# Report of Proceedings

OF THE

## Eighth Annual Meeting

OF THE

# American Water Works Association

HELD AT

## CLEVELAND, OHIO.

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and begin it at the present time. I think we should look ahead when somebody that follows us will provide for that time.

THE PRESIDENT:—Several of our States have taken legislative action in regard to their water supply, and Massachusetts has taken more pains than any other State. It has a Commissioner to whom all matters are reported. Each of the towns that have a system of sewerage have to report to him, and if any nuisances they are brought to this Commissioner. If we have any member here from Massachusetts that could give us any information on that subject we shall be glad of it.

MR. DARLING:—While I am not from that State, that question, of course, has been seen in the working of our New England Association. Every manager of water works is required to furnish samples of the water that they use in their works to these Commissioners and the analysis is given, and we expect soon to get a final report in regard to it. They have, as you say, probably taken more pains than any other State and it has laws more stringent than others and the result will be very beneficial. There can be no doubt about that.

MR. DUNHAM:—I might add to what Mr. Darling has just stated. In sending out for samples of water to all superintendents they send not only once or twice a year, but every month, for the past year or so they have been sending out bottles requesting their return for the analysis. They have an appropriation of about thirty thousand dollars for that purpose.

THE PRESIDENT:—If no one else wishes to speak further on this question, the next on our regular programme will be a paper,—"The use of Salt Glazed Vitrified Pipe," by our brother Mr. S. E. Babcock.

## *THE USE OF SALT GLAZED VITRIFIED PIPE IN WATER WORKS CONDUITS.*

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It having been my lot to construct two quite extensive systems of gravity water works within the last six years, one at Amsterdam, New York, costing $285,000, and the other at Little Falls, New York, on which I am now engaged, costing $300,000, and in both cases the source of supply being so far distant that the use of cast iron pipes for conduits would have rendered the construction on the gravity plan almost practically prohibitory, as the additional cost would have placed too heavy a burden on the tax-payers—at least they would have fancied so—my attention was called to the use of salt-glazed vitrified pipe as a substitute for iron; as also in rebuilding the conduit at Johnstown, N. Y., which was done during the time stated. In each case I have successfully constructed the conduit of vitrified pipe, and all of them, to this date, have not required one dollar's repairs, but are actually in the same condition as when laid, all having been in constant use from date of completion.

I have, therefore, thought that a proper description of the method of construction might be of service to some of the members of this association, should they be called upon to design a conduit in similar localities.

I will first give a brief description of the alignment and grades of the Amsterdam and the Little Falls conduits.

## DESCRIPTION OF AMSTERDAM CONDUIT.

The water supply at Amsterdam is six miles distant and consists of three small mountain streams which I successfully diverted by vitrified pipe conduits and open channels into one. From this point I brought them across the country to the channel of a summer dry stream, upon which, at a point near the city, I built a combined storage and distribution reservoir. The three mountain streams were known as the McQueen and Rogers streams, and the dry stream as Bunn creek. There are two intervening ridges, or divides, between McQueen and Bunn creeks, necessitating heavy cutting to divert the water.

McQueen creek is dammed by a substantial masonry structure at a point just below the junction with the West Branch, the dam being 4 feet high; the channel of McQueen creek was widened and deepened for about 1,000 feet back; a new open channel or reservoir was excavated in direction of line to Bunn creek for about 800 feet, and until the excavation represented a cut of seven feet, to allow a sufficient depth of soil to cover the conduit and protect the same from frosts. At this point of termination of open channel, a substantial masonry inlet-chamber was designed and constructed, having suitable iron racks and fine screens, with bulkhead gate to shut down the water. From this point a vitrified salt-glazed pipe conduit 18 inches in internal diameter, has been laid to a suitable point to empty the water of Rogers, West Branch and McQueen creeks into Bunn creek. The pipe is of the pattern known as the hub and spigot, and is laid with Portland cement joints. The conduit is laid upon the true hydraulic grade line, excepting two or three points of depression, where it has been necessary to depress from one to two feet to admit of sufficient covering of soil over the pipe without changing or embanking up above the original surface of the ground. The conduit is laid to a grade with a total fall of 18 14-100 feet for 10361 feet. From this point the surface of the ground is precipitous in direction of Bunn creek, having passed now through the second divide, and a twelve-inch vitrified conduit is laid down to the channel of Bunn creek with a fall of 38 feet in 1,000 feet. The conduit has a capacity, when running full, of 2,851,300 gallons per diem, being in excess of the amount which may be expected from the Rogers, West Branch and McQueen creeks. Rogers creek is dammed up by a similar masonry structure four feet high; the water is then diverted and carried easterly in an open channel through about 1,000 feet of low undulating ground to the west edge of a road. At this point a masonry inlet-chamber, similar to the one on McQueen creek, is constructed, and the water is passed through a 15-inch vitrified salt-glazed pipe conduit 1,500 feet long, emptying into an open water channel of the West Branch. The water of Rogers creek then passes down the channel of the West Branch, and both empty into McQueen creek at a point above the dam upon the same. From the end of vitrified pipe conduit on Bunn creek, the water flows in the open channel of Bunn creek two miles to the storage and distribution reservoir of 100,000,000 gallons capacity.

### DESCRIPTION OF LITTLE FALLS CONDUIT.

The conduit at Little Falls is a much more elaborate affair. The water supply is a mountain stream known as Beaver creek. It lies due north from the village of Little Falls, and is distant about eleven miles by road from Main street or center of the village.

