SUMMARY

H.M. Chick

The Washington Aqueduct was the first attempt in the city of Washington to obtain the city's water supply from one source. Previous to its installation the water supply had been obtained from nearby springs and wells. As the city grew in population and spred out, this source became wholly inadequate. Several locations were investigated as sources of water for this new system. The Potomac at Great Falls was finally decided upon as the best point from which to bring water to the city. A dam was erected there to regulate the water flowing into the aqueduct. The details of the history and construction of the dam at this point will be found in Mr. Lozupone's thesis .

The aqueduct itself was 9 feet in diameter and was lined with three rings of brick. In bringing the aqueduct from Great Falls to the Georgetown reservoir, six bridges were necessary. Of these six , two are outstanding, They are the Rock Creek and the Cabin John bridges. The former is no longer standing, but the latter is still in service supporting both the conduit and a roadway. It was for the first 40 years, the longest single span masonry arch in the world, In 1903, however, it was replaced in this respect by the Luxemburg bridge in Europe with a span of 277.7 feet.

With the completion of the aqueduct in 1863, water was supplied directly to the city with no filtering. In 1882, Congress deemed it advisable to increase the water supply and to accomplish this, the Washington Aqueduct Tunnel was constructed to carry water from the Georgetown reservoir to a new reservoir to be constructed called the McMillan Park reservoir, It was here that the first filtration plant, one of the slow-filter type, was located. With the completion of this project, the City of Washington found themselves equiped with a very excellent water supply system.

HISTORY AND CONSTRUCTION OF THE AQUEDUCT LEADING TO McMILLAN PARK, WASHINGTON, D. C.

PART I

HISTORY OF THE AQUEDUCT

The aqueduct ultimately leading into McMillan Park, Washington, D. C. begins at a dam across the Potomac River about one mile above Great Falls, Maryland. The dam is located about eleven miles north of Washington. The reasons for constructing this new water supply system may be easily seen in studying the early history of water supply in the Capital.

The City of Washington was founded in 1791. Its source of water supply was the usual source of those days, namely, springs and wells. The city was located on a relatively low level with a result that at all times there was a generous supply of ground water. The movement toward better water supply is in several books and papers attributed to President Washington and L'Enfant. It is stated that these two spent considerable time in investigating such systems of water supply. However, in the records at Dalecarlia it states that such is not the case. The President at that time was completely absorbed in affairs of state and Major L'Enfant was interested in a water supply in connection with a large waterfall which he proposed for its scenic effect in front of the Capitol. There were several springs and wells from which the population of the city obtained its water. The four largest and best known of these springs are as follows:

(1) Old City Spring--North side of C Street between 4-1 2 Street and 6th Street.

(2) Caffreys Spring--North side of F Street between 9th and 10th Streets.

(3) Franklin Square Spring--Between I and K Streets and 13th and 14th Streets.

(4) Smith Spring--

The water of Old City Spring was the first water to be piped in the City of Washington. It was piped in 1802. The first pipes used when compared with the rubble and brick aqueduct were crude conveyors. They were made of seasoned logs hollowed out in the center and joined together with connections made of wrought iron. Water was only piped in this manner short distances because of leakage. The Government Buildings were the principal receivers of this piped water, although several houses on Pennsylvania Avenue received water in this manner. The Franklin Square Springs were the source of supply for the White House and adjacent executive buildings. The Smith Spring supplied the Capitol and Pennsylvania Avenue. The pipes were layed by the people who expected to use the water.

A relatively generous supply of water was available from the springs and wells around the Capitol for domestic use for the first fifty years of its existence (1790-1840), and the system of supplying water was entirely satisfactory to the public. It was the government who first began to look for a better source of water supply. It did not think that the water piped from Smith's Spring in 1832 to the Capitol to protect the valuable records stored there from fire was a satisfactory means of protection although it had served its purpose for many years. There were several plans proposed for obtaining this water supply. One of the plans propsed was "Skinner's Scheme", a description of which may be found in Government Document Number 281, March 8, 1830. It is sufficient to say that it was entirely impractical but it was however the first plan to consider the Potomac River as supplying the entire City of Washington. Two more plans were proposed by Robert Mills who like Skinner was a C.E. A complete description of these projects are found in Government Document Number 544, April 3, 1830. His projects were entirely logical but were not adopted, however.

