SPECIAL REPORT.

OFFICE OF THE CITY WATER WORKS,
Baltimore, June 2d, 1862.

To the Chairman and Members of the Water Board.

GENTLEMEN: The New Works being virtually completed and in successful operation, I have the honor to submit to the Board the following special report, in fulfillment of the duties which their construction has imposed upon the Engineer Corps, whose professional labors are now brought to a close.

To aid the written description of the natural features of the country occupied by the lake and traversed by the aqueduct, an accurate topographic map thereof has been prepared and is hereto appended; upon which is also laid down a longitudinal section through the entire line of aqueduct between the lake and the northern boundary of the city.

Although my monthly reports and estimates have kept the Board fully advised of the progress and details of the Works ever since their construction was commenced—early in the year 1858—yet the repetition of much that has been already said in regard to them is absolutely necessary to the purposes of a final review of the whole subject. This design also compels a reference to the history of this enterprise anterior to the date (February, 1858) which marks my earliest official connection therewith; and leads me to present a brief review of the still earlier history of the Company, to whose enterprise the people of Baltimore were so long indebted for their only supply of hydrant water, and from whom the city

finally purchased the property and water privileges which now constitute a large portion of the existing City Water Works.

From the official records of the late Baltimore Water Company (which, through the courtesy of their President—Gen. Columbus O'Donnell—I have been permitted to examine) are gathered the following interesting facts in relation to

THE OLD WATER WORKS.

It appears that as far back as the year 1804, certain public spirited citizens formed an Association for the purpose of "Introducing a copious supply of wholesome water into the city of Baltimore," and applied to the State Legislature for an act of incorporation, under the title of "The Baltimore Water Company."

A charter was immediately granted, but, on account of objectionable restrictions, it was not accepted, and the Company proceeded with the business of their undertaking by effecting a purchase from Messrs. John Eager Howard, Josias Pennington and James Ogleby of several parcels of land, embracing the water privileges of that part of Jones' Falls which lies immediately above and below the present Eager street bridge.

All these transactions took place in the latter part of the year 1804, when the Company was represented by the following named gentlemen: Mr. John McKim, President, and Messrs. William Cooke, John Donnell, Solomon Etting, Jas. A. Buchanan, Jonathan Ellicott, and James Mosher, Directors.

Having secured the services of an Engineer, (Mr. John Davis, of Philadelphia,) the Company proceeded to construct their water works in the following year; and in June, 1805, contracted with Samuel Hughes, of Harford county, for a supply of cast-iron water pipes, of various calibre, varying from 2½ to 6 inches, at prices also varying from $65 to $80 per ton.

In November the application for an act of incorporation

was renewed, but the apparent improbability of their being able then to obtain the necessary authority from the State, impelled the Company to appeal to the Mayor and City Council for a grant of the privilege to "open streets, lanes and alleys for the purpose of laying down water pipes."

In December a conference was held between the Directors and a Committee of the Council in regard to the purchase of the Company's stock by the city, but nothing definite arose therefrom, and in February, 1806, the privilege to lay down pipes in the streets was granted by city ordinance.

Previous to the month of May, 1807, the Company appears to have furnished no water to the city, except a small amount which was supplied by natural flow directly from Col. Howard's spring; but in this month the pumps which had been erected at the intersection of Centre and Calvert streets were put into successful operation, and thenceforward water was obtained from Jones' Falls, and furnished to the city, almost exclusively through this process of artificial elevation into reservoirs of various heights, ranging from 65 to 136 feet above tide-water.

Up to December, 1808, the Company did not succeed in obtaining a desirable form of charter, but in that month the Legislature granted a suitable one, and it was forthwith accepted.

In 1811 the income from water rents amounted to nearly $9,000 per annum, but from this period till the year 1830 the increase of the Company's receipts from this source appears to have been very gradual, and consequently their works did not require much improvement or extension.

In 1830 the subject was again agitated in the Council in relation to the purchase of the Works, and the Company offered to sell them to the city for the sum of $350,000; but this offer was not accepted, and the official discussion of the matter was again suspended till January, 1833, when, in response to a renewed application by the City Council, the Company (having in the meantime enlarged their water privileges by the purchase of Salisbury Mill, and expended large sums of money in the construction of a new pump-house

and reservoir) increased their demand to $500,000, and in consequence the negotiations for a transfer of the Works from private to public trust were once more suspended. At this date the whole number of supplies charged on the books of the Company amounted to 2,164, and the annual income therefrom was $21,300.

In February, 1835, the Company was again approached by the City Council in relation to the purchase of the water works, but after some correspondence had taken place between the parties, and the former had offered to sell their interests for the sum of $550,000, these negotiations were brought to a close in the month of April following by a withdrawal of the Company's offer.

At this date there were about eighteen miles of pipes laid down in the streets of the city—one-fourth of which was of the old defective pattern, of cast-iron—one-fourth of wood, and the remainder of iron, of the improved pattern of the present day. The annual receipts from water rents were $25,500.

From the year 1835 to 1852 the demand for water appears to have increased quite rapidly, and the Company seems to have kept pace with the demand by purchasing additional water privileges in the valley of Jones' Falls, erecting new pumps, building new reservoirs, and extending their system of supply pipes throughout the city, so that in the last named year the income from water rents amounted to $80,000.

At this time, in reply to a fifth application upon the part of the city, the Company proposed to sell the Works for $1,250,000, and although this offer was not accepted, it formed the basis upon which negotiations were again resumed in 1853, and finally concluded in August, 1854, by a formal transfer of the entire works into the hands of the city authorities for the sum of $1,350,000.

This sale embraced not only the Water Works proper, but likewise several large mills and much valuable real estate which had been incidentally purchased by the Company in the acquisition of its water privileges and reservoir sites.

At the date of the sale, the Water Works proper consisted

of two small pools of water in the valley of Jones' Falls, which were formed by the original dams of the Mount Royal and Rock Mills, and from which the whole supply of water for the city was conducted in large iron mains to a receiving reservoir located within the city limits on the east bank of the Falls a short distance below the Charles street bridge. From this reservoir water was distributed to those points of the city lying below a level of 60 feet above mean tide, by direct gravitation—but for the higher portions it was raised thence by means of pumping machinery, into a second reservoir, situated at the intersection of Charles and Chase streets, and from this point distributed to all other elevations not exceeding a height of 136 feet above tide.

The distributing pipes were almost exclusively of iron, and the extent of their net-work throughout the city was about fifty miles.

The joint capacity of the two reservoirs was only twenty-five millions of gallons, and that of the two mill-pools which could be made available did not exceed ten millions more—consequently the water furnished to the city was seldom entirely free from earthy impurities, and frequently quite turbid, from the effects of rain storms.

