DEPARTMENT FOR SUPPLYING THE CITY WITH WATER.

ANNUAL REPORT

OF THE

CHIEF ENGINEER OF THE WATER DEPARTMENT

OF THE

CITY OF PHILADELPHIA,

EMBRACING

THE REPORT

UPON

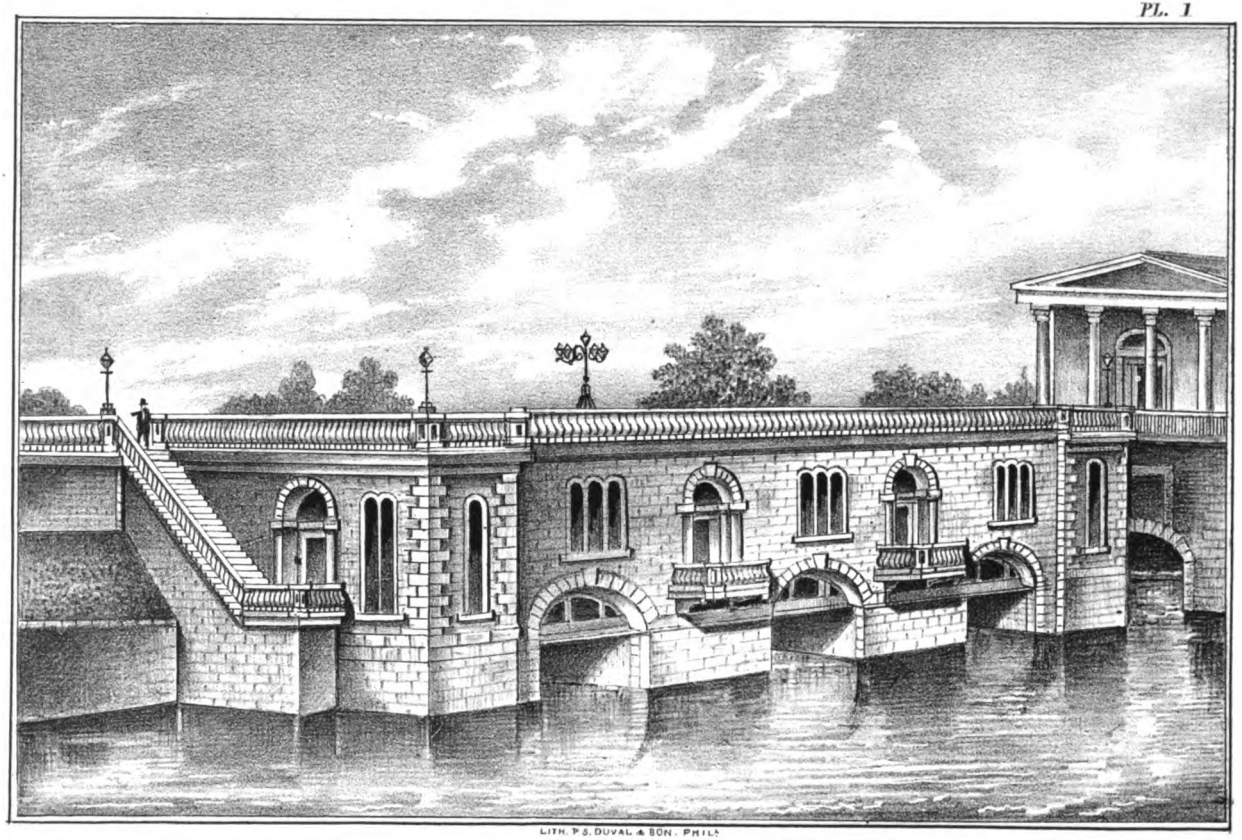
EXPERIMENTS MADE WITH TURBINE WHEELS,

AT

FAIRMOUNT WORKS.

PRESENTED TO COUNCILS FEBRUARY 21, 1861.

PHILADELPHIA:
WM. F. GEDDES, PRINTER, 320 CHESTNUT STREET.



LITH. P.S. DUVAL & SON. PHILA.

NEW MILL HOUSE AT FAIRMOUNT.

H. P. M. Birkinbine, Chief Engineer.

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Charles Thompson Jones,
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Fairmount Works,	James Shockley,	Christopher Hughes.
Schuylkill "	Joshua Bartley,	William Hodge.
Delaware "	Benjamin Norman,	Benjamin Berry.
24th Ward "	James Gregory,	James Buckley.

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ANNUAL REPORT

OF THE

CHIEF ENGINEER OF THE WATER DEPARTMENT,

PRESENTED TO COUNCILS FEBRUARY, 1861.

To the Select and Common Councils of the City of Philadelphia:

Gentlemen:—In obedience to the ordinances regulating this Department, it becomes my duty to report to you the condition and operation of the Works. At times, during the past year, the Works have been taxed to their utmost capacity, and frequently beyond what in fairness the machinery should be required to perform. Still the Department have been able to meet all the demands made upon them, and in no case has there been a deficiency of water in the reservoirs, although considerable embarrassment has been felt in many parts of the city for the want of mains of sufficient capacity to supply the necessary amount of water. In these localities the water could only be procured from the lower draws, and in some instances, at the time of greatest consumption, could be procured but for a few hours of the day even from taps in the cellars, or lower parts of the houses. This difficulty was occasioned solely by the want of mains of sufficient capacity; for, with but few exceptions, the reservoirs have been kept quite full.

The amount of pipe laid during the year has been very large, and the number of consumers added greater than in any previous year. The income from the Works has also increased, although not to the degree that would have been realized, had not the present commercial difficulties interfered with the collection of bills for pipe. An unusually large number of bills have thus been sent to the Solicitor for lien.

The character of the water supplied to a great city is a matter of the most vital importance. Upon this, more than upon almost any other circumstance, depend its health and comfort, and consequently to a great extent, its prosperity. By the patient and thorough investigations of the British Government into the health of towns, the rise, prevalence and fatality of many contagious and even common diseases, have been traced to the impure or scant supply of this most needful element*

We have always boasted of the purity of the water supplied to this City from the Schuylkill River, and with justice; for its character has been unexceptionable, and not subject to that periodical offensiveness in taste and odor experienced in the supply of so many cities. No complaints have ever been made of the water, except in times of freshets, when it has been turbid, but not offensive to taste or smell, the discoloration being caused simply by finely divided particles of clay held in suspension. The only exceptions have been, first, in the case of those supplied from mains through which there is no circulation, or from dead ends in which the water is liable to become offensive; and again, in September, 1859, for several days complaints were made of the odor and taste of the water in many parts of the City. As this latter is the only case of the kind which has occurred, it may be well to examine it briefly.

The water in the river had been extremely low for some time, and just as it commenced to rise the phenomenon was observed.

*The Department would take this opportunity of acknowledging the receipt of valuable documents issued by the British Government on this subject, from the Hon. George M. Dallas, our Minister at the Court of St. James.

The great freshet of the year which followed, entirely scoured the river and removed all cause of complaint. Investigations were immediately set on foot by the Department, and carried out as fully as possible, without a special appropriation. The difficulty was experienced for so short a time (three days) that no opportunity was given for inquiry before the rise of the river. Since then, careful observations have been made, but no recurrence of the offensive odor has been traced, and the few complaints which have reached the office have been found to result from want of circulation. The difficulty was probably caused by the stagnant water from shallow parts of the river and pools, which had been put in motion and sent down by the rising stream.

In pursuing these investigations, the Department have carefully examined the river from Fairmount to Flat Rock Dam, including the drainage into the river and the Fairmount Dam, with all its surroundings.

No amount of care or money expended in procuring and maintaining the purity of the water supply can be estimated as too great. And over that part of the river—Fairmount Dam—where the City, both by Legislative enactments and by purchase, have the entire control, (except as to navigation,) the most jealous care should be exercised, and no encroachments or drainage allowed that would in any way affect its purity. The importance of carefully guarding the water supply was early felt; long before the Schuylkill was crowded with the teeming population which now people its banks, or the demands of the City had any way approximated the present large supply. As early as April 12th, 1828, Legislative enactments were procured to protect the purity of the river. We quote the following:—

Act of the Legislature of the State of Pennsylvania, February 7th, 1832.

"That if any person or persons shall hereafter wilfully take, lead, conduct, carry off, or throw, or shall cause to be taken, led, conducted, carried off, or thrown into that part of the river Schuylkill which is between the dam at Flat Rock and the dam at Fairmount, near the city of Philadelphia, any carrion, or carcass

of any dead horse, or other animal, or any excrement of filth from any slaughter-house, vault, well, sink, culvert, privy or necessary, any offal or putrid or noxious matter from dye-house, still-house, tan-yard or manufactory, or any matter or liquid calculated to render the water of said river impure, every such person shall for each and every such offence forfeit and pay a sum not less than five dollars nor more than fifty dollars, at the discretion of the magistrate; to be recovered, with costs of suit, in the same manner as debts under one hundred dollars are by law recoverable, by any person who shall sue for the same, before any justice of the peace within the county of Philadelphia, one half to the use of the person prosecuting and suing, and the other half to the use of the Mayor, Aldermen and Citizens of Philadelphia

"That no length of possession whatever shall be available to bar or prevent the correction or removal of any nuisance existing or which may hereafter exist, at or near that part of the river Schuylkill which is between the dam at Flat Rock and the dam at Fairmount."

Observe also the following:—

Extract from the final Agreement between the Mayor, Aldermen, and Citizens of Philadelphia and the Schuylkill Navigation Company, relative to the water power, &c., at Fairmount, June 14, 1824:—

"And that whensoever hereafter the said President, Managers and Company, shall sell, demise or dispose of any water power at Flat Rock, or water power produced by the dam or canal at Flat Rock, they will introduce into the deed or other instrument of sale, demise or disposition, one or more clause or clauses, covenant or covenants, on the part of the purchaser, lessee or grantee, whereby he, his heirs, assigns or successors shall be at all times during the continuance of their possession and title, effectually restrained and protected from suffering any dye stuffs, or any noxious, fetid or injurious articles or matter whatsoever, to flow, pass or fall from their respective premises into the river Schuylkill, and shall be obliged and bound to confine all such dye stuffs, or noxious, fetid or injurious articles or matters, within one or more

wells or repositories, sunk or made upon their respective premises, and at a reasonable distance from the margin of the said river Schuylkill, and of any canal, water-course or passage leading into the same."

FAIRMOUNT DAM:

DRAINAGE INTO IT.

It is a remarkable and important fact, that the water-shed sloping towards, and draining into Fairmount Dam, is of very limited extent. This is particularly the fact on the eastern, and most densely populated, side of the dam. It will be seen at once, that this is highly favorable to maintaining the purity of the water it contains.

EASTERN BANK.

Commencing on the east side, just at the dam, the first drainage is a small open sewer, coming in immediately above the steamboat wharf. This drains but a limited area, that lying between the parks and west of Pennsylvania avenue. But while the amount of sewage is small, its character is very objectionable, from the drainage of the stables and a street railroad station, which it receives; and coming in, as it does, immediately at the head race, should receive prompt attention. The drainage of this district might be conveyed by an iron pipe, under water, across the head race and to the comb of the dam, and there discharged over the dam; or a catch-reservoir or tank could be constructed, and so arranged that the ordinary flow of sewage would drop into it; thus, only in time of rain storms, when the sewage was mixed with a large amount of water, would it pass over the tank. The sewage could be drained of its superfluous water by filtration, and the sludge or solid matter could be deodorised, and removed as frequently as it might become necessary to do so. Something should be done with this sewer at once, as its immediate proximity to the works render its discharge into the dam extremely objectionable.

Next we have the whole extent of the park protecting the

river front from all objectionable drainage, and forever imposing an effectual barrier to encroachments on the purity of the water.

There is, however, a stream coming in just below the Schuylkill Works, of a very objectionable character, on account of the breweries located upon it and drained by it. It is extremely offensive at all seasons, and commonly emits a disagreeable odor. It was expected that the great sewer, constructed on Pennsylvania Avenue and Twenty-fourth Street, would have drained this stream. The sewer is finished to within a short distance, and it will require but a slight alteration of grade to enable it to carry away all this objectionable drainage, and empty it below the dam. It is desirable that such alteration be immediately made, so that the river may be relieved of this drainage, and the offensive smell removed from the Works.

