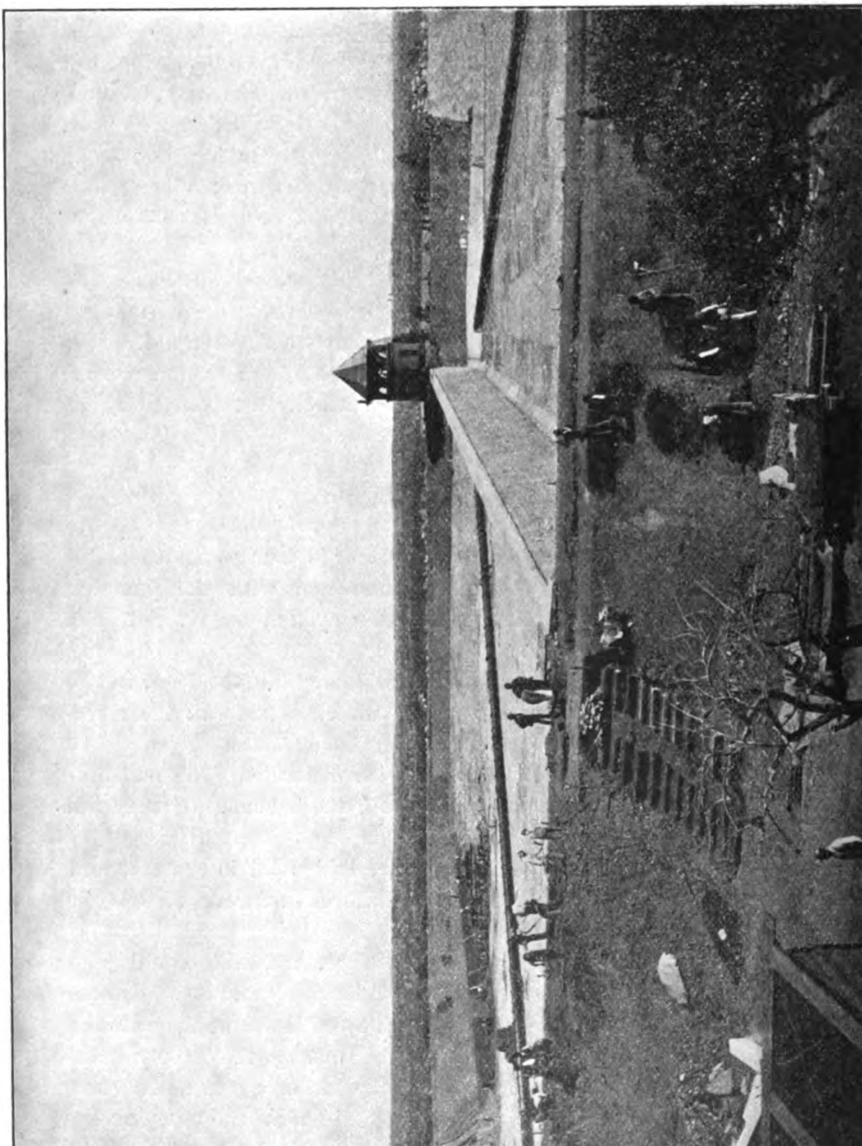
To increase the pressure, a large reservoir is being constructed at Payson Park — this reservoir being connected with the pumping station and the centre of the distributing system by riveted steel pipes, 40 inches in diameter.

This reservoir is 750 feet by 500 feet wide and 20 feet deep, in two compartments, separated by a masonry wall. When full the reservoir will contain 44,000,000 gallons.

