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The water works of Binghamton

The

WATER WORKS OF

Binghamton.

A thesis for the degree of Bachelor of Civil Engineering.

Walter Loring Webb.

May, 1884.

Contents.

Water Works in general.

There are four general methods of affording a water supply to a community. The oldest and (under some circumstances) the cheapest system is the gravity system. This system involves no pumping and unless the length of reservoir system and aqueduct is very great, the running expenses are comparatively small. This system consists in impounding the rain-fall of a large catchment area or water-shed and leading it by aqueducts and water courses to a storage reservoir. This reservoir must be placed at a sufficient elevation to overcome the friction of the mains and pipes and force the water to any required height in the City. Occasionally situations are found where the topographical conditions are such, that this system is the best and cheapest, but ordinarily there are many objections to it.

A storage reservoir that depends entirely on the catchment of rain or the flow of springs for its supply ought to be large enough to contain four months supply. Such a water shed is generally at a considerable distance from the City to be supplied and therefore the cost of a lengthy aqueduct must be added and often the cost of distributing reservoirs in the city.

The second method is a combination of the gravity and pumping systems. By this method the water is pumped directly from wells, springs or rivers, to a distributing reservoir placed at a sufficient elevation. This has the advantage over the first method of requiring a much smaller reservoir and therefore the cost of the reservoir is much smaller. It is also much easier to find a location near the City where a relatively small reservoir can be placed than to find a location for a much larger one where its water supply has to flow into it. Again, the chances are that the reservoir into which the water is pumped will not need so long an aqueduct as the other. The pumps can operate at regular speed and this conduces to a higher duty of the engines than when the pressure is variable. If the engines are large enough, they need to work only a portion of the twenty four hours and this dispenses with a considerable cost for attendance. In case of accident to the pumps the reservoir will ordinarily contain enough to meet the demand while any ordinary repairs are being made. In this system as well as in the first, it is seldom that a practicable location for a reservoir can be found that will give a sufficient head for fire purposes. In these cases the extra cost of fire engines must be taken into consideration.

The third system is the stand pipe system. The stand-pipe is a gigantic vessel generally made of iron and either made air tight at the top and the water forced in until the compressed air makes a sufficient pressure, or else, made open at the top and built a little higher than the head of water required to produce the necessary pressure. The main advantage of the stand pipe system consists in the fact that, during certain hours of the day and night, the demand for water is so much reduced that a much less pressure is required to meet the demand, and if the water is lowered in the stand pipe during those hours the lift of the pumps will not be so great. When the water is pumped into a reservoir the lift of the pumps is constant and is a maximum, since the elevation of the reservoir must be sufficient to produce the maximum pressure required. Hence the average lift with the stand pipe system is less than with the reservoir pumping system. The stand pipe is very apt to freeze in the winter in cold climates and in many of our Northern cities such a plan would be impracticable. In Jersey city the stand pipe blew over and it is evident that the problem of securing such a tall slender structure (at Erie, Pa., 220 feet high and five feet in diameter) is no small part of the whole work.

The fourth system is the Holly system. This system comprises the following essential features.

1st. The water is pumped directly into the mains.

2nd. The pressure can be regulated at the will of the engineer by increasing or diminishing the work done by the engine.

3rd. An Automatic regulator keeps the pressure constant regardless of the amount of water drawn from the mains. If all the mains were closed so that no water flowed through the pipes, the engine would stop automatically.

General plan of Works in Binghamton.

In 1867 the City of Binghamton commenced their system of water works by erecting an engine house on Court street on the Eastern side of the City. Two wells about twenty five feet in diameter and about twenty feet deep were dug. They purchased a steam pump of the Holly Manufacturing Co. This was one of the first contracts ever made by the Holly Company. In 1875 they purchased of the same Company a Holly Quadruplex engine at a cost of $17,000.00 and with a capacity of 2,000,000 gallons per day. In February, 1882, they still further increased their works by purchasing a six million gallon engine at a cost of nearly $25,000.00. This has been their main engine ever since. The engine first purchased has been discarded and the one purchased in 1875 is used only when repairs are being made on the other or when it is started up simply to keep it in good condition as is done about every two weeks.

The well area has been increased from 982 sq.ft. to about 2858 sq.ft. besides having had pipes laid into the river from which water is drawn when the supply in the wells is low. The wells are all sunk to a depth of about twenty feet but the available depth has been made much greater by sinking a number of pipes into the wells at depths varying from seventeen to thirty feet.

These works are run entirely on the principles of the Holly system and may be taken as a type of the system.

Reasons for adopting the Holly system.

In 1875, surveys were made with a view of building a reservoir on a hill south east of Binghamton across the Susquehanna river, from which a head of several hundred feet could be obtained. One of the great objections to this plan, if not the greatest, was the immense length of flow (and consequent loss of head by friction) that would be required of the water. There was no adequate source of supply found on or near the site for the reservoir and the water would have to be pumped up from the river or from wells in the valley as at present. If this plan had been followed out, they would have had on the one hand the advantages of the gravity system, but on the other hand a very extensive system of pumping would have been necessary. The friction in the pipes from the pumps to the reservoir would be considerable and the power required in the pumps would be considerably more than the theoretical power which such a reservoir head would afford. Again the friction in the pipes from the reservoir back to the city (coming back not far from where it started) would be large and the actual pressure in the city would be much less than the theoretical pressure due to the height of the reservoir. Owing to these two sources of loss of head, the available pressure in the City would be much less than that due to the work of the pumps, or, in others words, the pressure indicated by a gauge in the City near the pumping station (on the reservoir system) would be less than the pressure by the same gauge, if the water were pumped directly into the mains, by a pressure head equal to the friction head of the pipes to and from the reservoir—assuming that the distance from the pumps direct to the gauge is so short that the friction of pipe between them [redacted] can be neglected. Hence by pumping directly into the mains this enormous loss of work is averted. It was probably in recognition of this fact that it was decided in 1887 to purchase an engine for pumping directly into the mains, although it was not thoroughly appreciated until the surveys of 1875 had shown this fact, as well as the great cost of such an undertaking. Therefore since the best source of water supply was in the valley near the city the Holly system was deemed the best and cheapest. The City was fortunate in being able to locate the pumping station close beside the D. L. & W. railroad and thus coal is brought directly to the works without their being obliged to cart it—making a great saving thereby.