In 1850, Congress appropriated $500.00 to enable the War Department to make an examination of the most available mode of supplying the City of Washington with pure water. It had been brought sharply to the attention of the people that even the larger springs and wells could still be only used locally. It became increasingly evident that the city must find a more generous supply of water. The appropriation of 1850 was followed in 1852 by an appropriation of $5,000.00 by Congress for "determining the best means of affording the City of Washington and Georgetown with an unfailing and abundant supply of good wholesome water." The first appropriation of $500.00 was used to make a survey of the water requirements of the city. Both Great Falls and Rock Creek were given consideration as potential sources of supply. The survey was conducted under the leadership of Col. George W. Hughes of Corps of Topographic Engineering. The second report, following the $5,000.00 appropriation was made by Lt. Montgomery C. Meigs. The complete report may be found in Senate Document Number 48, February 22, 1853. This report contained the Meigs plan which consisted of circular brick cavity or conduit from Great Falls to Georgetown, a receiving reservoir formed by damming Little Falls Branch, a distribution reservoir, and a series of high service reservoirs to serve the points of higher elevation in the city. The State of Maryland granted its consent to this project by a special law on May 3, 1853. The consent was to take effect only when the approval of the Chesapeake and Ohio Canal Company had been obtained. This approval was obtained in June, 1853. The approval of President Franklin Pierce was obtained on June 28, 1853. It was President Pierce who made the decision to use a nine foot conduit rather than a seven foot one. The main reasons for this decision was that the nine foot conduit gave a cross section area 1.6 times the area of a seven foot one. Congress in March, 1853, appropriated $100,000.00 for

Senate Doc 403 - 66th 2nd Sess

Report of Maj. M. C. Tyler

PLATE IV

This map shows the drainage area of the Potomac at Great Falls.

commencing the work under Captain Meigs. Surveys were begun at once to secure the necessary property rights.

The task of obtaining the necessary property rights before Captain Meigs was longer, more difficult, and more expensive than he had anticipated. In a few cases the owners would not sell under any conditions, and all of the property had to be condemned and appraised by a special jury. One of the most difficult cases and one which caused a revision of the original plans was that of the Great Falls Manufacturing Company. This company maintained that they were the "owners of the Great Falls of the Potomac with the tract of land thereunto belonging." This prevented the government from obtaining title to that tract of land, but it finally arranged to buy a small plot of land just above Lock No. 20. The result of this change in plans was that the conduit was shortened some 2,985 feet.

PART II

CONSTRUCTION OF THE AQUEDUCT

A force of laborers and mechanics were collected at Great Falls in the early part of November, 1853. This was about eight months after Congress had given its approval to the project. The first operations were directed particularly toward the construction of the feeder. It was that part of the aqueduct which took the water from the Potomac, carried it under the Chesapeake and Ohio Canal, and into the control house. The feeder is only a few hundred feet long. Operations were also directed toward the opening of the first mile of work.

The Dam From The Maryland Side

Another view of the Dam at Great Falls

Mouth of the Feeder

The Control House at Great Falls

The force of three hundred to four hundred men continued working through that winter and the following spring. By June, 1854, practically all of the initial appropriation of $100,000 had been used and Congress had adjourned without making a second appropriation. Work was suspended. However, by this time all lands needed in Maryland had been condemned, a sandstone quarry had been bought in Seneca, seven miles above Great Falls, and a small portion of the brick conduit had been constructed.

The temporary suspension of construction was a very fortunate occurance for Captain Meigs. The preliminary plans and estimates had been made in a very hasty manner. Construction could not have proceeded in an orderly manner in the shape they were. The year delay gave Captain Meigs ample time to get his plans in better shape.

Work was resumed in March, 1855, immediately following an appropriation of $250,000 by Congress, and contracts for grading and culverts were advertised. The law at that time required a period of 60 days before the bids could be opened. This held back that phase of construction considerably. Construction was again suspended in the spring of 1856. This time it was not due to the lack of appropriations by Congress because it had just appropriated another $250,000. The suspension was due to the fact that the law made the money available for existing liabilities. This discontinuance was a serious handicap since contracts were suspended, men laid off, and construction subjected to deterioration.