Half way between the Schuylkill Works and the Columbia Avenue Bridge, a small stream enters at the Rolling Mill. This also brings with it a considerable amount of objectionable matter from the breweries situated upon it. It could also be drained by an extension of the culvert already mentioned, or by the use of a catch-reservoir, in which the water could deposit its impurities, (as described above,) and come out comparatively pure. The former means, that of the sewer, would certainly and entirely remedy the difficulty. From this point down, the drainage into the Schuylkill cannot be too jealously guarded. It is most probable that impurities received into the river in this part of its course, pass into the Works without much change in their properties; those which enter above this point have time to settle, or to undergo chemical changes, rendering them much less objectionable. From this point to the Falls Village, there is but one stream flowing into the river; it is not contaminated; and from the limited area which it drains, it cannot become very objectionable, until the district is much more densely populated.

At the Falls, a considerable stream enters the river. Its drainage ground is extensive, the water shed reaching to the crossing of the Germantown Turnpike and the Reading Rail Road. This brings down a large amount of objectionable matter, as there are two large dye-works situated but a short distance above

its mouth, from which large quantities of spent dye-stuffs and wash-water are constantly discharged. In ordinary stages of the river, the discolorations arising from this source can be distinctly traced in the river at least one hundred yards below the mouth of the creek. To remedy this evil, large catch-reservoirs might be constructed, in which the water would deposit the greater portion of its impurities; but even if of sufficient capacity to receive the drainage of several days, they would scarcely render the water fit to enter the dam. Above this, the drainage from the chemical works, although in much smaller quantity, is frequently extremely objectionable in character. These works might sink at least the most objectionable part of their drainage, by constructing large and deep wells; they are sufficiently removed from the river, to render this means entirely effectual.

The drainage from the Falls Village itself, although objectionable, is not so great at present as to be of serious moment at that distance from the Water Works.

With the waters of the Wissahickon, much that is objectionable is brought down from the numerous factories, and large population upon it and its tributaries. The volume of water is very considerable, as it drains a large area of country. The character of this drainage is, to a great degree, neutralized by the quantity of water with which it mingles, and by the numerous dams, in its course. These not only act as subsiding reservoirs, but, by keeping back the water, give time for the oxidising of the organic matter it holds in solution. By keeping these dams well cleaned out, so as to secure as great a depth of water in them as possible, and by restricting the factories from locating any nearer the mouth of the stream, the purity of the water at its entrance into the Schuylkill may be ensured, at least until population and manufacturing have greatly increased on its banks.

From the Wissahickon to Manayunk, the shore is high and precipitous, allowing but a scanty drainage into the river. At Manayunk, the entire refuse of the gas works, including not only the water used in washing the gas, charged, as it is, with the ammoniacal liquor, but also a great amount of waste tar is allowed to flow into the Schuylkill. The Department have been informed

that the manufacture of gas at these works will be discontinued in a short time. If this be the case, no further action is necessary. Should the manufacture be continued, this drainage should be prohibited, as it not only mixes objectionable ingredients in the water, but the floating matter thrown upon the surface is repulsive in appearance. All the factories along the river front of Manayunk drain their offal directly into the river. Among them is a number of dye houses, which dispose of their spent liquid dye, and what is more inexcusable, their spent dye-stuffs, in the same manner. Indeed, the river is used as a common sewer by all the factories; and no pains are taken to prevent any refuse or objectionable matter from passing directly into it.

FAIRMOUNT DAM: WESTERN BANK.

Going back now to the dam, and commencing on the western side, we find a considerable stream coming in between the dam and the Twenty-fourth Ward Works. A few years ago the estuary of this stream was a deep, broad bay; but since the construction of the Rail Road and the improvements of that part of the Ward which is drained by the creek, it has silted up, so that only a channel of sufficient capacity to vent the water is left, the remainder of the estuary having been converted into a mud flat. The loose material brought down by the creek has acted in conjunction with that brought down by the river, to extend the shore line immediately below its mouth, some distance into the river. The creek is now a common sewer, draining a large district, in which a number of slaughter-houses and other offensive establishments are located. The estuary generally emits a very disagreeable odor. The proximity of this creek to the overfall of the dam, and its situation on the opposite side from Fairmount Works, and below the Twenty-fourth Ward Works, render it innocuous at present. It will be necessary, at no very distant day, however, to conduct this creek to some point below the dam.

Immediately above the Twenty-fourth Ward Works a small stream comes in, which is still pure, flowing principally through the grounds of Solitude. The next two streams are small and

pure as yet. One enters the river some distance above Girard Avenue Bridge, and the other at Belmont Cottage.

Above the Columbia Avenue Bridge there is a stream, with an objectionable establishment on its banks, which, consequently, at times discharges impure matters into the river. This might be dealt with as proposed in the cases already mentioned as existing on the other side. South of the Falls R. R. Bridge, another small stream enters, not yet contaminated. Above this bridge there is a stream which supplies a large dyeing establishment, located immediately upon the bank of the river, which discharges a large amount of spent dye-stuff and wash-water into it. Indeed, the river is made the immediate receptacle for all the drainage of these works. The next creek is still pure, and the next, which enters the river above the Falls Bridge, at Pencoid Iron Works. Opposite Manayunk, above the canal bridge, a creek comes in, upon which several dyeing establishments are located, and from which a large amount of objectionable matter is drained. At the Manayunk bridge there is another, whose drainage is of the same character, and further up still another. As population increases upon these streams, and as manufacturers perceive and occupy the advantageous sites they offer, the drainage will of course, be injuriously affected; but by care we may prevent their exerting a deleterious influence upon the water in the dam.

The sewage of Manayunk does not at present materially affect the purity of the water; most of it flows first into the canal, where it is mixed with so large an amount of water, that its deleterious effect is neutralized. When sewers are constructed, as is now proposed, to carry the sewage under the canal directly to the river, by providing them with catch-reservoirs, as above described, and by prohibiting the drainage of water-closets into them, any injurious effect may be prevented, even should the population of the town be largely augmented.

ENCROACHMENTS UPON FAIRMOUNT DAM.

Various encroachments have been made upon the dam since its construction, considerably reducing the area of its surface, and diminishing its depth.

The guard pier, used as a landing by the steamboats, extends a long way into the river, which is necessary, however, to protect the Works from ice. The wharves above it project a considerable distance into the river; and a large part of the ground lying between the parks, for which the City is now asked to pay so great a sum, has been made by filling out into the dam. Large encroachments were also made, in attempting to carry into execution the grand project of establishing a depot for transhipping all the freight brought down the Schuylkill Canal, at Lemon Hill. Here the shore was originally bold and rocky, with deep water along side. A portion of the hill was cut down and thrown into the river, for the purpose of forming wharves. By this means the shore line was carried out from 150 to 200 feet into the dam, on the south front of the park. The construction of a pier running parallel with the shore was also commenced, and numerous lay-byes were proposed. Nothing but the expected commercial importance of the project could have furnished an excuse for allowing such a wholesale encroachment upon the dam. In the old plans, this pier in the river is called a pier to *protect Fairmount Works;* but from what, and in what manner, is not stated; and in this late day it is impossible to do more than conjecture. It is probable such language was used to quiet the Council Committee on water, or the Superintendent of the Water Works, so that they might make no objection; or to get pecuniary assistance from the City. Happily for the Works, and the purity of the water, the enterprise failed; but not until irreparable injury had been done to the dam, by filling in; and to the beauty of the park, by destroying the bold bluff.

Nor did the encroachments cease then. In the construction of ice-houses, and in the improvement of the park, the work of filling in has gone on. In regard to the extension of the park, the question arises, how far its beauty is improved by substituting green sward in place of bright water. The encroachments already made and proposed, contemplate an extension of fully three hundred feet into the river. The original shore line occupied about the position of the centre of the great avenue, now laid out in the park. The Department

felt it necessary, in the fall, to call the attention of Councils to these encroachments, and objected to the construction of the building for the skaters' club, at the promontory forming the south-western point of the park. Nevertheless the encroachments are still going on, much to the detriment of the Water Works; however, in the judgment of some, they may improve the appearance of the park. The effect has been, and still is, to form large deposits of mud in that part of the Dam which is sheltered by the promontory from the scour of the river in time of freshet. These deposits will be carried out still further if the encroachments continue; and the pretence of protecting the Works put forth under the old Lloyd enterprise, and lately revived, will be found utterly groundless. The filling in and forming a wharf front, as proposed, will not obviate the difficulty. The mud brought down by the river, will continue to accumulate, and the only effect will be, to throw the deposits further out into the stream. The proper method to be pursued, if maintaining the purity of the water be an object, is to form a deep shore line by dredging. Indeed, the interests of the City would have been best served by procuring all the material necessary for filling in the park, by dredging the dam, and, as far as practicable, restoring the original shore line.

The accumulation of mud has been very great along the south front of the park, and in front of the wharves, to the Dam itself. There is a large deposit also in the head race, reducing the water way more than one-half of its original area. Indeed, that entire section of the Dam which is sheltered by the promontory from the scour of the river, is more than half filled with mud. All the coves along the front of the park, as far up as the Avenue bridge, are in a similar condition. It is also proposed in improving the park, to fill these coves out to deep water. This would be a very injudicious proceeding. They should rather be cleared out by dredging, and restored, as far as practicable, to their original condition. The creek coming in at the Schuylkill Works has brought down a large amount of solid matter, which is deposited below its mouth. When this creek is turned into the sewer, as proposed, and conveyed below the dam, and the deposits already formed are removed, this difficulty will be remedied.

The bend which the river makes at the Girard Avenue Bridge, directs the current which strikes the western abutment, across to the eastern shore, which it follows to the south-west point of the park. This has permitted an extensive deposit of mud on the western side of the river, reaching about half way across, and stretching southward from the bridge to within a short distance of the dam. In ordinary stages of the river, the depth of water on this flat will not average two feet; in low stages, of course it is worse; and the mud is agitated by every empty boat which passes up. The loaded ones are obliged to go out into the channel, which, immediately off Turtle Rock, is from 35 to 36 feet deep. In summer, the action of the sun upon the mud has certainly a deleterious effect upon the water. Sometimes it even emits an offensive odor. As the river channel is between the flat and Fairmount Works, it has little, if any, effect so far on the water supplied to the City. But, as the muddy deposit is receiving constant addition, and as the demands of the City upon the river are also increasing, the time cannot be far distant when serious difficulties may be apprehended from this source, combined with the encroachments at the park, as already described. The work of dredging should be immediately commenced and continued, until the river is to some extent restored to its original condition. The Schuylkill Navigation Company, in order to avoid the inconvenience caused to their business by this mud flat, at one time proposed making a new towing path on the west side, projecting in some places from the present shore line 150 feet into the river. This would not be so certain a remedy for the difficulty under which the Company now suffer, as dredging; and there is no doubt they would join the City and bear a part of the expense, as the navigation would be much improved by the operation, and the steam tug now employed in towing the loaded boats could be dispensed with. The water taken from the dam by the Twenty-fourth Ward Works is materially affected by this mud flat, and it is only through the efficient operation of the subsiding reservoir connected with these works, that the difficulty has been obviated thus far, and water of an entirely satisfactory character supplied to the Ward.

The filling up of the cove in front of the Schuylkill Works, was a permanent injury to them. It was found that mud accumulated in this cove, and instead of removing it from time to time, and so allowing the cove to act as a subsiding reservoir, it was filled in and a wharf constructed, reaching out into deep water, so that the scour of the river would prevent the accumulation of mud. So far, this wharf has answered the purpose. But had the space thus enclosed between the wharf and the forebay been excavated, and a subsiding reservoir constructed, this would have had a beneficial effect. The result of the present arrangement is, that it is necessary to take the water directly from the channel of the river without any opportunity of subsiding. Had it such an opportunity, the character of the water would be greatly improved. Rarely, if ever, would it be supplied in a turbid condition. There is ample room for the construction of a very effective subsiding reservoir between the Works and the river.