Although the investigations of the subject which were made under the authority and direction of the Mayor and City Council in the years 1852 and '53, led to the purchase of the old Water Works, as a preliminary step towards the accomplishment of the great purpose of furnishing all parts of the city with a full supply of wholesome water at the public expense—and notwithstanding the fact that the various examinations and surveys, which were made by several competent engineers, (who were acting under the same authority,) already clearly demonstrated the practicability of introducing an abundance of excellent water from any one of several distinct sources of supply, at a reasonable cost, yet nothing decisive was done till the year 1857.

Early in this year, the administration of the Water Department was formally reorganized by the creation of a Board of Water Commissioners, who were authorized and

directed by the ordinance defining their duties, "To provide for an increased supply of water to the city of Baltimore from Jones' Falls." Having fully investigated the subject and selected a plan, the Board proceeded at once to make all the purchases and condemnations of land and water privileges necessary to the construction of

THE NEW WORKS.

The plan selected was the one recommended in the previously published report of Mr. James Slade, which contemplated the introduction of water from Jones' Falls at a height of 220 feet above mid-tide, by natural flow only.

During the summer and autumn of 1857, my predecessor (Mr. Wampler) under the general directions of Mr. Slade (who acted as Consulting Engineer) made all the surveys required in the process of a final location of the lake and conduit line, and defining the boundaries of the property acquired by condemnation or purchase.

Having concluded these preliminary arrangements, the Board dispensed with the services of Mr. Wampler, and in February, 1858, appointed the undersigned to the chief professional charge of the works, with instructions to build them according to the original design of Mr. Slade, and such modifications and improvements thereof as later experience might induce him to propose, or others to suggest and the Board approve.

Thus the work of construction was fairly commenced in the early part of 1858, and at once prosecuted by active preparations for its execution by public contract. The three principal tunnels of the conduit line were placed under contract and their excavation was commenced in the month of April of the same year.

Instead of pursuing the history of the New Works in the chronological order hitherto adopted, it is deemed more suitable to the main object of my present report, that the details of the plan, progress and cost of their construction should be exhibited in distinct views of the several parts, according

to the order of their natural divisions; therefore I proceed with their presentation in the following form:

THE LAKE.

This sheet of water is entirely artificial, and was formed by the erection of a dam across the valley of Jones' Falls, in a narrow pass, near what is commonly known as the Relay Station of the Northern Central Railway, whereby the flow of that stream was arrested and its waters forced to accumulate in the natural basin into which the valley expands immediately above the dam.

In addition to these natural features, which are so favorable to the formation of a large retaining reservoir, the prominent natural feature of this basin consists in its being the point of confluence for the entire water shed of the valleys of Bowen's Mill Run from the East, Roland's Run from the North, and Green Spring (which forms the head of Jones' Falls) from the West.

The original design did not provide for any great alteration of the natural bottom and margin of this basin, and, apart from the dam, the estimated cost of the earth and stone work necessary to its improvement did not exceed $15,000; but maturer reflection dictated the necessity of excavating all the higher portions of the bottom to a uniform depth of ten feet below the artificial water surface, in order to prevent the growth of aquatic plants, and thus cut off the most prolific source of the impurities to which all placid and especially shallow bodies of water are more or less liable during the extreme heat of summer.

This excavation of the bottom extended over an area of about fifty acres, and the material, which was largely composed of sand and gravel, was used in the formation of a marginal embankment. All vegetable and other perishable matter that would be apt, in any way, to affect the purity of the water, was likewise removed from the entire area of the bottom and sides of the basin—not only below the line of high water, but for a distance of several feet above it.

This work being completed, the lake was brought into partial use in the month of February, 1861; but since the 20th of April following, the city has been supplied exclusively from this source.

The practical experience of the past year has already disproved nearly all that had been previously asserted in opposition to the arguments which were favorable to the introduction of water from Jones' Falls, and among other developments, has clearly shown that the present inhabitants are furnished with an abundant supply of wholesome water throughout all seasons of the year.

Guagings of the stream which were made and reported by Mr. Slade, in 1852, coupled with those which have been made in the lowest stages of water that have occurred in the past four years, also establish the fact that even in seasons of unusual drought, the daily influx of water at the lake is double the amount of the present daily requirements of the city; consequently it is reasonable to assume that the supply from this source will meet all the wants of an increasing population for twenty years to come; and after that period remain as an important auxiliary to any system of Water Works that the necessities of a coming generation may demand.

The experience of the past year developed no kind of impurity in the lake water beyond that which occasionally arises from the effects of heavy and protracted rain storms, and from which it is impossible to guard any like body of water that, from its natural location in a deep valley, is the necessary receptacle of many square miles of surface drainage—but this evil can be mitigated, if not entirely remedied in the present case, by the construction of additional distributing reservoirs, until their united capacity shall equal a twenty days' supply for the present population, and thenceforward keep pace therewith according to its periodical increase. Even with the present reservoir capacity of only ten days' supply, (independent of the lake,) the necessity for an introduction of water in a turbid condition has occurred but twice during the past fifteen months, and, with careful

management, it is presumed that such necessity need not occur again till the close of next winter, when the release of frost from the surface of the earth, and the advent of copious and long continued rains, accompanied by high winds, will undoubtedly cause a repetition of the nuisance.

So long as the requirements of the city do not equal the minimum influx of water to the lake during the heat of the summer months, and a small surplus continues to flow over the crest of the dam, it is also presumed that the surface of the lake will be free from the accumulation of infusoria, such as have occasionally been a source of considerable annoyance to the consumers of the Croton and Cochituate waters. But even if the lake should not be entirely exempt from pollutions of this nature, for a few days in every year, the results of experience and scientific investigation in similar cases have already proved that the infusoria produce no unwholesome ingredient, and merely impart to the water the unpleasant "fishy" taste and odor which form the only subject of general complaint.

It is believed that a daily agitation of the surface of the lake by artificial means, during very hot, dry, and calm weather, would effectually prevent the formation of this disagreeable scum of animalcules.

Although the original design of construction did not contemplate the necessity of protecting the shores of the lake from the abrading effects of the water while agitated by high winds, it was always evident that certain exposed parts would soon require a protection of stone rip-rap, and eventually that all other portions of the water margin which are composed of loamy material, should be protected by a coating of coarse gravel.

As this work was not provided for in the original contract for the construction of the lake, and as it could be more cheaply and conveniently done by means of boats, after the basin should become filled with water, and its shores washed down to a narrow belt of shelving beach, its execution was not commenced till late in the past year, and is still proceeding under the directions of the Water Engineer of the

city, into whose charge the operating portions of the new works were consigned, by order of the Board, on the first of January, instant.

When the lake is filled to the point of overflowing, the height of its surface is 225 feet above mean-tide at Baltimore; and the area thereof is 116 acres. The extent of its capacity is computed to be five hundred millions of gallons, (wine measure,) and of this amount four hundred millions of gallons can be drawn off and conveyed to the city by means of the aqueduct.