Beaver, as well as Spruce creek, into which it empties near the point of diversion, is a tributary of East Canada creek: the line of Beaver creek runs about due east. The ground lying between Beaver and Spruce creeks and Little Falls is depressed by two streams, Gillet and Cathaticane, or Crum creek, both running southeasterly, Gillett creek emptying into East Canada, and Cathaticane, or Crum creek, into the Mohawk river, and dividing the intervening ground about equally into four sections, or two divides and two basins or depressions.

I have utilized vitrified salt-glazed stone-ware pipe wherever I could locate the lines to a hydraulic grade line, or line of no pressure, and in the two depressions or valleys where the conduit is under pressure, substituted cast iron pipe, crossing the same up to the ground called for, by hydraulic grade line of no pressure, produced.

Beaver creek is dammed by a substantial masonry structure at the point of divergence. The dam has a spill-way 50 feet wide and floods 0.75 of an acre. The dam is six feet high; the south abutment of the dam is formed into a receiving chamber and inlet of conduit line, and is provided with a movable inlet weir, which may be raised or lowered to allow any quantity of water up to the capacity of conduit to flow into the chamber and thence into the conduit; the saddle of the dam is two feet above the top of conduit. The water starts off from the receiving chamber in a 20 in. iron conduit pipe for fifty feet, to take the first shock off the water acquiring its velocity; it is thence continued with 20 in. vitrified salt-glazed stone ware pipe for 10,000 feet grade eight feet to the mile, the line following the contour of the ground required to give the necessary fill on top of pipe to protect the same, and to insure its lying in natural and not artificial ground. Here a heavy sand cut is encountered for about 1,000 feet. From this point, as a heavier grade can now be given, 18 in. vitrified pipe begins and continues 9,400 feet, grade 13 feet to the mile, to the edge of the basin of Gillett creek; from here the line is continued with an 18 in. cast iron pipe 6,200 feet long, which follows along surface or contour of the depression of

Gillett creek, rises up to the southerly side of said depression, and ends at a point at which the hydraulic grade line produced would give natural ground to start off with vitrified pipe again.

Vitrified pipe starts here, 18 in. diameter, and is carried along on the hydraulic line to the beginning of the depression of Cathaticane, or Crum creek, 9,100 feet. From this point 16 in. iron pipe 9,400 feet long, grade 32 feet to the mile, is used across the depression and up to the top of divide, the southern shed of which runs to the village of Little Falls. From this point 15 in vitrified pipe is again used for 900 feet, grade 79 feet to the mile; then 12 in. vitrified pipe is used for 1,000 feet, grade 105 feet to the mile; the conduit proper stops here, a total distance of 8 72-100 miles.

## SPECIFICATIONS FOR PIPE.

The essential points in the specifications for the salt-glazed pipe which I adopted are as follows:

LITTLE FALLS WATER WORKS—SPECIFICATIONS FOR SALT-GLAZED VITRIFIED PIPE.

The pipe shall all be of the best quality of salt-glazed vitrified stone ware pipe. All shall be of the kind known as "hub and spigot."

The pipe shall have a thickness of one twelfth the diameter of the pipe. (This it will be observed, is heavier than the ordinary commercial pipe.)

The hubs or sockets shall be three inches deep to the main pipe. (At Amsterdam I used the ordinary depth of sockets, which is two and one quarter inches, but at Little Falls increased the depth to three inches, my experience convincing me that the increase would make easier and more satisfactory work.) All hubs or sockets must be of sufficient diameter to receive to their full depth the spigot end of the next following pipe, without any chipping of either pipe, and shall have a space or joint room of not less than three eighths of an inch in width all around for the cement mortar joint.

All pipes supplied shall be moulded under pressure, and the socket of every pipe shall be pressed on or formed with the body of the pipe, and care shall be taken that the sockets are truly concentric with the pipes. All pipes shall be cylindrical, and the spigot end of every pipe shall fit into the socket, leaving the thickness of joint not less than that specified. Five per cent will be the allowable inspection divergence of the greatest from the least internal diameter, in departing from a true cylindrical cross section.

The pipes shall be well glazed all over. All pipes not well or uniformly glazed will be rejected. All pipes not perfectly burned will be rejected. All pipes having any fire cracks which the engineer of said water works shall consider injurious, shall be condemned and their places supplied by other pipes.

All pipes having transportation cracks shall be peremptorily ejected.

All pipes having blisters which the engineer of said water works shall consider injurious, shall be condemned and their places supplied by other pipes.

All pipes having excresences or iron pimples in the interior of the pipe, which in the opinion of the engineer aforesaid may impede the flow of water, shall be rejected and their places supplied by other pipe.

All pipe not thoroughly vitrified or fused, or which betrays the use of improper materials or methods in its manufacture, shall be rejected.

If a piece be broken out of the rim forming the hub or socket of a pipe, it shall be rejected, if the length of said broken piece is greater than one tenth of the diameter of the pipe, measured on the inside face of the hub or socket; provided, however, that the body of the pipe shall be perfect and without breaks or cracks.

If a piece be broken out of the socket end of a pipe which shall extend over one inch into body of pipe, to sound pipe, or shall be greater in length than one tenth of the diameter of the pipe, the pipe shall be rejected, and two or more such breaks, either of socket or spigot, shall condemn such pipe, even if both are under the area designated.

## SPECIFICATIONS FOR PIPE LAYING.

The method of laying the pipe appears by the following specifications:

The excavations in conduit trench, both iron and vitrified pipe, shall be made to the lines and grades to be given by the engineer from time to time, and in such manner and to such widths as will give ample room for building the structures they are to contain.

The conduit will be laid to true grade from end to end of each section of vitrified pipe. The cast iron portion of conduit shall be laid to conform to the contour of the ground where laid, and trench shall be of such depth as to require a back fill of 3½ feet on top of pipe when laid.

