THESIS
OF
JAMES M. PORTER.

CLASS '86.

—Lehigh-Pumping-Station.—

—— Delaware Pumping Station ——

Review
of the
Water Supply
of
Easton Pa

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Introduction

The supplying of cities with water dates back to a very remote period as in Persia and in Judea. The "pools of Solomon" near Bethlehem supplied and stills supplies Jerusalem with water. These pools consist of three large reservoirs (the largest being about 660'x280') connected together and furnish ~~the~~ the city, six miles distant, with water through a ten inch earthen pipe. The ancient city of Mexico was furnished with water by means of an aqueduct. The Incas of Peru in order to irrigate their sandy soil, brought water from mountains several hundred miles distant

Their aqueducts passed along the precip-
-itous sides of the Andes, penetrated
mountains of solid rock, and crossed
great chasms and deep valleys, many
miles long, upon high walls of solid
masonry. In Egypt and Babylon, sim-
-ilar works were constructed, though
many, if not all of these are now
in ruins. The aqueducts are considered
among the wonders of Ancient Rome,
since the skill of that nation in such
works, exceeded all others, ancient or
modern. Considering the number of
aqueducts (at one time twenty-four), the
great expense of bringing water, thirty
forty, or even one hundred miles, upon
piers and arches of solid masonry, often
two-hundred and three-hundred feet high,

of penetrating mountains of rock, and the incredible quanity of water brought to Rome, for the use of the public, for fountains, baths, private houses, gardens, it must be acknowledged that they can justly claim the honor they have won. The extreme length and circuitous route followed by the Roman Aqueducts, may be accounted for from the then want of strong metallic pipes. It was necessary to construct the water course upon a gradual descent, lest by the rush of the water the structure would be destroyed. Hence they adopted the plan of adding to the length, thus reducing the grade and pressure. Since the introduction of metallic pipe, this system is but partially followed, because the strength of the pipe admits of frequent changes of grade, even the descending of one bank of a river valley and ascending the other. However care must be taken that the pipe may not be subjected to any unnecessary pressure. For large aqueducts, stone channels, like the ones made by the Romans, have the advantage over iron pipes, being of greater capacity and duribility. Of this class the New Croton Aqueduct for New York, probably surpasses all others. Until fifty years ago most modern cities were not nearly so well supplied with water, as were many ancient ones. But a great change has been brought about. The importance of a copious supply of water for the preservation of health in our large cities is fully acknowledged. The Croton of New York, the Fairmount of Philadelphia with those of Boston and Brooklyn are among the improvements for this purpose in the United States. Water gives at once a powerful stimulant to vegetation and a cheap motive power. The influ-ence of water on vegetation is too well known for it to be mentioned here. We only need to say that little land exists which may not become pro-ductive if watered, and that there is no soil so fertile that its productive-ness cannot be increased by irrigation. In short we may say that scarcely any barren land exists, except those being absolutely deprived of water, and that the maximum of production can only be obtained by watering. In the present day the great industries use steam as their motive power, it being produced by means of coal, but mineral fuel is not recreated. The great resources of fuel placed by nature at our disposal will certainly be sufficient for the present generation, also for the one following. We may foresee and even calculate the time when the prec-ious resources will be wanting. On this account it must henceforth be economized, either by better arrangement and a better control of our fires, or else searching nature and utilizing the auxiliary forces, which may for certain purposes, replace steam. Among these forces the fall of water holds a prominent position, on account of its economy and in the many cases in which it can be used to advantage. The motive force of the streams of Europe has been estimated at, from 273,508,970 to 364.678.620 horse power. The unceasing motion of aerial circulation is constantly raising and carrying immense quantities of water taken from the ocean and spreading them over the principal mountain chains. Thence they return to the sea through various brooks and rivers, to be again taken up and carried back once more. This inces-sant, creation of force, seems to be intimate-ly connected with our planet, and so will only come to an end upon the destruction of the planet. If wisely looked after it will be one of the most precious resources for industrial pursuits. Water besides being a motive power and a stimulant has become the base of hygiene and domestic comforts. Every day larger supplies are called for in our cities and towns. The small ration of water that supplied our fathers is no longer enough for us. In vain is it largely increased, but it is always less than the requrements of the people. Needs of this kind have become so urgent, that in countries where the grouping of the population is not trammeled by old customs or by necessities of position, cities are seen to spring up at those points, where large supplies of water satisfy new demands. But if from all these points of view, the wise caring for water, becomes more and more desirable, it must also be noticed that it becomes more and more difficult. Few in number and very small in the beginning were the mills, getting power out of streams. But these establishments have multiplied out of proportion on some streams and in perfecting their plant, have needed a greater supply of water. During three-quarters of the year, the water is sufficient for the factories, and the owners live in peace But when summer sets in, the rivers only contain a thin stream of water in the midst of a wide bed. Penury begins and with it comes fierce competition and law suits before all the courts. Armed with their laws and regulations, the courts intervene, but almost always without success. The force of circum-

-stances carries away both the careful equity of the judges and the real good will of the people themselves. It would be difficult to tell the amount of strength, intelligence, work, and money spent in these constantly renewed struggles and the unceasing trouble that they bring about in the relations of the inhabitants. Taking proper care of the water, by keeping for the summer, a part of the winter's surplus, would do more to pacify the interested, to set at rest internal discords, than the wisest rules, however carefully the be applied.