The following statement embraces the cost of all contract and other work that has been done under my personal direction, and a large proportion of the rip-rapping and other improvements which have been executed since their control passed from my hands.

COST OF THE LAKE.

Graduation.—Clearing and Grubbing, ($150\frac{6}{10}$ acres)	$10,542 00
Excavation and removal of earth and rock, and formation of embankment, (281,394 cubic yards, at average price of $0.24\frac{1}{10}$.)	68,809 18
Masonry.—Culverts and the abutments of carriage road and railway bridges, (2,924 perches, at average price of $\$9.16\frac{3}{10}$.)	26,793 08
Bridging.—Superstructures for carriage roads only	2,844 98
Fences.—Enclosing lake and marginal possessions	3,763 31
Total	$112,752 55

The construction of the lake was commenced in the spring of 1859, and, though then incomplete, it was made available for practical service before the close of the year 1860.

THE DAM.

Mr. Slade's original design was to form this structure principally of earth, and to protect it with a sheathing of stone—the manner of construction being in the language of his published report, as follows:

"The dams at the lakes will be carried up 5 feet above high water mark in them. They will be 20 feet wide on top; the inner slopes will be three to one; the outer slopes two to one. The inside slope will be faced with stone from the top of the bank to 14 feet below high water. A portion of the dam of 150 feet in length will be sunk 5 feet below the rest of it, which will make an overfall for the surplus water of the streams. This overfall will be of stone on its bottom and sides. It will continue down on the outside of the dams, and be continued 700 feet to another low dam, over which the water will fall to a rubble apron way, from which it will flow into the bed of the stream, without wearing it away."

"Between the two dams a pool of water will be made to break the force of the surplus water as it flows over the principal dam."

"In the middle of the dams a puddle wall of earth will be built, which will be 10 feet wide at the top, and increase 10 feet in width for every 10 feet in depth, below the top of the dam. The outside of the dams, each side of the overfall, will be sodded."

As before mentioned, the site which had been selected for the dam was in a narrow part of the valley; and, as the proposed work was to be of unusual magnitude, the difficulties and danger which always attend such operations were greatly enhanced in this case by the want of sufficient space in which the construction of the dam could be carried on, without confining the stream to dangerously narrow limits during the progress of the work.

In addition to the difficulties and danger thus to be encountered throughout the period of its construction, still

greater hazard to both life and property was to be apprehended from a possible breach in the dam after its completion; therefore as a small breach in the stone sheathing of an earth dam would be almost certainly followed by a rapid demolition of the entire structure, and the consequent sudden discharge of the accumulated waters of the lake into the valley below, the original plan of construction was finally abandoned and that of the present stone dam substituted therefor.

One of the natural features of the locality, peculiarly favorable to the adoption of this plan, was the presence of a solid rock formation across the entire valley, at a depth varying from five to ten feet below the natural surface, into which the foundations of the masonry were sunk to a depth of two or three feet, and upon which imperishable basis the whole structure has been erected.

The overfall of the dam has a clear water way of 120 feet in width, and is flanked by wing walls which rise 6 feet above its comb or crest. The core of the overfall and the greater portion of the wing walls are formed of heavy rubble work, but the exterior of the gate chambers, the side walls and face of the overfall, and all other exposed parts of the dam, are made of large blocks of cut stone—called rock ashlar work—the interior of the gate chambers and the shell of the gate house alone being composed of fine cut or dressed ashlar work. A large portion of the rubble stone was obtained from the rough granitic rock of the neighboring hill sides; but all the cut work was made of lime stone, principally obtained from the extensive marble quarries at Texas, in Baltimore county.

The height of the masonry of the overfall from base to crest is 40 feet, while that of the wings varies from 46 feet down to 1 foot. The rear of these walls is perpendicular, but the front or face of the overfall is inclined and curved in such a manner as to shed the greatest floods without producing any violent concussion or regurgitation. From the rear to the toe of the overfall at its base the masonry is 60 feet thick, and at no point in the overfall or wings is the

masonry less in thickness than one-half of the height of the superincumbent mass.

The wings are entirely enclosed in heavy earth embankments, and the rear of the overfall is protected in the same manner—a portion of this earthwork, immediately in contact with the masonry, being formed of puddled clay.

The gate chambers consist of two distinct apartments, the floors of which are at the respective heights of 201 and 210 feet above tide—or respectively 24 and 15 feet below the crest of the dam, and the usual surface of the lake. The lower chamber is provided with gates which regulate the discharge of water through the waste flume, and by means of which the lake can be drained to the bottom. The higher chamber is provided with gates by which the flow of water into the conduit is regulated; and another gate for occasional use, when a connection between the waste and conduit chambers may be needed.

The gate chambers are enclosed by a substantial stone house, upon the floor of which are placed the screw-stands of the several gates.

On the lake shore, a few hundred feet above the gate house, a small frame cottage was also built for the accommodation of the gate keeper.

All the masonry of the dam was carefully laid in full beds of fresh hydraulic cement mortar, and, where necessary, thoroughly grouted with the same material.

COST OF THE DAM.

Graduation.—Excavation and removal of earth and rock from the foundations, and the formation of backfilling and other embankment, inclusive of puddling, 56,071 cub. yds., at av. pr. of $47\frac{6}{10}$ cts.....	$26,670 90
Masonry.—All kinds—inclusive of the dressed work of the gate chambers—13,680 perc's, at av. pr. of $\$8.06\frac{2}{10}$.....	110,284 99
Amount carried forward.....	$136,955 89

Amount brought forward.....		$136,955 89
Gate House.—Superstructure.....	$4,558 25	
Gates and other brass and iron work.....	8,497 84	
		13,056 09
Cottage (for gate-keeper) and other incidentals.....		2,178 67
Total.....		$152,190 65

This work was placed under contract late in the Autumn of 1858; but its construction was not fairly commenced till the following Spring. By the latter part of the year 1860 the work was sufficiently advanced to admit of its being brought into practical use, and before the close of the following year was thoroughly finished.

The graduation and masonry of both the lake and dam were executed by the same parties, under two distinct contracts and business firms; the contractors of the lake being Messrs. Crowley, Hoblitzell & Co., and of the dam, Messrs. Hoblitzell, Crowley & Co.

THE CONDUIT LINE.

This commences at the upper gate chamber of the dam, and extends towards the city, along the eastern slopes of the valley of Jones' Falls, for a distance of $3\frac{6}{10}$ miles to an elevated point about a mile and a half from the northern limits of the city, where it terminates in the Hampden Reservoir.

In addition to the ordinary breaks which are produced by the smaller lateral valleys of tributary rivulets, the slopes of this portion of the main valley are very much broken by the repeated occurrence of large spurs and intervening coves; consequently, in order to keep the floor of the conduit upon a uniformly descending plane of only one foot per mile, the construction of this work has involved an unusual amount of tunneling and heavy embankment for so short a length of line.