The joints of the vitrified pipes shall be made of Portland cement mortar, in combination with gaskets of clean, sound hemp yarn or jute, braided or twisted, and tightly driven, as follows:

Each length or strand of the jute shall be of a diameter to loosely fill the width of joint, and shall be thoroughly soaked in a Portland cement mortar, made of a thick paste of clean cement and water, and shall be of a length to go once around the circumference of the pipe and lap over two to three inches. This shall be driven home with caulking tools, and shall be succeeded by a sufficient number of strands to fill the joint-room to within one half an inch of the outside of bell, breaking joints with the laps. All driven home and thoroughly jointed together. The joint shall then be finished by filling the remaining one half inch of joint-room with a clear Portland cement mortar, the joint-room when finished being completely filled all around the pipe to the outside lines of the bells.

The contractor will furnish the pipe layer with a bag, stuffed with shavings or hay, of a size sufficient to fit the pipe, rather tightly, with a rope about ten yards in length fastened at one end to the mouth of the bag.

The bag must be placed in the first pipe, the rope passing through each pipe as it is laid down. After the joints are made, the bag is then to be drawn forward at such times before the cement has set as to smooth off and produce a true surface at each cement joint and a continuous thin coating of cement on the lower half of the pipe.

In refilling the trenches, the earth shall be carefully packed and rammed with proper tools for the purpose. Care shall be taken to give the pipe a proper bearing throughout the entire length. The earth filling above the pipe shall be sufficiently packed and rammed to prevent after settlement, and puddled to the satisfaction of the engineer when so directed.

In rock excavation, the material around the pipe and for 1½ feet above the same shall be earth, free from stone or rock fragments. The balance of the trench may be filled with such portion of the rock excavation as shall measure not more than one cubic foot, provided a sufficient amount of earth be mixed with the same to bond it together like a mortar, and if necessary suitable material satisfactory to the engineer shall be borrowed to make said filling.

For the first hundred feet from the receiving chamber the pipe shall be bedded in a wall of mortar extending all over the bottom of the trench and extending up to pass the center of the pipe, filling the trench completely up to this point. The object and intent of this being to prevent an under leakage at the beginning or receiving chamber end of the conduit.

In order to secure a natural bed for each pipe, the contractor will cause the trench to be excavated down to such depth as the engineer shall direct, by the regular trench gang, to be followed up by a trained gang to dig the additional depth, just to grade as fast as the pipe is laid.

Having now in detail described the method of laying out and constructing the vitrified pipe conduits, I submit the following remarks on the durability and cost as compared with a cast iron conduit of equal capacity, using the Little Falls conduit as the basis of comparison, that being the more elaborate and difficult construction, as also introducing the feature of substituting cast iron pipe in the intermediate sections where pressure in the pipe is encountered.

## DURABILITY OF VITRIFIED PIPE.

That sound vitrified pipe is itself durable would seem hardly worth devoting much time to demonstrate. Sewers built of it have been unearthed in the excavation of Pompeii and Herculaneum, which cities were destroyed by an eruption of Vesuvius, A. D. 79.

## REV. F. S. DE HASS, LATE U. S. CONSUL TO JERUSALEM, PALESTINE, WRITES:

"Vitrified Clay is among the most durable materials known. While the Marble palaces, temples and tombs of Rome and other ancient cities have crumbled to dust, those built of brick remain almost perfect. The use of Terra Cotta for images, ornaments, drain pipes, coffins and vessels of different kinds, dates back to the remote ages. Sewers, and tiling used in construction, have been found in Pompeii, Troy and Ninevah, also in Ur of the Chaldees, the home of Abraham, and the oldest cities in the world. Here it was in general use, and the tombs are drained with clay pipes as sound as when laid in the ground 4,000 years ago.

"The coffins also are of the same material, and of different shapes, some like caskets with lids and others round like bottles, which were sealed up after the corpse was inserted; and there they are by thousands at the present time, sound as when they came from the potters' hands. Nothing is now known more lasting than Terra Cotta."

Whether the ancients used salt to glaze their pipes with does not appear, but that it adds to the durability of the pipe the following description of the process of glazing will make manifest:

*Salt-glazed* pipes are necessarily made from good clay, which will stand a great degree of heat. The pipes, after being made and dried, are placed in a close kiln and gradually subjected to an intense heat. When this heat is of sufficient intensity, coarse salt is thrown upon the fire in small quantities; a portion of the salt vaporizes; which vapor, combining with the silica of the clay, produces a soda-salt or glass, which is a glaze and is a part of the body of the pipe. It requires good clay to endure heat of sufficient intensity to vaporize the salt, and this heat is so great that the pipes are thoroughly vitrified and very hard, and glazed inside and out.

### DURABILITY OF CONDUIT AS LAID.

As the Conduit as laid upon my plan, i. e., laying the pipe to the hydraulic grade line required to discharge the amount of water needed, will always be a line of no pressure, conditions precisely similar to the ordinary sewer as laid, there can be no tendency to rupture or break of any kind due to the water passing through the conduit, and the only danger to be apprehended is from an external pressure crushing the pipe, or to an unequal bearing or settlement of the conduit. The following tests show the strength of the pipes to resist external pressure:

Tests made by Mr. A. V. Abbot, Engineer, New York. A wooden box was made large enough to receive the pipe and allow from two to three inches of sand to be packed in at the sides, giving the pipe, as near as possible, the position it would occupy when laid in the earth. The pressure was then put on top of the pipe, with the following results—average of two pieces each size—each piece being twenty-four inches long:

| DIAMETER. | THICKNESS. | CRUSHED AT |
|---|---|---|
| 18 inches. | 1¼ inches. | 14,238 lbs. |
| 15 " | 1¼ " | 24,030 " |
| 12 " | 1 " | 11,540 " |
| 6 " | ¾ " | 28,065 " |

Again, the fact is that in deep cuts the filling over the pipe is partially supported by the sides of the cut, the angle of support or repose of the back filling being at an angle of 45° with a horizontal at the top level of the pipe, the earth or back filling forms an arch bridge from this point up, so that the only point to be carefully guarded, is to see that the back filling immediately surrounding the pipe is carefully put in, and that the pipe is laid on the natural ground, so that there may be no undue, unequal settlement, and in places where the ground is soft and yielding, to build up with concrete.