This state of affairs was brought to the attention of Congress and as a result the first large appropriation of $1,000,000 was obtained in 1857. This appropriation was followed by another in 1858, for $800,000. As a result of these two large appropriations, a period of activity lasting two years followed. At the beginning of this period, 2028 feet of the conduit had been built and work on the bridges and reservoirs had not even been started. When this period of activity ceased in June, 1859, due to lack of funds again, 98% of the conduit was finished and Cabin John Bridge was the only large item of the work unfinished.

When work was closed down in 1859, it remained that way until June, 1860, when Congress appropriated $5000,000 to complete the project. It was at this time that Meigs was removed by the Secretary of War until September, 1861. Meigs was replaced by Captain Bonham. Many interruptions occurred in the year 1861. It was the first year of the Civil War. Most of the laborers working on the

Aqueduct were transfered to the Engineering Division of the Army and were employed erecting entrenchments on Virginian shores.

In June, 1862, the affairs of the Washington Aqueduct were turned over to the Interior Department, and Meigs was transfered to the regular army as Quartermaster General at Washington. At this time the conduit was practically finished, Cabin John Bridge was half completed, and the dam at Great Falls was not even started.

Water from the Potomac was first introduced into the conduit on December 3, 1863, and on December 5 allowed to flow into the receiving reservoir. It showed remarkable water-tightness in most places. The conduit was again closed on January 14, but following that it was not closed again for twenty-seven years (September, 1891). The conduit has been drained and inspected at frequent intervals though since 1896.

The conduit is a circular brick ring with a 0.18% grade or a fall of 9 inches per 5000 feet. A copy of the specifications of conduit and materials is given below to explain the construction of the aqueduct.

Specifications for Conduit: The conduit will be circular and generally 9 feet interior diameter; it will when of brick generally be built of three separate 4 1/2 inch rings of hard brick. When it passes through the ground risings as high as the intrados of the arch, the inner rim will sometimes be omitted, and the brick work reduced to nine inches.

In rock cuts and other deep cuts where suitable stone is on hand, concrete or rubble stone masonry will be substituted for brick, in whole or in part, particularly in the lower or reversed arch.

The center of the conduit at any point is the grade of the conduit at that point. The excavation and embankment will be made to the level of the grade at each place of operation before the contractor for the conduit will be allowed to commence his work there. The excavation for the lower semi-circle or reverse arch, however, will generally be made by the contractor for the conduit and it will be trimmed out in advance of the laying of the masonry.

Brick Masonry in Conduit: The bricks, at the time of laying will be thoroughly wet; every brick must be laid and pressed down into a full bed of mortar, which shall cover its bed and joint; and this bedding shall be done at one operation for each brick so that no mortar need be washed in after the brick is placed. The inner edge of the joint of each course will be the least possible to admit of mortar between the bricks. The joint of mortar between each two rings will not be less than 3 8 inch in thickness.

Stone Masonry of Conduit: This will be made of small rubble stone, none of which will exceed 14 inches in width or depth. Each stone will be laid in a full bed of mortar and hammered until the mortar is pressed out at the front and the joints are completely filled. Its inner surface will be well plastered with a coat of cement mortar and be floated smooth and even.

Concrete: One barrel of cement (300 lb. net) with two and one-half barrels of sand and 30 cubic feet of stone will make a batch of concrete. The mortar having been spread on a bed of plank, the broken stone will be spread evenly over it and the whole mass turned over twice and thoroughly mixed with a hoe or shovel. When mixed and laid it should be rammed into a compact and water-tight mass. (Note: These proportions are roughly 1: 2 1/2: 10 which is much weaker than used at present).

Mortar: The mortar for masonry will be made of two and one-half parts of sand to one part of cement. The sand and cement after being measured, will be mixed dry and small quantities only taken from the heap, will be mixed with water as required. (Note: The mortar for concrete was made first and the amount of water was kept low.).

Cement: All cement must pass the test of setting hard under water and not breaking into lumps. This was of course natural cement as Portland cement was not made at that time. It came from Maryland, New Jersey and Pennsylvania, and was delivered on the dock in Georgetown. The inspectors tested small specimens which were considered good if the set occurred in 30 minutes or less.

Sand: None but good clean sharp flint sand will be received. Proposals will state the number of bushels the bidder will undertake to deliver. (Note: Contract price was 6 cents a bushel, delivered on the bank of the canal in prepared bins. Lower prices were later due to competition.).