Presuming that very hard rock would be encountered in all the tunnels, and that the excavation of these portions of the line would be especially difficult and tedious, the three principal tunnels were placed under contract (as before stated) in the month of April, 1858, and thenceforward prosecuted with vigor, both by day and night.

In the month of June following the remainder of the graduation, (including several short tunnels,) and all the masonry of the conduit line, (except the brick work,) were placed under contract, and two months thereafter contracts were made with several parties for the manufacture and delivery of six millions of bricks for the conduit.

Contrary to all anticipations, very little hard rock was met with in any of the excavations—either of tunnels or open cuts—consequently the work of graduation proceeded with such unexpected rapidity that several of the approach cuts of the three principal tunnels were prepared for the reception of the brick work as early as the month of September; and forthwith the construction of the conduit was commenced at these points.

Before the close of the year 1858 two of these tunnels were thoroughly excavated, and by the 1st of April, 1859, (less than twelve months from the date of its commencement) the entire excavation of the third one was completed.

The length of these three tunnels was respectively 1,000, 1,225, and 2,950 feet—and in the aggregate, 5,175 feet, or nearly one mile!

The building of the conduit, which was commenced in September, 1858, was diligently prosecuted at all points where the open cuts and embankments had been prepared for its reception, till the advent of winter compelled the stoppage of such work in the open air; but throughout the winter it was carried on, both by day and night, in each of the three long tunnels.

By the 1st of January, 1860, just twenty months from the date of its commencement, the whole conduit line was virtually completed.

The conduit (which is an exact copy of that of the Cochituate Water Works) is oval in shape, and made exclusively of bricks cemented by hydraulic mortar. The bricks are laid in two concentric rings, each being four inches in thickness, and covered on its exterior with a coating of mortar one-half an inch thick, thus forming altogether a shell of nine inches in thickness. The lower half of this shell is an exact semi-circle, and the upper a semi-ellipse; the interior dimensions of which, when combined, give a height of 6⅓ feet, a width of 5 feet, and an area of cross section equal to 24¾ square feet.

At the point of its departure from the dam the floor of the conduit is coincident with that of the upper gate chamber, and is therefore 15 feet below the usual surface of the lake; yet by means of the intervening gates, which regulate the influx of water, the conduit is preserved from any greater depth of submersion than is necessary to the maintenance of the high water level in Hampden Reservoir—and as this level is 8 feet lower than that of the lake, the depth of back water in the gate chamber never exceeds 7 feet.

At its terminus in the reservoir the floor of the conduit is 11½ feet below the surface of high water; consequently the average depth of its submersion, from end to end, is equal to 9¼ feet.

This constant submersion of the whole conduit is necessary to the accomplishment of the original design to make nearly all the reserved water in the lake available in seasons of extreme drought, and also to maintain in the distributing reservoir the highest water level that a due regard to the safety of the conduit would justify.

In order to keep the water from rising above the prescribed level, and to prevent any undue waste thereof in dry seasons, a sufficient waste weir has been made in the conduit immediately below the dam, by which all surplus water is readily and safely discharged, and through which reliable means the gate-keeper, at that point, can, at all times, easily ascertain the existence of any necessity, either to diminish or increase the influx from the lake.

A second but smaller waste weir has been made in the conduit, about midway between the dam and the reservoir, over the top of which a portion of any surplus water will find ready vent; and through the gates with which it is provided, water can be at all times discharged from the lowest part of the conduit, in case it should be desirable. The chamber of this waste weir is covered by a small house, built of marble.

In all the tunnels and open cuts, the brick work rests upon the natural materials—whether rock or earth—in which the excavation was originally made; but in all the embankments the conduit is supported on a continuous wall of rubble stone, laid in full mortar. The top of this wall is invariably ten feet broad at the level of the bottom of the brick work, and increases in thickness downwards to its base, at the rate of one foot for every five feet of the whole height.

The largest of these support walls contains nearly ten thousand perches of masonry.

To facilitate the operations of repairing and cleaning, suitable man-holes have been made in the top of the conduit, throughout its length, at intervals not exceeding a quarter of a mile, except a single omission, (occurring at the longest tunnel,) where the interval is necessarily trebled. The locality of each man-hole is marked by a small index stone, of pyramidal shape, which is planted in the top of the backfilling, immediately over the slab which covers the mouth of the aperture.

The impossibility of accomplishing a thorough inspection of the brick work in the tunnels, if built by contract, and the necessity of having all portions of this work executed with the greatest possible care and skill, led to the organization of a large force of mechanics and laborers, and their employment "*by the day*," instead of "*by the job*," as the best means of effecting the desired object. This force was divided into several distinct parties, each of which was placed under the immediate superintendence of a master-mechanic, while their joint operations were directed and governed by the engineer corps.

A large proportion of the excavation of the longer tunnels was accomplished by means of shafts, which were sunk perpendicularly from the surface of the earth to the bottom of the horizontal drifts, at intervals of 550 feet. These shafts being provided with all the requisite machinery for hoisting the excavated material, and, where necessary, for pumping water; they were also made available in the construction of the conduit, and were the principal means of expediting the most tedious and difficult portions of the whole work. Upon the completion of the brick work all the shafts were refilled.

Necessarily a few of the open cuts, at various points on the line of the conduit, were also refilled to the height of the original surface; but as a general rule the backfilling of the cuts was not permitted to exceed the height of the intervening enbankments, which height was fixed at four feet above the top of the conduit.

More or less water was encountered in all the tunnels, but no considerable impediment to the prosecution of the work was caused thereby, except in the two longer ones, where the flow from several large spring veins was so copious that neither the excavation nor brick work could be carried on without incessant pumping.

For many reasons the entire exclusion of the springs from the conduit was deemed advisable—therefore in order to prevent the water, thus excluded from the interior, from following the "lead" of the exterior, and washing out the packing of puddle material which surrounds the upper half of the conduit, and likewise the backfilling in the approach cuts, transverse walls of brick masonry, about eighteen inches in thickness, were built entirely around the conduit, and into corresponding grooves excavated from the interior surface of the tunnel, near each end of the latter, and at intermediate intervals of its length, from two to three hundred feet apart—thus forming a succession of collars or flanges, which have proved to be perfectly efficacious bars to any longitudinal flow of the pent up springs.

The timber work which was necessarily used to support

the roof of nearly all the tunnelling, was not removed, except at the points where the collars of masonry were built, but was securely enclosed into the packing material, which encases the upper part of the conduit, where it can produce no possible injury to the conduit even if eventually it should decay.