RESULTS AT AMSTERDAM AND LITTLE FALLS.

That the results of construction bear me out in this, I have the proof in the actual working of both the Amsterdam and the Little Falls conduits. The Amsterdam conduit is laid generally in very heavy cuts, ranging from 12 to 22 feet. At Little Falls, one heavy cut for 1,000 feet is in the deepest point 32 feet; and yet, Mr. A. H. Delgraff, Superintendent at Amsterdam, writes in every report to date, that there has been no repairs on the conduit. His last, the sixth report on the works, 1887, says:

"CONDUIT LINES.—The conduit lines still continue to do the work assigned them in a satisfactory manner, and no moneys have been spent in repairs during the year."

At Little Falls the upper half of the conduit to Gillet Creek has been in use two years, and the whole since July last, and as yet there has not been one dollar's repairs, although on the iron portion we have had three breaks. If the proof of the pudding is chewing the string, I think these two conduits have demonstrated their durability. The same thing holds true of the Johnstown works.

The conduit at Johnstown is about 1 mile long, 15 inches in diameter and similar in construction to the Amsterdam conduit. It has now been in use four years without any repairs.

CONTINUITY OF SMOOTH PIPE.

I desire to call attention to the fact that the use of a bag drawn ahead continuously, after the pipe laying, has the effect of producing a continuous smooth pipe the entire length of the conduit, the small particles of cement mortar which are forced up into the chamber of the pipe in caulking being smoothed over in the line of the flow of the water and the joints entirely obliterated. Very careful measurements on a weir at the outlet of the Little Falls conduit showed, when conduit was running, full head, a daily flow of 4¼ million gallons, although the calculated capacity was 3 million gallons.

VALVES IN LINE.

To prevent a pressure ever being put on conduit, under no circumstances must any valve be placed in the line, but it must be an open conduit from end to end; the water must be regulated at the head, or by introduction of a branch pipe with valves on branch, which may then be located at any point at which it is desirable to draw the water off. On the Little Falls conduit I placed branches and blow-offs on each section of the iron pipe at their lowest points.

ECONOMIC FEATURES OF COST.

The most important item in the whole matter, however, is the relative cost as compared with cast iron pipe. The saving is well worth looking into wherever new works are being designed, or additional supplies added to existing systems, to see if it is applicable to the case in hand.

Taking the actual results of the cost of constructing the Little Falls conduit, the comparative statement, excluding the cost of dam, inlet chamber, etc., common to any plan, will be as follows:

| | |
|---|---|
| Total cost of conduit, 8 72-100 miles long.......... | $86,085 27 |
| Vitrified Pipe portion, 5 63-100 miles long......... | 45,544 43 |
| Cast Iron portion, 3 09-100 miles long................. | 40,540 80 |

If cast iron pipe had been used exclusively in place of vitrified pipe, the sizes, owing to the contour of the ground, would still have been the same as were used in the line as actually constructed; the total cost of conduit at contract prices would have been $147,409.29.

If it had been possible to follow on the hydraulic grade line the entire length of the conduit, using vitrified pipe exclusively, the total cost would have been $57,206.64.

The relative cost, Vitrified and Iron, may be generally summarized as follows: Taking the ordinary trench, say 4 ft. covering on top of pipe, 3 miles of vitrified may be laid for the cost of one of iron. The cost of laying vitrified, trench being all ready, taking 18-inch pipe as a basis, one expert pipe layer and four laborers will lay 200 to 300 lengths per day, using ½ bbl. cement and 50 lbs. jute. The collaring followed up the next day by one handy man and two laborers, using ¾ bbl. cement and ¾ bbl. sand.

From the actual workings of the conduits at Amsterdam, Johnstown and Little Falls, I am satisfied that, if properly laid, a salt-glazed pipe conduit is as durable as any that can be laid, as well as being economical, as the above results of actual work show There being no pressure, there can be no breaks to repair; maintenance is reduced to the minimum.

## LIMITATION OF ITS USE.

Yet I think I must state that the application of vitrified in place of cast iron pipe must be limited to conduits of two feet to thirty inches in diameter, and to those localities where a line can be run to follow the hydraulic grade line, terminating at a distribution reservoir adjacent to town, which will give sufficient head for the distribution system, or ending at a pump well.

## CONCLUSION.

I believe that the use of vitrified pipe conduits will enable many localities to avail themselves of the better and purer water supplies, that are, without its use, too far distant to be financially available. For example, the Little Falls water is brought at such a moderate cost as to enable them to sell their surplus water at a profit at five cents per 1,000 gallons. It would have been too heavy a burden with cast iron, or at least the tax-payers would have objected to the heavy expense. They probably would have resorted to pumping from the Mohawk river, which takes all the drainage of the cities above them. In the one case they have a pure mountain trout stream of three to four million gallons flow. In the other they would have had the sewage-contaminated Mohawk river, the constant daily expense of pumping, with no surplus of water to sell.

Mr. Wadsworth:—What are the lengths of the pipes?

Mr. Babcock:—Two feet.

Mr. Wadsworth:—When these sections are laid is each one embedded in the earth beforé the joint is made and cemented?

Mr. Babcock:—Should you fill and tamp you could not drive the joint. You are obliged to lay the pipe and drive the jute home then tamp the earth around the pipe.