Plans of wells and Engine house.

The engine and boiler house is of brick and built according to the plan as shown in the accompanying drafts. On each side of the entrance is a well twenty feet deep and twenty five feet in diameter. The walls are laid up with dry rubble for the lower four feet and with cement mortar for the remainder of the distance. In June 1875, a well was excavated by the side of the river. Its dimensions are 12'x12' inside. It was dug 14' below low water mark of the river and was walled up with timber for the first ten feet. The top was covered with timber and on this was laid two feet of broken stone. On these were laid layers of fine gravel and sand. The object of this was to thoroughly filter all water which should come in from the river. It worked well for a time but the filter gradually became choked up with sediment. With evident lack of foresight, no provision whatever was made for shutting off the water so that the filter could be cleaned. The filter being choked up, nearly all the supply from the river was cut off from this well and the most of the water comes in from springs on the north side of the well. In the summer of 1878, a fourteen inch pipe was run from this well seventy two feet into the river. This pipe was provided with a stop valve and no water was drawn from the river until November when the demand increased, as it always does during the frosty months, and occasional drafts have been made on the river since that time. This well is connected with the others by a twelve inch pipe which is provided with a stop valve so that connection may be entirely shut off if required.

In July 1882, six six-inch pipes were driven in the well on the east side of the main building. Five of them were sunk to a depth of from seventeen to nineteen feet and a large flow of water was obtained from these. The other was sunk thirty feet but the flow was not as great as from the others. Three more five inch pipes were also sunk in the same well, but, either from not striking the vein, or from getting clogged, but little water would flow from them.

In the spring of 1888, four six-inch pipes were driven twenty feet in the well on the west side of the engine house. This increased the flow so much that only a little water was required to be drawn from the river during the summer. A little while after a still further addition was made to the well system by digging a compound well divided into eight compartments. Each compartment is 20′ 1½″ x 10′, inside dimensions, and about twenty feet deep. The total length inside the two end walls is therefore 175′. This is connected with the old well on the east side of the building with a 30″ pipe. The compartments are separated by a two foot wall which has an arched opening through it whose base is two feet above the bottom of the well. The bottom of the well is about ten feet below average low water mark in the river. It is proposed to run a pipe from the bottom of the well to a crib 150 feet from the river bank. At this point the pipe would be laid nine feet under low water mark, leaving a fall of one foot from the river toward the well. The total length of this pipe would be 276 feet. The river end would be enclosed in a crib which would have an inner box 4′ X 12′. The space between the inner and outer boxes would be filled with loose stones and gravel and thus make a filter for the water. The pipe is to be thirty inches in diameter. Ten feet from the point where the pipe starts from the well, a valve well six feet in diameter and of sufficient depth has already been dug and a thirty inch stop valve has been placed on the pipe in this well. This is as far as the pipe at present extends.

All the wells are connected with each other—the two old wells being connected by an arch-way running under the engine house. The pipe from the well by the side of the river runs to this arch-way. The water ordinarily stands at a depth of about five or six feet.

It is proposed as a further source of supply to dig another trench well on the west side of the lot similar to the one on the east side. The supply from these can further be increased by driving six-inch pipes at intervals of fifteen to twenty feet. In the opinion of the superintendent measures like these will insure a water supply for at least the next ten years. They avoid, as much as possible, using river water, although as will be shown afterward the water taken from the river is very good drinking water. What they will do for a water supply when the city has grown so that the present supply is inadequate, will perhaps be a serious question some years hence.

Plans of water mains and pipes.

When the water works were first built a great deal of cement pipe was used. These were made by making a sheet iron pipe considerably larger than the required inside diameter and lining it with a thick layer of hydraulic cement. This pipe after having been thoroughly dried is very strong and capable of sustaining considerable pressure. Since the city (and consequently the water works) have increased, the pressure on the pipes near the pumping station has to be very much greater than formerly in order to obtain a given pressure at the extremities. The pressure will be increased by the friction resistance of the increased length of pipe. This has produced a greater pressure than such pipes are capable of bearing. The sheet iron on these pipes is so thin that it only requires a comparatively short time for it to rust away and when the strength of the iron is gone the cement has but little strength to sustain the great pressure that has to be brought on them especially in times of fires when the pressure is raised. The largest of these pipes is twelve inches, inside diameter. These pipes are now fast being replaced by iron pipes. The water pressure now carried for fires is from sixty to seventy pounds and it is kept as low as this on account of the comparatively weak condition of the pipes. If the pipes were all of iron they would be able to carry 100-120 pounds pressure at fires. The "domestic pressure" is kept at about 45 pounds.

Jan. 1, 1884, there had been 24 miles 880 feet of mains laid. Of this amount a little over half, or 12 miles 2491 feet, consists of iron pipe. The amount in sizes are as follows:-

20 inch	1850 feet.
16 "	265 "
12 "	1 mile- 2890 "
10 "	929 "
8 "	1 mile-569 "
6 "	9 miles-1428 "

4 inch------------------11 miles-3964 feet.

24 miles-880 feet.

Plan of boilers and furnaces.