Above this point, the encroachments upon the river do not at present, in any degree, vitiate the water supply of the City; but if we are to look to this source for our supply for all time to come, the whole extent of the dam should be guarded with the most jealous care. At the Rolling Mill, above the Schuylkill Works, considerable encroachments have been made in constructing wharves, besides which, all the refuse of the mill is now thrown into the river, thus gradually pushing out the shore line. The eastern abutment of the Columbia Avenue Bridge has created a bar immediately below. A large ice-house has been constructed just above the bridge; more than half of the ground occupied by it, has been made by filling out into the river. Above this point no very serious encroachments have been made. The wharves at Laurel Hill, Falls, Wissahickon and Manayunk, have not been projected into the River to such an extent as to work permanent injury.

WHAT MEASURES ARE NECESSARY.

That the drainage into the dam and the encroachments upon its area, as now described, must interfere with the purity of the

water supplied to the City no one can doubt; but to what extent is a matter not so easily decided. It is certain that, up to the present time, no positively injurious effect in a sanitary point of view, can be traced to the water supply; and there may be none for years to come. But there is no doubt, that as population increases around the dam and manufacturing establishments multiply, there will be a time, when the water of the river will be rendered unfit for use, unless careful attention is paid and sufficient guards are thrown around it, at an early date. At present, no injurious effects can probably arise from any part of the river, except that south of the bridge at Columbia Avenue. Any impurity entering above this point would become innocuous by the action of the water; and the solid matter would subside before reaching the dam. How far it is necessary at present to interfere with the manufactories situated above this point, is a question which you can best decide. That the City has sufficient legislative power to compel all now draining into the dam to desist from the practice, seems to be evident from the laws and agreements quoted above. But how far it would be wise to interfere with the large manufacturing interests which add so greatly to our permanent prosperity, is also a subject for your consideration. Much can be done, however, without putting manufacturers to large expense or great inconvenience. They might be prohibited from making the river a common sewer to carry off all refuse, and especially the discharge of privies, as is the practice in most of the factories. Indeed, if nothing but what could not be otherwise disposed of, was drained into the river, it might be allowed, at least for the present. But from that part of the river south of Columbia Avenue, immediate steps should be taken to remove all accumulation of detritus, and prevent all encroachments, and the drainage into it of any objectionable matter; and the whole shore should be guarded with the most jealous care. Nothing so effectual could be devised to preserve the purity of the water and prevent the accumulation of detritus, as a sluice in the dam. It is certainly a great oversight that none was constructed when the dam was built; one which should be remedied at the earliest moment.

CONDITION AND OPERATION OF THE WORKS.

FAIRMOUNT WORKS.

The Dam.—In the low stages of the water during the past summer, when it fell below the comb of the Dam, several opportunities for examining the condition of this work were presented and carefully improved. It was found that the timbers above low water line were decayed to such an extent, as to necessitate their early removal. Preparations for this work should be made during the present year. The dam was built in 1819-21, and re-built, from low water up, in 1842-3. The expense of re-building was about $60,000; the present cost, with similar materials and in the same manner, on account of the advance in price of labor and material, would be about $75,000. As the wood-work above water on the lower face of the dam is subject to rapid decay, requiring renewal about every twenty years, it would be a far more economical policy to re-build with more durable material. Stone work would require more than double the outlay just named, but if properly done, it would never require renewal or attention. The arrangements for re-building should be made so as to ensure the commencement of the work as early as practicable in 1862; for reconstruction with masonry work, will require at least two years. The dam may be considered entirely safe for that length of time; longer than this, however, it would not be prudent to trust to it, and in a matter of such paramount importance, no risk whatever should be run.

Works.—The Works are generally in good order; the heavy service required of them during the season of greatest demand, injured the machinery to a considerable extent, but opportunity

will be taken through the winter to put them in the best possible order. Several of the wheels and pumps should be re-built at an early day, but with care, they can probably be made to run another season. Two of the breasts of the wheels will be re-built during the winter, and such other repairs made to the flumes and gates as are necessary. The floors of several of the pump-chambers must also be renewed. The wood-work in the mill-house decays at a rapid rate, and the annual cost of renewals is very great. It is a matter of regret that so much perishable material was allowed to enter into the construction of these Works. The new Works will not suffer from such defect, wood being nowhere employed save in the doors, door-frames, window-frames and sashes.

As soon as the new Works are in operation, it will no doubt be found desirable to commence the remodelling of the old mill-house and machinery, and to replace the present breast wheels with turbines. When the new Works are completed, and the connections made with the Spring Garden and Delaware reservoirs, all the steam engines employed in pumping water, except those at the Twenty-fourth Ward Works, can be dispensed with, at least during the winter months.

These works supply the 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th and 10th wards.

The 1st, 2d, 3d and 4th are supplied from the Corinthian Avenue reservoir; and the 5th, 6th, 7th, 8th, 9th and 10th from Fairmount reservoirs.

The water is pumped by eight breast wheels, driving each a 16 inch pump, and one turbine, driving a 16 inch pump.

No. 1. OPERATION OF FAIRMOUNT WATER WORKS FOR 1860.

MONTHS.	WATER.		OIL.			TALLOW.		
	Number of gallons pumped each month during the year.	Average number of gallons pumped per day, each month.	Number of quarts of oil used each month during the year.	Number of gallons raised into the Reservoir, per quart of oil.	Duty in million gallons raised one foot high per quart of oil.	Number of pounds of tallow used each month during the year.	Number of gallons raised into Reservoir, per pound of tallow.	Duty in million gallons raised one foot high, per pound of tallow.
January,	253,306,735	8,171,185	28	9,046,669	904	7	36,186,676	3,618
February,	229,986,750	7,930,578	28	8,213,802	821	4	57,496,687	5,749
March,	277,490,545	8,951,307	32	8,671,579	867	8	34,686,316	3,468
April,	314,449,740	10,481,658	28	11,230,347	1.123	2	157,224,870	15,722
May,	276,706,155	8,926,005	28	9,882,362	988			
June,	335,685,515	11,189,517	30	11,189,517	1.118	2	167,842,757	16,784
July,	385,850,025	12,446,775	82	4,705,488	470	6	64,308,334	6,430
August,	365,375,532	11,786,307	90	4,059,728	405	6	60,895,922	6,089
September,	342,577,125	11,419,237	72½	4,725,201	472	23	14,894,657	1,489
October,	330,156,200	10,650,200	94	3,512,300	351	5½	60,028,400	6,002
November,	261,720,910	8,724,030	71	3,686,210	368	10	26,172,091	2,617
December,	239,683,785	7,731,735	92	2.605,258	260	9	26,631,531	2,663
	3,612,989,017	9,867,378	675½	6,794,038	679	82½	64,215,294	6,421

The following exhibits the cost of running these Works, during the past year:—

RUNNING EXPENSES OF FAIRMOUNT WORKS.

Salaries of engineers and labor,		$2,281 68
Gas for lighting,		338 87
56¼ tons of coal, for warming Works, at $3 87,		217 68
168¾ gallons of oil, at $1 00,		168 75
82½ lbs. of tallow, at 12½ cts.		10 31
Packing, and small stores,		558 96
Repairs,		2,719 41
		$6,295 66
Interest on cost of Works and water-power,		36,000 00
		$42,295 66

Cost of raising water into reservoir, per million gallons,
including interest on cost of Works, . . $11 71
not including interest on cost of Works, . 1 74
Cost of raising water per million gallons, one foot high,
including interest on Works, . 11 7—10 cts.
not including interest on cost of Works, 01 7—10 "

It will be seen from the above, that had the amount of water pumped by Fairmount Works this year, been no greater than it was last year, there would have been no saving to report in the running expenses of these Works. A little carelessness in the use of oil, tallow, gas, &c., has no doubt been the cause of this. This is to be regretted, for it was hoped that a small positive saving could have been effected.

An apparatus for supplying air to the air vessels, invented by Mr. A. H. Rauch, of Bethlehem, was tested on the pump worked by the turbine with very satisfactory results. The application of the apparatus to other pumps is at present under consideration by the Department.

SCHUYLKILL WORKS.

These Works are now undergoing complete repair. They have rendered valuable service the past year, and have, in fact, become of the first importance. The engines are now in better condition than ever, being much more effective and reliable. The stand pipe at these Works is a great annoyance during the winter season. When the cold is extreme, ice is formed in large quantities in the pipe, and, partaking of the movement of the water, it oscillates with every stroke of the pump. The stand pipe not being cylindrical, but conical in shape, the ice rising with the water, is driven with great force against its sides, producing a concussion which may be heard at a great distance, and a recoil upon the machinery which is very destructive.

Measures should be taken to protect the pipe from the frost, and an alteration should be made in its shape. Slight accidents are happening to the machinery from this cause every winter, necessitating an expense of several hundred dollars for repairs. The risks of more serious injury are very great.

Another large engine should be constructed at these Works, as heretofore recommended; and it cannot be commenced at too early a date, for in seasons of drought, we are forced to rely on these Works for a partial supply to the district depending on the Fairmount Works.

There are now four steam engines in these Works.

No's 1 and 2, reciprocating over-head beam engine, 36 in. × 6 feet; pump 18 in. × 6 feet.

No. 3, reciprocating bell-crank engine, 36 in. × 6 feet; pump 21 in. × 6 feet.

No. 4, Cornish over-head beam engine, 60 in. × 10 feet; pump 30 in. × 10 feet,

Which supply the 11th, 12th, 13th, 14th, 15th and 20th Wards.

During the year, No. 1 pumped 352,302,560 gallons; No. 2, 530,115,200 gallons; No. 3, 545,362,500 gallons, and No. 4, 1,269,580,950 gallons.

No. 2. OPERATION OF SCHUYLKILL WORKS FOR 1860.

MONTHS.	WATER.		COAL.			OIL.			TALLOW.		
	Number of gallons pumped each month during the year.	Average number of gallons pumped per day each month.	Pounds of coal consumed each month during the year.	Number of gallons raised into Reservoir per pound of coal,	Duty in gallons, raised one foot high per pound of coal.	Number of quarts of oil used each month during the year.	Number of gallons raised into the Reservoir per quart of oil.	Duty in million gallons raised one foot high per quart of oil.	Number of pounds of tallow used each month during the year.	Number of gallons raised into the Reservoir per pound of tallow.	Duty in million gallons raised one foot high per pound of tallow.
January, ...	179,131,200	5,778,425	562,464	318.4	36,616	56	3,198,771	367	174	1,029,489	118
February, ...	150,191,580	5,179,020	396,480	378	43,470	71	2,115,374	243	126	1,191,996	137
March, ...	181,917,450	5,868,304	475,328	382.7	44,012	84	2,166,874	249	173	1,051,545	120
April, ...	210,726,170	7,024,205	573,440	367.4	42,251	77	2,736,703	314	148	1,423,825	163
May, ...	229,132,150	7,391,359	641,760	357.3	41,895	85	2,695,672	310	136	1,648,432	189
June, ...	239,451,660	7,981,722	752,080	318	36,570	89	2,690,468	309	167	1,433,842	164
July, ...	335,197,340	10,812,817	1,048,768	319.6	36,754	94	3,565,928	410	196	1,710,190	196
August, ...	308,073,840	9,937,865	1,121,232	275.6	31,694	82	2,756,998	317	190	1,621,441	186
September, ...	273,544,010	9,118,133	866,096	315.8	36,317	77	2,552,519	408	184	1,486,652	170
October, ...	234,976,570	7,579,889	779,520	301.4	34,661	63	3,729,786	428	150	1,566,510	180
November, ...	203,807,890	6,793,596	634,928	320.9	36,903	56	3,639,426	418	128	1,592,241	183
December, ...	150,810,350	4,864,850	407,904	368.1	41,331	38	3,968,693	455	96	1,570,941	180
	2,696,960,210	7,360,849	8,260,000	335.8	38,539	872	2,984,767	352	1,868	1,443,925	165

Average duty for the year, 32,115,800 pounds, raised one foot high, by the consumption of 100 lbs. of anthracite coal.
Average duty for 1859, 25,570,300 " " " " " " " " "

No. 3. COAL, OIL AND TALLOW ACCOUNT OF SCHUYLKILL WORKS, 1860.