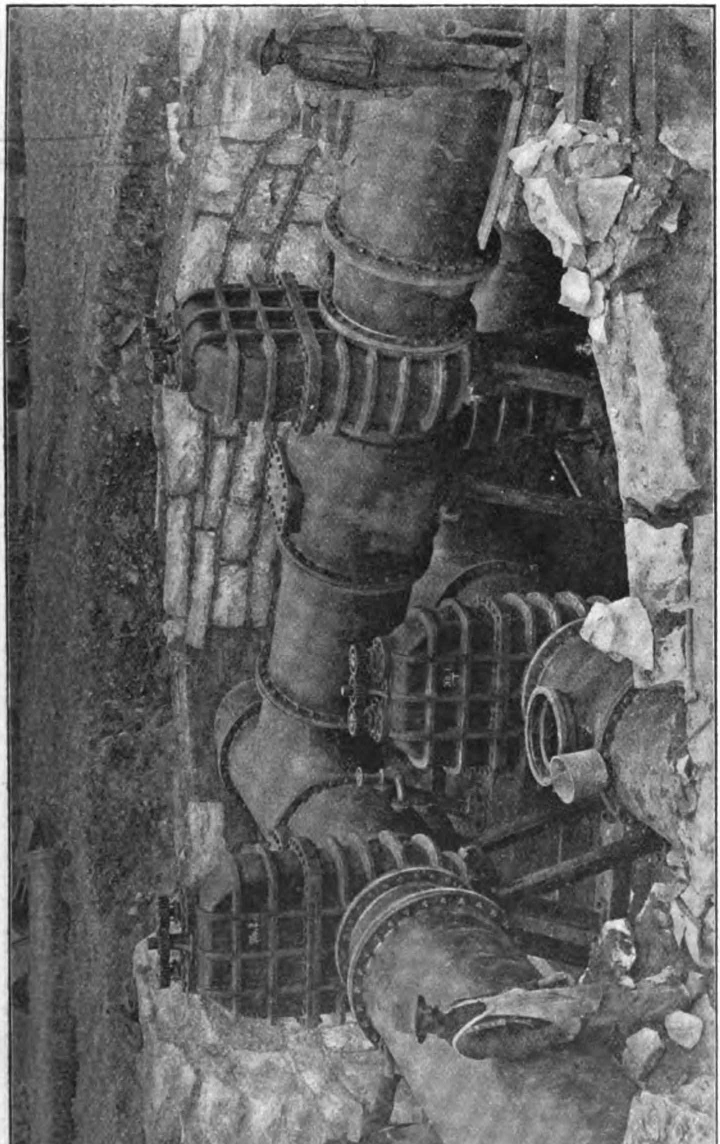
The entire reservoir will be lined with concrete. The embankments made from materials excavated from the basin are of the form shown in the plate.

The core wall is formed of field stone, laid solid in cement, and resting on the sheet of concrete at the natural surface. This is all plastered with Portland cement plaster.

The gate chamber will be circular in shape, and will contain the gates and valves controlling the force and supply mains and waste pipes. The water will be delivered by the force mains at the extreme corners of the basins and will be taken out by the supply main through a perforated drum or strainer at the end of a movable section of pipe, which is jointed at one end to a fixed end of the pipe coming from the chamber, the other end of the movable section, to which the strainer is attached, being raised or lowered by means of a float

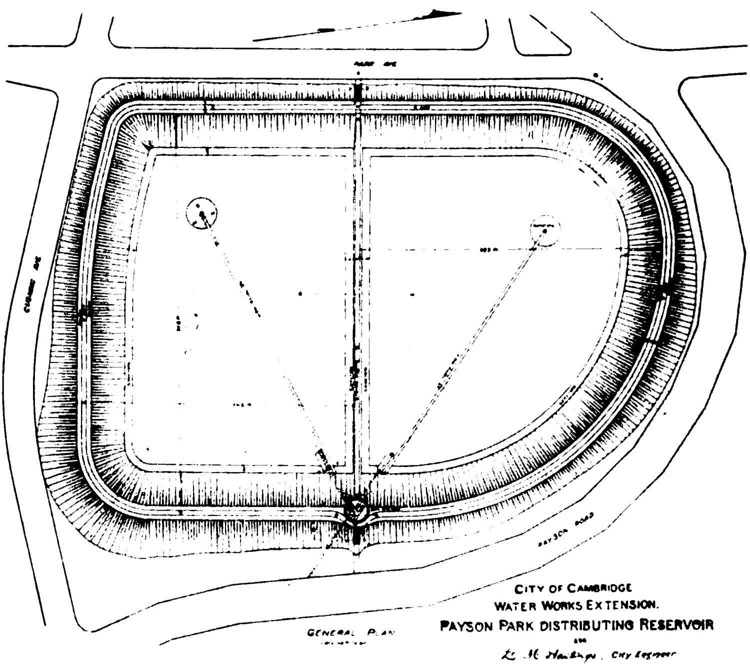


PAYSON PARK RESERVOIR.