From the day that the conduit was completed up to the present time, not a single fracture has been discovered throughout its length, and although the almost imperceptible filtration of water through the delicate pores of the solid brick and cement work (commonly called "sweating,") precludes the assumption that it is literally impervious to water, yet practically speaking it has thus far proved to be a perfect aqueduct of its kind.

The contractors engaged upon this work were as named in the following list:

F. C. Crowley—graduation and stone masonry of Hampden tunnel and approaches.

John W. Maxwell & Co.—graduation and stone masonry of Buchanan tunnel and approaches.

Jas. H. Hoblitzell & Co.—graduation and stone masonry of all other portions of the line, including the Harper and all the short tunnels.

Robinson, Bros. & Co —over two millions of bricks.

Henry Wilson—three hundred and fifty thousand bricks.

Daniel Donnelly—three hundred thousand bricks.

Meyer Steigerwald—four hundred thousand bricks.

John L. Reese, Jr.—over one million bricks.

James M. Lester—nearly two millions of bricks.

COST OF THE CONDUIT LINE.

1. In Tunnels.

Graduation.—Excavation of tunnels and their shafts, 15,153 cub. yds., at av. pr. of $8.87 3 ..... $134,415 19

Amount brought forward.....		$134,415 19
Conduit.—Bricks delivered, inspected and piled, 2,067 M, at av. pr. of $12.15 1/8.....	$25,133 01	
Cement, 48,367 bus., at av. pr. $0.34.....	16,445 00	
Sand, 1,277 cub. yds., at av. pr. $1.50.....	1,915 00	
Tools, lumber, &c., (including engines and pumps).....	5,539 46	
Oil, lamps, &c. (2,880 gals. oil)..	3,077 38	
Labor of laying conduit, (superintendents, bricklayers, laborers, carpenters and masons)...	44,383 68	
Labor of packing between the arch and the sides and roof of the tunnels.....	3,385 50	
		99,879 03
Tot'l 6,348½ lineal ft. in tun's at av. pr. $36.90½..		$234,294 22

The brick work alone averaged, per foot, $15.73⅓, in tunnels.

2. Outside of Tunnels.

Graduation.—Excavation of earth and rock, and formation of embankments, 200,472 cub. yds., at av. pr. of $0.45 1/8.....		$91,339 08
Masonry.—Culverts, 2,254 perches, at av. pr. of $5.40⅓.....	$12,179 22	
Support wall, (under the conduit in embankm'ts,) 16,262 perc's, at av. pr. of $3.97 1/8.....	64,696 48	
		76,875 70
Waste Weir of Conduit.—Masonry of gate chamber, 86 perches, at av. pr. of $11.05 1/8.....	$ 951 00	
Superstructure.....	1,552 50	
Gates, other brass and iron work,	1,445 50	
		3,949 00
Amount carried forward.....		$172,162 78

Amount brought forward.....		$172,162 78
Conduit.—Bricks delivered, inspected and piled, 4,104,390, at av. pr. of 12.39\frac{3}{16}$.....	$50,866 95	
Cement, 71,155 bus., at av. pr. of $0.34.....	24,192 63	
Sand, 1,843 cub. yds., at av. pr. of $1.50.	2,765 00	
Tools, lumber, &c.....	4,316 48	
Labor of laying conduit, (superintendents, bricklayers, laborers, carpenters and masons)...	47,740 29	
		129,881 35
Total, 13,706½ lineal feet outside of tunnels, at av. pr. of 22.03\frac{3}{3}$.....		$302,045 13

The brick work alone averaged per foot 9.50\frac{1}{2}$, outside of tunnels, not including 40 feet in length of stone waste weirs, (13,666½ net length). Total cost of Conduit Line, (inside and outside of tunnels,) $536,339 35.

A general comparison of the leading features of cost, as above stated, with the deductions made from the estimates presented in Mr. Slades' published report, (before alluded to) gives the following results.

The average cost per cubic yard of the tunnel excavations (including shafts and timber work,) is sixty per centum less, and that of all other graduation twenty-five per cent. less than was originally estimated for those items.

The average cost per perch of the culvert masonry is ten per cent. less, and that of the support walls one hundred per cent. greater than the original estimate.

The average cost per lineal foot of the conduit alone (including packing, &c., in tunnels,) is fifty per cent. greater than was first estimated, but the cost per lineal foot of the entire line (embracing all the above mentioned elements of construction,) is not quite three per cent. less than the average of the original estimate.

In order to give room for the timber supports outside of

the space required for the brick work, all the tunnels were increased in size from an area of 45 square feet to that of 60⅛ square feet. This increase of size, together with an increase of length in the three tunnels originally designed, and a substitution of several short tunnels in lieu of deep cuts, doubled the quantity originally estimated for this description of excavation; but, as compensation for this increase, the aggregate amount of all kinds of excavation was diminished fully forty-five per cent.

The amount of culvert masonry has been reduced about thirty-three per cent., but the amount of support walling has been increased fourteen per cent.

THE HAMPDEN RESERVOIR.

This is located on the Falls Turnpike near Hampden village, and immediately east of Druid Hill Park, from which latter it is separated by the valley of Jones' Falls.

Its shape is a perfect semi-circle; the radius of which is 500 feet in length, and the chord of its arc, which forms the straight side of the reservoir, towards the turnpike, is 1000 feet long.

This form was selected not only as the best adapted to the peculiar natural features of the locality, but also as the most suitable for a contemplated necessary extension of the present reservoir to a still greater capacity at no distant day.

In view of this necessity, the entire plan contemplates the addition of an exact counterpart to the existing semi-circular basin, and the retention of the present straight side as a division embankment between the two halves of what would then become a reservoir of perfectly circular form; the construction of which would, of course, involve the farther necessity of diverting a few hundred feet of the turnpike from its present course to a more circuitous one around the eastern half of the improvement.

The greater portion of the present basin is formed by a deep excavation in the natural surface—the remaining

smaller portion consisting of an artificial embankment of earth.

In order to make the excavated parts perfectly water-tight the sides or slopes thereof are covered with what is technically called a "lining," which consists of puddled clay, three feet thick, covered by a coating of gravel two feet thick, and over all a protecting pavement of stone eighteen inches thick. The interior slopes of the embanked parts are treated in a similar manner, but for additional security against leakage the core of these is made exclusively of puddled clay, which forms a perpendicular wall, varying in thickness from five feet at the top, to ten, twenty, and thirty feet at its base, according to the height of the embankment above the natural surface, into which latter the puddle wall is sunk to a depth of several feet.

The original design was to cover the bottom in the same manner as the interior slopes of the basin; but in the present case only two-thirds of the superficial area have been paved with stone—the remaining third of the bottom puddle lining being protected by an increased coating of gravel.

The sides of the excavation and embankment are sloped towards the interior of the reservoir, at the uniform rate of six feet horizontally to every four feet of the vertical descent from top to bottom, while the exterior of the embankment is formed to a flatter slope of six to every three feet.

