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THE WATER SYSTEM OF BURLINGTON, VT.

BY

F. H. CRANDALL, C. E., Superintendent.

[Read September, 1895.]

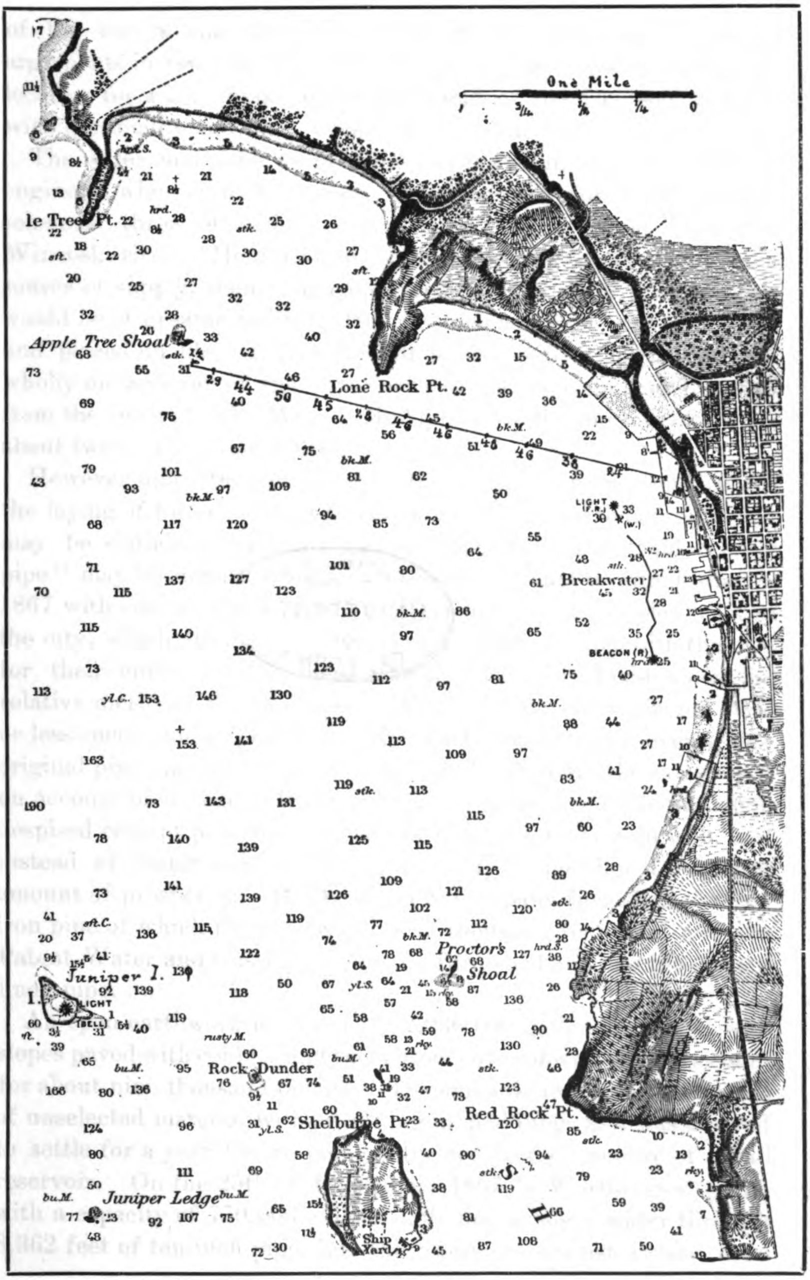
MR. PRESIDENT AND GENTLEMEN: As it has been suggested that a description of the Burlington works would be appropriate, and lest you should undertake to investigate for yourselves and come to an untimely end in the north railroad yard, I will, with your permission, occupy a few moments in their description.

An act to incorporate the City of Burlington passed the legislature in November, 1864, and was accepted at a town meeting held in January, 1865. On the first day of October of the following year the city came into possession, by purchase, of the plant of the Burlington Aqueduct Company, comprising an underground brick reservoir of about 75,000 gallons capacity, several thousand feet of small cast and wrought iron mains and about two hundred lead services. Lead has since given place to galvanized iron as a material for services.

The reservoir of the Aqueduct Company constructed on the same general plan as the covered reservoirs recently built in Newton and Brookline, was supplied at first from springs higher up the hill.

At the time of the purchase of the works by the city, the gravity supply, some five to fifteen thousand gallons per day was augmented by a pump taking water from Lake Champlain with a maximum capacity of 63,000 gallons daily. The Aqueduct Company made no attempt at fire protection.