MONTHS.	COAL.		OIL.		TALLOW.	
	Amount of coal received each month during the year.	Amount of coal consumed each month during the year.	Number of quarts of oil received each month during the year.	Number of quarts of oil used each month during the year.	Number of pounds of tallow received during the year.	Number of pounds of tallow used during each month of the year.
	T. cwt. qr. lbs.	T. cwt. qr. lbs.				
January 1, am't on hand,	207 0 0 0		106		269	
January,	109 11 3 0	251 2 0 0		56		174
February,	179 1 3 0	177 0 0 0	182	71		126
March,	209 5 2 0	212 4 0 0		84		173
April,	267 3 0 0	256 0 0 0	178	77		148
May,	375 19 0 0	286 10 0 0		85	854	136
June,	582 1 0 0	335 15 0 0		89		167
July,	621 15 0 0	468 4 0 0		94		196
August,	283 16 0 0	500 11 0 0	176	82		190
September,	354 0 0 0	386 13 0 0		77		184
October,	154 4 0 0	348 0 0 0	351	63	678	150
November,	277 17 0 0	283 9 0 0	167	56	290	128
December,	455 9 0 0	182 2 0 0		38	339	96
	4,077 3 0 0	3,687 10 0 0	1,160	872	2,430	1,868
	Burnt in stoves,	20 11 0 0				
		3,708 1 0 0				

The following exhibits the cost of running these Works during the past year:—

RUNNING EXPENSES OF SCHUYLKILL WORKS.

Salaries of engineers, firemen, &c.,		$7,169 12
Tons. cwt.		
3,687. 10, coal used for engines,		
20. 11, " " warming.		
3,708 01, coal, at $3 27 per ton,		12,125 32
218 gallons of oil, at $1 00 per gallon,		218 00
341½ " fluid, for lighting,		170 61
1,868 lbs. of tallow, at 12½ cts.		233 50
Packing, and small stores,		417 21
Repairs,		2,602 53
		$22,936 29
Interest on cost of Works, ($150,000,)		9,000 00
		$31,936 29

Cost of raising water into reservoir per million gallons,	
including interest on Works,	$11 83
not including interest on cost of Works,	8 50
Cost of raising water per million gallons one foot high,	
including interest on cost of Works,	10 3—10 cts.
not including interest on cost of Works,	07 4—10 "

The operation of these Works the past year has been very satisfactory, and a marked saving has been effected in almost every item of expenditure over 1859, which is due, in great part, to the efficiency of the engineers in charge. It is believed that still further saving can be effected, and the engines brought to a higher degree of efficiency.

The economical character of the Cornish engine is clearly shown at these Works, where both kinds, the reciprocating and the Cornish, are in operation side by side. The actual duty of the Cornish engine is 50,000,000 lbs., raised one foot by 100 lbs. of coal; while the mean duty of all the engines at these works for the year, was but 32,000,000 lbs.

In the more elevated parts of the district supplied from these Works, the same difficulties have been experienced in procuring water as already described, arising from the same cause, viz: not from any scantiness in the reservoirs, but from imperfect distribution; the mains now in use being of too contracted calibre. The large annual increase of water takers constantly increases the difficulty. The laying of new mains, which has been so often urged upon your attention, would undoubtedly add to the revenue, as well as exhibit a just regard to obligations already incurred, and but partially fulfilled, to numerous water takers, who, though taxed at full rates, are often annoyed by intermittent and scanty supply.

DELAWARE WORKS.

The amount of water supplied from these works was but little above that of the previous year. This is accounted for by the fact that the capacity of the single main issuing from the reservoir of these Works, is fully absorbed by previously existing demands. A large number of new attachments have been made, but every one added makes it necessary to divide the same amount of water among a larger number of consumers. Frankford has suffered greatly for want of a better supply; on the days in which the demands are greatest, no water can be drawn in that town, except in a few instances at the bottom of the hill. A copious supply to this district would certainly augment the revenue.

No complaints have been made of the quality of water, except by those drawing from pipes which have had no circulation.

A small saving has been effected in running these Works, and their condition may now be considered better than at any former period of their history. The machinery is all kept in the most thorough repair, and the engines never worked as economically or effectually as they now do. For this marked improvement the engineers certainly deserve much praise.

These Works supply the 16th, 17th, 18th, 19th and 23rd Wards.

Engines.—No. 1, Horizontal High Pres. Engine, 30 in. × 6 feet; pump 18 in. × 6 feet.

No. 2, Beam Condensing Engine, 36 in. × 6 feet; pump 20 in. × 6 feet. Pumped by engine No. 1, 171,581,640 gallons.

" " " 2, 702,980,820 "

No. 4. OPERATION OF THE DELAWARE WORKS FOR 1860.

MONTHS.	WATER.		COAL.			OIL.			TALLOW.		
	Number of gallons pumped each month during the year.	Average number of gallons pumped per day, each month.	Pounds of coal consumed each month, during the year.	Number of gallons raised into the Reservoir, per pound of coal.	Duty in million gallons, raised one foot high, per pound of coal.	Number of quarts of oil used each month, during the year.	Number of gallons raised into the Reservoir, per quart of oil.	Duty in million gallons raised one foot high, per quart of oil,	Number of pounds of tallow used each month during the year.	Number of gallons raised into the Reservoir, per pound of tallow.	Duty in million gallons raised one foot high, per pound of tallow.
January,.....	59,792,900	1,928,803	277,365	215.5	24,136	23	2,512,735	281	45	1,328,731	148
February,.....	43,502,640	1,500,091	253,550	171.9	19,152	22	1,977,392	221	43	1,011,689	113
March, ...	67,304,400	2,171,109	289,480	232.5	26,040	22	3,059,245	342	30	2,343,480	262
April, ...	69,107,180	2,303,572	310,770	222.3	24,897	25	2,764,286	309	42	1,645,409	184
May,.....	67,974,600	2,192,729	339,385	200.2	22,422	26	2,614,407	292	55	1,235,901	138
June,.....	82,069,260	2,735,642	343,465	230	25,760	32	2,564,664	287	46	1,784,114	199
July, ...	93,469,590	3,015,148	400,380	233.4	26,140	29	3,223,089	360	50	1,869,391	209
August, ...	92,288,370	2,977,044	362,888	254.3	28,481	27	3,418,087	382	46	2,006,268	224
September, ...	82,158,740	2,738,624	360,380	227.9	25,524	26	3,159,951	353	30	2,738,624	306
October, ...	81,214,880	2,619,834	340,795	238.3	26,689	24	3,383,953	378	42	1,933,687	216
November,.....	70,071,720	2,335,724	339,090	206.6	23,139	25	2,802,868	313	42	1,670,755	187
December,.....	63,190,700	2,038,410	305,025	207.1	23,195	18	3,510,594	393	34	1,858,550	207
	872,144,980	2,379,727	3,922,573	219.9	24,631	299	2,915,939	325	505	1,785,549	199

Average duty for the year, 20,525,800 pounds raised one foot high, by the consumption of 100 lbs. anthracite coal.
Average for 1859, 19,720,800 " " " " " "

No. 5. COAL, OIL AND TALLOW ACCOUNT OF THE DELAWARE WORKS FOR 1860.

MONTHS.	COAL.		OIL.		TALLOW.	
	Amount of coal received each month during the year.	Amount of coal consumed each month during the year.	Number of quarts of oil received each month during the year.	Number of quarts of oil used each month during the year.	Number of pounds of tallow received each month during the year.	Number of pounds of tallow used each month during the year.
	T. cwt. qr. lbs.	T. cwt. qr. lbs.				
January 1, am't on hand,	400 0 0 0		240		292	
January,		123 16 1 25		23		45
February,		113 3 3 10		22		43
March,		129 4 2 16		22		30
April,	103 0 0 0	138 14 2 26		25		42
May,	156 0 0 0	151 10 0 25		26		55
June,	154 0 0 0	153 6 2 17		32		46
July,	178 0 0 0	178 14 3 08		29	300	50
August,	169 0 0 0	162 0 0 08		27		46
September,	162 0 0 0	160 17 2 20		26		30
October,	144 0 0 0	152 2 3 07		24		42
November,	149 0 0 0	151 7 2 10		25		42
December,	300 0 0 0	136 3 1 21	174	18	318	34
	1,915 0 0 0	1,751 2 3 25	414	299	910	505
	Burnt in stoves,	2 0 0 0				
		1,753 2 3 25				

The following exhibits the cost of running these Works during the past year :—

RUNNING EXPENSES OF DELAWARE WORKS.

Salaries of engineers, firemen, &c.,		$4,385 60
Tons. cwt. qr. lbs.		
1,751 2 3 25	coal used for engines,	
2 0 0 0	" " " warming.	
1,753 2 3 25	coal, at $3 52 per ton,	6,171 08
74¾	gallons of oil, at $1 00 per gal.	74 75
150	" fluid, for lighting,	76 35
505	pounds of tallow, at 12½ cts.	63 12
Packing and small stores,		134 91
Repairs,		623 99
		$11,529 80
Interest on cost of Works, ($150,000,)		9,000 00
		$20,529 80

Cost of raising water into reservoir per million gallons,
including interest on cost of Works, $23 54
not including interest on cost of Works, 13 22
Cost of raising water per million gallons one foot high,
including interest on cost of Works, 21 cents,
not including interest on cost of Works, 11.8—10 cts.

TWENTY-FOURTH WARD WORKS.

The Department have succeeded in keeping up a much more copious supply from these Works, during the year, than was expected of them. How they may succeed the coming season, it is impossible to surmise. There is certainly a limit to their capacity so long as they are without a reservoir, and that limit it is believed, is passed even now. The engines have been worked to 18 strokes per minute; a velocity greater than is consistent with the safety of the machinery. Nothing less than the imperative demands of the district could have justified imposing upon them such an arduous and perilous service. As these engines are simple in construction, and of unusual strength, the repairs demanded, notwithstanding, were but slight.

The supply of water to the district has been uninterrupted. Notwithstanding the increase in the amount of water pumped, a saving has been effected over former years, in every item of expense. This, with the constant supply of water maintained, reflects credit upon the engineers in charge; as also does the condition in which the machinery is kept. These Works, it will be seen, are the most economical of all that belong to the Department; and when a reservoir is constructed, they will pay a liberal profit—at present, they pay all expenses. The reason they have, at times, been made to appear to disadvantage is, that the element of height was not taken properly into account in charging supplies—these Works being required to raise the water more than twice as high as any of the others; also, in charging labor, the fact that there is no reservoir was overlooked; and in calculating the cost of the Works, all the supply and service mains, stops, plugs, &c., have been charged to the Works; while, in fact, the service mains have been paid for by the property in front of which they were laid.

The water pumped by these Works supplies the Twenty-Fourth Ward.

There are two Cornish bull engines; each with steam cylinder 50 in. diameter; stroke, 8 feet; pump, 17 in. diameter; stroke, 8 feet.