Brick: None but well-made, hard, burnt brick, entirely acceptable to the engineer, will be received. They must be made in moulds conforming in size to the municipal regulations of Washington City.

All materials such as cement, brick, sand, forms, centers, etc., were furnished by the United States for the purpose of economy. Also to aid in economy the amount of materials for each unit of work were computed and if the contractors exceeded that amount, the value of the wasted materials were deducted from his monthly statements. Construction under contract was done on the unit basis cost throughout.

Earth Excavation----------	$0.15	per cu. yd.
Hard Rock Excavation------	1.25	" " "
Soft Rock Excavation------	0.75	" " "
Laying Brick--------------	2.25	" " "
Laying Stone Masonry------	3.00	" " "
Furnishing Seneca Sandstone	0.26	" " ft.
Concrete in place---------	3.25	" " yd.
Finishing Brick-----------	8.25	" Thousand.

The only machine for construction at that time was the steam driven derrick. As a result tunnels were found to be cheaper than deep, open rock cuts. There were eleven tunnels from Great Falls to Dalecarlia ranging from 11 feet to 1437 feet in length for a total length of 5392 feet. The tunnels were more or less irregular in shape and contained a circle 11 feet in diameter. It was the original plan of Captain Meigs to line all tunnels with a 2 foot lining of brick. However he later changed his mind and decided that one foot was sufficient. When he found that the cost of the entire aqueduct was much greater than his estimate, he decided to omit the lining entirely in the longer tunnels. As a result, five of the short tunnels were lined with brick for a total length of 1028 feet. The remaining six tunnels were not lined at all. These tunnels held up in this condition fairly well for the first fifty years, but in 1891 when the first inspection was made, Col. Elliot noticed that several small rock slips had occurred and blocked the passage to a depth of 4 feet.

Lining of these tunnels was begun in 1911 under Col. Longfitt. Because the reservoirs could only supply the city for four days and since it would then take two weeks to fill them, the job of lining was the most difficult and expensive one connected with the aqueduct. Work continued over a period of seven years at a cost of $50,000 and only 1,000 feet had been lined. At this rate it would have taken 28 years to finish the job. This was not necessary however since a movement was in progress for a new aqueduct which would then enable them to drain the old conduit and make the necessary repairs.

Dalecarlia

CABIN JOHN BRIDGE

The Washington Aqueduct had six bridges altogether. Two of the bridges were far greater in size and importance than the others. These were the Cabin John Bridge and the Rock Creek Bridge. The picture of Bridge No. 3 is an example of the smaller bridges. The Rock Creek Bridge was the only one in which arch ribs were utilized to convey the water supply of a city and at the same time support a roadway. Now, however, it no longer exists. It carried its actual load for over half a century and probably now would still be in service if it had been wide enough.

Bridge No. 3

Work was begun on the Cabin John Bridge early in 1857. All soil and rock formation was cleared or blasted away until a solid ledge of the hill was exposed. Here a proper face was made for the reception of the arch by a hydraulic bed of cement and broken stone.