The initial appropriation by the city for water works was $150,000. Before a decision was reached as to the most desirable point from which to obtain the city's water supply, a spirited if not acrimonious debate as to the relative merits of lake and river water was indulged in, and the columns of the local papers teemed with all sorts of exaggerations



LOCATION OF INTAKE, BURLINGTON HARBOR.

of the merits and demerits of the different locations, one of the arguments in favor of the river being that at times the proposed location for a lake intake at the north end of the bay was covered with the muddy and filthy waters of the river.

The water committee secured the services of an eminent hydraulic engineer who submitted plans and estimates for four different schemes, three of which contemplated taking water from the Winooski river. He did not hesitate to recommend the river as a source of supply, though he considered that the water from the lake would be of greater purity. His recommendations were accepted, and placed on file. It was decided to use cement lined pipe, not wholly on account of the superiority of the pipe, but, as I gather from the report of Mr. Wm. J. McAlpine, for the purpose of saving about twelve thousand dollars.

However much the judgment of those who were responsible for the laying of the cement pipe, which many of us are today replacing, may be criticized, and however disrespectfully the "old cement pipe" may be regarded today, we are still obliged to admit that in 1867 with cast iron pipe at $75 to $80 per ton and samples of it in the city, which after a few years use could be crushed with the heel for their entire length, there was a reasonable doubt about the relative merits of the two pipes. We are every year replacing more or less small cement pipe with larger cast iron pipe, but even if the original pipe had been cast iron, we should be doing the same thing on account of its size. It may be that in many instances the much despised cement pipe has served its day and generation well, and instead of being our debtor is in reality responsible for a large amount of prosperity. R. D. Wood & Company furnished the cast iron pipe of which there were several thousand feet used and the Patent Water and Gas Pipe Company furnished and laid the cement lined pipe.

An open earthwork reservoir of 2,236,000 gallons capacity, with slopes paved with cobbles and the bottom covered with sand, was built for about nine thousand dollars. The embankment was constructed of unselected material without rolling or puddling, and was allowed to settle for a year before being subjected to the pressure of a full reservoir. On the 25th of December, 1867, a Worthington pump with a capacity of 750,000 gallons daily first pumped water through 8,362 feet of ten inch pipe, into the reservoir, against a static head of 125 pounds. Water is pumped directly into the distributing mains, the surplus going to the reservoir.

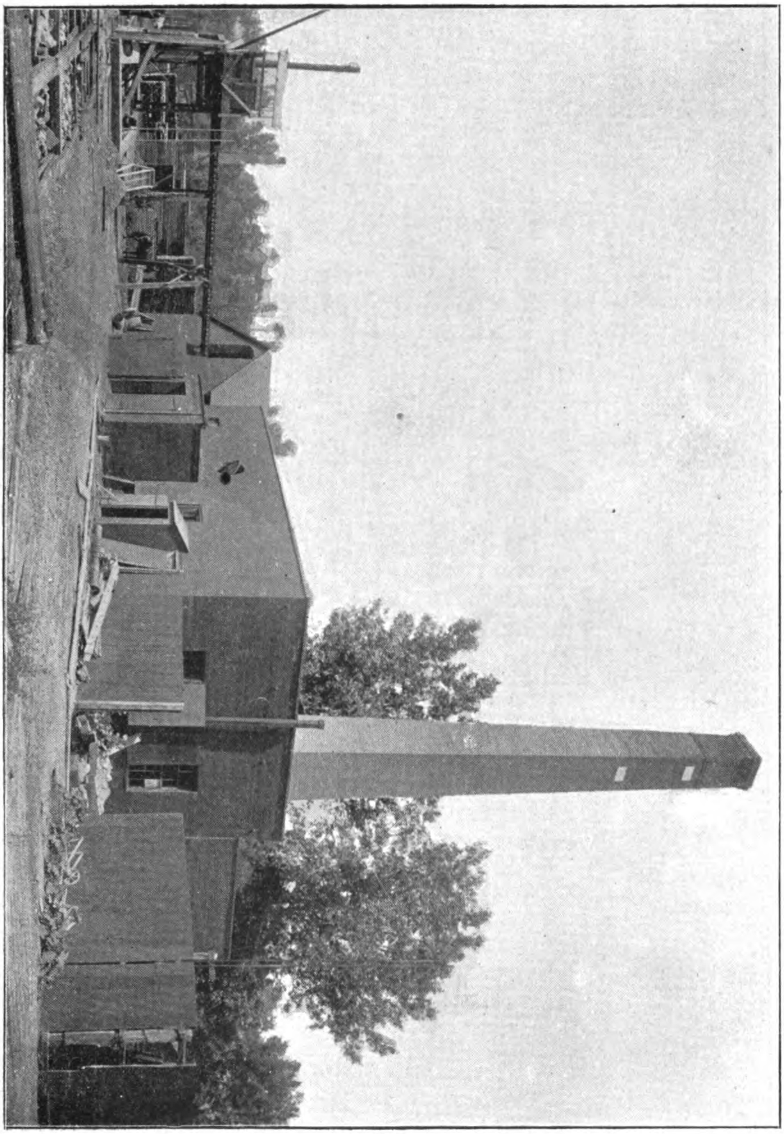
The pump and the engineer who was then in charge have since that time served the city faithfully and efficiently, celebrating the 27th anniversary of their association together in business in the midst of a conflagration which crumbled brick walls, collapsed cast iron pipes and left of the thickly piled lumber yard on three sides of the station, hardly ruins enough to indicate what it had been. A second three quarter million Worthington pump was the following year added to the plant at an expense of $8,000.