The top of the embankment is uniformly fifteen feet in width, and three feet above high water mark—and wherever the hillside rose above the top of the embankment, a bench was excavated therein to a uniform width of fifteen feet from the margin of the basin, and a corresponding level with the embankment, thus affording a convenient pathway around the entire reservoir.

The depth of the basin is uniformly 23 feet, and that of the water 20 feet, when at its highest mark which is (as before stated) 217 feet above mid-tide.

The superficial area at the margin is $8\frac{1}{8}$ acres—at the line of high water mark $7\frac{7}{8}$ acres—and on the bottom $6\frac{1}{4}$ acres.

Up to high water mark its capacity is 46,365,875 gallons,

(wine measure,) but as the conduit, which has a capacity of 3,712,500 gallons, is necessarily full of water whenever the reservoir is filled, its capacity is rated in round numbers at fifty millions of gallons.

The terminus of the conduit line proper is in a small stone chamber on the north-west side of the reservoir, where the water from the lake is usually discharged directly into the basin of the reservoir; but the conduit itself is extended from this influent chamber around the circular side of the reservoir into the chamber of the effluent gate house, which is situated on the south side of the basin.

The influent chamber is so arranged that the flow of water into the reservoir can be arrested at any moment, (by the simple means of stop-planks,) and turned through the lateral extension of the conduit in the effluent chamber; and as the latter can be readily cut off from all communication with the reservoir, the city by this means can be supplied with water directly from the lake, without any necessary interposition of the reservoir.

The effluent chamber is furnished with a screen of copper wire, the meshes of which, being about one-eighth of an inch square, are fine enough to arrest the passage of very small fish, and all substances that could possibly choke the smallest service pipes in the city.

This screen is an endless sheet of net work, suspended upon a roller of two feet in diameter across the effluent chamber, from side to side and from top to bottom, and is kept in a perpendicular position by two other similar rollers —one of which rests with its whole weight in the bottom loop of the screen, while the other is placed midway between the top and bottom. The upper and middle rollers are susceptible of no other movement beyond that of a simple revolution upon their axes; but the lower one is so arranged that, in addition to this movement, it is raised or lowered, in a perpendicular direction only, by the least contraction or extension of the sheet of wire netting in which it is suspended.

The common "jack" or "roller" towel, which is to be met

with in almost every public wash room, is a simple but perfect illustration of the form of this screen; and, with the addition of two more rollers placed therein, (as above described,) would as perfectly illustrate the operations of its revolutions. The necessity of an occasional revolution of the entire screen, for the purpose of cleansing it, is obvious.

The effluent chamber is provided with four gates for regulating the discharge of water,—three of which guard the entrances of a corresponding number of distributing mains,—and the fourth one, the entrance of the drain pipe,—the former being placed abreast, on the side of the chamber farthest from the basin of the reservoir and the latter in the passage way for water leading from the basin into the chamber.

This arrangement will permit the uninterrupted use of the drain pipe whenever it may be desirable or necessary to separate the effluent chamber from the reservoir, and use it independently of the latter.

Like the gate chambers of the dam, this one is enclosed by a handsome superstructure of marble, from the floor of which the screen and gates are operated at pleasure.

A small frame cottage is also provided for the gatekeeper of this reservoir.

COST OF HAMPDEN RESERVOIR.

Graduation.—Excavation of earth and rock in basin, and formation of embankment and spoil bank, including puddled core of bank and the gravel and puddle lining of the whole reservoir—447,800 c. yds. at av. pr. of 0.29 $\frac{2}{10}$	$130,555 49	
Masonry.—Stone lining of basin, 15,034 perches at av. pr. of $2.58 $\frac{2}{10}$	$38,909 58	
Influent and effluent gate, chambers, 1,230 perches at av. pr. of $12.09 $\frac{4}{10}$	14,876 25	
		53,785 83
Amount carried forward		$184,341 32

Amount brought forward.....		$184,341 32
Gate House.—Superstructure.....	$4,195 08	
Copper Screen.....	900 00	
Gates and other brass and iron work (including 472½ feet of 30 inch drain pipe).....	12,558 39	
		17,653 47
Gatekeeper's cottage and incidentals (fences, watching, &c.....		4,648 74
Total.....		$206,643 53

This work was commenced in the autumn of 1858, and was completed in the spring of 1861. The contractors were Messrs. John W. Maxwell & Co.

THE PIPE LINE.

This conducts the water from Hampden Reservoir to the northern limits of the city, and is composed of two distinct lines of iron pipes—each thirty inches in diameter—which, being laid side by side in a single trench, form together a direct conduit, seven thousand and one hundred feet long.

As before noted, the chamber of this reservoir is provided with the necessary gates and connections for three separate lines of effluent pipes—but as two of these were more than sufficient to meet the requirements of the original plan of the New Works, the third line was not laid down farther than was necessary to clear a deep cut in which both the effluent and drain pipes are buried immediately upon their departure from the gate house. The present terminus of this third line is indicated by a short piece of thirty inch pipe, which is partially buried, in an erect position, in the back filling of the pipe trench, two hundred feet from the front of the gate house.

Leaving the gate house of Hampden Reservoir and descending the steep slopes of the valley, in a direct course towards Jones' Falls, the pipe line was carried under and

across that stream to the road bed of the Northern Central Railway.

As the bed of the road from the point just noted nearly to the city limits, although graded to a width sufficient to accommodate two railway tracks, was then occupied by one only, and offered the most eligible location for the pipe line that could be found on the west bank of the falls, the right to its use for this purpose was obtained, and the pipes were laid down in a trench excavated therein from the point of their first contact with the road to a point opposite the Mount Royal Mills. From this point the pipe line passes through the embankment to the pipe vault of the Mount Royal Reservoir, and thence under the bed of West Oliver street extended to the intersection of the latter with North Boundary avenue.

In the bed of the railroad the pipes were laid to a uniform depth of four feet below its graded surface.

At all other points of the line they were buried not less than four feet—and ranging from this depth to twenty feet.

In order to secure the pipes from every possible danger to which they might be exposed at the crossing of the falls, they were buried in a trench excavated entirely across the bed of the stream to a depth varying from five to eight feet, and, as the crossing was in an oblique direction and mostly in solid rock, this portion of the work was both difficult and and tedious of execution.

A considerable amount of solid rock was also encountered in other parts of the pipe trench, principally upon the line of the railroad,—but the major part of the excavation was composed of earth and loose rock.

At the highest point in the line on the west side of the falls, the pipes are provided with air cocks, and at the lowest point, with lateral drain pipes and stops. Ready access to these is had by means of man-holes which are placed in the back filling of the trench, and indicated on the surface by index stones.