History of Easton's Supply

The first water introduced into Easton was brought in three inch wooden pipe, from several springs on Chestnut Hill by the Easton Water Company. This company was incorporated March 24th 1817 and by an Act of Assembly was authorized to issue stock to the amount of ten thousand dollars and to construct the necessary works. The population of Easton at that time (1817) was between three and four thousand. This Company is still in existence and continues to supply its patrons with water from the same springs. The

Easton Company supplied the borough for twenty-eight years before the supply became too small. By an Act of Assembly January 15th 1846 authority was given the Easton Company, "to build a wing-wall or dam on the Delaware River above its junction with the Bushkill from, the West side or shore to the island" Under this Act the Company built the dam and the power thus gained, ran a water wheel, to which they had pumps geared. The foundations of this "Old Pump House" still remains, just North of the Wilson Foundry. It was in connection with these pumps, that the reservoir on College Hill was built. They pumped directly into the main leading to this reservoir, from which the water flowed by gravity. The water wheel arrangement did not prove satisfactory and was soon superceded by a steam engine, these works together with the Springs on Chestnut Hill supplied the town till 1860. On May 4th 1854 the "West Ward Water Company" was incor-porated with a capital stock of twenty thousand dollars. This Company commenced building a Pumping Station on the Lehigh River, intending to take water from that River and force it into a reservoir, to be at the corner of Northampton and Fifteenth Streets and from the reservoir, the flow was to be by gravity. After six years of existence and completing about one-half of their proposed works, they became insolvent and were sold out by Sheriffs Sale, to the "Lehigh Water Company" which was incorporated March 20th 1860 for the purpose of completing the half-finished works of the West Ward Company. This the Lehigh Company did and now upon it and the Springs of the Easton Company depend the water supply of Easton. The Lehigh Pumping Station contains a steam pump of the Cornish Beam pattern and is now idle being held as a reserve. In 1881 the Lehigh Company placed a Station on the Delaware River containing a Geo H Corliss Horizontal Pump of two millions gallons capacity.

Systems of Supply

In furnishing Easton with water three systems are employed, the gravity, the modified gravity and the direct pumping system. The first system is the one used by the Easton Company and supplies water, from springs on Chestnut Hill, to the older residences. The last two belong to the Lehigh Company who supply water taken from the Delaware and Lehigh rivers, on which they have pumping stations. From these stations mains lead to a common reservoir at the corner of Fifteenth and Northampton Streets. This at the time the reservoir was built, was the highest point within the borough limits. It being in the highest point has not proved it to be in the best location possible, for the under strata of rock is composed of soft limestone, giving great trouble in causing the reservoir to leak. The Station on the Lehigh is used only in case of accident to the works on the Delaware and is at present idle and undergoing extensive repairs. This Station when running pumps directly into the reservoir, from which the town is supplied by gravity, while the Delaware Station pumps directly into the mains, supplies the town first, and the surplus water, if any, going into the reservoir. The Easton Company's supply is taken from five springs on Chestnut Hill, having a discharge of about twenty four gallons per minute. Their reservoir is on Fifth Street into which the surplus water flows, after the town has been supplied.

Chemical Analysis of the Water

Professor W. W. Chandler of Lehigh University, at the request of the Lehigh Water Company made a chemical analysis of the water in botht the Delaware and Lehigh rivers, and through the kindness of the Company I have been furnished with a copy of the results. Both sample waters were taken on the morning of September 14th 1880, at a time when the rivers were very low. Sample water of the Lehigh was taken near the cribwork, whence the Company draws its supply. The tast and smell of the water was found to be good, and it contained little suspended matter. The sample of the Delaware water was taken at a rock in mid stream near the mouth of the Bushkill. The water was found to be of good taste and smell, a little swampy and containing some suspended matter that rendered it slighly turbid. Professor Chandler regarded both waters as good and compared favorably with water supplied to most of large cities and towns. For manufacturing purposes he recomends the Delaware water as he found it to contain less inorganic matter, to which is due the incrustations of boilers &c. For domestic purposes he considered the Lehigh water preferable as it contained less Chlorine, about the same free Ammonia and much less Albumenoid Ammonia. The Professor said that rivers receiving drainage from cities and towns did not in his opinion render the water unfit for domestic purposes as running streams would purify themselves, and the more rapid the stream the better the purification. The following gives his results, in which the figures give the amount of each ingredient in grains per gallon.

	Lehigh	Delaware
Lime	1.132	0.856
Oxide of Lime and Alumina	0.023	0.035
Magnesia	0.581	0.315
Silica	0.317	0.267
Chlorine	0.122	0.153
Sulphuric Anhydride	0.706	0.139
Organic and Volatile matter	0.437	0.397
Alkalies, Carbonic acid.	1.598	1.040

The following shows the Lehigh and Delaware water compared with the supply of other cities, according to Professor Chandler's results.

	Free Ammonia.	Album. Ammonia	Chloride.
Lehigh	0.018	0.066	2.09
Delaware	0.022	0.106	2.63
Boston	0.037	0.100	3.40
Lowell	0.012	0.039	1.80
Waltham	0.012	0.013.	3.40.

The figures give the amount of each ingredient in grains per gallon as before.

Delaware Pumping Station

The Delaware Station contains a "George H Corliss High Duty Pump" calculated to give two millions gallons per twenty four hours. The engine is horizontal, of the rotative type and contains two steam cylinders, one high and the other of low pressure, placed side by side. The steam cylinders have steam jacketed sides and heads, the condensation of which is returned to the boilers by a pump. Each steam piston drives a standing rocker arm, which is connected to the cross-head by means of a short link. The main shaft, common to both engines turns in two pillow block, mounted one on each pump discharge chamber, between which the fly-wheel revolves. The ends of the shaft are provided with overhanging cranks and pins set at quarters, to which is strapped one end of the connecting rod, the other end being attached to the cross head. To the middle of each rocker arm is attached a short link which is connected to a cross head and that in turns works the pump rod to which is attached the plunger. The rocker arm driven by the Low Pressure Cylinder also runs the air pump and the pump that returns the condensation due to the steam jacketing to the boilers. The other rocker arm attached to the High Pressure Cylinder drives the feed pump for the boilers. The valves are driven by eccentrics mounted on the main shaft. The receiving and discharging valves of the pumps number four hundred and eleven for the two pumps and are of metal, working on metal stems and seats. The following are the dimensions of the engine.