No 6. **OPERATION OF TWENTY-FOURTH WARD WORKS FOR 1860.**

MONTHS.	WATER.		COAL.			OIL.			TALLOW.		
	Number of gallons pumped each month during the year.	Average number of gallons pumped per day each month.	Pounds of coal consumed each month, during the year.	Number of gallons raised into the Stand Pipe, per pound of coal.	Duty in million gallons, raised one foot high, per pound of coal.	Number of quarts of oil used each month during the year.	Number of gallons raised into the Stand Pipe, per quart of oil.	Duty in million gallons raised one foot high, per quart of oil.	Number of pounds of tallow used each month during the year.	Number of gallons raised into the Stand Pipe, per pound of tallow.	Duty in million gallons raised one foot high, per pound of tallow.
January, ...	20,361,780	656,831	116,750	174.4	40,112	3	6,787,260	1,561	14	1,454,412	333
February, ...	17,723,790	611,165	91,250	194	44,620	2	8,861,895	2,038	14	1,265,985	290
March, ...	19,133,100	617,196	94,350	202.7	46,641	3	6,377,700	1,466	14	1,366,650	314
April, ...	19,913,040	663,768	105,450	188.8	43,424	3	6,637,680	1,526	14	1,422,360	327
May, ...	21,613,050	697,195	108,200	199.7	45,931	3	7,204,350	1,656	16	1,350,815	310
June, ...	24,552,450	818,415	116,000	211	48,530	3	8,184,150	1,063	18	1,364,025	413
July, ...	27,618,210	890,910	125,500	220.6	50,738	4	6,904,552	1,588	24	1,150,758	264
August, ...	33,183,540	1,070,436	158,000	212.2	48,806	4½	7,374,120	1,696	22	1,508,433	346
September, ...	26,092,620	869,754	129,400	201.6	46,368	4	6,523,155	1,500	19	1,373,295	415
October, ...	27,049,950	872,579	132,950	203,4	46,782	3	9,016,650	2,073	12	2,254,162	518
November, ...	22,481,100	749,370	110,400	203 6	46,828	4	5,620,275	1,292	14	1,605,792	369
December, ...	23,923,440	771,723	120,550	198.4	45,632	4	5,980,860	1,375	16	1,495,215	343
	283,646,070	774,112	1,408,800	200.8	46,201	40½	7,122,720	1,569	197	1,467,575	253

Average duty for the year, 38,500,800 pounds raised one foot high, by the consumption of 100 lbs. of anthracite coal.
Average duty for 1859, 28,520,800 " " " " " " "

No. 7. COAL, OIL AND TALLOW ACCOUNT OF 24TH WARD WORKS, 1860.

MONTHS.	COAL.		OIL.		TALLOW.	
	Amount of coal received each month during the year.	Amount of coal consumed each month during the year.	Number of quarts of oil received each month during the year.	Number of quarts of oil used each month during the year.	Number of pounds of tallow received each month during the year.	Number of pounds of tallow used each month during the year.
	T. cwt. qr. lbs.	T. cwt. qr. lbs.				
January 1, am't on hand,	5 0 0 0		32		20	
January,	55 12 0 11	52 2 1 18		3		14
February,	41 18 0 19	40 14 2 26		2		14
March,	44 10 0 16	42 2 1 18		3		14
April,	41 2 1 0	47 1 2 2		3	300	14
May,	48 4 0 24	48 6 0 8		3		16
June,	54 17 2 24	51 15 2 24		3		18
July,	58 12 3 20	56 0 2 4		4		24
August,	69 1 0 0	70 10 2 24		4½		22
September,	63 11 1 0	57 15 1 12		4		19
October,	60 11 0 15	59 7 0 6		3		12
November,	57 10 0 0	49 5 2 24	168	4		14
December,	95 17 2 4	53 16 1 10		4		16
	696 8 1 21	628 18 2 8	200	40½	320	197
	Burnt in stoves,	1 19 2 21				
		630 18 1 0				

The following exhibits the cost of running these Works during the past year:—

RUNNING EXPENSES OF TWENTY-FOURTH WARD WORKS.

Salaries of engineers and firemen,	.	$2.500 00
Tons. cwt. qr. lbs.		
628 18 2 08 coal used for engines,		
1 19 2 21 " " warming.		
630 18 1 01 coal, at $3 67 per ton,		2,315 45
10⅛ gallons of oil, at $1 00 per gal.		10 13
213½ " fluid, for lighting,		105 60
197 lbs. tallow, at 12½ cts. per pound,		24 62
Packing and small stores, . . .	.	44 16
Repairs, ...	.	1,086 91
		$6,086 87
Interest on cost of Works, ($55,000,)		3,300 00
		$9,386 87

Cost of raising water into Stand Pipe, per million gallons,
including interest on cost of Works, . . $33 17
not including interest on cost of Works, . 21 50
Cost of raising water per million gallons one foot high,
including interest on cost of Works, 14 4—10 cts.
not including interest on cost of Works, 09 3—10 "

Pumped by the North Engine, 138,903,480 gallons.
" " South " 144,742,590 "

No. 8.

TOTAL QUANTITY OF WATER PUMPED BY ALL THE WORKS OF THE DEPARTMENT DURING THE YEAR 1860.

Months.	Number of gallons pumped each month during the year.	Average number of gallons pumped per day each month.
January	512,592,615	16,535,245
February	441,404,760	15,220,854
March	545,845,495	17,607,919
April	614,196,130	20,473,204
May	595,425,955	19,207,288
June	681,758,885	22,725,296
July	842,135,165	27,165,650
August	798,921,282	25,771,654
September	724,372,495	24,145,747
October	673,397,600	21,722,503
November	558,081,620	18,602,720
December	477,608,275	15,406,718
Total	7,465,740,277	20,382,066

Fairmount	Works	supplied	3,612,987,017 gallons.
Schuylkill	"	"	2,696,960,210 "
Delaware	"	"	872,144,980 "
24th Ward	"	"	283,646,070 "

The whole amount of water supplied during the year was equal to 27,774,420 tons, or an average per day of 75,886 tons.

It will be observed, that the increase of water pumped has not been proportionably as great as the increased number of water takers, and amount of service main laid the past year. This is accounted for by the perfect repair in which all the machinery, pumps, mains, reservoirs, stops and fire-plugs are; as well as to the prevention, in great part, of the indiscriminate and unlawful use of fire-plugs.

In contemplating the limited capacity of all the Works, the Department cannot but look forward with apprehension to the coming

season. During the month of July last, the amount of water used, frequently exceeded that pumped, by five million of gallons per day, and nothing but the limited capacity of the distributing mains prevented the exhaustion of the reservoirs several times during the summer. It is plain, that without additional machinery, any increase in the supply during the season of greatest demand, will be impossible. Contingencies might arise, such as the breaking out of a contagious disease, creating a sudden extraordinary demand upon the Works, in which case, a failure of the supply would produce the most direful results.

It is hoped that the necessary appropriation for completing the new Works at Fairmount, for building the large engine at Schuylkill Works, and for constructing a reservoir for Twenty-fourth Ward Works, will be made at an early date; the necessities of the City positively demand these, as soon as they can be put into operation. It is believed that the City can sell a much larger amount of water than at present, and with the same proportionate profit.

We may be permitted also to express our regret, that your honorable body has not thought it advisable to make the small appropriation recommended by his honor the Mayor, by the Committee on Water, and so frequently by the Department, for preliminary surveys and examinations, with a view to secure a supply of water from sources beyond the limits of the City.

It will be seen by table No. 9, that the running expenses of the Works have been further reduced seven thousand six hundred and fifteen dollars and twenty-nine cents. A part of this saving is due to the increased amount of water pumped. It will also be seen by table No. 10, that the average consumption of coal per horse power per hour, has been reduced from 7.7 pounds to 6.9 pounds. In making these estimates, all the coal and supplies bought for the year, are charged against the Works.

No. 9.

TABLE SHOWING THE COMPARATIVE COST OF PUMPING WATER IN 1859 AND 1860.

Works.	Million gallons pumped during the year 1860.	Height of Reservoirs in feet.	Cost of raising one million gallons into Reservoirs in 1859, including repairs.	Cost of raising one million gallons into Reservoirs in 1860, including repairs.	Difference in cost per million gallons raised into Reservoirs in 1859 and 1860.	Saving in running expenses of 1860 over 1859.	Saving in running expenses of 1860 over 1858.
Fairmount..	3,613	100	$12 33	$11 71	$0 62	$2,240 06	$10,658 35
Schuylkill...	2,697	115	12 90	11 83	1 07	2,885 79	7,740 39
Delaware....	872	112	23 63	23 54	09	78 48	8,658 96
24th Ward..	284	230	41 66	33 17	8 49	2,410 96	5,171 64

Saving in running expenses of 1860 over 1859.....$7,615 29
Saving in running expenses of 1860 over 1858.....$32,229 34

No. 10.

COMPARATIVE ECONOMY OF THE WORKS IN COAL, OIL AND TALLOW.

Works.	Average number of gallons raised one foot high per pound of coal.	Average number of pounds of coal per horse power per hour.	Average number of pounds raised one foot high by one hundred pounds of anthracite coal.	Average number of million gallons raised one foot high per quart of oil.	Average number of million gallons raised one foot high per pound of tallow.
Fairmount.....				679.	6,421.
Schuylkill.....	38,539	6.1	32,115,800	352.	165.
Delaware	24,631	9.6	20,525,800	325.	199.
24th Ward.	46,201	5.1	38,500,800	1.569	353.
	36,457	6.9		731.	1,784.

It is confidently believed, from the interest manifested by the engineers and their assistants, that still further reduction in the expenses will be made. Much of the above saving is doubtless due to their experience in managing the Works as well as to their ability.

RESERVOIRS.

These are all in good condition, requiring but the ordinary annual repairs, except the Corinthian Avenue reservoir. This still leaks when filled to a height above 16 feet; until partially repaired last summer, it never held over eleven feet of water without leaking. It should be emptied, cleaned out and thoroughly repaired, before the raising of it is completed. If the repairs are commenced early, the reservoir can be finished and fit for use, with its enlarged capacity, before the heavy demands of the summer. A site should also be selected for another reservoir in the Twentieth Ward; at such an elevation that the surface of the water in it would be 150 feet above City datum. It would then command all the City north of Girard Avenue and south of the old Germantown borough line. The water for such a reservoir could be supplied by a stand pipe at the Schuylkill Works reservoir. The reservoir for the Twenty-fourth Ward is also greatly needed; indeed, it is absolutely necessary to the supply of the district. The Department is almost as deficient in reservoir capacity as in mains for distribution.

GROUNDS.

The improvements made in the grounds during the past year, have been the new ascents to the reservoirs at Fairmount. A regular graded foot-path has replaced the old wooden steps, which were much decayed. Two ascents have been made, one starting from the Callowhill Street entrance, and the other from a point opposite the saloon. They are now completed, with the exception of the railing, which it is hoped the Department will be enabled to place at an early day, as the present temporary substitute is unsafe, and detracts from the neatness of the grounds. The statue of Diana, which formerly stood above the spring, has been removed to a pedestal, on account of the dilapidated condition of the old foundation. It was also carefully cleaned. Unfortunately it has since suffered the loss of the forearm. By whom this piece of vandalism was perpetrated is unknown. Such

demonstrations are the more to be regretted, as it was hoped that an appropriation would be made for statuary for this park.

Considerable advance has been made in beautifying the lot north of the reservoir. The new fountains have formed an interesting and attractive feature to the numerous visitors. It is hoped that a liberal policy will be pursued in further beautifying and improving these grounds, as they are the most favorite resort of the mass of our citizens, and add much to their enjoyment. The seats distributed about the grounds have been much used; an additional number is required to accommodate the great number of visitors on pleasant days. It is also hoped that sufficient means will be placed in the hands of the Department, to put all the buildings in thorough repair. As a result of deferring these repairs, the buildings are receiving permanent injury.

DISTRIBUTION.

The amount of service mains laid during the past year is greater than in any previous year. Since the consolidation, there has been a constantly increasing demand for them; and, notwithstanding the large appropriation made for this purpose, ($100,000,) over 22,000 feet are still needed, and which, for want of sufficient means, could neither be purchased nor laid by the Department. Yet, with all this service main, no feeder or supply main has been laid during the year; these extensions have, therefore, only increased the difficulties experienced in supplying the requisite amount of water to each consumer. The Department would again urge the necessity of laying the large mains so often pressed upon your consideration.

The expense of laying pipe was slightly increased last year; it was 26 9-10ths cents per foot. This includes every expense but material; i. e., labor, surveying, recording, making stops, plugs, ferrules, &c., &c. The previous year it cost but 26 cents, showing an increase in this item of expense of 9-10ths cent a foot. This is to be regretted, especially as the only reason that can be assigned is the immediate and highly undesirable connection of the Department with politics, three exciting elections having

occurred during the past year. Nevertheless, under the circumstances, the purveyors deserve credit for their good management, for under other management, and a different organization of the Department, at such times pipe-laying has cost the City as much as sixty-three cents a foot.