At the point where the supply pipe of the Mount Royal reservoir diverges from the main line and where one of the

effluent pipes of the reservoir is also connected with the latter, the mains of the pipe line proper are likewise connected, so as to form a network of junctions by which the water can be turned from one line to the other. These links of communication between the several lines of pipes are provided with stopcocks, by which the flow of water from one to the other can be regulated or entirely cut off at pleasure.

This nest of junctions and stopcocks is enclosed in a substantial vault of brick and stone masonry, which is buried in the bank of the reservoir, and forms a part of that work.

All of the pipes which form this line and its lateral branches, were tested before use by submitting them to a hydraulic pressure of three hundred pounds to each square inch of internal surface—and, for experiment, one of them was tested up to a pressure of four hundred pounds without exhibiting the least signs of defect.

The manufacture of the pipes and the excavation of the trench were executed by contractors—the former by Messrs. Poole & Hunt, and the latter by Messrs. John W. Maxwell & Co. The stopcocks were furnished by Messrs. Mayger & Shaffer.

The process of delivering and laying the pipes was accomplished by means of organized forces of mechanics and laborers, who were employed by the day.

The excavation of the trench was commenced in the month of August, 1860, and the entire line was completed and brought into immediate use in the month of February, 1861.

COST OF THE PIPE LINE.

Graduation.—Excavation of earth and rock in trench, and refilling same, 51,808 cub. yds., at av. pr. of 0.47\frac{8}{16}$	$24,758 37
Masonry.—Culverts, manholes, and retaining walls, 480 perches, at av. pr. of 3.29\frac{8}{16}$	1,580 68
Amount carried forward	$26,339 05

Amount brought forward.....		$26,339 05
Piping.—(cost at foundry, including proving)—Straight 30 inch pipes, 14,851½ lineal feet, (net) at av. pr. of $5.59 $\frac{8}{10}$.....	$83,045 61	
Curves and branches, 30 inch, 203½ feet, (net) at $14.31 $\frac{7}{10}$...	2,913 44	
Stopcocks, 3 and 4 way pipes and curves (30 inch) used in vault..	5,001 55	
Small pipes, branches and cocks, and 30 inch sleeves.....	1,190 46	
		92,151 06
Transportation of pipes and stopcocks.....		5,762 57
Tools of all kinds, lumber, coke, rope yarn, &c...		2,768 12
Lead, and hauling same, (87,835 lbs.).....		5,305 50
Labor of laying and caulking pipes.....		8,670 86
Watching and incidentals, (timbering R. R., replacing fences, &c.).....		1,702 98
Total, (15,097½ feet of 30 inch main, at $9.45)...		$142,700 14

This average price of $9.45 includes the whole line, with stops, curves, &c., but an average price of $8.94 will express the cost of the straight pipes as laid.

Some fears were expressed that the joints of the pipes which are laid in the railroad bed would be seriously affected by the tremor that always accompanies the rapid transit of heavy trains of cars; but, although a few feet of the pipe line, where it crosses from the east to the west side of the main track, has been subjected to the severest possible trial of the effects of this tremor for eighteen months, and a quarter of a mile of the line, which is now covered by a side track, has undergone the same kind of practical test for the past three months, yet the joints have remained perfect, and no apprehensions on this account need now be entertained.

THE MOUNT ROYAL RESERVOIR.

This is located on that part of the Mount Royal Mill property which is cut off by the railroad, and lies in the angle

that is bounded on the east by the railroad, and on the south by the avenue which marks the northern limits of the city.

A large portion of the bottom of the basin is formed by an excavation made in the original surface of the ground, but by far the larger proportion of the work consists of embankments, made of material chiefly obtained by grading the adjoining streets.

The mode of constructing the embankment and lining the whole interior of the basin with puddled clay, covered with gravel, and protected by stone paving, was precisely similar to that of Hampden reservoir, with the exception of an entire omission of the bottom paving, farther than a narrow belt ten feet in width around the foot of the interior slope.

The form of the basin is a perfect circle, five hundred and fifty feet in diameter; its depth is 23 feet—and up to high water mark, which is 20 feet above the bottom, and 150 feet above tide, its capacity is thirty millions of gallons. When filled its water surface presents an area of five acres.

The influent branch of the pipe line is carried through the embankment, and terminates at the foot of the inner slope of the latter, in a balance valve which is operated by a buoy that floats upon the surface of the water in the reservoir.

This self-acting apparatus was intended to operate whenever the water should approach the required depth of 20 feet, and thereafter to regulate the influx so as to maintain the water at or near that depth, and prevent the entrance of any surplus.

The practical operation of the valve during two distinct trials of its efficiency was very unsatisfactory, and resulted in a serious breach of one of the mains of the pipe line—therefore its use has been dispensed with till the cause of its irregularity of action can be satisfactorily proved, and a suitable remedy devised and applied. In the meantime the flow of water is exclusively regulated through the stopcocks in the vault, which are operated by manual labor; but as the perfection of the balance valve is still regarded as not only possible, but very desirable, it is hoped that this appa-

ratus may be permitted to remain in its present harmless state, with the expectation of its becoming useful eventually.

The mouth of the drain pipe is placed directly under the terminus of the influent pipe, from which point the former is carried through the embankment underneath the floor of the pipe vault, and thence in a trench down the slope of the hill to the bed of the falls. The stopcock of this drain is placed in the floor of the pipe vault, and within three feet thereof the drain receives the waste pipe, which carries off all surplus water from the surface of the reservoir. The drain pipe is 20 inches in diameter, and the waste pipe 12 inches.

The screen well through which the water passes from the reservoir into city is situated in the centre of the basin.

This is built of stone, lined with brick, and is covered by an ornamental superstructure of iron. The screen is similar to that of the Hampden gate-house. The water enters the well through a gateway in the western side, and passes from it on the eastern through two effluent mains, each of which is 30 inches in diameter. These mains extend across the bottom of the reservoir, from the well to the pipe vault, where both are provided with stopcocks, and one of them forms a junction with the net work of the pipe line, while the other, which is not required for present use, is carried through the vault to the outside of the embankment, and there terminates in the bed of the graded street, about 100 feet south of the pipe vault, whence it can be readily extended into the city without involving any mutilation of the reservoir. The terminus of this independent line is marked by a piece of small pipe, painted red, which is planted opposite to it, on the side of the street.

As the reservoir is supplied with water from a head which is sixty-seven feet higher than its own surface, advantage was taken of this feature to add to its ornamentation by the introduction of a fountain. This is fed directly from one of the mains of the pipe line, through a pipe of eight inches calibre, which taps the former inside the pipe vault, and is carried thence through the embankment and upon the bot-

tom of the reservoir directly to the screen well, through which it ascends to the apex of its superstructure, where the orifice of the pipe is contracted to three inches, forming a single jet of that diameter.

The play of the fountain is regulated in the pipe vault by means of a stopcock, which is attached to the eight inch pipe.