High Pressure Cylinder diam.	9"
" " " Piston Rod diam	1 5/8"
" " " " Stroke	48"
Low Pressure Cylinder diam.	18"
" " " Piston Rod diam	2 1/8"
" " " " Stroke	48"
Pump Plunger (two) diam.	8 1/2"
" " (rod "	2"
" " " Stroke	24"
Fly Wheel diameter.	13'
" " weight	7 tons
Main Shaft diam	6 1/4"
" " length	13'

The boilers furnishing steam to the engine are two in number, of the vertical return tubular variety, and are each of the following dimensions.

Diameter of shell	48"
Length of shell	14'
Thickness of shell.	5/16"
Number of tubes,	53
Diameter of tubes outside	3"
Grate circular diameter.	4½'
Heating surface, both boilers.	1542.21 sq ft
Grate surface " "	31.8 sq ft
Ratio, heating to grate surface	48.49
Ratio grate surface to cross section of tubes	1.5'
Height of stack	83'
Cross section of stack (3'x 3')	9 sq ft.

The suction pipe is twelve inches in diameter and leads from the pump Cylinder to the inner supply well, the surface of low water in which, being sixteen feet below the pumps, thus giving a lift to the pump of that height. The inner well is separated from another one of the same size (six' by six') by two screens one four and the other six meshes to the inch. The outer well is supplied with water through a twenty-four inch pipe leading seventy six feet into the river whence it takes a turn down stream. The screens separating the two wells work in vertical slots and are so arranged to be taken out for cleaning or repairs. Between the wells is a gate, to be closed when cleaning the inner well, the water being pumped out by an independent pump arranged for that purpose. The water upon the main pump passes through the air chamber, enters the main which contains the check and relief valves. The latter valve raises at one hundred and twenty five pounds pressure and allows the surplus water to pass through a six inch pipe into the inner well, thus releiving the mains of the extra pressure. The pressure at which this valve raises is regulated by two vertical springs, which can be set at most any pressure required. The water before leaving the Station passes the Check valve, from which it enters the twenty inch main leading to College Hill from which it can be tracked by reference to the Map.

The duty of a Pumping engine is the number of pounds of water lifted one foot high by the consumption of one hundred pounds of coal. The accuracy with which work of this kind can be ascertained makes a comparison of results obtained from different engines at once simple and easy. They are reduced to a common standard by multiplying the number of pounds of water pumped with one hundred pounds of coal, by the height in feet through which it is raised. The product expresses "the duty" in millions. A modification of this expression, more recently introduced, is called "the foot pound duty". In this form, one pound of coal is taken, instead of one hundred, as the basis of the calculation, the result being one hundredth of the first expression. So that fifty million duty by Watt's standard, which is based on one hundred pounds, would be called five hundred thousand foot pound duty. A duty test does not, however fully express the working characteristics or merits of an engine. It is confined to an experiment of a few hours duration, under the most careful handling and with everything in the best possible condition. To be entitled to a substantial reputation, an engine should exhibit satisfactory annual workings results in addition to those of a short duty trial. Obviously no engine can make a high continous record that can not show a high duty under a special trial. But it is true that an engine which can show this high duty may be of comparatively small value for water works purposes by reason of excessive cost, liability to derangement, necessity for frequent repairs, or inordinate cost of attendance. Therefore it is that prudent hydraulic engineers attach but little value to isolated duty tests, unless corroborated by a record of good current performances. It has, moreover, happened that some discredit has been thrown upon special trials by sudden or arbitrary changes made in the way of estimating the work done, or unusual allowances in the coal account. It is necessary that duty trials should conform, as far as may be possible, to a common standard, if the results are to be relied upon for the purpose of comparison. For a long time a reasonable uniformity was maintained but within the last few years departures from precedent have been made, almost, it would seem, at the caprice of the operator. A casual reader needs, therefore, to be on his guard when he sees an isolated quotation of high duties. The records should be searched to see whether it was based upon "combustible" only, or upon ordinary coal, that is to say, whether rejecting ashes and cinders, or including the same, Whether upon coal used in pumping only, or upon the total coal consumed. It should also be ascertained whether unusual allowances had been made for resistance due to the passage of water through bends and turns in the pump and pipes. Whether a deduction for pump leakage has been insisted upon, or whether the calculated displacement.

of the pump plunger has been allowed.
Whether the coal was of good quality and in ordinary merchantable condition, or whether, for the purpose of improving the result, the parties interested had been allowed to cull and pick the fuel used.
In view of the increasing inability to deduce commercial and practical conclusions from such tests, which appear to have strayed from their original purpose, and assume the character of a scientific experiment, we seem to be driven to the annual official records as the best testimony at command, in regard to the relative merits of engines.

The formula adopted by the Philadelphia Water Department for duty tests is as follows;

$$Duty = \frac{P \times V \times H \times 100}{F}$$

Wherein P represents pounds of water, delivered per stroke, as ascertained by measurement of the plungers and calculations of their displacement; V, the number of strokes made during the trial; H, the head pressure in feet, including friction through the main, as ascertained by gauges placed on the ascending main, just beyond the air chamber; F, the number of pounds of coal actually consumed during the trial, not deducting ashes or clinkers, neither reckoning the coal used in getting up steam nor banking fires,

Monthly Record

of the performance of the Corliss Pumping Engine for the year 1885

Month.	Actual time rung Days D.	H.	Hours and min.		Amount of Coal Con. -lbs-	Height of Deliv. in feet	Mean Steam Press. lbs	Vacuum in inches	Revolutions per Min	Revolutions per Month	U.S. Stand Gals. pumped per Month	Extra stops
Jan.	21	22	526	45	126.187	255.5	107.	25.6	62.5	2,005,869	45,994,576	37
Feb	19	01	457	15	97.720	250.5	107	25.4	62.5	1711.916	39,254,234	3
March	29	07	703	05	145.925	256.0	107	25.2	62.5	2,096,495	48,072,630	14
April	16	14	398	35	60.050	256.3	107	25.7	52.3	834279	18,854,705	5
May	21	01	505	35	103.342	256.6	107	24.3	52.3	1,588,691	35,904,416	5
June	24	19	595	40	117.778	259.0	107	23.7	52.3	1.890.205	42,718,633	1
July	26	11	635	10	135.770	250.0	107	21.0	52.3	2.025.615	45,778,899	6
Aug.	26	21	645	05	140.137	251.0	107	15.4	53.2	2051.214	46,357,436	4
Sept.	25	19	619	00	137.895	257.0	107	15.8	53.3	1970.200	44,526,520	2
Oct.	20	15	495	00	117.368	266.7	107	17.5	53.3	1562487	35,312,206	22
Nov.	22	11	539	40	103.958	266.5	107	22.5	53.2	1404.403	31,739,507	3
Dec.	19	14	470	05	112.380	262.0	107	22.4	52.7	1499.989	33,899,751	12
Totals, and Averages	274	11			1,398,510	257	107	22.04		20.641.363	468413575	114