This connection with politics, is far from advantageous to the City, or agreeable to those who wish only to do their duty and serve the City faithfully, in whatever capacity they may be employed. It is extremely difficult to dispense the patronage of the Department, so as to promote its true interests. Politically considered, a man may be very valuable, who is destitute of qualifications for some responsible position, to which his appointment is urged. Could it be done without endangering the proper working of the Department, the entire patronage would be cheerfully resigned by its head, who would feel himself relieved of an onerous duty. While the Department have been anxiously endeavoring to oblige their friends in every way possible, without sacrificing the best interests of the City, we are sensible, nevertheless, of having alienated friends and given offence, where, had we consulted our feelings alone, we would cheerfully have yielded to the wishes of others.

Liability to removal also acts unfavorably, by taking away much of the interest, and much of the stimulus to industry and fidelity, which would be felt, if it was known that the term of office depended on good behavior alone.

The frequent elections, with the excitement attending upon them, and the possibility of removal in the event of a change in the political complexion of the councils, has a demoralizing tendency, and is greatly to the disadvantage of the Department. As a large amount of actual experience is necessary for the proper performance of its duties, every change in the officers is attended with great loss to the City. Indeed, the Department may be considered as just now, after nearly three years experience, in a satisfactory working condition. If you reflect for a moment upon the character and magnitude of our machinery; the number of works and vast extent of the distribution; upon the immense population, for whose comfort, health and security the City has

undertaken in this Department to provide; finally upon the important revenue derived from the Works, which must vary in amount with the capability and experience, as well as the integrity of the officers, you will be prepared to estimate the importance and appropriateness of the remarks just made. Would it not be for the interest of the City so to re-organize the Department as to make it permanent in its character, with the official tenures dependent upon such qualifications as capability, honesty and diligence alone.

The Department would also call your attention to the salaries allowed, as too low for the duties to be performed and the character of the men required for their proper performance.

This is the case in a most marked degree with the Inspectors, who receive but $600, and the Purveyors, who receive but $650. Indeed, the officers of this Department are more poorly paid than those of any other; taking the Gas Trust as a criterion, they are at least 20 per cent. less in all the corresponding offices. As there are no perquisites—nothing that can be honestly acquired above the salary—as the entire time of the officers is demanded, so that no other business can be prosecuted by them, and as the Department under its present organization yields a large revenue over all expenses, and has increased its business greatly since the present salaries were fixed, it must be admitted that the subject is one meriting the favorable attention of your honorable body.

DISTRIBUTION.

The number of feet of new pipe laid in the year 1860 *was:*

Of three-inch pipe . . .	1063
Of four-inch pipe	24414
Of six-inch pipe	65716
Of eight-inch pipe	1569
Of ten-inch pipe	4778
Of twelve-inch pipe . . .	983
Total of new pipe laid	97,828 ft.

or 18.52 miles.

Of which one and one-tenth per cent. is three inch pipe. Twenty-four and nine-tenths per cent. is four inch. Sixty-six and five-tenths per cent. is six inch. One and six-tenths per cent. is eight inch. Four and nine-tenths per cent. is ten inch. One per cent. is twelve inch. Average size of pipe 5.8 inch.

The number of feet of Pipe relaid was:

Of four-inch pipe	737
Of six-inch pipe	1695
Of ten-inch pipe	284
	2716 ft.

or .51 of a mile.

Of which twenty-seven and one-tenth per cent. is four inch. Sixty-two and four-tenths per cent. is six inch. Ten and five-tenths per cent. is ten inch.

Total number of feet of pipe laid in the year 1860, 100,544 ft. or 19.04 miles.

Of which one per cent. is three inch. Twenty-five per cent. is four inch. Sixty-six and three-tenths per cent. is six inch. Two and six-tenths per cent. is eight inch. Five per cent. is ten inch. One-tenth per cent. is twelve inch. Average size of the whole pipe laid is 5.8 inch.

The whole number of three-way fire-plugs for steam fire engines set during the year, 32.

The whole number of public hydrants, . . .	30
To which should be added for old hydrant pumps, .	100
Total number in charge of Department, . .	130

The number of new stop-valves set during the year, 224.

The whole number of common fire-plugs set in the year, 146.

The number of holes drilled for making new attachments were 1,920, at an average cost of $1 49 per each attachment.

The number of shut-offs for repairs to public mains was 198, and for repairs to private hydrants 303.

The population of water takers from the City Works is 533,584, with an aggregate area of supply of 3719.65 sq. inches, from which a revenue is received of $146.46 per sq. inch of area of supply mains from reservoirs.

FIRST DISTRICT.

ACCOUNT OF IRON PIPES LAID IN THE FIRST, SECOND, THIRD AND FOURTH WARDS, 1860.

Street.	Location.	Size. Inches.	Feet.
Lentz.	From Thirteenth, eastward,	4	286
Twenty-seventh.	" Federal to Gray's Ferry Road,	6	410
Gray's Ferry Road.	" Washington to Twenty-ninth,	6	1358
Nineteenth.	" Shippen to Fitzwater,	6	260
Catharine.	" Twentieth to Twenty-first,	6	542
Ellsworth.	" Broad to Fifteenth,	6	550
Fifteenth.	" Ellsworth to Federal,	6	380
Watkins.	" Sixth to Seventh,	4	447
Pierce.	" " "	4	447
Celeste.	" " "	4	447
Amelia.	" " "	4	340
Moore.	" Front to Second, north side,	6	590
"	" " " south side,	4	595
Federal.	" Twenty-fifth to Twenty-eighth,	6	1335
Twenty-eighth.	" Federal to Grays' Ferry Road,	6	60
Moore.	" Sixth to west of Seventh, north side,	6	612
"	" Sixth to west of Seventh, south side,	4	602
Twelfth.	" Federal to Wharton,	6	513
Twenty-second.	" South to Shippen,	6	325
Webster.	" Seventeenth to Eighteenth,	4	450
Twelfth.	" Passyunk Road to Mifflin,	6	850
Fifth.	" Washington to Carpenter,	10	465

Street.	Location.	Size. Inches.	Feet.
Tiernan.	From Ellsworth to Federal,	4	378
Clement.	" Carpenter to Washington,	4	420
Broad.	" Washington to Reed,	6	3723
Cross.	" Tenth to Passyunk Road,	4	450
Tasker.	" Front to Church,	6	265
Dickerson.	" Meadow to Ash,	6	459
Webster.	" Twentieth to Twenty-first,	4	540
Thirteenth.	" Reed to Jackson,	6	3617
Pierce.	" Eleventh to Twelfth,	4	440
Wharton.	" Tenth to Passyunk Road,	6	340
Ninth.	" Morris to Snyder,	6	1867
"	" Morris to Moore, east side,	4	469
Wharton.	" Thirteenth to Sixteenth,	6	1575
Moore.	" Otsego, eastward, north side,	4	320
"	" " " south side,	6	320
Tasker	" Tenth, eastward, to Passyunk Road,	6	565
Pemberton.	" Eighteenth to Nineteenth,	4	450
Fitzwater.	" Nineteenth to Twentieth,	6	450
	Connections,	6	256
	"	10	60
	Fire Plug attachments,	4	728

Total number of feet of pipe laid in First District, 29,547
Or 5.50 miles; all of which was new pipe.

Twenty-six and four-tenths per cent. of the above pipe was 4 inch pipe. Seventy-one and eight-tenths per cent. 6 inch. One and eight-tenths per cent. 10 inch pipe. Average size, 5.5 inches.

SECOND DISTRICT.

ACCOUNT OF IRON PIPES LAID IN THE SIXTH, SEVENTH, EIGHTH, NINTH, TENTH AND TWENTY-FOURTH WARDS, 1860.

Street.	Location.	Size. Inches.	Feet.
Burton.	From Sixteenth to Seventeenth,	3	372
Baltimore Avenue.	" Thirty-ninth to Fortieth,	8	809
Ninth.	" Spruce to Pine,	6	532
Twenty-second.	" Pine to Locust,	12	983
Cherry.	" Twenty-first to Twenty-second,	6	447
McAlpine.	" Walnut to Locust,	4	417
Race.	" Thirty-second to Thirty-fourth,	6	835
Barring.	" Thirty-third to Mansion,	6	696
"	" Thirty-fourth to Thirty-fifth, relaid,	6	434
Thirty-second.	" Barring to Hamilton,	5	250
Barring.	" Thirty-sixth to Lancaster Avenue,	6	1057
Green.	" Thirty-fourth to Thirty-sixth,	6	731
Currant.	" Locust to Miles Alley,	3	364
Delancy.	" Twentieth to Twenty-first,	4	548
Oak.	" Margaretta to Park,	4	541
Hamilton.	" Thirty-sixth to Lancaster Avenue,	6	1356
Delaware Avenue.	" Spruce to Walnut,	6	956
Forty-second.	" Locust to Spruce,	6	192
"	" " " relaid,	6	185
"	" Market to Oak,	6	277
Oak.	" Forty-second to Forty-third,	4	591
Pine.	" Twentieth, westward,	6	170
Ashburton.	" Twenty-fourth to Twenty-fifth,	4	324
Aspen.	" Locust to Walnut,	3	318
Race.	" Twenty-second to Freedlander,	6	700
Spruce.	" Forty-second to west of Forty-third,	8	760

Street.	Location.	Size. Inches.	Feet.
Walnut,	From Forty-first, eastward, relaid,	6	100
"	" " westward, "	6	246
Forty-first,	" Walnut, northward, relaid,	6	219
	Connections,	3	9
	"	6	160
	Plug attachments,	4	412

Total number of feet of pipe laid in Second District, 15,990
Or, 3.02 miles. Average, 5.3 inches diameter.

The number of feet of pipe relaid was:—
Of six inch pipe, 1183, or .22 of a mile.
The number of feet of new pipe laid was:—

Of three inch pipe,	1063
Of four inch,	2833
Of six inch,	8359
Of eight inch,	1569
Of twelve inch,	983
Total number of feet of new pipe laid,	14,807

Or, 2.80 miles.

Of the new pipe laid, seven and two-tenths per cent. was 3 inch pipe, nineteen and one-tenth per cent. 4 inch, fifty-six and five-tenths per cent. 6 inch, ten and six-tenths per cent. 8 inch, six and six-tenths per cent. 12 inch. Average size, 6 inches.

THIRD DISTRICT.

ACCOUNT OF IRON PIPES LAID IN THE ELEVENTH, TWELFTH, SIXTEENTH, SEVENTEENTH, NINETEENTH AND TWENTY-THIRD WARDS, 1860.

Street.	Location.	Size. Inches.	Feet.
Sixth.	From Girard Avenue to Thompson, east side,	6	410
"	" Thompson, northward, east side,	4	73
Thompson.	" Sixth to Fifth,	6	523
Columbia.	" Cadwalader to Germantown Road,	6	276
Thompson.	" Fifth to Lawrence,	4	238
Hope.	" Oxford to Putnam,	4	390
Cedar.	" Otis to Dauphin,	6	489
"	" York to Lehigh,	6	2427
Wilson.	" York to Dauphin,	4	376
Norris.	" Girard Avenue to Thompson,	6	586
Richmond.	" Division to Tioga,	6	2890
Salmon.	" Somerset to Ann,	4	1155
Ritter.	" Norris to Dauphin,	4	443
Hope.	" Columbia to Berks,	4	1302
Adams.	" Emerald to Holman,	6	924
Huntingdon.	" Front to Mascher,	6	578
Adams.	" Frankford Road to Cedar,	6	1511
Mascher.	" Norris to Diamond,	6	542
Salmon.	" Huntingdon to Lehigh,	6	769
Mascher.	" Susquehanna to Cambria,	6	4041
Memphis.	" Vienna to Lehigh,	6	2871
Sorrel.	" Melvale to Bath,	4	487
Fourth.	" Montgomery to Norris,	6	1130
Edgemont.	" Huntingdon to Anthracite,	4	252
Tulip.	" Vienna to Norris,	6	386
	Connections,	6	78
	Plug attachment,	4	563

Street.		Location.	Size. Inches.	Feet.
		Connections,	4	109
Germantown Road.	"	Otto to Thompson, relaid,	10	284
"	"	" " "	4	136
Thompson.	"	Germantown Road to Lawrence, relaid.	4	601

Total amount of pipe laid in the Third District, 26,840
Or 5.08 miles.