In 1878 one of the boilers was set with a Jarvis Furnace. This gave such satisfaction that others were put in and now three of the four boilers are set with this furnace. The principal feature of this furnace consists in supplying pure air, heated to a very high temperature, to the gases which are generated in the furnace and producing a gas flame, thus consuming a great deal of gas that would otherwise be wasted. The air passes in by small openings in the front and traverses long expanding ducts built in the furnace wall and enters, highly heated, through opening on the bridge wall and on the sides of the furnace walls. When screenings are used they are moistened with about forty per cent of water. When this fuel is burned a large amount of hydrogen coming from the water, is evolved. This passes through the furnace and when it reaches the heated air (oxygen) they combine making an oxy-hydrogen flame. The essential fuel of this furnace is therefore gas. This furnace is adapted for burning almost any kind of fuel without the use of a blower. This includes anthracite coal screenings, bitumenous slack coal, pea coal, wet peat, wet hops, saw-dust, logwood chips, rice chaff, wet begasse, &c. The Jarvis Company advises the use of a small amount of bitumenous coal mixed with the screenings, but, as will be shown farther on, the coal screenings have been used alone a great deal at Binghamton and as there is abundant opportunity at the Water Works to test the economy of such firing, it is probably considered more economical. An inspection of the Superintendent's report for 1888 will show that during the first few months of the year the duty of the engine was much higher than during the remaining months and yet for the first eight months of the year, the screenings were used alone. Of course it cannot be claimed that an inferior fuel could make a higher duty per pound of fuel used; but it shows that with this furnace, using coal screenings alone will probably not reduce the duty as fast as it will reduce the cost. (More of this will be found under the head Cost of Maintenance.)

Plan of engines and regulator.

There are two Holly Quadruplex engines in the works but it is never necessary, so far as power is concerned, to use more than one of them at once. They are essentially of the same design except as to size. Each one has four steam cylinders and four doulle acting pumps. The cylinders are inclined at an angle of 45° and the pumps are in direct line with the cylinders. The piston rods are connected (as shown in the plate) to a common shaft. The crank pin for one pair of connecting rods is set 135° in advance of the other. By this method, eight impulses are given to the machinery during each revolution and as the shaft carries a fly wheel the motion is about as near perfectly uniform as can be obtained by crank motion.

The cylinders can all be worked as direct acting engines or the steam may be admitted directly to only one or two cylinders and then by exhausting into the other cylinders convert the engine to a compound engine.

The valve gear is the ordinary slide valve worked by an eccentric and admits the steam through the whole stroke. A double puppet valve(H) is connected with each steam chest and regulates the point of cut off. This valve is operated by a revolving spiral cam(C) which moves in an axial direction, and which can vary the admission of steam from zero to full stroke. This regulator is one of the great essential features of the Holly system. It consists essentially of a water cylinder(A) which is connected directly with the water mains. When the pressure changes from the normal in either way the lever(B) throws the friction clutch(D) into gear. This moves a chain of gearing and belts and finally the cam (C) in plate III is moved so as to alter to point of cut off.

For example, if there was a sudden draft on the mains owing to a fire or some similar cause, the pressure in the mains would at once lower. This would cause the regulator to work the cams so that the admission of steam into the cylinders would be lengthened—the engines would do more work—the water would be pumped into the mains faster and the normal pressure would be restored. If it is desired to raise the pressure for a fire the wheel(E) is turned until the pressure in the cylinder is the required pressure. The regulator at once adjusts the engine to its increased work and this higher pressure will be for the time the normal pressure which the regulator will automatically maintain. The regulator always maintains the pressure in the mains at the point to which it has been adjusted for a normal pressure.

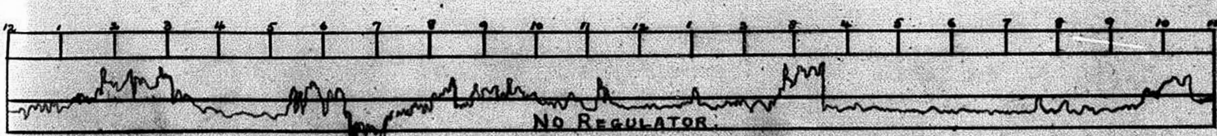
The necessity of having some means of equalizing the pressure which would otherwise be greatly changed by the varying demands on the mains, is shown by an inspection of the following diagrams which show the variations of pressure for periods of twenty four hours each. The first three were attached to the Holly engines at Lockport, and the fourth was attached to the pumps at Sandusky, Ohio, which had no regulator. Unfortunately, in the report from which these diagrams were taken, no lines were drawn in the diagram by which the absolute pressure can be determined nor even a scale by which the number of pounds variation in the pressure can be determined. But a close approximation can be made by considering the statement, given in the report, that in the first diagram, the variation of pressure was less than five pounds as long as the regulator was attached, but when the regulator was detached, as it was for four hours and a half, the variation was about thirty five pounds. The other diagrams were probably drawn on the same scale as the first.

LOCKPORT, N.Y., MAY 17, 1878.

LOCKPORT, MAY 27, 1878.

PRESSURE DIAGRAMS.

LOCKPORT, MAY 28, 1878.



SANDUSKY, OHIO.

W. L. WEBB, Del.

C = pounds of coal used during trial.

Duty means the number of pounds of water which is raised one foot for every 100 pounds of coal used.

As the details of the solution of the formula were not given in the report the calculation is made as follows:-

The diameter of the pump is 9."125 and the area of one side of the piston $= \frac{\pi d^2}{4} =$ 65."397; but the piston rod is attached to the other side of the piston, and on that side the effective area = area of piston − area of cross section of rod.

Area of cross section of rod $= \frac{\pi d^2}{4} = \frac{\pi \, \overline{2.083}^2}{4} = 3."408$

Effective area of one side = 65."397 − 3."408 = 61."989

Area of reverse side ———————— 65."397

2)127."386

Mean area of piston — — — — — — — — 63."693

The stroke is 24" and therefore the mean theoretical amount of water pumped at each single pump stroke = 63.693 × 24 = 1528.632 cu. in.