The Burlington water works comprise about thirty-five miles of street mains, about twenty-two miles of which are cast iron; two earth work low service reservoirs, with a combined capacity of about seven million gallons; one iron high service reservoir with a capacity of 163,000 gallons; a motor to furnish the supply for the high service; two Worthington pumps which formed a part of the original installation; two forty horse power horizontal tubular boilers and a twenty-four inch cast iron intake conduit nearly three miles in length, which was laid in 1894.

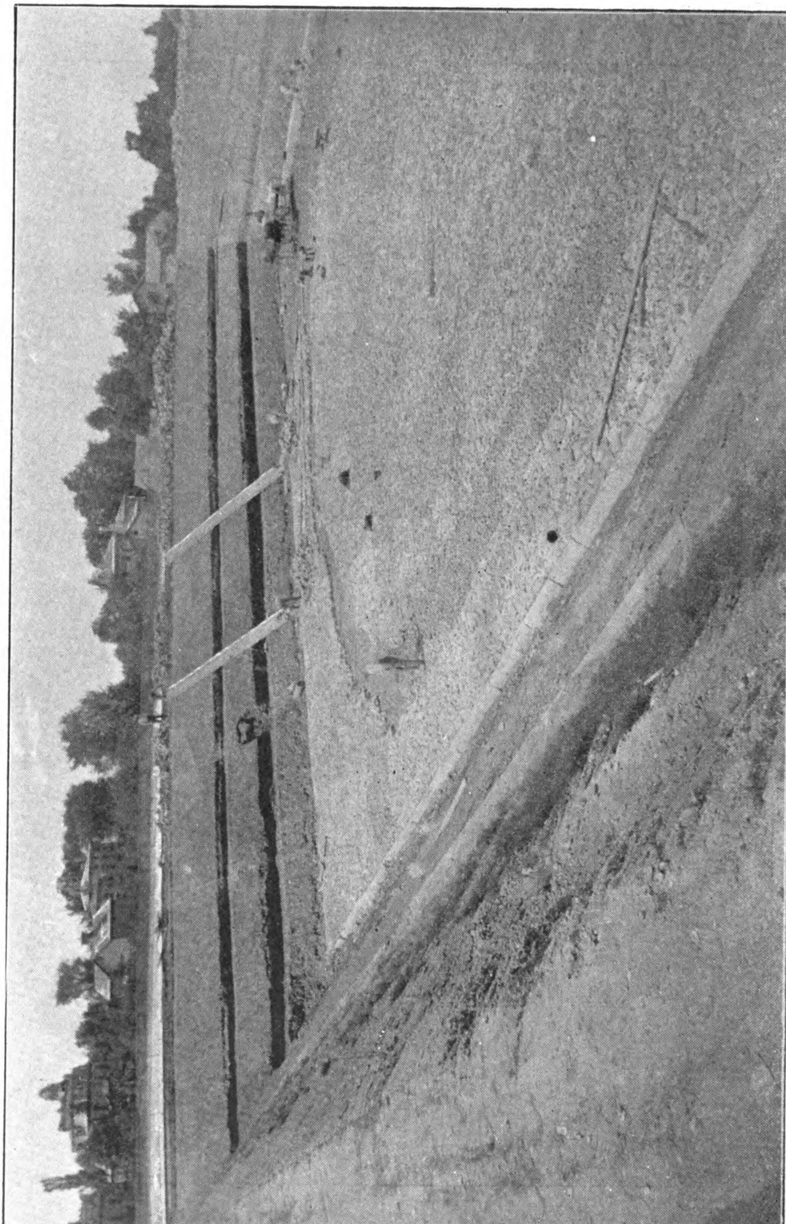
The new reservoir holding about four million gallons, was built in 1888, having a concrete bottom and slopes lined with brick laid in cement except for the upper third, against which the fluctuation of ice in winter is expected, which is lined with granite laid in gravel. The cost was about $23,000. Two years later about $11,000 were expended in remodeling the old reservoir, bringing it to the same general plan as the new one. Since then it has become possible to thoroughly clean the reservoirs, and that work has been done regularly each season, and there has been hardly any cause for complaint on account of fishy taste and odor.