The record is worked out from weekly averages which in turn are taken from daily and these from hourly statements. The number of gallons pumped is the theoretical and not the actual quantity, so in the statement no loss for leakage &c was taken into account.
The actual quanity of water necessary to supply the wants of the town, was estimated by measuring the fall of the water in the reservoir during the time when both the Delaware and the Lehigh pumps were idle, and from that calculating the amount drawn out, allowence being made for leak-age. The height was noted at every opportunity offered and the amount of water calculated and the results averaged. Upon this bases it was found that 385.000.000 gallons were consumed in a year. This of course is only an

approximate result, and is about the only way to get at the actual quanity pump-ed, without using meters. The theoretical quanity was calculated from the displacement of the pump plungers, which gives 468.413.513 gallons for the years supply, or an excess of 123.413.513 gallons (which is 26.34 per cent) over the actual quanity consumed. Substituting the yearly totals and averages in the formula for duty we have in pounds lifted one foot per one hundred pounds of coal; theoretical,

$$\text{Duty} = \frac{22.93 \times 8\tfrac{1}{3} \times 20.641363 \times 257 \times 100}{1328584.5} = 72.382.442$$

The theoretical Duty in gallons =

$$= \frac{22.93 \times 20.641363 \times 257 \times 100}{1328584.5} = 8.678.950$$

Actual duty in foot pounds per hundred lbs coal

$$\text{Duty} = \frac{385000000 \times 8\tfrac{1}{3} \times 257 \times 100}{13285845} = 54.416.000$$

$$\text{Same in gallons} = \frac{385000000 \times 257 \times 100}{13285845} = 6524720$$

In the calculations for duty five per cent of the coal was assumed to be the loss in running it over screens, and hauling. which would make the coal consumed to be 132,8584.5 pounds. The quanity of water that actualy left the pumps for consumtion was found to be 385,000,000, gallons in a year, or 105.408 gallons per day, 43.920 gallons per hour which is at the rate of 12.2 gallons per second. The water upon leaving the Station passes through a twenty inch main for six hundred feet, The water in order to pass through a pipe of this size at the rate of 12.2 gallons per second would require a velocity of 5.589 feet per second. The formula for finding the frictional head due to the resistances within a pipe, is as follows;

$$h'' = \frac{V^2 \times 4 \times m \times l}{2g \times d}$$

Wherein v is the velocity of flow in feet per second, d the radius, m as coefficient of flow and the length of pipe and g the acceleration due to gravity. To find the head necessary to overcome the resistances in the twenty inch main leading from the Delaware Station, we have the v equal to 5.589, d = 1.6667 ft, l = 600 ft and 2g equal to 64.4 m is taken to be .00482 Substituting these in the above formula we have for the required head h''

$$h'' = \frac{31.1364 \times 4 \times .00482 \times 600}{64.4 \times 1.6667} = 5.7107 \text{ ft.}$$

To find the head due to the above velocity

Subsitute in the formula

$$h = \frac{v^2}{2g}$$

which gives $h = \frac{31.1364}{64.4} = .4834$ ft.

The elevations shown on the accompanying map are refered to the Borough datum line, which is low water mark at the junction of the Delaware and the Bush-kill. Low water mark on the Delaware at this point, is five feet below that, at the Pumping Station, and as the pumps have a lift of sixteen feet, counting from low water at the Station, the sum of these two heights must be deducted from the elevations shown on the map when reference is made to the pump Cylinders as the datum.

The average head pumped against last year (1885) was 257 feet which includes the sixteen foot lift, deducting this gives for the total head 241 feet. The elevation of the end of the twenty inch main, at the Corner of High and Broad-head Streets, referred to the pump cylinder and allowing it to be five feet under ground is 106.9 feet. which deducted from the total head, at the pumping Station, gives for the head, at that point 134.1 feet. From this head (134.1 ft) must be taken the heads due to velocity, due to resistence in the pipe and as the pipe is less than a thousand diameters in length, the head due to entry must be deducted. Taking this head to be one half of the head due to the velocity and deducting the sum of these heads from the total head, at the Corner of High and Broadhead Streets, gives for the available head at that point;

$$H-(h+h'+h'')=134.1-(.4834+.2417+5.7007)=127.67 \text{ ft.}$$

Lehigh - Pumping - Station

The Lehigh Pumping Station contains a "Cornish Steam Pump," a single low pressure engine of the beam pattern. The demensions are as follows.

Cylinder, diameter	52"
" stroke,	10'
Pump Cylinder, stroke	8'
" " diameter,	18"
Beam length	24'

The pump delivers 105 gallons per stroke and is run on the average at 7 3/4 revolutions per minute. At this rate it delivers 813 3/4 gallons per minute, against 108 lbs pressure, using 35 pounds of steam. The supply of water is taken from the river through a conduct made of cribwork. The conduct is four feet square in cross section, and leads fifty feet into the stream when it takes a turn down stream for twenty feet. Last year (1885) this pump ran thirty six days, delivered 30.000.000. gallons and consumed 180.000 pounds of coal. The head pumped against being on the average 243 feet. The Duty of this engine in pounds per one hundred pound of coal, is

$$\text{Duty} = \frac{30,000,000 \times 8\tfrac{1}{3} \times 100 \times 243}{180,000} = 33.750.000$$

Mains.