$\frac{1528.632}{1728} =$ .8846 cu. ft.

.8846 × 62.4 = 55.20 pounds.

In pumping there is always a certain amount of leakage and from other experiments made on pumps of this kind it has been calculated that about 97.5%

of the theoretical amount of water is actually pump-ed.

∴ 55.20 X 97.5 = 53.82 pounds of water delivered at each single stroke of the pumps = P of formula.

The number of revolutions during the experiment was 49235, but in each revolution of the fly wheel eight strokes of the pumps are made. Therefore the number of strokes = 8 × 49235 = 393880 = N of the formula.

The pressure indicated by the gauge was 40 pounds to the sq. in. The indication of the gauge really means reading plus atmospheric pressure (which the water encounters when it leaves the service pipes). The water is forced from the wells into the pumps by the pressure of the atmosphere but since the gauge is only 22' 3 above the surface of the water in the wells, the pumps are <u>aided</u> by a pressure equal to atmospheric pressure minus the pressure due to the height 22' 3. It is estimated that the friction of the water in passing through the engine and suction pipe is equivalent to a pressure of one pound. Therefore the true pressure that the pistons have to work against =

40+1+atmos. pr. — (atmos. pr. — press. due to 22.6)

$= 40+1+22.6 \times \frac{62.4}{144}$

$= 41+9.8$

$= 50.8$ = pressure on the pumps in pounds per sq. in.

But $50.8 \times \frac{144}{62.4} = 117.28$ = height in feet due to such a pressure = H of formula.

Recapitulation of data.

P = 58.82 H = 117.28

N = 898880 C = 8100

$$\text{Duty} = \frac{58.82 \times 898880 \times 117.28}{8100} \times 100 = 80{,}165{,}000$$

= number of pounds of water raised one foot by the expenditure of 100 pounds of coal. This result differs by about 1.5% from the result worked out by Mr. John Evans who conducted the experiment, (i.e. 81514000). As the details of his solution were not given in his report, it is impossible to tell just what caused the discrepancy but an inspection of the formula will show that it would only take a slight difference in the pressure—less than a pound— to cause the difference in the results. It will be seen that no deduction was made in this experiment for cinders, ashes and unburned coal. If this had been done the result would have been

$$\frac{80185000 \times 8100}{8100 - 840} = 90040000.$$

Although it would be fair to make an allowance for unburned coal, it is unfair to allow for cinders and ashes, and as it is unknown what part of the 840 pounds residue consisted of unburned coal, the lower duty must be taken. The contract called for a duty of 50,000,000 ft. lbs. and this test gave a surplus of over 60%.

During the month of January 1888, the six million gallon engine gave a regular duty of 65,689,840 foot lbs. and the daily average delivery was over 235500 gallons. During the remainder of the year the daily pumping was less while the amount of coal consumed was in general more and consequently the regular duty averaged but 54568910 foot lbs. It must be remembered however that a test duty of an engine is always made with the best coal, picked and screened. During 1888, over 98% of the total amount of coal used was coal screenings, the remainder (less than two per cent) being bitumenous coal and a little cord wood.

The domestic pressure during the year was kept at 45 pounds and the fire pressure varied between 60 and 70.

40+1+atmos. pr. — (atmos. pr. — press. due to 22.6)

$= 40+1+22.6 \times \frac{62.4}{144}$

= 41+9.8

= 50.3 = pressure on the pumps in pounds per sq. in.

But $50.3 \times \frac{144}{62.4} = 117.28$ = height in feet due to such a pressure = H of formula.

Recapitulation of data.

P = 58.82 H = 117.28

N = 898880 C = 8100

$$\text{Duty} = \frac{58.82 \times 898880 \times 117.28}{8100} \times 100 = 80{,}185{,}000$$

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During the month of January 1888, the six million gallon engine gave a regular duty of 65689840 foot lbs. and the daily average delivery was over 285500 gallons. During the remainder of the year the daily pumping was less while the amount of coal consumed was in general more and consequently the regular duty averaged but 54568910 foot lbs. It must be remembered however that a test duty of an engine is always made with the best coal, picked and screened. During 1888, over 98% of the total amount of coal used was coal screenings, the remainder (less than two per cent) being bitumenous coal and a little cord wood.

The domestic pressure during the year was kept at 45 pounds and the fire pressure varied between 60 and 70.

Cost of maintenance.

In April 1878 one of the boilers was reset with a Jarvis patent furnace for burning coal dust. Since then two more of the four boilers have been reset with this furnace. This has reduced the cost of maintenance very much for not only has the amount of fuel been reduced but they are also able to substitute coal dust or culm for the bitumenous coal previously used. At first the anthracite coal dust was mixed with 10 per cent of bitumenous coal but the proportion of bitumenous coal has now been so reduced that last year it was used only four months during the year. The remainder of the time screenings were used alone.

The following will show how the fuel account has been reduced during a number of years past.

Year	Cost of fuel	Year	Cost of fuel
1872	$8249.76	1878	$1761.61
1873	$8393.65	1879	$856.28
1874	$6880.97	1880	
1875	$6149.20	1881	
1876	$3888.93	1882	$1006.08
1877	$3016.85	1883	$1076.01

No one cause can be ascribed for this reduction. It has been due partly to the reduction in the price of coal, strict attention to firing, new pumping machinery, covering of steam pipes and perhaps principally to the resetting of the boilers and the employment of coal dust.

Although there was an increase in the cost of fuel consumed during the last few years there was really a slight reduction in the cost, as will be seen by the following.