The high service supply is furnished by a motor, designed and built by Mr. W. H. Lang of this city, which, for every 20 gallons passing through it either to or from the lower reservoir, forces about a gallon to the higher level. The motor is situated in the low service main in the low service reservoir yard and pumps directly into the distribution pipes of the high service, the surplus going to the high service tank, and in case the later overflows, the excess returns to the lower reservoirs.

The iron high service tank is thirty feet in diameter by thirty-two feet in height and rests on a stone foundation built up from solid



PUMPING STATION.



RESERVOIR DURING CONSTRUCTION.

ledge and is enclosed in a brick building with slated roof. The eight inch combined inlet and outlet pipe enters the tank about a foot above the bottom. A four inch overflow from the top conducts surplus back to the lower reservoirs. On the bottom a four inch blow-off is attached. On the side of the tank about two feet above the bottom and directly opposite the door of the brick building is an eliptical man-hole of sufficient size to admit men and tools for cleaning. Both the outside and inside of the tank have been covered at different times with several different paints and coatings, of which Alkatraz asphalt seems to give the best satisfaction.

Meters were used in Burlington even before the works were purchased by the city and since then the number has been constantly increasing. On the high service, a meter is required on every service where there is a sewer connection, owing to the insufficiency of the supply, the motor having for some time past been greatly over taxed. Meters are also required on all services larger than half inch used for other than fire purposes. Half inch meters are furnished by the city free of charge, the taker being at the expense of setting the meter in a manner approved by the department. Meter testing is conducted in the water works store room, which is conveniently fitted for that purpose and is abundantly supplied with water from a four inch service.

Our average daily consumption has now reached a point slightly in excess of the capacity of one pump, running all the time, and a new pumping plant will probably be soon installed both to secure greater capacity and the greater economy in operation of modern pumps over those of a quarter of a century ago.

From the construction of the works in 1867-8 to the fall of 1894, Burlington drew her water supply from a short distance from the face of the dock at the north of the bay and emptied her sewage at the south of the bay, of late years into a nicely, though entirely unwittingly, prepared settling basin. During all these years the sewage output has been on the increase but the various committees who have been delegated to investigate the matter have reported that though it was possible for the city's water supply to become contaminated from its proximity to the sewer outfall three-quarters of a mile distant, it was not at all probable. Later the above mentioned settling basin became a nuisance and the city forced to abandon it and proposing to empty her sewage directly into the bay off the face of a dock, it became apparent that the condition of the intake all ready none too good, was likely to become worse.