GATE CHAMBER AND FITTINGS—PAYSON PARK RESERVOIR.

and tackle. The chamber will be surmounted by a gate house, also circular, of brick and stone, from the second or observation story of which, magnificent views of the country can be obtained. The elevation of the water in the reservoir will be 162 feet above the



water in Fresh Pond, or about the same elevation as the water in the new storage basin in Waltham. The whole city will be supplied from this reservoir when it is completed, giving a uniform pressure and only one service.

40″ RIVETED STEEL PIPE.

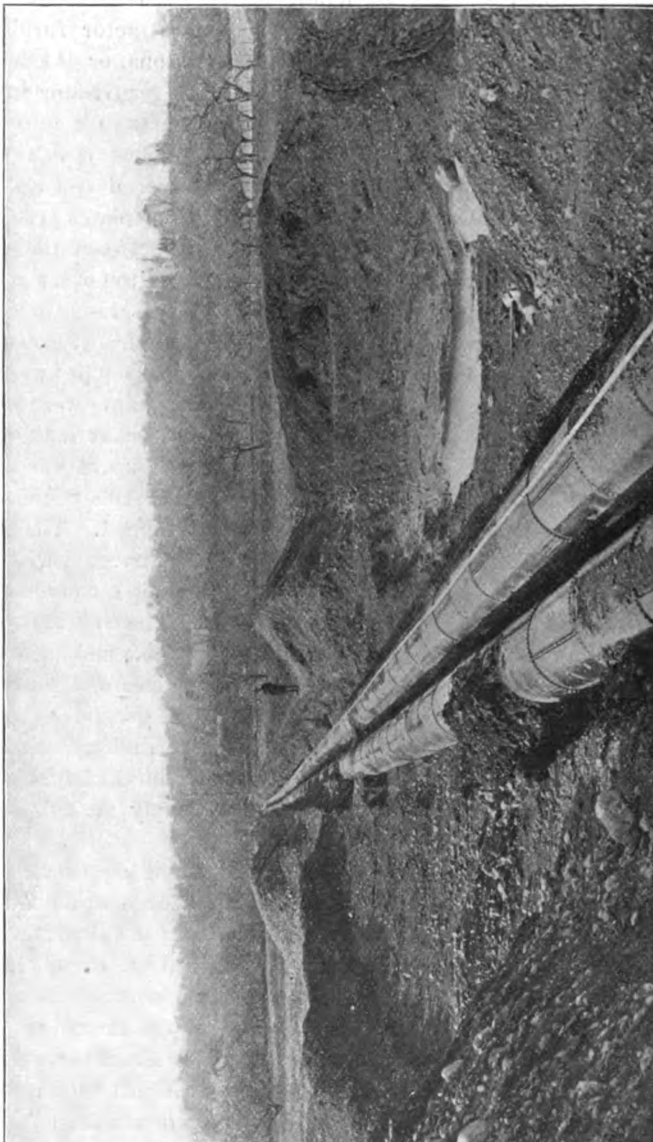
The riveted steel pipe forming the force and supply mains is made of steel plates $\frac{5}{16}$ of an inch in thickness, and about seven feet long, rolled to circular shape and riveted and caulked like an immensely long boiler. Plates were put together in the inside and outside courses, four plates making one section, about twenty-eight feet long. Each section was then dipped in a protective coating made of linseed oil and asphaltum, and baked in an oven till hard. The

sections were then delivered on the line, and placed in the trench and the sections riveted together by hand. The trenching and refilling for the pipe was done by the city, and the contractor furnished, placed, and riveted the pipe. Twenty-three sections, or 644 feet of pipe, was the largest amount of pipe placed ready for riveting in any one day. Curves were made by shearing the plates to a mitre and then riveting up. One hundred feet was the smallest radius used. At two points on the line the pipe was carried over deep cuts. At one, for a railroad, and once over a roadway. The plates here were ⅜ inch thick, and the pipe made self supporting between the abutments. In one case a clear span of 75 feet, and in the other a span of 94 feet was used. In the long span the pipe was re-enforced by riveting on to the top and bottom two heavy 6″ angle irons, extending about two thirds of the length of the span. As these pipes were exposed to large variations of temperature, expansion joints were placed at one end of each exposed pipe, to allow a free movement of the pipe. After the pipe was placed in the trench and riveted up, it was tested in sections of convenient length, to a pressure of 100 pounds per square inch by water pressure, and all leaks stopped. The joints made in the field and all defects in coating were covered with two coats of asphalt paint. The contract price for the pipe, complete and tested in the trench, was $4.57 per lineal foot. The cost of trenching and refilling for the pipe was about $1.75 per foot, making a total cost of about $6.32 per foot. The top of the pipes was placed at an average depth of 4 feet below the surface of the ground.