The successful founding of good cast iron pipes requires no inconsiderable amount of skill, such as is acquired only by long practical experience and keen watchfull observation, All these qualities are possessed to an eminent degree by the Warren Foundry and Machine Company, who have their works at Phillipsburg N.J. Most of the Lehigh Co's pipes were made by this Company, and of their standard form and sizes. The iron used by this Company in the manufacture of their pipes, is taken from several different furnaces, using certain proportions from each depending upon the use to be made of the pipe. All the pipes made by this

Company are cast vertically in dry sand and with bell end up, except in case of orders to the contrary. The usual length is twelve feet for all sizes, except the two inch pipe, which is nine feet. All pipes before leaving the Foundry are subjected to a Hydraulic test under three hundred pounds pressure, and while under pressure under go a hammer test. The coating given the pipes is plain Coal tar taken from the neighboring Gas Works. The formula for thickness of pipes as used by the Warren Foundry and Machine Co. is as follows

$$t = .00006 \times H \times D + .0155 D + 0.296$$

Wherein t is the thickness required in inches or parts

H being head of water in feet

D being diameter of pipe in inches

Table showing thickness of Metals and Weight per length for different sizes of pipe under various heads

$$t = 00006 \times H \times D + 0155 D + 0.296.$$

Size	50 ft Head		100 ft Head		150 ft Head		200 ft Head		250 ft Head		300 ft Head	
	Thickness of Metal	Weigh per Length	Thickness of metal	Weigh of Length	Thickness of metal	Weight per length	Thickness of metal	Weight per length	Thickness of metal	Weight per length	Thickness of metal	Weight per length
2	0.294	63	0.312	67½	0.330	72	0.348	76½	0.366	81	0.384	86
3	0.344	144	0.353	149	0.362	153	0.371	157	0.380	161	0.390	166
4	0.361	197	0.373	204	0.385	211	0.397	218	0.409	226	0.421	235
5	0.378	254	0.393	265	0.408	275	0.423	286	0.438	298	0.453	309
6	0.393	315	0.411	330	0.429	345	0.447	361	0.465	377	0.483	393
8	0.422	445	0.450	475	0.474	502	0.498	529	0.522	557	0.546	584
10	0.459	600	0.489	641	0.519	682	0.549	723	0.579	766	0.609	808
12	0.491	768	0.527	826	0.563	885	0.599	944	0.635	1004	0.671	1064
14	0.524	952	0.566	1031	0.608	1111	0.650	1191	0.692	1272	0.734	1352
16	0.580	1215	0.604	1253	0.652	1360	0.700	1463	0.748	1568	0.796	1673
18	0.589	1370	0.643	1500	0.697	1630	0.751	1761	0.805	1894	0.859	2026
20	0.622	1603	0.682	1763	0.742	1924	0.802	2086	0.862	2248	0.922	2412
24	0.687	2120	0.759	2349	0.831	2580	0.903	2811	0.972	3045	1.047	3279
30	0.785	3020	0.875	3376	0.965	3735	1.055	4095	1.145	4458	1.235	4822
36	0.882	4070	0.990	4581	1.098	5096	1.206	5613	1.314	6133	1.422	6656
42	0.980	5265	1.106	5958	1.232	6657	1.358	7360	1.484	8070	1.610	8804
48	1.078	6616	1.222	7521	1.366	8431	1.510	9340	1.654	10269	1.7890	11195

Service-Pipe

The Service pipe is of galvanised iron ranging from one half to two inches in diameter, The Service Cock is made of brass. The pipe is readely inserted into the main while under full pressure, by a device patented by William Young. of Easton Pa, which is used in a large number of our Cities and towns, Fig 1 is a side elevation Fig 2 a sectional elevation and Fig 3 a section elevation of Fig 2 taken on the line x x. Similar letters of reference indicate corresponding parts, A B. represents the two parts of the drill Case, which are clamped tightly together by the bolts C and have a hole D formed, half in each part for the drill E. The drill passes through a stuffing box F and a detachable washer G in a sockett H having a concave face suited to the convexity of the pipe, which is to be clamped against a packing gaskett I on the side of the pipe, which makes a water tight joint. There is also a gasket K in the bottom of the socket H. The gaskets and the washers are made in two parts. so as to be removed, when the pipe is put on and made fast, as the pipe then contains a stop cock that would prevent them from being slipped off over the end. L is a cock traversing the drill hole to close it when the drill is drawn out. It has a handle M on the outside for turning it and has a deep notch N cut in it coinsiding with the drill hole, to let the drill pass into the pipe for drilling

Fig 2 shows it in this position. After drilling and the point of the drill has passed beyond the Cock, the latter is turned so that the part O comes up and stops the hole. The drill is then drawn out through the stuffing box F and a pipe containing a stop cock at one end and a thread at the other is put through the stuffing box, the cock N is turned back again, and the pipe is pushed forward and screwed into place in the main. After which the apparatus is removed. R is a passage for blowing out chips by the water. It may either have pipe connections S fastened on in connection with it, for conducting the washings away, by a flexible pipe or it may be entirely closed by a screw cap. to be taken off when the drill case is washed out. The drill case is clamped on the pipe by the ordinary clamp U V W, and the feed screw X for drilling is held by an arm Y on the bar U. The drill is worked by a ratchet, pawl and lever. This machine is made in two sizes No 1 for taps 3/8" to 1" inclusive and No 2 for taps from 1" to 1 3/4" inclusive. The price ranges from $90 to $135.

House Connections

A tap is screwed into the main by means of the Tapping Machine and the service pipe connected. This pipe is laid about four and one half feet under the side walk into the building. A stop cock is located just inside of the curbstone, by which the water is shut off or let on with a long wrench from the side walk. The stop containing the wrench are enclosed in a long box. The service pipe and all connections are generally cut and made at the shop of the plumer, who is paid by the consummer and not by the Company. The Lehigh Company issue Plumners permits gratis upon application

at their office but pay for no work
done in making connection or tapping
main.