Year	Cost of fuel	Gallons pumped	Cost per million gallons pumped	Cost of raising one million gallons one foot	Pumping Expenses.
1879	$858.28	575840500	$1.48	6.4 cents	$4880.58
1880	—			5.5 "	$4084.28
1881				5.1 "	$4572.00
1882	1006.08	682886810	1.47	5.48 "	$4945.87
1883	1076,01	748949286	1.44	4.51 "	$4598.70

It will be seen that these figures are a very great reduction on previous years. For example in 1878 the average daily use of water was 1335407 gallons. The average daily cost of coal was $\frac{1761.61}{365} =$ $4826. This makes an average cost of $\frac{4826}{1.335407}$ or $3.61 per million gallons which is more than twice as much as in 1879.

Chemical character of water supply.

It is a largely accepted opinion in Binghamton and vicinity that the whole supply of water in the wells comes from the river. The following circumstnce was noticed while pipes were being driven in one of the well, which would seem to show that the water of the wells is derived from a vein of water coming from the north. The pipes on the south side toward the river were driven first and the water was flowing out of them clear when those on the north side were put down. While these were being cleaned out with a sand pump, the water flowing out of the pipes on the south side was observed to be very roily. If the water had been flowing from the river, the water from the pipes on the south side would have remained clear regardless of what was going on on the north side of the well.

In 1888, the following analyses of the water from the different sources from which the works drew their supply, were made by Willis G. Tucker, the Public Analyst for this State. This investigation was undertaken at the instance of the State Board of Health in order that it might mitigate needless fears in regard to the potable water of the city.

State Board of Health-New York

Analysis of potable Water,

(Parts in 100000).

Received from Dr. J.G. Orten, Binghamton, N.Y. Source—Susquehanna river, 200 feet up stream above supply pipe of water works.

Date when drawn---------------------Jan. 12, 1888.

" " tested-----------------------Jan. 17, 1888

Appearance in two foot tube, clear very slight greenish tint.

Smell when heated to 100° F.-------------------None

Chlorine in chlorides--------------------------.32

Phosphoric acid in phosphates-----------------None

Nitrogen in nitrates and nitrites--------------.81

Free Ammonia----------------------------------.0082

Albuminoid Ammonia---------------------------.0004

Oxygen absorbed { 15 min. to 80° F.----------.0432
Oxygen absorbed { 4 hours at 80° F ----------.0936

Hardness, equivalent to Carb'te of lime { before boiling 5.7
Hardness, equivalent to Carb'te of lime { after " 5.0

Total solids dried at 220° F.----------------8.00

Microscopical examination of deposit-----None

(Signed) Willis G. Tucker,

Public Analyst.

Albany, N. Y. Jan. 24, 1888.

State Board of Health, New York.

Analysis of potable water

(Parts in 100000).

Received from Dr. J. G. Orton, Binghamton, N. Y.

Source ------------------- - Well of water works

Date when drawn --------- -- -- -- - Jan. 12, 1888

" " tested ------- ---- ---- Jan. 17, 1888.

Appearance in two foot tube, clear, ver slight greenish tint.

Smell when heated to 100° F ------------------ None

Chlorine in chlorides -------------------- .58

Phosphoric acid in phosphates -------- ----- None

Nitrogen in nitrates and nitrites ---------- .84

Free Ammonia --------------- --- -- ----- 0040

Albumenoid Ammonia ------------------------- 0082

Oxygen absorbed { 15 min. to 80° F. ---------- 0594; 4 hours at 80° F. --- ------ 0689 }

Hardness equiv. to carb. te of lime { before boiling 10°; after boiling 4°7 }

Total solids dried at 200° F. -------------- 12.80

Microscopical examination of deposits- ---- None.

(Signed). Willis G. Tucker,

Public Analyst,

Albany N.Y. -Jan. 24, 1888.

State Board of Health New York.

Analysis of potable water.

(Parts in 100000)

Received from Dr. J. G. Orton, Binghamton N.Y.

Sourse---Artesian wells supplying a part of city water.

Date when drawn-------------------	Jan. 31 1888.
" " tested--------- -------	Feb. 6, 1888.

Appearance in two foot tube, clear, very slight green-ish tint.

Smell when heated to 100°F.-------------	None
Chlorin in chlorides----- ---- -----	.44
Phosphoric acid in phosphates--- ----------	None
Nitrogen in nitrates and nitrites----------	2.85
Free Ammonia--------------- --------	0018
Albumenoid Ammonia-----------------------	0028
Oxygen absorbed — 15 min. to 80° F. -------	.0108
Oxygen absorbed — 4 hours at 80°F.--------	-0189

~~4 hours at 30 F~~

Hardness, equiv. to carb'te of lime { before boiling 15° / after boiling 64°

Total solids dried at 220 F. -------------- 19.40

Microscopical examination of deposits. ----- None.

Remarks.

The chlorine, nitrogen in nitrates and nitrites, and total solids in this water are low. Phosphates are absent. Free and albumenoid ammonia also low, while the amount of oxygen absorbed would rank it according to Tidy, as a water of "great organic purity" Judged from a chemical stand-point alone, this is a good water.

(Signed) Willis G. Tucker,
Public Analyst.

Dated, Albany, N.Y. Feb. 12, 1888.

Analyses were also made by Dr. Edward S. Wood about the same time, who pronounced the water very fine. He wrote, "An excellent water. Almost precisely the same as in August, 1881. So far as chemical analysis can show both waters (i.e. from the well and from the river) are especially good for domestic use, far better than most of our City waters, and I do not think that any sickness can be attributed to them."

Use of meters.