The number of feet of pipe relaid was:—

Of four inch pipe,	737
Of ten inch pipe,	284
Total amount of feet of pipe relaid,	1021

Or .19 of a mile.

The number of feet of new pipe laid was:—

Of four inch pipe,	5388
Of six inch pipe,	20431
Total number of feet of new pipe laid,	25,819

Or 4.88 miles.

Of the new pipe laid, twenty-nine tenths per cent. is four inch pipe. Seventy-nine and one-tenth per cent. is six inch pipe. Average size, 5.5. inches.

TWENTY-THIRD WARD.

Street	Location.	Size. Inches.	Feet.
Allen.	From Frankford Road to Leiper,	6	822
Leiper.	" Allen to Oxford Road,	6	1312
	Plug attachments,	4	40

Total amount of pipe laid in Twenty-third Ward, 2174
Or .41 of a mile.

Of which two per cent. of the pipe laid is four inch pipe. Ninety-eight per cent six inch pipe. Average size, 5.9 inches.

FOURTH DISTRICT.

ACCOUNT OF IRON PIPES LAID IN THE THIRTEENTH, FOURTEENTH, FIFTEENTH, TWENTIETH, AND TWENTY-FIRST WARDS, 1860.

Street.	Location.	Size. Inches.	Feet.
Buttonwood.	From Sixteenth to Nineteenth,	6	1340
Alder.	" Girard Avenue to Thompson,	4	604
Ontario.	" Thompson to Jefferson,	4	969
Mary.	" " "	4	968
Seybert.	" Fifteenth to Seventeenth,	4	891
Brandywine.	" Twentieth to Twenty-first,	4	515
Shirley.	" Coates to Wylie,	6	550
Cameron.	" Frances to Wylie,	4	396
Spring Garden.	" Eighteenth to Twenty-third,	10	2364
" "	" Broad to Sixteenth,	10	963
Twenty-third.	" Biddle to Spring Garden,	6	306
Wallace.	" Nineteenth to Twenty-first,	6	940
Thirteenth.	" Columbia to Montgomery,	10	576
Parrish.	" Nineteenth to Corinthian Av.	6	853
Pagoda.	" Pennsylvania Av. to Arrell,	4	335
Fifteenth.	" Master to Jefferson,	6	552
Arrell.	" Twenty-fourth to Twenty-fifth,	6	497
Landing Avenue.	" Rialto House to Park,	6	664
Park.	" Landing Av. to Fish Pond,	4	733
Twenty-fourth.	" Pennsylvania Av. to Coates,	6	800
Ninth.	" Columbia to Montgomery,	6	560
Columbia.	" Twenty-first to Twenty-second,	6	488
Twenty-second.	" Columbia to Montgomery,	6	550
Jefferson.	" Ninth to Tenth,	6	511
Hutchinson.	" Master to Jefferson,	4	530
Judson.	" Hare to Powell,	4	470
Eleventh.	" Columbia to Montgomery,	6	543
Henrietta.	" Twenty-first to Twenty-second,	6	456
West.	" Parrish, south to Fire Plug,	4	268
Cabot.	" Sixteenth to Seventeenth,	4	465

Street.	Location.	Size. Inches.	Feet.
Eighteenth.	From Stiles to Thompson,	6	330
"	" Girard Av. to Ridge Av.	6	256
Twenty-first.	" College Av. to Master,	10	350
Columbia.	" Twenty-second to Twenty-fourth,	6	930
Seventeenth.	" Girard Av. to Master,	6	1272
Mount Vernon.	" Twenty-first to Twenty-second,	6	500
	Plug attachments,	4	1102
	Connections,	6	489
	"	4	107
Total number of feet of pipe laid in Fourth District,			25,993
Or 5.02 miles.			

The number of feet of pipe relaid was:—

Of six inches, . . 512 feet.

The number of feet of new pipe laid was:—

Of four inch, ...	8,353
Of six inch, ...	12,875
Of ten inch, ...	4,253
Total of new pipe, ...	25,481

Of the new pipe laid, thirty-two and eight-tenths per cent. was four inch pipe. Fifty and five-tenths per cent. is six inch. Sixteen and seven-tenths per cent. is ten inch. Average size, 6 inches.

RECAPITULATION OF PIPES LAID IN 1860.

WARDS.	3 in. diam.	4 in. diam.	6 in. diam.	8 in. diam.	10 in. diam.	12 in. diam.	TOTAL.
1, 2, 3, 4,.....		7,800	21,222		525		29,547
5, 6, 7, 8, 9, 10, 24,	1,063	2,833	9,542	1,569		983	15,990
11, 12, 16, 17, 18, 19,		6,125	20,431		284		26,840
13, 14, 15, 20, 21,		8,353	13,387		4,253		25,993
23,.....		40	2,134				2,174
	1,063	25,151	66,716	1,569	5,062	983	100,544

TABLE SHOWING THE COMPARATIVE COST OF LABOR LAYING WATER PIPE IN THE SEVERAL DISTRICTS.

DISTRICT.	Feet.	Average size of diameter.	Cost per foot per inch of diameter.	Cost per lineal foot.
First, new pipe.	29,547	5.5 inch.	3.13 cts.	17 cts.
Second, "	14,807	6. "	2.67 "	16 "
Second, re-laid pipe..	1,183	6. "		
Third, new pipe.....	25,819	5.5 "	2.92 "	16 "
Third, re-laid pipe ...	1,021	5.6 "	8.6 "	45 "
Fourth, new pipe.....	25,481	6. "	3.42 "	20 "
Fourth, re-laid pipe..	512	6. "		
Twenty-third Ward..	2,174	5.9 "	5.19 "	34 "
	100,544	5.8 inch.	3 cts.	18 cts.

Being a total of 224 feet more than 19 miles.

Number of feet previously laid, . .	1,618,105
Laid in the year 1860, ...	100,544
Total, ...	1,718,649

Being a total of 325½ miles of water main laid in the City.

ACCOUNT OF THE NUMBER OF HOLES DRILLED FOR MAKING NEW ATTACHMENTS TO PUBLIC MAINS DURING THE YEAR 1860.

Months.	Half inch diameter.	Five-eighths inch diameter.	Three-fourths inch diameter.	One inch diameter.	Total holes and attachments made.	Shut off for repairs to private pipes.	Shut off for repairs to public pipes.	Average cost per attachment.
January, ...	64	7	2	1	74	54	60	$2 64
February, ...	52	4	2	0	58	20	12	2 93
March, ...	111	27	2	2	142	18	7	1 88
April, ...	132	27	1	0	160	21	16	1 56
May, ...	159	30	3	3	195	18	11	1 42
June, ...	164	46	5	5	220	15	5	1 11
July, ...	170	28	6	3	207	11	17	1 13
August, ...	127	25	7	3	162	19	13	1 53
September, ...	142	50	5	2	199	23	15	1 24
October, ...	142	57	5	2	206	31	18	1 29
November, ...	129	56	7	0	192	35	10	1 32
December, ...	68	31	4	2	105	38	14	1 97
	1460	388	49	23	1920	303	198	$1 49

THE ABOVE ATTACHMENTS WERE MADE IN THE DISTRICTS AS FOLLOWS:

District.	Half inch diameter.	Five-eighths inch diameter.	Three-fourths inch diameter.	One inch diameter.	Total holes and attachments made.	Shut off for repairs to private pipes.	Shut off for repairs to public pipes.	Average cost per attachment.
First	279	62	13	7	361	88	68	$1 81
Second	352	99	13	7	471	92	24	1 49
Third	377	59	15	5	456	85	77	1 57
Fourth	452	168	8	4	632	38	29	1 24
	1460	388	49	23	1920	303	198	$1 49

ACCOUNT OF NEW STOPS AND FIRE-PLUGS SET IN 1860.

DISTRICT.	No. of Stops.		No. of Fire Plugs.
First	55		42
Second	48		27
Third	56		39
Fourth	62		49
Twenty-third Ward	3		6
New Stops	224	New Fire Plugs	163
Account per last report	3302	Account per last report	2501
Total	3526	Total	2664

Water pipes have been ordered to be laid in the following streets by councils, but were not laid for want of sufficient appropriation:

Pipes ordered to be laid in the First District.

Twenth-sixth.	From Park to Grays Ferry Road.
Moore.	" Seventh to Ninth.
Twelfth.	" Wharton to Passyunk Road.
Twenty-eighth.	" Federal to Park.
Wharton.	" Sixteenth to Seventeenth.
Park.	" Twenty-seventh to Twenty-eighth.
Twenty-seventh.	" Federal to Ingraham.
Ninth.	" Snyder to Buck Road.
Anthony.	" Dickerson, northward.
Pierce.	" Seventh to Eighth.
Watkins.	" " "
Cuba.	" Moore, southward.

Pipes ordered to be laid in the Second District.

Spruce.	From Forty-third to Forty-fifth.
Hamilton.	" Thirty-second to Thirty-third.

Pipes ordered to be laid in the Third District.

York.	From Second to Germantown Road.
Toronto.	" Melvale to Bank.
Howard.	" Reading Rail Road to Cumberland.
Fourth.	" Norris to Diamond.
Brinton.	" Master to Jefferson.
Montgomery.	" Howard to Front.
Girard Avenue.	" Ash to Norris.
Norris.	" Girard Avenue to Richmond.
York.	" Canal to Richmond.

Pipes ordered to be laid in the Fourth District.

Montgomery.	From Sixth to Broad.
Master.	" Twenty-seventh to Twenty-eighth.
Twenty-third.	" College Avenue to Jefferson.

To lay the above streets will require 23,678 feet of pipe.

FIRE-PLUGS OR HYDRANTS FOR STEAM FIRE-ENGINES.

The concussion produced by the rapid action of the pumps of steam fire-engines, is the cause of many accidents to our ordinary fire-plug; and in several instances leaks and even fractures have been produced in the mains. There is also a difficulty in procuring from an ordinary plug a sufficient volume of water to supply these engines. To obviate these difficulties the Department designed a fire-plug, operating in all respects like the ordinary one so long in use in this City, except that the size was increased so as to give a clear water-way of four inches. An additional feature was introduced to meet the difficulty arising from the concussion; around the plug an outer cylinder is constructed, forming an annular space, with air enclosed, which receives the ram of the water, and effectually relieves the plugs and mains of the shocks so destructive to them. These plugs are fitted with three discharge nozzles, two for ordinary hose connections, and one for the suction of the steamers.

LOCATION OF THREE-WAY FIRE-PLUGS FOR THE USE OF STEAM FIRE-ENGINES.

First District.

In Second Street, east side, above Christian Street.
In Fifth Street, east side, above Morris Street.
In Washington Avenue, S. E. cor. of Fifth Street.
In Tenth Street, N. E. cor. of Reed Street.
In Broad Street, N. W. cor. of Fitzwater Street.

Second District.

In Chestnut Street, south side, between Fourth and Fifth Street.
In Seventh Street, east side, above Market Street.
In Fifteenth Street, east side, below Walnut Street.
In Lombard Street, north side, between Tenth and Eleventh Sts
In South Street, north side, bet. Eighteenth and Nineteenth Sts.
In Twenty-first Street, east side, below Market Street.
In Pennsylvania Hospital, (West Philadelphia.)
In Race Street, south side, between Broad and Juniper Streets.
In Park Street, west side, above Market Street.
In Filbert Street, south side, bet. Fifteenth and Sixteenth Sts.
In Seventeenth Street, west side, below Chestnut Street.
In Third Street, S. W. cor. of Gaskill Street.
In Armatt Street, cor. of Main Street, (Germantown.)
In Third Street, west side, below Arch Street.