Mr. Wadsworth:—Do you ever have any breaks in the cement?

Mr. Babcock:—No, sir; the work has run six years and there never has been a spade put into the ground.

Mr. Wadsworth:—What do you mean by True Hydraulic Grade Line?

Mr. Babcock:—It is the grade at which the impetus given to flowing water by the incline, is just balanced by the retardation due to its friction. The line you follow—the contour of the ground—is not the true line. I have brought with me the maps of the construction. I shall exhibit them if anybody cares to see how far the contour line will depart from the true line.

Mr. Wadsworth:—In going through soil filed with quicksand or soft muck, do you have any trouble in keeping your conduit clear?

Mr. Babcock:—At Johnstown they had originally iron pipe, and ran it very near an air line; it has constantly worked bad; and the Engineer called me in to help him. He was unfortunate in building a high dam on quicksand bottom; I abandoned that entirely and built a stone dam, packed and concreted it. We laid a twenty inch sewer from our reservoir over a very short distance, this was about two-thirds quicksand. I had to resort to an experiment; there was so much sand came through as to make a perfect stream below the conduit. I laid it with open ditches and put rye straw around the joints to catch the sand and retain it there. If I had a muck bottom I should concrete it, or lay timber and make a solid foundation.

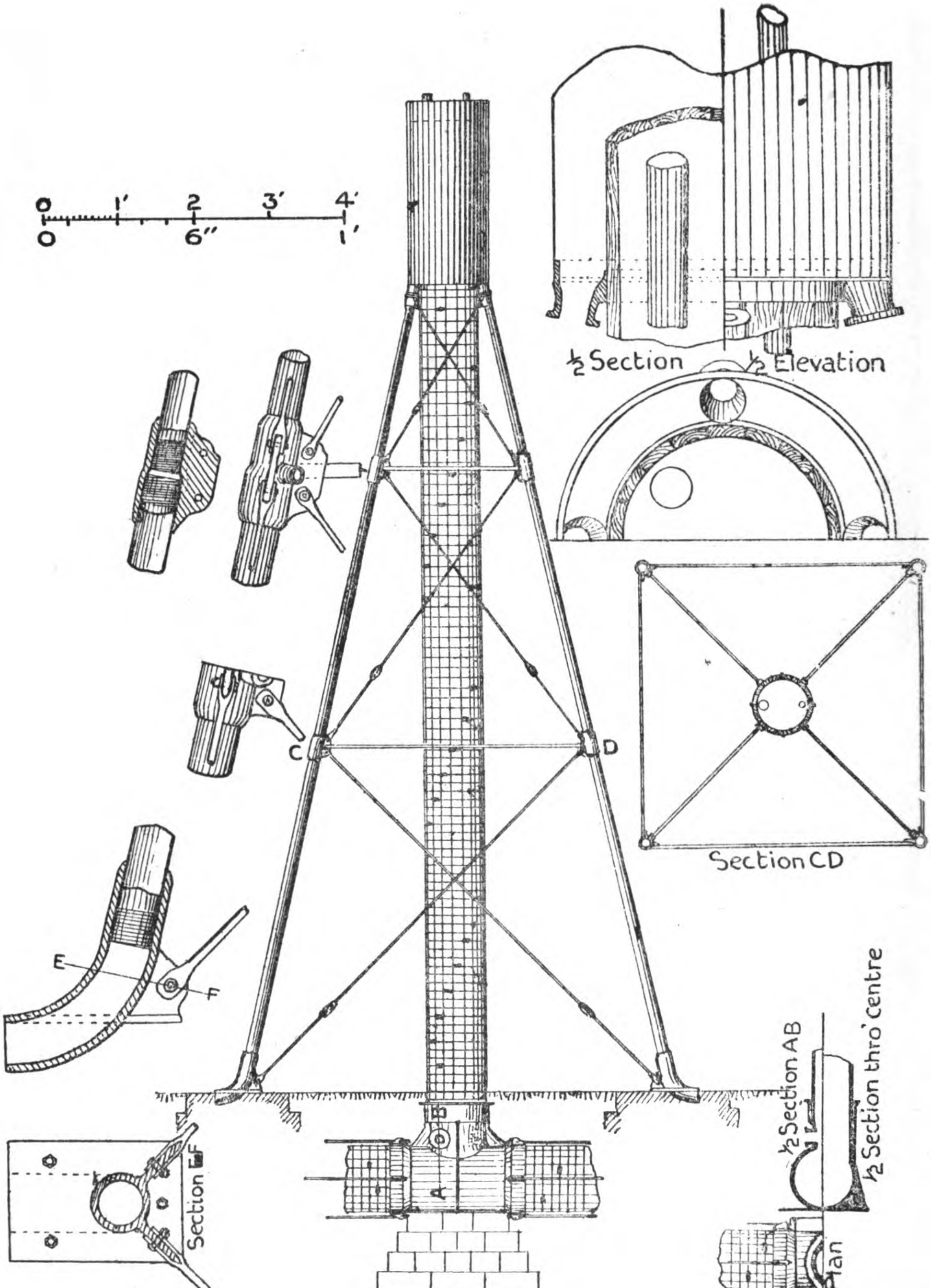
Mr. Dunham:—It is stated in the paper that the actual delivery through the conduit was four and a half millions daily, while the computed capacity was three millions. I would like to inquire as to the formula used.

MR. BABCOCK:—I used Neville's Tables, but it has been found by actual measurement that the tables are about one-third short; I use them because they are commonly cited.

MR. DUNHAM:—It is also stated that the pipe for the purposes of a conduit of less than eighteen inches should not be used.