Fire-Plug-Pressure

	Elevation	Plug Pressure	Cor. Head.
Northampton Cor of:			
Front	24.39	90 lbs	207.37
Third	41.8	79 "	182.03
Fourth	47.3	78 "	179.72
Fifth	77.3	66 "	152.07
Sixth	104.3	57 "	140.55
Seventh	73.1	68 "	156.68
Twelfth	163.4	36 "	82.94
Fourteenth,	202.39	20 "	46.08
Ferry Cor of			
Front	18.6	91 "	209.91
Stilgreaves	31.7	87 "	200.46
Third	37.7	83 "	191.24
Fourth	39.7	82 "	188.91

Fire-Plug Pressure

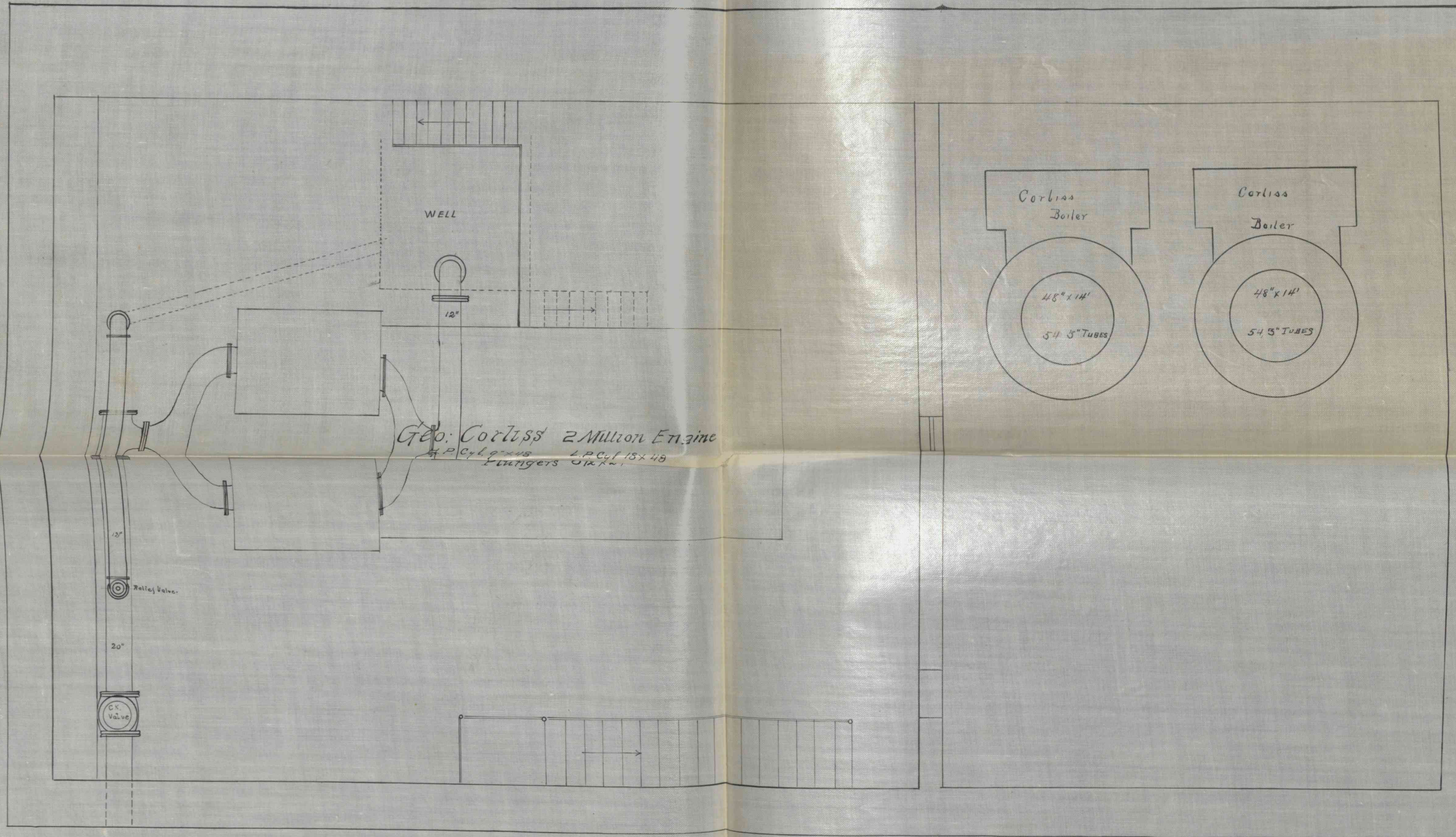
	Elevation	Plug Pressure	Cor Head.
Ferry St Cor.			
Fifth	97.6	58	133.64
Sixth	127.9	47	108.29
Seventh	143.9	44	101.38
Ninth	141.16	44	101.38
Eleventh	151.3	42	99.08
Thirteenth	183.1	26	59.90.
McCartney			
near Chestnut	167.4	37	85.1
Cattell			
High	178.9	32	73.6
Monroe	154.9	38	87.4
Clinton	171.4	37	85.1
Lovers Lane		25.	57.5

Fire-Plug Pressure

	Elevation	Plug Press	Cor. Head
New St Cor of			
McCartney	187.0	28.	64.51
Porter	178.0	33.	75.90
College Grounds			
Front of Gym.	- - -	27	62.1
West of Obs		25	57.5
North of Pardee		29.	66.7
Front St Cor of:			
Spring Garden	18.2	94	216.59
Delaware		93	214.28
Second St Cor of			
Bushkill	32.4	85.	195.85
Spring Garden	40.9	82	188.91
Northampton	38.04	85.	195.85

Fire Plug Pressure.