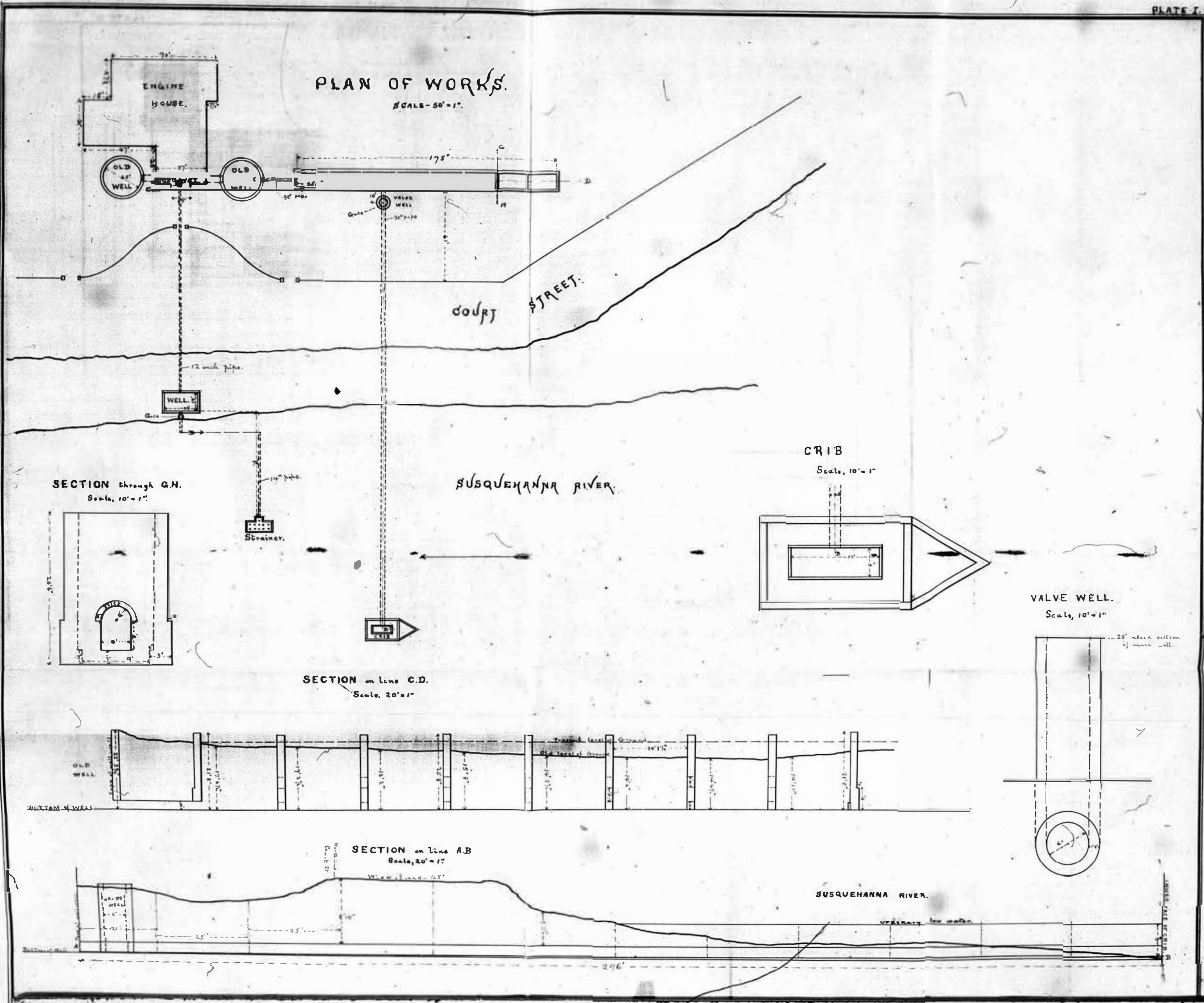
During the last few years a large number of meters have been put in especially in places where a great deal of waste is going on. At the close of 1878 there were only three in use but now the number has been increased to 112. There has been considerable discussion among those interested in water works in regard to the use of meters. The adherents to their use say that it is the only way of equalizing the water rates and of preventing a large amount of waste. In other words, the consumer pays for what he uses and no more and the water works gets credit for what it has done.