MR. BABCOCK:—No, sir; that is not so; not above twenty-four or thirty inch; simply because it is a difficult matter to manufacture; after you get above thirty inches the pipe in drying will get out of shape; and another thing, the pipe would be very hard to handle in a rough country.

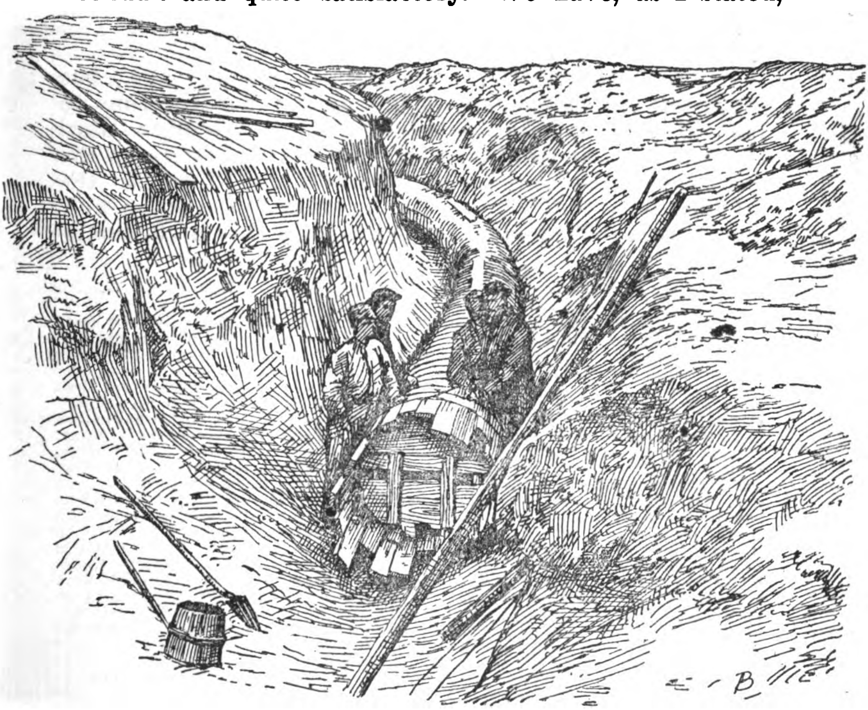
MR. HOLME, Jr.—None of us of course will dispute the durability of salt-glazed vitrified pipe in the building of conduits, for we know it has durability and lasting qualities, but there are certain defects in it which I think have been overcome by the system of constructing a conduit recently used by us at Denver, which is now working very satisfactorily. We have had some of this work in use for six years, which was simply put in as an experiment; we have since built 7 or 8 miles of 20 in. to 36 in. conduit, which has cost us from $1.10 to $2.15 per ft. It will stand a pressure of from 10 to 60 lbs., and we have had it under the pressure of 40 lbs., with no ill results. We have 2½ ft. fall per mile in this conduit which I mention. It is constructed of California redwood, the durability of which I think is equal to that of solid or vitrified pipe. I was sent into California I think about 3 years ago to look into the durability of California redwood. I traveled up and down the State, visited the redwood forests, saw railroad ties that had been in use 40 years, saw piles that had been driven from 15 to 20 years, both in almost perfect condition, and saw a railroad manager's office that was finished off with railroad ties that had been in use 25 years—they having been sawed into proper form and sizes. We had this redwood sawed in the form of staves, a certain number of staves to the circle. We built our pipe by laying these staves one upon the other and then fastening them together with wrought-iron bands. Indeed, all the staves are bound in this way. The pipe is thus enabled to stand a very heavy pressure. They are placed 3 or 4 ft. apart on the pipe. Since we have had




**DETAILS OF REDWOOD STAND PIPE. CHAS. A. ALLEN, DENVER, COL., ENGR.**

this conduit in operation we have never had any leakages and have no trouble at all. The cost of this work is materially less than that of any other material now in use. The wood is made perfectly smooth before putting together, and the plan of construction is very simple and valves can be used on any part of the pipe. Our pipe, which is banded together with 5x8 in. wrought-iron bands and is under 60 lbs. pressure, has not a leak in it—I think we have something to be proud of. The diameter of the pipe I speak of is 24 in. We also have 30 in. under 40 lbs. pressure. Our reservoir is situated on the highest hill in the city. One advantage is that a valve can be placed at any point on the line, and the cost is so small comparatively that we could afford to build 5 or 6 of these conduits in the way described cheaper than we could put in one regular cast-iron line.

The drawings of this pipe are here on exhibition. This pipe is simple in construction and we find it a good conduit and quite satisfactory. We have, as I stated,



LAYING REDWOOD PIPE.

seven miles of this pipe 36, 30 and 24 inch diameter, made of California redwood, and of native pine about six miles; the native pine is forty-eight inch diameter.

MR. TUBBS:—Do you ever have a break in your pipe? Can you shut off the water to make repairs as readily as you could a cast iron main?

MR. HOLME:—Before the pipe had seasoned sufficiently we turned the water on, and the result was that very little water oozed from the pipe—not enough to spurt, but just a little ooze. As soon as the pipe had swollen, we had no further trouble with it. We can build under water or in water, can build in two or three feet of water, and we find no trouble in connecting this pipe with cast-iron pipe. We tested the pipe before we laid another; we tested it to 120 pounds pressure per square inch. The only question is one of durability. There is no question but that it will last 25 or 30 years—we could afford to build it half a dozen times (as I have said before) for what it would cost to put in one line of cast-iron pipe.