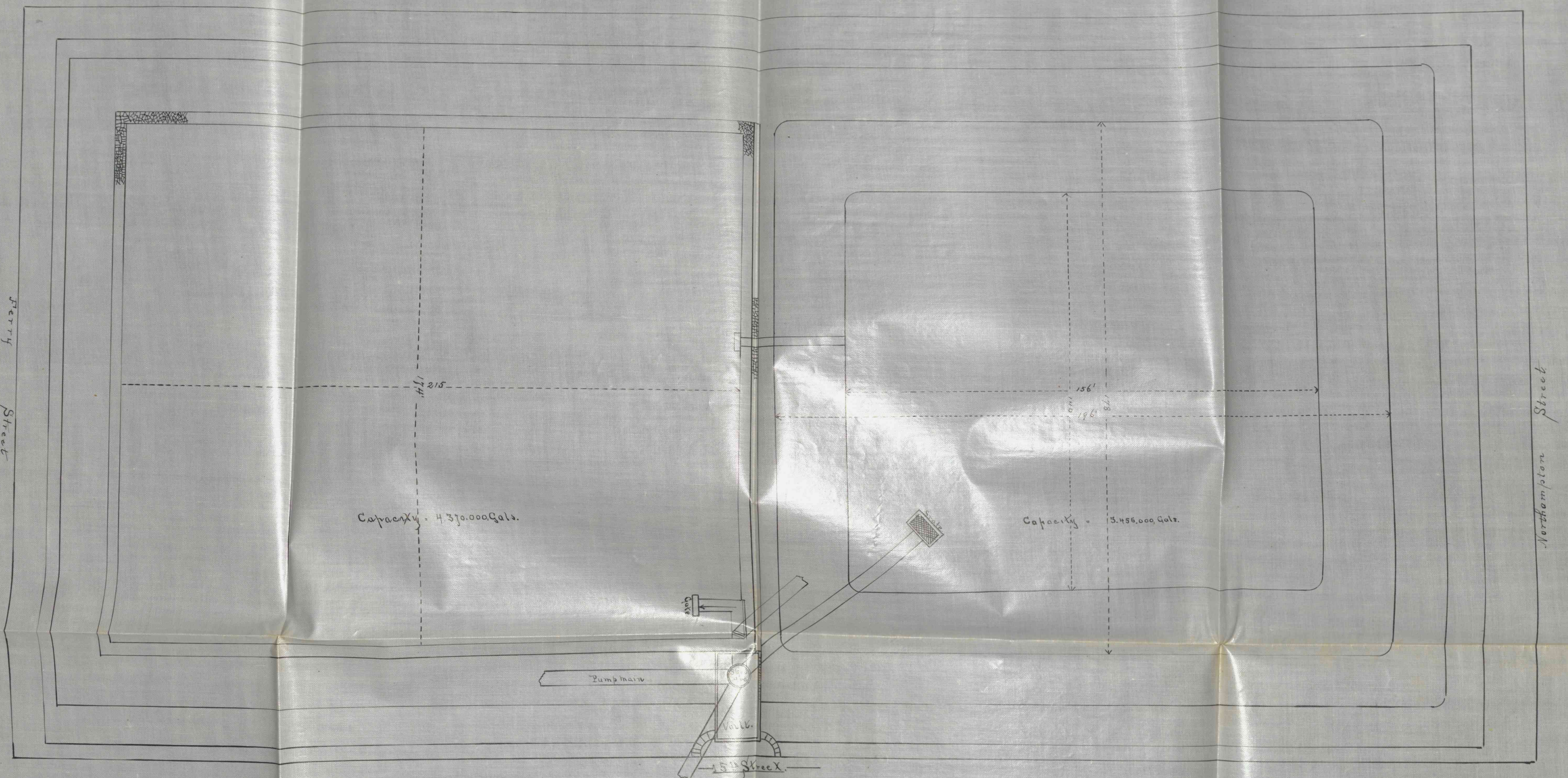
	Elevation	Plug Press	Cor Head
<u>Third</u>			
Spring Garden	48.5	83.	189.81
Bushkill	32.3	87	198.91
Bt Ferry & Lehigh	20.1	90	207.37
<u>Fourth</u>			
Spring Garden	45.6	80	182.95
Bushkill	31.47	86.	196.68



Plan of Lehigh Water Companys Delaware Pumping Station

Scale 1/4" = 1'

J. M. [illegible] Del.

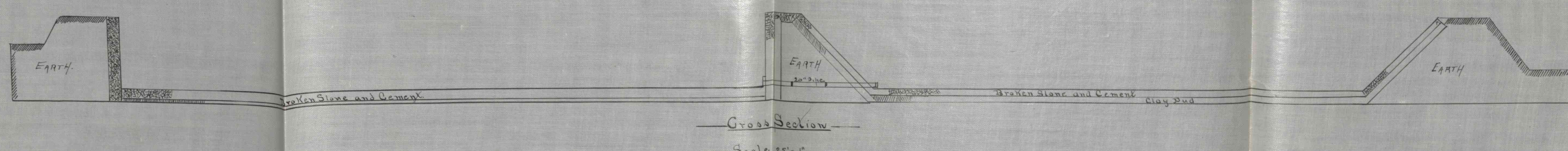


Plan of Lehigh Water Companys Reservoir

15th Street Easton Pa.

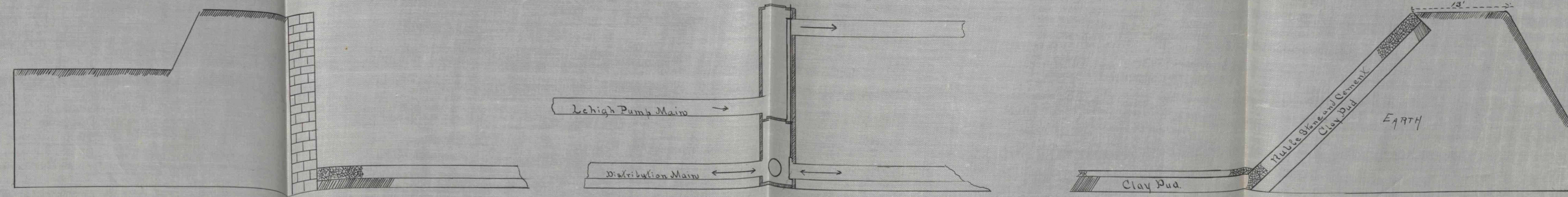
Robt. E. Kuhn. Engr.