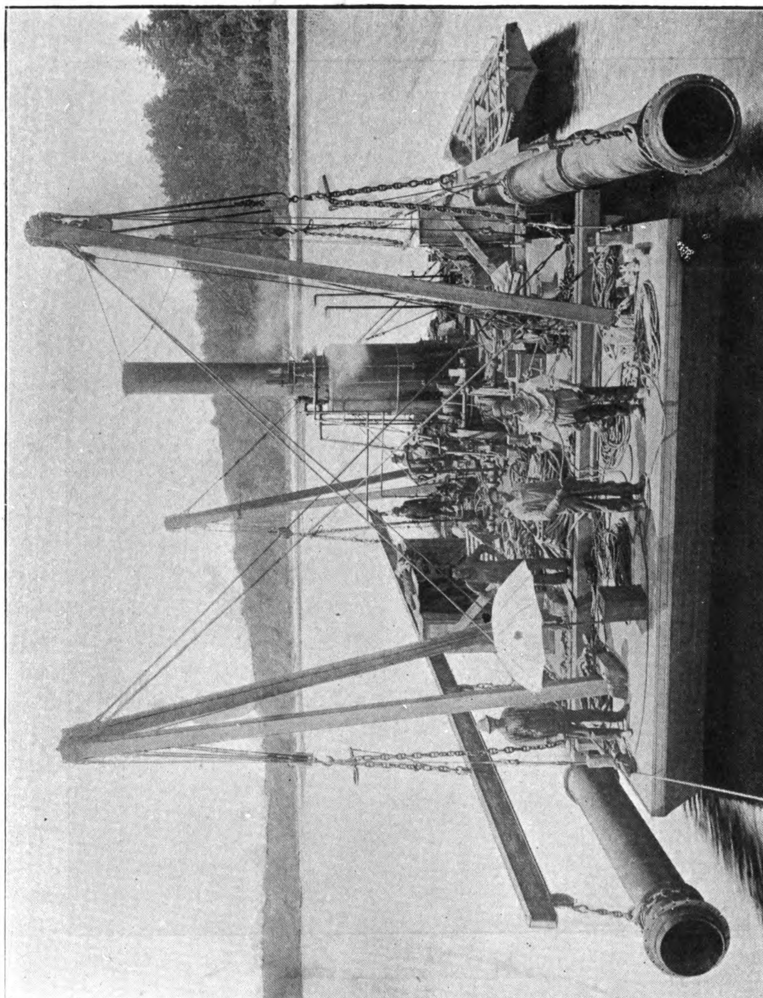
Steps were immediately taken to remedy the evil and after a careful investigation of the possible sources of gravity supply and the different locations at which water could be taken from the lake, it was decided to locate the intake on what is known as Appletree Reef, just outside of the bay next north of that on which the city of Burlington is situated. Plans and specifications were prepared for the extension, the work was advertised and on October 7th, 1893, eight bids, ranging from $56,919 to $145,000 were opened at the water office. As the lowest bid was considered too high, bids were again asked for and just one month later, five were received, ranging from $47,900 to $59,500 and the contract was awarded to Mr. J. G. Falcon of Evanston, Illinois, the lowest bidder.

The intake conduit is of coated cast iron pipe, 24 inches in diameter, and was laid in sections of seventy-five feet each, connected under water by means of Falcon ball joints. This joint is made of a ball cast of such diameter, larger than the pipe on which it is to be used, as to admit the desired deflection to be obtained without obstructing the water way, and a flanged spherical ring of about three-eighths inch greater radius than the ball and of such width that the ball cannot pass through it. These two parts are leaded together and attached to one end and a flanged bell, planed so as to make a tight thimble for the ring which is attached to the other end of a section to be laid.

The flanged joint is made by a diver with the aid of a thin rubber packing, and after it has been for a short time in our lake water the oxidation which takes place on the planed surface of the ring and thimble makes it entirely water tight. In a case like that of our intake, where there is no current of constant and high velocity to keep open and increase the size of leaks induced by changes of temperature or settlement, it may safely be expected that all small holes will be closed by oxidation. The 75 foot lengths of regular bell and spigot pipe were leaded together on shore in the usual manner and were tested by hydraulic pressure, a special flange being bolted to each end for that purpose.

The scow used for laying the pipe was built and work commenced at the station in the winter and before the opening of navigation. The pump well was sunk, pipe laid through it from the face of the

FASTENING FLEXIBLE JOINT.



ON SCOW.

dock and a 24 inch gate placed on the conduit in the well. By closing this gate and placing a flange on the outer end of the last section laid, it became possible at any time to test the conduit in place in the same manner in which the sections had previously been tested on shore.

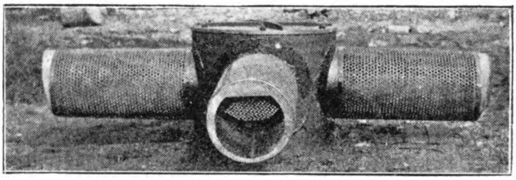
The outer or intake end of the conduit is located in about 30 feet of water on Appletree Reef, the end being turned up at an angle of ninety degrees and the size of the conduit increased at the bend to 30 inches. The highest point of the copper screen, which caps the upright, stands about fourteen feet below the surface at ordinary low water, and about five feet above the oak crib filled with stone which surrounds the upright. By closing a 24 inch gate, located just outside of the crib and the one before mentioned in the well at the pumping station, and forcing water under pressure into the conduit between the two gates, the tightness may at any time be easily tested. The tests which have been made, since the completion and acceptance of the work, have in each case proved satisfactory.

DISCUSSION.

MR. NOYES. If I understood him correctly, Mr. Crandall said that in the early part of the work, iron pipe was used, and that it did not give satisfactory results as compared with cement pipe. I would like to ask if there was any special reason to account for that, whether it was a poor iron, or whether it was owing to the peculiar quality of the water which acted upon the pipes?