THE SECRETARY:—The City of Quincy, Ills., has lately put in a 30 inch conduit of similar construction to that of Denver. In this case they used Georgia Hard Pine, and laid it continuously, joints being broken as the staves were laid; the pipe was laid last winter, as the influent from mid-channel in the river to the pump well, and is from 1600 to 1700 feet in length, and is giving satisfaction.*

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*NOTE.—Since the meeting Col. E. Prince, C. E., has furnished the following, describing the Quincy conduit. SEC'Y: The pipe or conduit was built on ways—in 3 sections of 540 feet each—and rolled into the Bay, then put together with wrought iron ½ sleeves, towed into the river, ballasted with stone, sunk, entered into a short pipe running out from the well, the crib put on and then sunk together with the upper end of the conduit. There were a great many things to be thought of and provided for and against, both in construction and in getting in place. The construction of the pipe itself was exceedingly simple. Staves, 3 in. x 6 in. x 16 ft of best kiln dried yellow pine were used. After being brought here the whole was taken to planing mill and each stave dressed on inside and two edges. 19 staves went around the circle, the inside of which was say, 30 in. outside 36 in. I did not bevel anything; the end of each stave was sawed into to a depth of 2 in. to receive a wrought iron butt plate ⅛ inch thick; plate say 4½ in. wide x 4 in. deep. The object of this is to assist in making the butt joint tight A half inch groove in the edge of each stave is filled with a separate tongue piece say 7-16 in x ⅞ in. wide, put in as the pipe is being constructed, butts of tongue pieces never being allowed to coincide with stave butts. Over each joint on the outside of the pipe placed No. 8 wrought iron plate 6 in. square, nail hole punched in each corner, through which hole nail was driven and clinched on inside of pipe. What bothered me most, and was the simplest thing about it, was the hooping. Of course, the pipe being perfectly straight, there was no chance to drive, and bolts were on many accounts objectionable. The plan I last thought about, and adopted worked like a charm, and was thus: At distances of 4 ft. i. e., covering all the butt joints and plates, passes a half inch c. h. iron hoop held in place by a half clamp, secured by a draw bolt. This clamp is tightened outside of the hoop until a link can be slipped over the bent ends of the hoop, when the ends are turned back over the

MR. HOOPER:—It has been done abroad in the French country fifty years under an eighty pound pressure. I saw in the Sonora Valley two years ago, a similar conduit in which water was brought down from a very high mountain and which had been in use eighteen years.

MR. DUNHAM:—If there is any question as to durability of wood pipe, I think our President can tell us as much about it as anyone.

PRESIDENT FANNING:—In constructing a system of water-works, in an Eastern city, I had to deliver water from the storage lake to the pumping station and to the turbines driving the pumps which were placed at a level 40 ft. lower than the lake, and distant more than a quarter of a mile from the lake. The water was conveyed from the dam at the outlet of the lake about 1,000 ft. in a canal to the brow of the slope at the foot of which stood the pump house. The water was to be taken down the slope to the pumps and to drive the turbines which actuated the pumping machinery. After consideration of several methods of construction of penstock for this purpose, a wood conduit was deemed advisable. The canal on the upper level was 10 ft. deep and the bottom of the conduit at the end of the canal was placed at the same level as the bottom of the canal, and the conduit then extended 700 ft. in length down the slope and connected with the turbines under a head of 40 ft. This conduit is 72 ins. clear diameter. It is constructed of southern pine staves. These staves are machine dressed on their edges to true radial lines, and in setting the machine cutters I tested by setting short pieces of staves on end on a floor, and adjusted the cutters until the staves placed in contact one after another would complete a true circle of 72 ins. diameter.

The trench to receive the conduit averaged about 10 ft. deep. The staves in the conduit were laid so as to break joints as a long mill floor is laid. Forms, on which to lay the lower semi-circumference of the conduit were placed in the trench. Then starting at the lower end the staves were placed in position, the lowest staves being stretched up the slope farther than higher staves and

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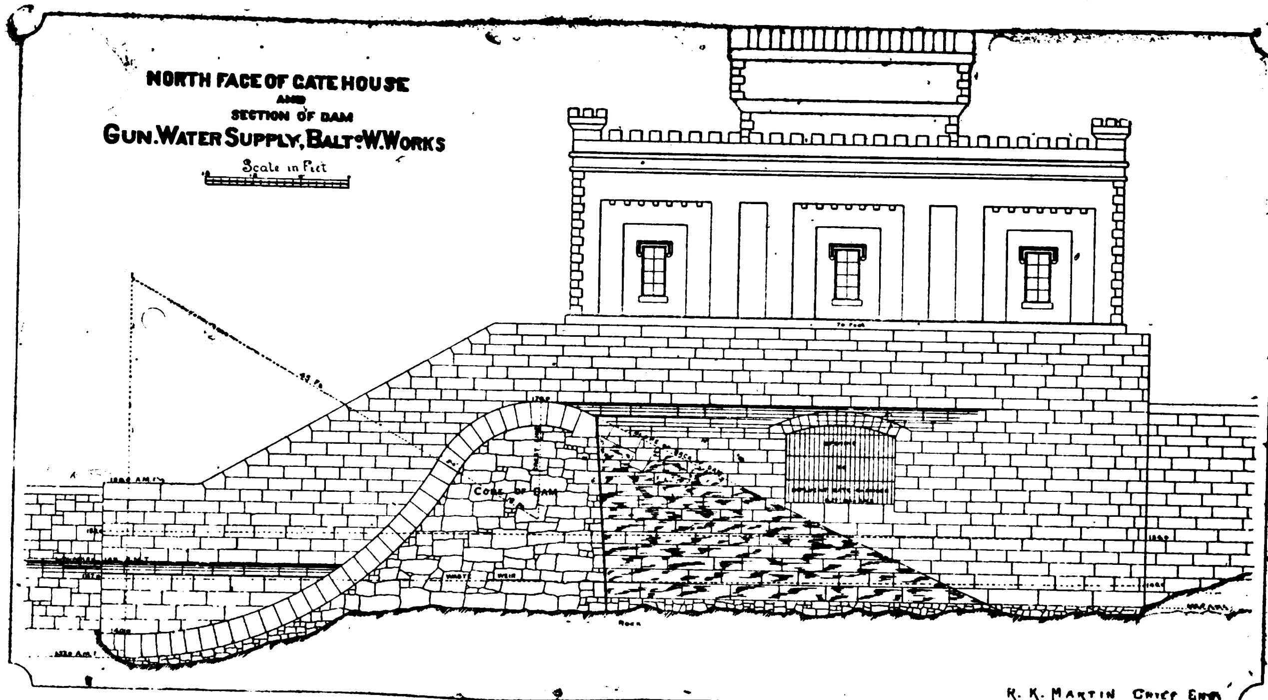
link, in so doing tightening the round hoop still more. After the bent ends were secured with the link and slightly bent back, the clamp was removed and the hoop pounded at all the seams so as to get a snug fit before the final driving back of the hoop ends. The sections of the pipe were secured by a half sleeve of boiler plate six feet long, in all cases a thimble of ⅛ inch iron entering and connecting each section. I used ⅝ in. round iron side rods running the whole length of the pipe from the crib to well anchorage. But the pipe was so stiff and strong that I doubt if they did any good.