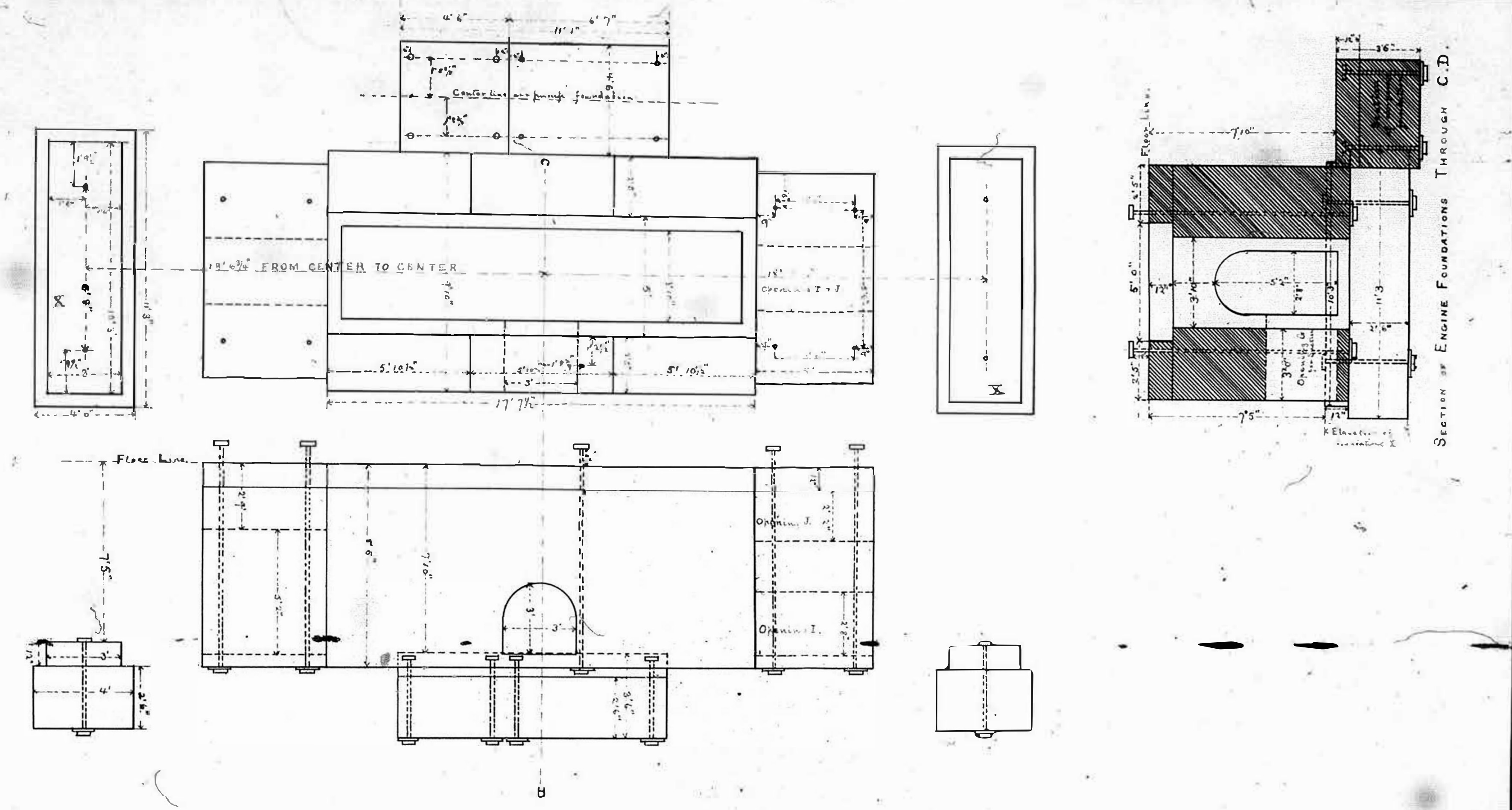
On the other hand, it is claimed that the cost of meters and the work of taking readings is no inconsiderable item of expense in the cost of maintenance It is also claimed that the use of meters has a tendency to check the free use of water for cleanliness (not only of person but of houses, streets, &c.) and having such a tendency it thereby induces sickness and all the other evils consequent on dirt and filth. Such an opinion was expressed by an engineer

of the

of the Croton Aqueduct who argued against the use of meters in New York City. The use of meters probably reduces waste and lessens the cost of maintenance, but with many people, the very thought that every additional gallon used adds to their bill acts as a check on the free use of water even to a more or less sacrifice of cleanliness.

There are many indications that the works at Binghamton are conducted in a very efficient as well as economical manner. It is noticeable that in the numerous comparisons that have been made on the cost of raising water in various places, Binghamton almost invariably takes the lead, sometimes having reduced the cost per gallon to only a small fraction of the cost in many of our large cities. The greatest drawback to the system is the large amount of defective cement pipe still in use, but, as was shown, a large amount of money is spent every year in replacing these pipes with iron pipes, and when this substitution is complete, the water works of Binghamton will compare favorably with almost any


PLAN OF WORKS.
SCALE - 50' = 1".
ENGINE HOUSE.
OLD WELL
OLD WELL
175'
VALVE WELL
COURT STREET.
12 inch pipe.
WELL
14" pipe
Strainer.
SUSQUEHANNA RIVER.
CRIB
Scale, 10' = 1"
SECTION through G.H.
Scale, 10' = 1".
VALVE WELL.
Scale, 10' = 1"
SECTION on line C.D.
Scale, 20' = 1"
Present level of Ground
Old level of Ground
OLD WELL
BOTTOM of WELL
SECTION on line A.B
Scale, 20' = 1".
SUSQUEHANNA RIVER.
Ordinary low water
296'
INNER FACE OF CRIB