MR. CRANDALL. I think that the trouble was occasioned by the quality of our water, which very readily attacks iron, and by the fact that there was no coating on the pipe. There was quite a lot of four inch pipe used by the Aqueduct Company, which was taken up at the time the new works were put in, and the pipes fell to pieces in taking them out of the ditch. Several years later, since my connection with the works, we amused ourselves when taking up some four inch pipe by stamping upon it and breaking it in. It was soft from end to end, and the iron thoroughly oxidized. We have a six inch main on Pearl street, uncoated pipe laid prior to 1865, which we expect will flood us every time we tap it.

MR. NOYES. I would like also to ask Mr. Crandall if he is now using coated iron pipe on the extension of his works, and if the water appears to attack the iron in the same way that it did the uncoated pipe?



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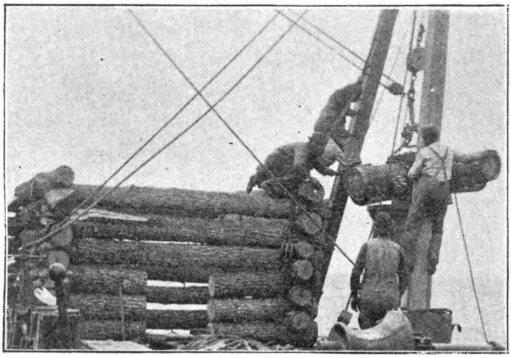

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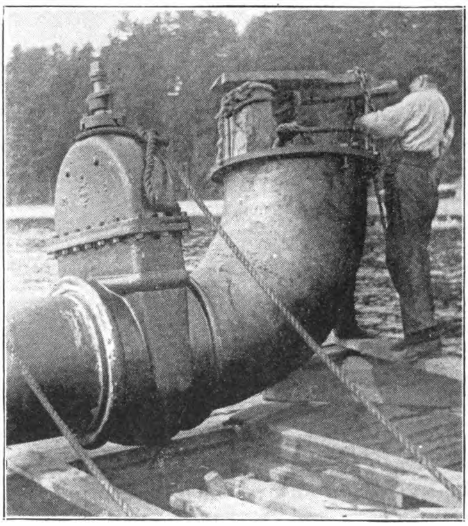

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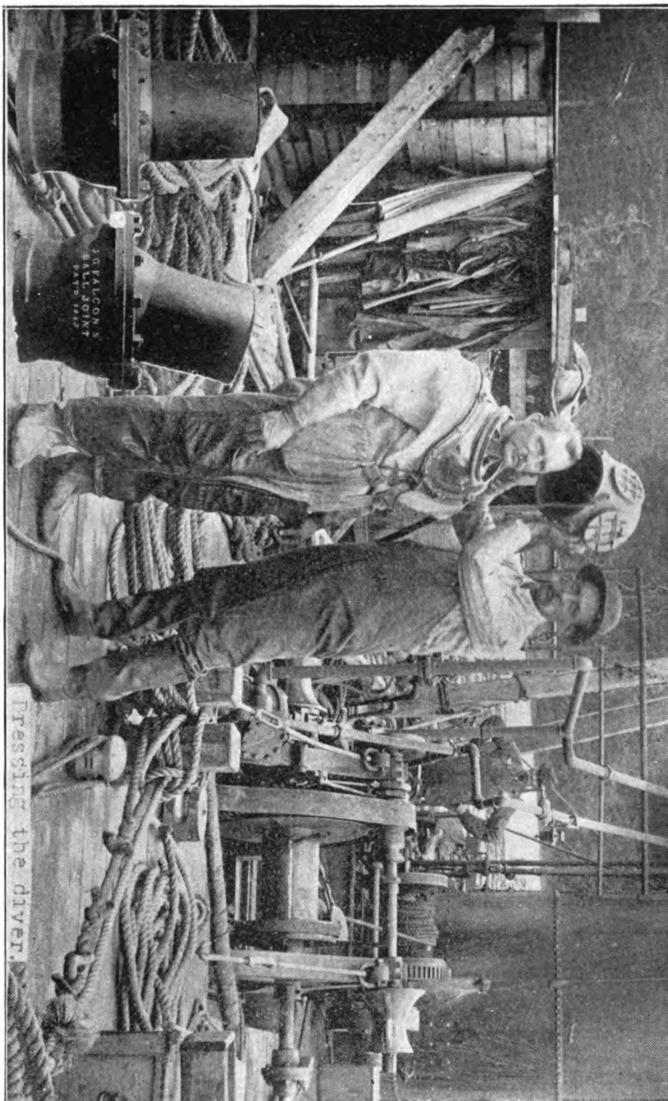
1—Screen. 2—Crib. 3—Gate and Bend.