NORTH FACE OF GATE HOUSE
AND
SECTION OF DAM
GUN. WATER SUPPLY, BALT° W. WORKS
Scale in Feet
CORE OF DAM
ROCK
R. K. MARTIN CHIEF ENGR

when the semi-circumference at the lower end was complete its iron hoops were placed in position and the full circle of the conduit completed. Thus the laying progressed up the hill, the lowest staves being kept in advance, and the iron hoops being placed and tightened as the full circle advanced. This work was performed by laborers under supervision of a competent foreman.

The hoops were made of iron 2½ ins. wide varying from ½ in. to ¼ in. in thickness, and each hoop had two tightening bolts at points opposite each other. The butting joints of the staves were made tight by introducing a thin plate of iron in each. Saw kerfs were cut tangentially, ⅜ in. deep across each end of each stave, and pieces of hoop iron ¾ in. wide and ⅛ in. longer than the width of the stave filled the kerf. The ends of the iron plates were sharpened so as to indent into the sides of each adjoining stave.

This six foot wood conduit, under 40 feet head pressure at its lower end has been in satisfactory use sixteen years, conveying water to the turbines and pumps and now gives promise of great durability.

One other instance I will mention, more intimately related to the subject of Mr. BABCOCK'S paper. This is a vitrified pipe conduct under pressure. We built an impounding resevoir by raising a natural lake 14 ft., thus securing a reservoir of 180 acres area. The dam was 14 feet high and the conduit leading water to the city was, in the gate chamber, placed at the level of the bottom of the dam. From thence it had a fall of 12 ins. per mile and extended 7,000 ft. toward the city, the remaining portion of the supply main being of iron.

At the lower end of the vitrified pipe was placed an open topped stand pipe rising to 3 ft. higher than the water in the lake reservoir. The use of the stand pipe was to lessen any shock of water ram that might possibly be reacted from the iron pipe back toward the reservoir.

This conduit is a Scotch clay vitrified pipe of 24 ins. diameter. Its joints are covered with wrought-iron sleeves packed with Portland cement. This conduit has been in use about twenty years under an average of reservoir pressure of 15 ft. head with satisfactory results.

MR. WADSWORTH:—In improving the water supply of a town in 1871, I ran across two wood mains of common size 6 ins. in diameter. These pipes were perfectly sound, except about 1 in. on the outside. I was told by some of the oldest inhabitants that they were laid 80 or 90 years ago and had been in use up to 20 years ago. They ran

1,000 ft. toward the mountain. These pipes, as far as I could see, were as ready to bring water as they ever were. Joints were butt or socket style.

Mr. Diven:—We have wood pipe put in in 1860, under a pressure of 60 lbs., which is giving entire satisfaction.

President Fanning:—One of the conditions of the successful use of wooden pipes underground seems to be that the soil shall be constantly moist and one which is perfectly free from the circulation of air. In removing an old bridge from one of the New England streams we found that the sills on which the old pier or abutment originally rested, had evidently been laid in the ground at a low stage of the water. They were just on the water surface when we took them out. When they had been removed I took a chip from one of them which showed the wood to be in an almost perfect state of preservation, and I now have it as a curiosity. Upon investigation I found that the sills were put in about 100 years previous. The fibre was but slightly soiled, and was nearly as tough as that in new wood.

Mr. Darling:—I would say, that circumstances may allow putting in wooden pipe, or one of the various other kinds of pipe which have been brought forward; but, I believe, that if you live anywhere near a foundry where they make pipe at a reasonable price, and of good quality, the most practical pipe that you can put into the ground is cast-iron pipe.

The President:—The next in order is a paper by Mr. H. W. Ayres, of Hartford, Conn.

Mr. Ayres then read:

## *THE CONSUMPTION OF WATER BY CITIES AND TOWNS.*

The actual average daily amounts of water used and wasted, by American cities and towns, at the present time, especially as reduced to a per capita basis, is a difficult matter to determine. As might be expected, returns from the smaller cities and towns are usually less reliable, and show wider differences than those of larger, more wealthy and consequently usually better equipped and managed corporations. Moreover, local causes produce more conspicuous results where the plant is small and the area of distribution limited From a careful examination of reports and other authentic sources, I find that many towns, with a population of about 5,000, supply from 20 to 100 or more gallons per day to each inhabitant, fairly representa-