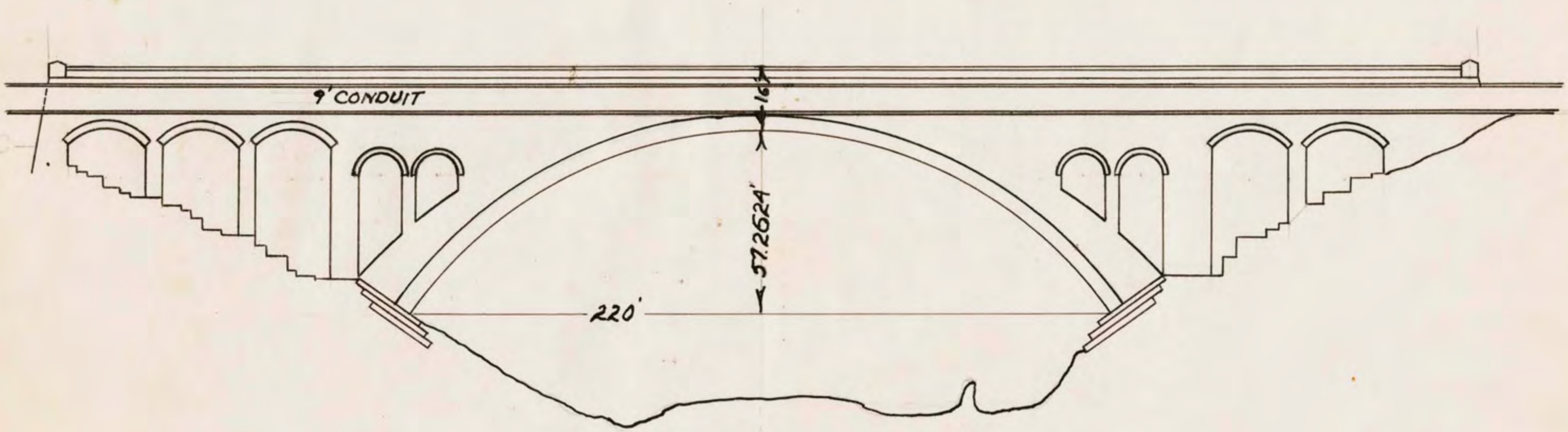
As the superstructure was to be very massive, it required a correspondingly heavy center or trestle to support it during construction. The trestle rested in a series of stone piers which piers still remain. In addition to this main trestle, a furhter framework was constructed to carry a system of traveling cranes by which means the stones were transported to various portions of the structure as it was used. All the granite and sandstone was transported on the Chesapeake and Ohio Canal, which was only 1,000 feet away from the bridge. The materials were carried from the canal to the bridge by constructing a dam across the creek near the canal and a lock to permit boats to pass from the canal up to the pool under the bridge. All of the abutment stone was secured from a quarry a few hundred feet up the valley.

The bridge is a single arch bridge. In the first designs, Captain Meigs planned to have it a series of small arches. As it was finally constructed, a single masonry arch, it was the longest of its kind in the world for 40 years or until 1903, when the Luxemburg bridge in Europe was constructed. Its span was 277.7 feet or 57.7 feet longer than the Cabin John Arch which was 220 feet.

The single arch is constructed of dressed granite from Quincy, Massachusetts, 4 foot 3 inches thick at the crown and 6 foot 2 inches thick at the spring line. It is backed with a secondary arch or rubble arch composed of Seneca sandstone. The spandrel arches are rock faced ashlar with rubble backing. There are five spandrel arches at the west end and four at the east end. These spandrels are hidden by the vertical side walls for the sake of appearance. All of the remaining face work is Seneca sandstone.

When the bridge was first placed in service in

CABIN JOHN BRIDGE



LOCATION	MASONRY cu.yds.	CONCRETE cu.yds.	BRICK WORK cu.yds.
West Abutment	2543.18	413.48	
East Abutment	3089.19	439.18	
Granite Arch	983.63		
Rubble Arch	1859.19		
Load	3002.63		
Under Spring Line	178.96		
Parapet Walls	257.40		
Conduit thru Bridge			516.00
Totat	11914.18	852.66	516.00

Radius of Intrados of Granite Ring = 134.2852'

Radius of Extrados of Granite Ring = 143.2695'

December, 1863, several leaks were observed. The water was shut off and the lower half plastered. When the water was turned on again the depth was kept below the middle level and no leaks were observed. However, in 1892, when an inspection was made of the entire aqueduct, this leak was found to be in the invert of the conduit about 40 feet west of the bridge, but the water was flowing under the conduit and washing out the abutments. This leakage was again repaired by plastering but this was not permanent and before long conditions became dangerous. The danger was eliminated by placing a metal lining of 501 feet of cast iron plated 3/4 - inch thick cast in the form of arcs of an 8 foot circle 3 inches wide within the conduit. In this condition it exists today.