J. M. Porter Del.



Cross Section

Scale 25' = 1"

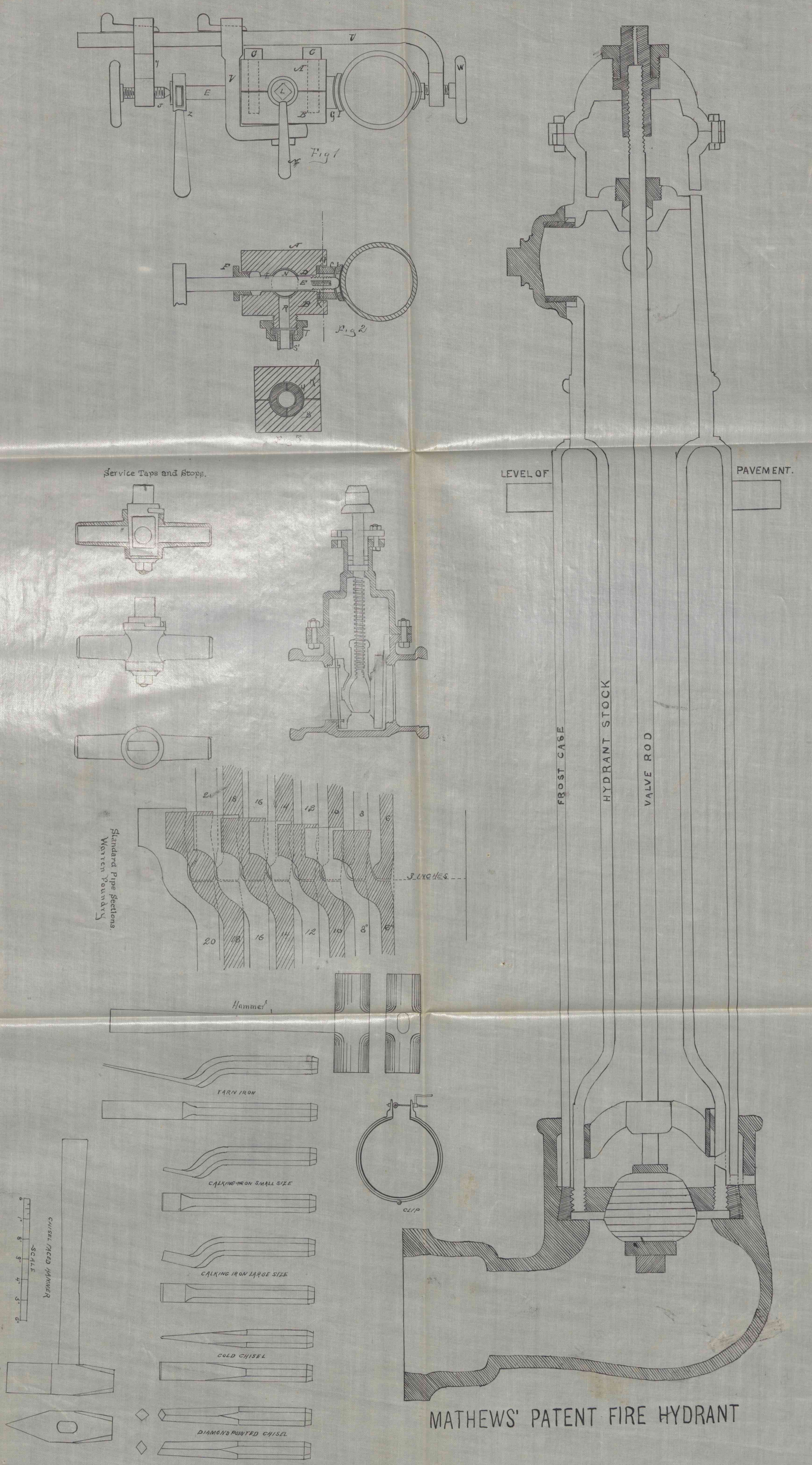


Vertical Cross Section of Stand Pipe

Scale 10 ft = One inch

W. YOUNG.

Apparatus for Tapping Water-Mains.



Tools used in Pipe Laying.

MATHEWS' PATENT FIRE HYDRANT


Total Head Level
Profile of Supply Main
Scale
Hor. 400' = 1"
Vert. 100' = 1"
J. M. Porter, Del.
Pumping Head of 257.3 ft.
Wagner St.
Broadhead 132.9
Reeder 157.9
New 161.4
Clinton
Front
Bushkill
Spring Garden
Second
Church 47.0
Northampton 38.04
Ferry 26.34
Third 37.72
Bank
Fourth 39.7
West Alley 55.8
Fifth 97.6
Sixth 127.9
Union 147.5
Walnut
Seventh 148.9
Eighth 150.0
Mulberry
Ninth 141.6
Poplar
Tenth 138.7
Blackberry
Eleventh 151.3
Elder
Twelfth 166.4
Cherry 173.1
Thirteenth 183.1
Beach 198.5
Fourteenth 211.2
Pine 204.1
Raspberry 217.1
Fifteenth 236.7
20" Pipe
High St.
4" Sub-Main
8" Sub-Main
5" Sub-Main
Reeder St.
16" Pipe
Frank St.
Spring Garden
Second St.
5" Sub-Main
12" Pipe
4" Sub-Main
Ferry
10" Pipe
4" Sub-Mains
4" Sub-Main
6" 06" Sub-Mains
4" Sub-Main
4" Sub-Mains
12" Pipe
St.
4" Sub-Main
6" Sub-Main
Fourteenth
Pine St.
6" Sub-Main
6" Sub-Main
300'
250'
320
310
340
1370
670
240'
80'
480
250'
350
240
220
280'
260'
310'
300
120
360
360'
310
210
210
200
200
270'
270
260
270
260
270
260
270