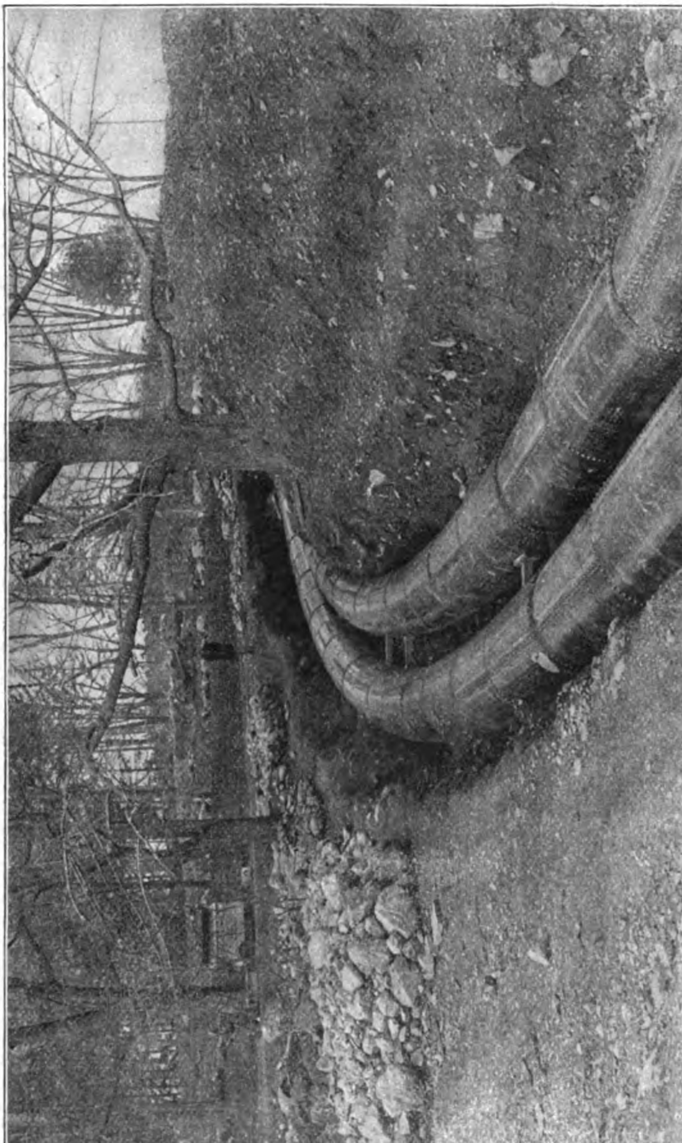
The total length of 40″ pipe laid or to be laid, including fittings and cast-iron pipe, is 24,500 feet. Eighty-four hundred feet of the line was laid with two pipes (the force and supply mains) in one trench, and about eighteen inches apart.

While the pipe was being laid, a curious accident happened, which illustrates the flexibility of even a pipe with as large a diameter as 40″. A stretch of pipe had been riveted up and awaited testing; the trench being in low ground, and not refilled, Oct. 13 and 14, a very heavy rain came and filled the low portion of the trench, and about four hundred and twenty-five feet of the pipe floated up, having less specific gravity empty than water, rising about three feet in places. The trench was dried out and the pipe forced back in place by loading on top, with but little damage to pipe or riveting.

The valves used in the line are 36 inches in diameter, and are made very strong and heavy, by the Coffin Valve Co. It was not thought



40" STEEL PIPE—PAYSON PARK RESERVOIR.