The Parapet of Cabin John Bridge

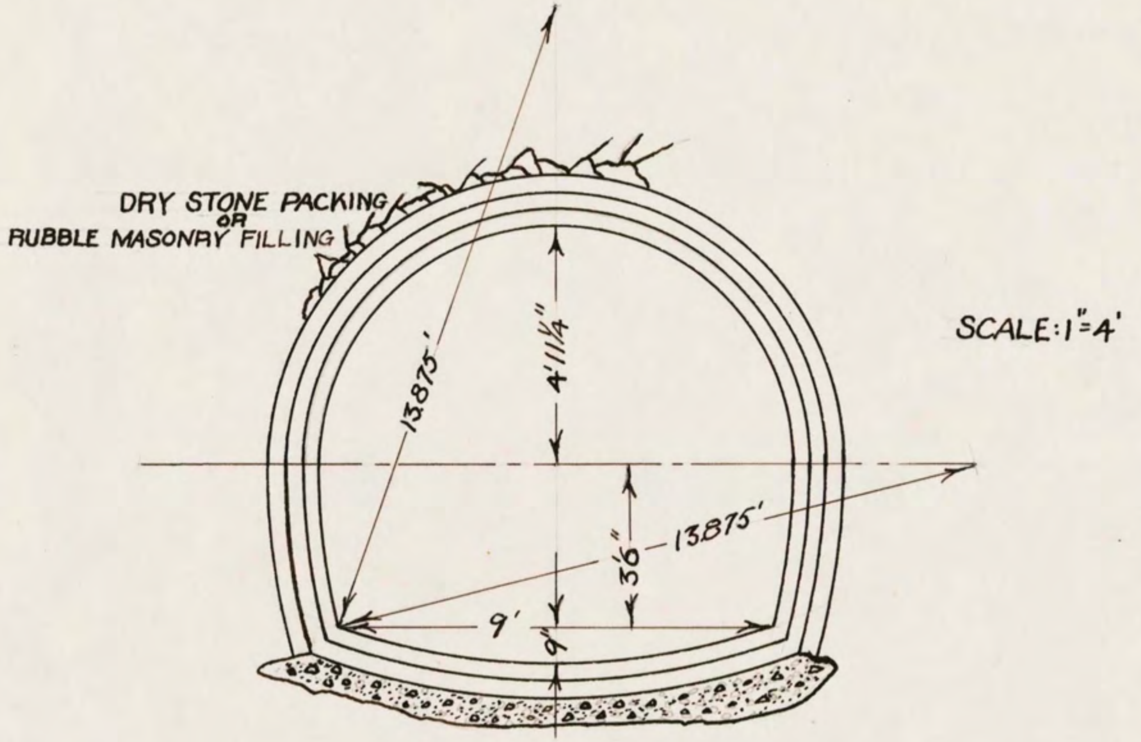
The Arch (Granite) of Cabin John Bridge

THE WASHINGTON AQUEDUCT TUNNEL
OR
THE LYDECKER TUNNEL

The Washington Aqueduct Tunnel is that part of the Washington Aqueduct which connects the Georgetown Reservoir and the McMillan Park Reservoir. In 1882, Major Lydecker was instructed to make such preliminary examination and surveys as were necessary in preparing a project for increasing the water supply of Washington. The result of this report was that Major Lydecker recommended either a tunnel through solid rock in a direct line between the points or a surface conduit. He stated that the advantages of the tunnel far outweighed the advantages of the surface conduit.

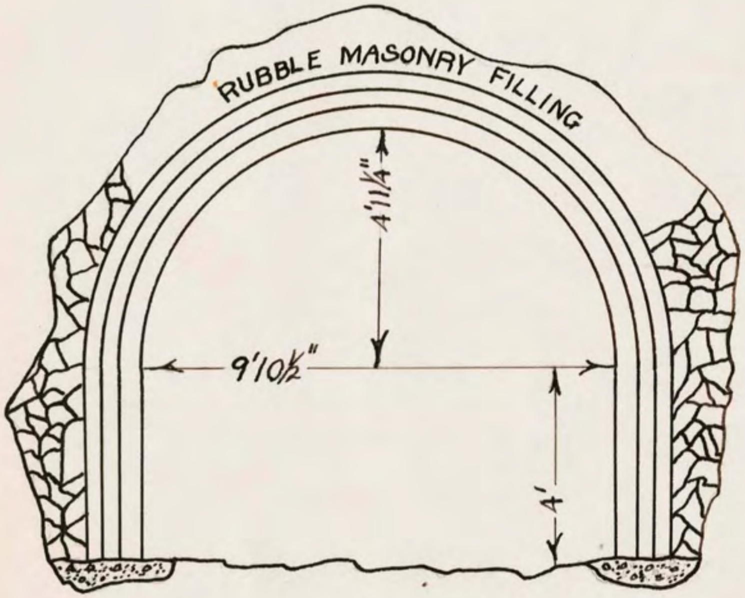
A trial shaft was driven at the eastern end of the tunnel because it was believed that here the rock bed was lowest. The shaft was 116 feet deep when it reached rock. As a result of this survey, Congress appropriated \$650,904.55 to start work. Construction was begun in 1883. Several shafts were lowered and work begun in both directions from these shafts. A picture of the present view of the Rock Creek shaft is shown below.