PREPARING TO DESCEND.

Mr. Crandall. We now use ordinary cast iron coated pipe. In 1888, we took out some pipe which had been down for 25 years, and it was found to have hardly a speck of rust on it. We are constantly taking out pieces of coated iron pipe which are in good condition.

A Member. I would like to ask about the material used for coating the high service tank, particularly the inside.

Mr. Crandall. We have used the government water-proof paint; the Dixon Graphite Company furnished us with a sample, and a local paint dealer has tried his hand at it; in fact the paints which have been used on that tank are too numerous to mention. About four years ago the Alkatraz Asphalt Company of Portland, Oregon, offered to give us a barrel if we would pay the freight on it, and the asphalt is now on the tank inside and out, covering about a quarter of the surface, and thus far it has proved satisfactory. It does not peel and the ice does not seem to affect it; it is just as good where the fluctuation occurs as it is at the bottom.

Mr. Williams. I would like to enquire a little more about the test of the intake. Mr. Crandall stated that the tests were satisfactory; but I would like to know exactly what his tests were, and their results.

Mr. Crandall. The pipe is laid on a bottom which is nearly level, but there are two summits in the distance, and on those summits were placed brass ferrules with two one-eighth inch holes bored in each ferrule. Before these holes were opened, the water was let on at a pressure of about 20 pounds, and we noted the amount of leakage and the same was done afterwards, showing the leakage occasioned by the holes. This was done each time that air vents were placed, and when the test was finally made, the pressure which they were subjected to was from 12 to 15 pounds, and the leakage, aside from that through the air vents, was about 100 gallons per hour in the entire length of about three miles.

Mr. Gilbert. I would like to ask a question in regard to the action of water on iron. We have all noticed that some pipe will fill up with rust much quicker than other pipe, not only in the mains, but more particularly in services. I am speaking of plain iron pipe, not coated pipe. Now it seems to me that this difference must be due to the quality of the iron; and I would like to know what quality of iron is least acted upon.

A MEMBER. I find that all common iron pipe, standing in water, will rust at about the same rate, and as far as I can see, the quality of the iron makes no difference. I think the filling up of a common iron pipe depends largely upon the pressure; services where the pressure is low fill up quicker than where it is higher. I have also noticed that the rust upon common iron pipe is much more easily washed off than it is from a coated pipe.

MR. GILBERT. We had a case where two services were connected with a main within two feet of each other. They were both laid the same year, but probably not from the same lot of pipe. The water from one of those services was satisfactory all the time, but from the other it was hardly fit to use. The water from all the other services along the street was good. The service pipe was finally changed and there has been no further trouble.

MR. FISH. I have always found that rapid rusting of service pipes has been accompanied by leaks, so that the water is constantly flowing through the pipes, and I would suggest that leaks be looked for in all such cases.

MR. HAZEN. One of the most interesting features of this Burlington supply is the use of Lake Champlain, both as a source of water supply and as a receptacle for the sewage of the city. That is a case which does not occur very often in New England, but which is much more common in the West. On the shores of the Great Lakes there are a number of cities, many of them much larger than Burlington, that are doing this same thing, and the question comes up in all these cases, how much is it necessary to dilute the sewage in order to make it safe for drinking water; or, in other words, how far out must the water intake be placed in order to get a safe or healthy drinking water, or can the intake be so placed at any reasonable distance as to give a safe water?

There are cases, as for example those of Chicago, Cleveland, Toronto and other lake cities, where the water has been taken from points too near the sewer outlets, and there has been so much sewage in the water that the cities have suffered from very high death rates and from sickness which they ought not to have had, and would not have had with better water; but, on the other hand, we must admit that there is a distance from which water may be taken that is far enough away from the sewer outlets so that the sewage will have at least no very great effect upon the health of the city.

The Chicago sewage mixes with the water of the lake and pollutes it so that, as I believe, it is not suitable for drinking, even at the four mile intake; but following the case further, we find that the sewage mixes with the water of Lake Michigan and eventually goes down through the Mackinaw Straits into and through Lake Huron and finally into the Detroit river and into the drinking water of Detroit. But after it has passed through these two great lakes and has become so enormously diluted and exposed to the air and light for months, no one would claim there was any serious danger from the Chicago sewage to the Detroit water. The engineer of the Detroit water works is here, and I think if he were looking for possible pollutions of the Detroit supply, he would look for them at points much nearer than Chicago. But the intake of the Chicago water works and the intake of the Detroit water works are a long distance apart, and the interesting question is at what point between those two limits does the water become safe for drinking and suitable for public water supply.