CURVE IN 40" STEEL PIPE — PAYSON PARK RESERVOIR.

that the reduction from 40″ to 36″ in diameter would impair the efficiency of the pipe.

The question of movements of the pipe due to temperature was carefully considered, and a simple form of stuffing-box expansion joint was introduced at the ends of the exposed portion of the pipes, as referred to above, where dangerous strains were liable to occur, and at the connections with the valves.

These joints were made in two sections of cast-iron, one section, having a spigot end, had on the inside a brass bushing attached. The other section had a long, deep hub, into which the first or spigot section fitted. The joint between the two sections was made up of lead and caulked; fifteen of these joints were used on this line. Air valves were placed at the summits and blow-offs at the low points.

NEW PUMP.

The pumping capacity is to be increased by the addition of a new high duty pump, of a capacity of 20,000,000 gallons per day, designed by E. D. Leavitt and now being built by the Groshon High Duty Pumping Engine Company of New York.

This engine will be 53 feet 3 inches in height, with fly wheel 25 feet in diameter, pumping 229 gallons of water for each stroke. There will be about five hundred tons of metal used in its construction. The engine is to possess the high qualities for which Mr. Leavitt's work is noted, with all the modern improvements.

The work above described is expected to cost from $1,250,000 to $1,500,000, and the supply is estimated to be sufficient to last the city of Cambridge for about twenty-five years, or until about 1920.

DISCUSSION.

Mr. Stearns. I would like to ask Mr. Hastings if any part of the system is in use now, either the reservoirs or pipes?

Mr. Hastings. Yes; part of the 40-inch pipe has been in use since last winter, but the reservoir is not completed, nor the storage basin.

Mr. Fuller. I would like to ask Mr. Hastings if all this water is to be pumped. I understood that the distributing reservoir at Payson Park is about the same level as the reservoir at Waltham; can any of the water be carried into the distributing reservoir without being pumped?

Mr. Hastings. No, sir. That matter was carefully considered, and it was found to be impracticable to lead it down from the storage basin, which is almost at the same elevation as the Payson Park reservoir. All the water will run down hill and then be pumped up to the reservoir back at practically the height it starts from.

The President. Are there any intervening hills which prevented you from adopting another plan?

Mr. Hastings. It was quite a complicated question, and it was also a question whether we should use the Stony Brook basin as a distributing reservoir or build another one. I could not begin to explain all the points, but it was decided after careful consideration that on the whole the best plan would be to use that simply as a storage basin and the other as a distributing reservoir. It seems absurd and unmechanical to let water run down hill and then pump it up again, but that is exactly what we are going to do.

Mr. Stearns. It is true, is it not, Mr. Hastings, that only a comparatively small part of the water will come from this new reservoir, so even if you provided for bringing that in it wouldn't aid you with regard to the rest?

Mr. Hastings. The question was, why should we build the Payson Park reservoir when we were to have another much larger one at the same height.

Mr. Stearns. I thought the idea was to get it without pumping at all.

Mr. Hastings. We couldn't do that. That was one of the questions involved. Part of the year we might draw it direct by gravity from this upper reservoir; the rest of the year we would have to pump against that head.

The President. Will you describe the waste way to that upper reservoir a little more fully? What is the capacity there represented in inches of rainfall, do you remember?

Mr. Hastings. I think 6 inches in 24 hours is estimated.

Mr. President. That is carried through those ports?

Mr. Hastings. Yes; there are five ports in the chamber, and what I call the relief waste way to serve in case of choking or any possible obstruction is 15 feet wide besides that.

The President. Is that in another part?

Mr. Hastings. Yes; in another part entirely independent of this chamber.

The President. That is a waste way?

Mr. Hastings. Yes, sir; for that purpose and nothing else.

The President. Can you tell us a little more fully about the coating of that pipe? Does it peal off, or is it hard?

Mr. Hastings. It seems to be quite hard. There was one place left open through the winter, and this spring, where it was bedded in clay, a few patches of it did come off. The frost seemed to have some effect on it, and some patches came off like a film.

The President. It didn't scale off in great flakes?

Mr. Hastings. No, sir; it was very firm and adhesive, that is in handling and getting it in place.

The President. What do you lay that to, a superior method employed?