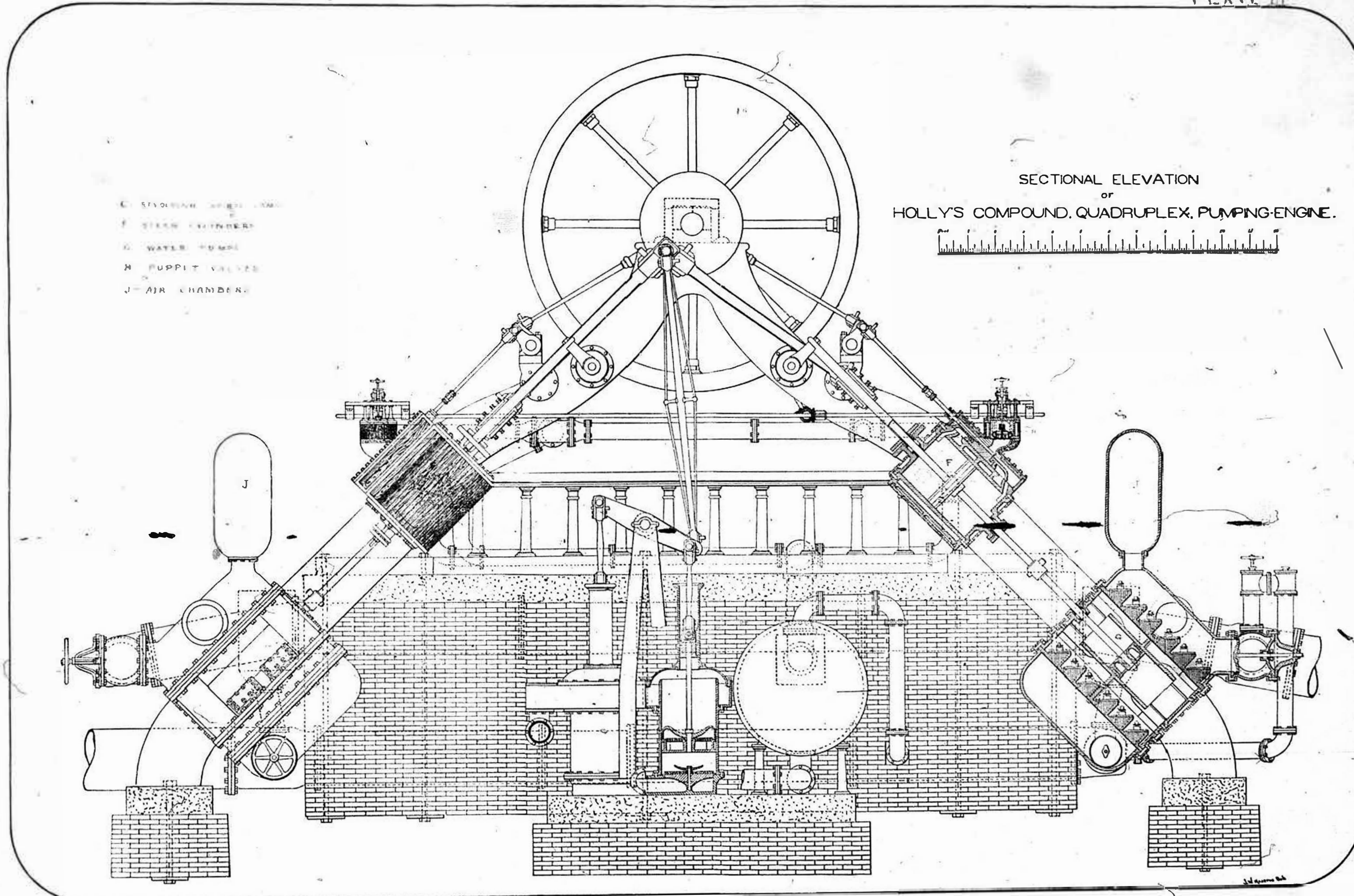


PLAN OF ENGINE FOUNDATIONS.

SCALE, 5'=1".

W. L. Webb - Del.

PLATE III


SECTIONAL ELEVATION
OF
HOLLY'S COMPOUND, QUADRUPLEX, PUMPING-ENGINE.
F STEAM CYLINDERS
G WATER PUMPS
H PUPPIT VALVES
J—AIR CHAMBER.
J
F
G

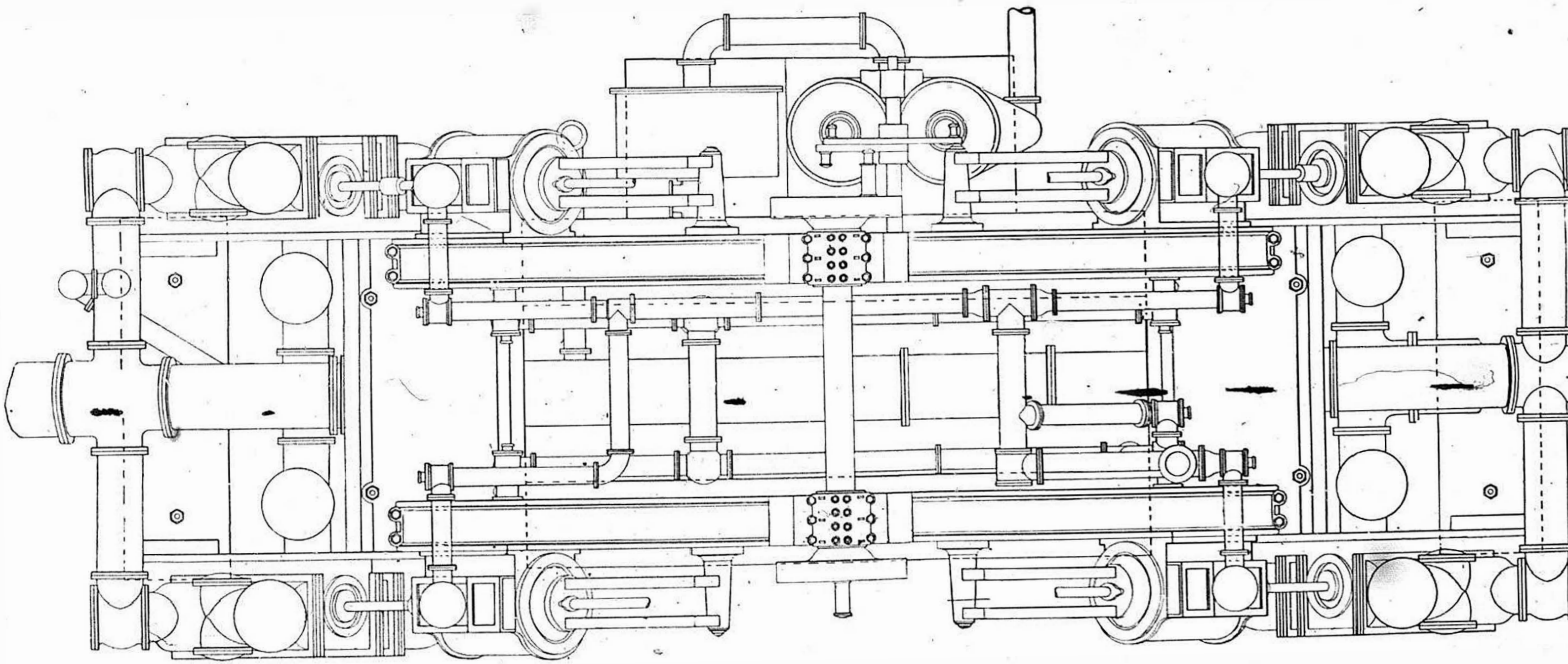
HOLLY'S

QUADPUPLEX COMPOUND

PUMPING ENGINE.

(PLAN)

Scale



B. HOLLY'S
AUTOMATIC.
PRESSURE-REGULATOR.