It seems to me that there is not any sharp line, but that the further the intakes are carried out the less the danger becomes. When Chicago carried her main intake out from two to four miles and abandoned at the same time the use of the old shore inlet, some three years ago, the death rate from typhoid fever in the city in the next year was reduced by 60 per cent., or to 40 per cent. of what it had been before.* That was regarded as a great achievement, and it was. The water was better, but it was and still is far from what it should be. The city, even since the reduction, has an enormously high death rate when it is compared with other cities with good water supplies. The four miles was not far enough; and it will be necessary to go much farther than that in order to secure a good water. Of course the distance to which it is necessary to go, depends in different cases upon the amount of sewage which is put in, and a large city like Chicago, disposing of the sewage from over a million people, pollutes the water to a greater extent and for a greater distance than a smaller place would do.

The question is naturally raised as to how much disease a water must cause in order to make it worth while to incur a heavy expen-

*The Water Supply of Chicago, its Source and Sanitary Aspects, by Arthur R. Reynolds, M. E. Commissioner of Health of Chicago, and Allen Hazen, American Public Health Association, 1893. Page 146.

diture to prevent it. It seems to me we have got to put this question upon something the same basis that we do the cases of other works for saving human life. If it is a question of abolishing a grade crossing, a city will not incur an expenditure of millions of dollars to save one or two human lives, but if the expenditure is less, or if many lives can be saved, the improvement will be demanded. It is necessary to show that the value of the lives bears some relation to the expense which is to be incurred in making the change. And that is what I believe should be done in regard to works for improving the quality of water supplies. The method which has suggested itself to me is to take the deaths which can be attributed with some degree of certainty to the water, and the losses arising from the sickness which comes from the same source, and estimate their value upon something the same principles which are used in other cases where the damage to and loss of human life are involved, including also an allowance for indirect damages, such as depreciation of property, etc., which cannot be so accurately estimated, and balance the damages done by the water, calculated in this way, against the cost of the works which would be necessary to secure a water which would avoid them, or most of them, and then determine whether the saving is enough to justify the expenditure of the money necessary to make the changes.

And I think you will be surprised in many cases, to find how great the saving will be, and how much expenditure it will justify to avoid the sickness and death. Take for example Chicago. In 1891, 1997 deaths were reported from typhoid fever. Probably more than 15,000 other people were seriously sick from this disease but did not die from it. The fever was, in my opinion, mainly due to the use of the Chicago water. It may be said that some cases would have occured had the city had ever so good a water supply, but on the other hand there were hundreds or thousands of other cases which were contracted in Chicago by people who were there temporarily, or who were working there, and left the city after they had contracted the disease, and so a part of typhoid fever contracted in Chicago was charged to the account of the cities and towns to which these people went. Taking this into account, I do not think the figure given is an over-estimate of what was actually caused by the water. Most of the victims were people in the prime of life; there were few children and few old people. All classes of society were effected to substantially the same extent, for we found that the wards along the lake front, where the finest residences in Chicago were located, had just as high death rates as those on the west side, and those along the Chicago river, which were in bad sanitary condition, and were commonly supposed to be the main strongholds of the disease.

Taking these facts into account, it seems that a value of not less than $5,000 should be put upon each of these lives, and that, for 2,000 lives lost, you see, aggregates $10,000,000 loss in one year alone, and that without taking into account the enormous number of cases of sickness which did not result fatally, or the diarrhœa and other minor injuries to health which were undoubtedly caused by the water, but which do not appear in the statistical reports of the Health Department. That $10,000,000 was the loss in one year, and was followed of course by other sums for other years, and the loss is of such a magnitude that it would fully justify very heavy expenditures to prevent it, such as would allow the positions of the intakes to be radically changed, or the treatment of the sewage, or the filtration of the water, as it has been found at Lawrence and in Europe it can be done, so as to render it safe for use. The case of Chicago is not exceptional, as precisely the same conditions prevail to a greater or less extent in many other cities. It seems to me we have got to look at this question in this general way, balancing the losses which result from the use of a poorer water, as nearly as we can calculate them, with the cost of improving the supply.

Professor Sedgwick is going to tell us tonight something about the conditions here in Burlington. I believe that they are comparatively good, and that Burlington, being a small city, and having extended the water intake out, as Mr. Crandall has told us, some three miles, the water obtained is comparatively good and the city has a low death rate from typhoid fever. But there are plenty of other cases where the conditions are different, and where the death rates are high, and it is a question which must be carefully examined wherever it is proposed to put sewage into the same body of water from which drinking water is taken.