Mr. Hastings. It is a kind of japan. It is dipped while the metal is hot, and the pores are supposed to be open, it is dipped in hot asphalt, which is then baked on like a japan. It really is a japan.

The President. Wasn't that same process used in treating some of the other steel lines?

Mr. Hastings. Yes, sir; Rochester and Allegheny.

The President. Didn't it come off of the Rochester pipe in great flakes?

Mr. Hastings. They used two processes. Half of their pipe line was dipped in common asphalt melted in a tank, and the pipe dipped in cold, what is called a maltha bath The other part was dipped in the combination I spoke of, a combination of asphalt and linseed oil, which is baked or fired right on to the metal.

The President. That seems to you to be satisfactory?

Mr. Hastings. It has worked very well so far; of course only time will prove its durability.

The President. How were the seams brought together, and what calculations were made as to the carrying capacity of the pipe?

Mr. Hastings. We didn't have to do a close figuring. The Water Board wanted it big enough, so I figured on an ample basis, and no fine estimates were made of the obstruction that these rings or rivet heads would cause. As long as I got it big enough, and a little more it was satisfactory.

The President. Were the embankments rolled in thin layers?

Mr. Hastings. Yes, sir; 4-inch layers and 6-inch on the outside.

Mr. Smith. You spoke of some portions where you had laid two lines of pipe. Was the pipe of different diameter, or why were the pipes laid in that way?

Mr. HASTINGS. The idea was that in running from the Fresh Pond station to the reservoir and then back into the city the two lines came together part of the way and then they diverged, one going to the pumping station and one to the city.

Mr. SMITH. It was all the same size pipe?

Mr. HASTINGS. Yes, exactly the same.

Mr. SMITH. But the water flowing in different directions?

Mr. HASTINGS. Yes, sir.

Mr. STEARNS. Is there a connection between those pipes so one can be used independently of the other?

Mr. HASTINGS. Yes; there are three gates and cross-over connections so that one can be used and switched off and the other one used alternately.

Mr. STEARNS. So by having the two pipes you have a reserve, and ordinarily you intend to pump to the reservoir through one and draw through the other, or will you have them both open?

Mr. HASTINGS. They would both be open and we can pump through one and draw through the other, or they can be switched off so we can use either one as a force main or as a supply main.

Mr. STEARNS. I don't know as I quite understand. Is it the intention to open both pipes so the water will go freely, or is all the water to be forced up to the reservoir through one pipe and to come back through the other pipe?

Mr. HASTINGS. Well, ordinarily we would pump right into the reservoir and draw it right back again.

Mr. STEARNS. Is that with the view of improving the quality of the water?

Mr. HASTINGS. Yes; the idea is to keep a constant circulation of water in the reservoir. If we didn't do that we should have stagnant water in the reservoir. We could pump into the circulation and simply have that pressure to pump against, but that would make stagnant water there, so it was thought best to pump into the reservoir and then draw it out.

Mr. STEARNS. So it is for the purpose of maintaining the good quality of the water?

Mr. HASTINGS. Yes, sir. that is the idea.

Mr. FULLER. Couldn't you have an arrangement of check-valves so you could discharge the water at the further end and take it from the nearer corner of the reservoir?

Mr. HASTINGS. Not if we only use one pipe for the force and supply main. If we pumped 6,000,000 gallons a day we would have the reservoir full and the water would simply go right around, and not into the reservoir at all, and the water in the reservoir would stay there as a pressure. That was one reason why we had two lines. The water will have now to go to the reservoir and come out, while if we had only one line and used that as a force and supply main, the water would stay in the reservoir and become stagnant.

Mr. FULLER. Couldn't you have a check-valve so the water would be discharged at that end and only come back at this end?

Mr. HASTINGS. But ordinarily you would be only pumping your consumption, which would mean you would pump into the city direct, and there would be no water going into the reservoir at all. It might lie there three months and never change. By having the two lines there has got to be a circulation.

Mr. FULLER. You mean the water which was pumped would be used, and the water in the reservoir would remain there?

Mr. HASTINGS. That is just it.

Mr. SMITH. Can you give us any explanation of how you were able to get such low prices on your work?

Mr. HASTINGS. No; I don't know as I can. We had quite a large number of bidders, and we seemed to strike a low period in the market. The contractors are doing very satisfactory work for the most part.