CROSS-SECTION of TUNNEL



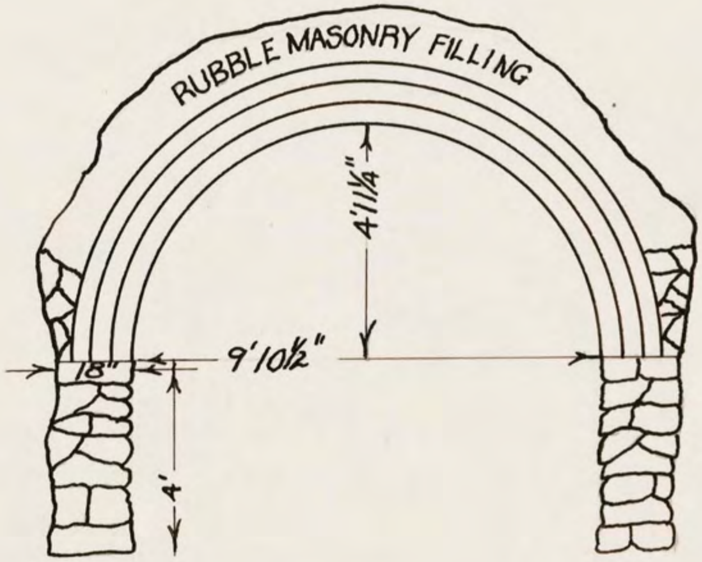
NO. 1

CROSS-SECTIONS of TUNNEL



NO. 2

SCALE: 1" = 4'



NO. 3

Operations were suspended in February, 1886, because appropriations were exhausted. At that time the total length of excavation was 18,540 feet of which 1490 feet were lined with masonry. The lining of all work before February, 1886, consisted of a facing of brick masonry laid in hydraulic cement mortars with a backing of concrete for the invert and side walls and of dry stone for the space between the arch and the rock through which the tunnel was excavated.

In August, 1886, Conress appropriated $395,000 to continue the work but only after an investigation by the Board of Engineers as to the methods of doing the work especially the character of the lining. This board concluded in their report that the exclusive use of concrete for lining was inpracticable, and they indorsed the use of the brick arch but recommended that the filling between the arch and the rock be done "with rubble laid in cement mortar." This of course increased the cost of filling from $2.50 per cu. yd. to $4.75 per cu. yd. Under these conditions work continued until September, 1887, when a halt was called because of lack of funds.

In March, 1888, Congress appropriated $355,000 and stated that all work was to be completed by November, 1, 1888. This was not accomplished, however, because in September, 1888, charges were made that the work was being done in an improper manner by the contractors, Work was suspended and an immediate investigation followed. The facts as reported show that systematic frauds had been in progress in the construction and that numerous and extensive voids existed in the lining of the tunnel.

On December 5, 1895, an expert commission consisting of Major W. L. Marshall, Captain James L. Lusk, Mr. Alphonse F. Teley, Mr. Desmond Fitz Gerald, and Lt. D. D. Gaillard met in Washington to decide on the feasibility of completing the tunnel. They decided favorably and work was again begun on July 15, 1898 and the tunnel was completed in 1905.

The length of the tunnel was 21,400 feet and the cross-section of it varies with the conditions as is shown in the accompaning sketches.

The construction of the Washington Aqueduct was a major factor in the development of that city. Before its construction the water supply was so low that it was difficult to keep the people of the city from tapping pipe lines to government buildings. But since its construction with the number of improvements made upon the system, it has been able to afford to the city of Washington an ample quantity of water.

McMillan Park Reservoir

BIBLIOGRAPHY

The Military Engineer

Annual Reports of the Office of the Washington Aqueduct
(1882 - 1905)

Records of the Columbian Historical Society

The records at Dalecarlia which were kindly furnished by Mr. Hardy.

The City of Washington by Newell