Adjoining the reservoir a neat stone cottage has been erected for the accommodation of the gate-keeper—and the whole work is enclosed by substantial fences.

All the graduation, and the larger proportion of the masonry in and around this reservoir were executed under a contract made with Messrs. Burke & Green.

The masonry of the pipe vault and screen well was built by mechanics and laborers, who were employed by the day; but the iron house which covers the well was erected under a contract with Messrs. Hayward & Bartlett, and the gate-keeper's cottage under another with Messrs. Binyon & Audoun.

COST OF THE MOUNT ROYAL RESERVOIR.

Graduation.—Excavation of earth and rock in basin and borrow pits, and formation of embankments, including puddle core of bank, and the puddle and gravel lining of the whole reservoir—308,234 cubic yards, at av. pr. of $0.23⅓		$71,945 11
Masonry.—Stone lining of basin—4,582 perches, at av. pr. of $3.35	$15,348 61	
Brick and stone work of pipe vault, screen well, &c.; 1,160 perches, at av. pr. of $7.64 5/6	$8,872 17	
		24,220 78
Iron Work, &c.—Ornamental house over screen well	$3,134 33	
Drain and fountain pipes, gate, &c	7,405 32	
	$10,539 65	
Amount carried forward		$96,165 89

Amount brought forward....	$10,539 65	$96,165 89
Copper screen.....	670 00	
		11,209 65
Gatekeeper's cottage, fences, watching, and incidentals.....		4,977 18
Total.....		$112,352 72

The construction of this reservoir was commenced in the month of December, 1859, and completed in May, 1862.

RECAPITULATION.

AGGREGATE COST.

The Lake	$112,752 55
" Dam	152,190 65
" Conduit Line	536,339 35
" Hampden Reservoir	206,643 53
" Pipe Line	142,700 14
" Mount Royal Reservoir	112,352 72
Engineering Expenses	50,030 41
Total	$1,313,009 35

AGGREGATE QUANTITIES AND AVERAGE PRICES.

Graduation—

	Quantities.	Av. Price.
Clearing and grubbing	$202\frac{6}{10}$ acres.	$63.50
Earth excavation	971,909 cub. yds.	$0.19\frac{7}{10}$
Loose rock excavation	209,749 "	$0.45\frac{8}{10}$
Solid rock excavation	78,519 "	$0.70\frac{9}{10}$
Puddling,(manipulat'n only)	85,602 "	$0.18\frac{6}{10}$
Extra haul, (per 100 feet)	421,765 "	$0.01\frac{3}{10}$
Tunnelling	15,153 "	8.87

Stone Masonry—

Rubble, laid dry	19,925 perches.	$2.71
Rubble, laid in mortar	25,630 "	4.33
Concrete	347 "	4.37
Rough hammered	2,708 "	5.59
Rock, Ashlar	7,221 "	10.60
Dressed Ashlar	1,514 "	18.25

Brick Masonry—

In Culv'ts and Pipe-vault arch	347 perches.	$15.32
Conduit, in Tunnels	4.134 "	24.16
Conduit, out of Tunnels	8,209 "	15.82

The hydraulic cement that was used in the construction of these works was exclusively of American manufacture, and was obtained from two principal sources of supply, namely: Rosendale in the State of New York, and Cumberland, in Maryland—but chiefly from the latter, whence came nearly all that was used in constructing the dam and conduit.

These two kinds of cement are regarded as being of equally good quality for ordinary purposes, but the Cumberland being much more active or quick setting in its operation is preferable to the Rosendale in all cases where running water, and especially springs have to be contended with.

Beside the contractors already mentioned in connection with the several parts of the work, the following named persons have contributed a large share of material and mechanical skill and labor towards the construction of the whole undertaking.

Messrs. A. & W. Denmead & Sons executed the iron work, and fitted up the gates of the several gate chambers, and cast the curved and branch pipes of the pipe line.

Messrs. Regester & Webb cast the brass gates.

Messrs. J. B. & T. F. Connolly built the stone houses which enclose the gate chambers of the Dam and Hampden Reservoir, and

Messrs. Reynolds & Brown, the frame cottages at those two points.

Messrs. Bollman & Co. planned and built the carriage road bridge, that spans the Falls immediately below the Dam.

Messrs. John W. Maxwell & Son built the stone house which encloses the gate chamber of the waste-weir midway in the conduit line.

Mr. Francis Fowler manufactured the wire screens of the two reservoirs.

Messrs. Thomas Dougherty, James M. Baker, Emanuel Irons, Henry Krager, George R. Callis, Darius Wheeler, Sr., and Darius Wheeler, Jr., were employed as master mechanics, supervising the operations of the bricklayers who were engaged upon the line of the conduit.

In regard to the professional skill and labor which has been applied to the construction of these works it is proper that the following named members of the engineer corps should be specially mentioned.

Frank F. Jones, Resident Engineer; H. Scott Thruston, Assistant—in charge of the Lake and Dam.

Robert Hooper, Jr., Resident Engineer; Henry M. Graves, Assistant—in charge of Conduit Line from Dam to Waste-weir until completed, after which the former had special charge of the Pipe Line.

Robert K. Martin, Resident Engineer; William L. Kenly, Assistant—in charge of remainder of Conduit Line and both Reservoirs.

During the construction of the Conduit, W. Eugene Webster was employed as Principal Assistant in charge of all the operations of that particular of the work.

To the faithful manner in which these officers, and the special inspectors who were attached to the engineering department, performed their respective duties, the general perfection of the whole work will bear ample testimony,—and, I am happy to say, that the manner in which each particular part of the work has been executed by contractors and mechanics, is highly creditable to all concerned in the construction of the New Works.

To the professional advice of Gen. M. C. Meigs (U. S. A.) is due the credit of important improvements in the original plans of the gate chambers, and of the architectural designs of their several ornamental superstructures, as also some beneficial changes in the mode of constructing other parts of the work.

In submitting this final report upon the manner and cost of constructing all portions of the new works that have been placed under my professional charge, and which have been completed thus far in general accordance with the city ordinances, I take the liberty of repeating the opinion, expressed in my last annual report, that, although the general intention to furnish the city with a bountiful supply of wholesome

water from Jones' Falls, has been practically accomplished, the farther intention to insure the purity of this supply at all times and under all circumstances, has not been perfectly carried out; and that this perfection of the works can be best attained by an extension of the Hampden Reservoir to a full circle (thereby doubling its capacity,) and the construction of a second, independent low service reservoir of equal capacity to, or even greater than that of the present Mount Royal.

Respectfully tendering to the present and former members of the Board my sincere acknowledgments for the confidence which has heretofore been reposed in my personal judgment and actions, I remain, gentlemen,

Your obedient servant,

CHARLES P. MANNING,
Chief Engineer of New Works.