Third District.

In New Market Street, west side, bet. Coates and Brown Sts.
In Front Street, west side, below Green Street.
In Main St., N. W. side, bet. Ruan and Pine Sts. (Frankford.)
In Main Street, N. W. cor. of Unity Street, (Frankford.)
In Main Street, N. W. cor. of Oxford Road, (Frankford.)
In Fourth Street, cor. of Old York Road.

Fourth District.

In Twenty-third Street, west side, below Wood Street.
In Buttonwood St., N. side, bet. Seventeenth and Eighteenth Sts.
In Broad Street, west side, above Coates Street.
In Callowhill Street, S. W. cor. of Broad Street.
In Twenty-fourth Street, east side, below Coates Street.
In Landing Avenue, north side, east of Twenty-ninth Street.
In Columbia Avenue, north side, east of Ridge Avenue.

RECAPITULATION.

First District 5, Second District 14, Third District 6, Fourth District 7. Total 32.

DRINKING HYDRANTS.

When the water was first introduced, it was a heavy tax upon the inhabitants; and as an act of simple justice, a number of pumps were erected and supplied with water from the City mains, to take the place of the existing well-pumps, which were becoming contaminated by the crowding of buildings, as well as to obviate the necessity for digging others. The supply for these pumps was received into a wooden tank sunk below the side walk, at the curb stone. The water was admitted by a ball cock, so as to keep the reservoir always full, and was raised from this tank by an ordinary wooden pump. There were objections to this mode of supply; such as the decay of the wood of the tank and pump, leakage from the gutters and pavement into the tank frequently contaminating the water, and the large amount of repairs they required. For many years past no new pumps have been erected, and a large number of them have been removed in response to petitions from the neighbors, who esteemed them a nuisance. But it seems quite indispensable to the public comfort, that some means of readily obtaining a supply of drinking water should be provided, especially on the great thoroughfares and in the more thickly populated parts of the City. Numerous petitions have

consequently been presented to councils, asking for the erection of drinking hydrants, which have led to the ordinance directing the construction of a number of them, the location of which will appear below. The Department have tried several different forms of hydrant; but have found great difficulty in procuring one that was in every respect adapted to the purpose. Being so much used, they are required to be durable, and to prevent waste of water they should be self-closing. The kind of hydrant now adopted, and which thus far has answered the purpose most satisfactorily, is that manufactured by Arthur, Burnham & Gilroy of this City.

LOCATION OF THE PUBLIC HYDRANTS.

First District.

In Federal Street, south side, at Jefferson Avenue.
N. E. cor. Front and Queen Streets.
In Second Street, east side, above Christian Street.
In Broad Street, west side, above Washington Avenue.

Second District.

S. W. cor. of Third and Market Streets.
S. E. cor. of Fifteenth and Market Streets.
N. W. cor. of Sixteenth and Walnut Streets.
S. W. cor. of Eighth and Arch Streets.
S. W. cor. of Twenty-first and Cherry Streets.
S. E. cor. of Ninth and Walnut Streets.
S. W. cor. of Tenth and Market Streets.
South side of Market Street, at the Bridge.
N. W. cor. of Eleventh and Spruce Streets.
S. W. cor. of Fifth and Arch Streets.
N. W. cor. of Seventeenth and Market Streets.
S. W. cor. of Vine Street and Delaware Avenue.
East side of Front above Walnut Street.
S. E cor. of Twentieth and Moravian Streets.
S. W. cor. of Front and Market Streets.

East side of Second Street, north of South Street.
S. W. cor. of Walnut and Dock Streets.
S. W. cor. of Second and Arch Streets.
S. W. cor. of Water and Arch Streets.
S. W. cor. of Broad and Chestnut Streets.

Third District.

N. W. cor. of Delaware Avenue and Poplar Street.
North side of Coates Street, at Second Street.
South side of Poplar Street, at Second Street.
West side of Second Street, above Willow Street.
S. E. cor. of Laurel and Second Streets.

Fourth District.

N. E. cor. of Spring Garden and Eighth Streets.

RECAPITULATION.

First District 4, Second District 20, Third District 5, Fourth District 1. Total 30.

NOTE:—To the Second District should be added about 100 wooden hydrant pumps, which are being replaced with drinking hydrants.

WATER METRES.

Several of the cities of Europe have had recourse to this means of measuring and charging for the water supplied, by the cubic foot or gallon. In this country, very few water metres have been used; but great efforts are being made by those interested in the manufacture and sale of the article, to induce their general adoption by the works of this country. So far, none have been introduced in this City. The Department purchased one, when reassessing the City, two years ago, to be used in case the water rate could not be settled satisfactorily to both the consumer and Depart-

ment; but no occasion for its use has arisen. Where the charges for water are so low as in Philadelphia, ($2.50 per annum and upwards,) the use of metres in any considerable numbers will not probably be found necessary. A peculiar difficulty would be experienced in keeping them in working order, on account of the sediment in the water at certain seasons of the year. The cost of good metres and putting them in, would average about $40 each; twelve per cent. on this amount to pay interest, depreciation and repairs, would be $4.80. There would be needed about 65,000 metres to supply all of our consumers; these would cost $2,600,000; twelve per cent. on this amount would be $312,000 *per annum*, to meet which, it would be necessary to double the present charges for the water supplied. No difficulty has been experienced by the Department in fixing the rate of water rent. It has sometimes been attended with trouble, but not where the parties supplied have been disposed to act with fairness. The charge here is not only less than in any other city of the country, but the allowances made are more liberal. It is apparent that no advantage would follow the introduction of metres in this City, as a general thing. They might, perhaps, be used for a few large consumers.

SHOP.

The Department would again call your attention to the necessity of more shop room, and the proper tools for doing the work. The City suffers a loss of several thousand dollars a year for the want of these accommodations, in building and repairing the stops, plugs, &c. The tools now on hand have been in use over thirty years, a period in which great improvements have been made in machinists' tools. In the absence of a steam engine, most of the work requires a much longer time, and a larger number of hands. Ten thousand dollars expended in enlarging the shop, and in procuring improved tools, would pay the City an increased profit of at least three thousand dollars a year. The shop has again yielded a satisfactory profit to the City, as will be seen by the accompanying statement of its operations. It has been credited for work at the regular prices charged for the same by the shops of the City.

There was furnished by the shop, during the year:—

To the First District, sixty-one fire-plugs, two fire-plugs for steamers, eleven 4 inch stops, thirty-seven 6 inch stops, and three 10 inch stops.

To the Second District, eighty-four fire-plugs, six fire-plugs for steamers, four 3 inch stops, twelve 4 inch stops, twenty-two 6 inch stops, four 8 inch stops, and three 12 inch stops.

To the Third District, fifty-five fire-plugs, three fire-plugs for steamers, nine 4 inch stops, and forty-four 6 inch stops.

To the Fourth District, seventy fire-plugs, five fire-plugs for steamers, eighteen 4 inch stops, thirty-nine 6 inch stops, and seven 10 inch stops.

To Frankford, nine fire-plugs, three 6 inch stops, and one 12 inch stop.

In all 279 fire-plugs, 16 fire-plugs for steamers, four 3 inch stops, fifty 4 inch stops, one hundred and forty-five 6 inch stops, four 8 inch stops, ten 10 inch stops, and four 12 inch stops.

By careful management, the shop was made to yield a profit of $4,902.32 above expenses. The following statement exhibits its operation:

Dr. to stock on hand, January 1st, 1860,			$3,564 11
" bills of material, iron, brass, &c.,			9,937 52
" wages paid hands,			5,671 03
			$19,172 66
Cr. by ferrules furnished Register's office,	$929 00		
" stops, fire-plugs, &c., furnished to First District,	3,742 72		
" stops, fire-plugs, &c., furnished to Second District,	4,432 33		
" stops, fire-plugs, &c., furnished to Third District,	3,730 22		
" stops, fire-plugs, &c., furnished to Fourth District,	4,706 71		
" stops, fire-plugs, &c., furnished to Frankford main,	393 13		
Amounts carried forward,		$17,934 11	$19,172 66

Amounts brought forward,	$17,934 11	$19,172 66
Cr. by repairs to Delaware Works,	10 00	
" " Twenty-fourth Ward Works,	17 02	
" " Fairmount Works,	27 55	
" " Schuylkill Works,	14 00	
" smith work for new ascents,	63 00	
" " " extensions,	60 99	
" " " buildings and grounds,	22 00	
" " " fountains,	12 93	
" brass castings returned,	11 20	
" iron " "	17 20	
" scrap iron, (sold,)	255 37	
" old brass and copper, (sold,)	131 90	
" stock on hand, January 1st, 1861,	5,496 71	
	$24,074 98	
Balance profit of shop,		$4,902 32
		$24,074 98

PIPE ACCOUNT.

The following table exhibits the receipts and expenditures of this branch of the Department :—

Table exhibiting the amount of pipe laid ; the amount expended in laying the same; amount received for same ; the amount sent to City Solicitor for lien, and the amount paid for same by the City since consolidation.

Years.	Feet of new pipe.	Gross amount expended.	Amount received for pipe.	Amount sent to Solicitor for lien.	Amount paid by City.
1855.	31,574	$40,673 09	$21,351 01	$7,980 71	$9,341 37
1856.	54,879	69,915 81	31,922 61	6,938 20	31,055 00
1857.	61,182	78,527 02	30,373 58	28,923 91	19,229 53
	147,635	$189,115 92	$83,647 20	$43,842 82	$59,625 90
1858.	67,519	80,944 12	37,145 91	29,448 40	14,349 81
1859.	97,993	115,705 81	63,249 13	27,302 11	25,154 57
1860.	97,095	99,142 79	62,697 57	26,459 47	9,985 75
Total,	262,607	$295,792 72	$163,092 61	$83,209 98	$49,490 13

The Department has not the means of giving any further explanation in respect to the three first years after consolidation, beyond what is exhibited above by the table

The following credits are due to the pipe account since 1858, which were paid from these items as charged above, viz:—

16 inch main from Poplar to Green,	$5,940 00
3,155 feet of pipe laid in Broad St., to take the place of wooden logs, from which no frontage could be collected,	3,786 00
1,100 feet of pipe, relaid on account of alterations in the grades of the streets,	1,381 50
Repairs done to Works by the shop,	321 84

1859.

The Frankford main, which cost	22,772 53
886 feet of pipe laid in the park at Fairmount,	1,063 20
1614 feet of pipe relaid on account of alterations in the grades of the streets and construction of sewers,	184 20
Repairs done in shop to Works, stops for 30 inch main, &c.,	5,878 54
2,676 feet of pipe relaid on account of change in grades of street and construction of sewers,	802 80
773 feet of pipe laid in Fairmount Park,	879 60
Repairs of Works done at shop,	620 62
Bills released by ordinance,	921 62
Bills remaining in the hands of the Department for collection January 1st, 1861,	31,374 51
	$75,926 96
Less deficiency on receipts of the three years as above,	49,490 13
Balance of profit to pipe account,	$26,436 83

FINANCE.

The revenue of the Department shows an increase over last year, but not so great as the year promised; but on account of the failing of receipts for pipe, it has proved to be less than was expected. The revenue will be exhibited in detail by the report of the Register, W. J. P. White, Esq., annexed.

By the accompanying table, it will be seen that the net profits of the Department for the last six years have been $1,524,844 07; of this sum, $955,900 79 has been earned in the three years of the present organization of the Department, and $568,943 28 the three previous years.

The following table exhibits the receipts, expenditures, and net revenue of the Department since consolidation:

YEARS.	Receipts.	Expenditures.	Net Income.	
1855.	$382,036 72	$250,895 37	$131,141 35	
1856.	351,936 49	138,954 85	212,981 64	
1857.	425,426 11	200,605 82	224,820 29	= $568,943 28
1858.	457,518 48	187,978 09	269,540 39	
1859.	551,180 08	225,082 03	326,098 05	
1860.	558,531 53	198,269 18	360,262 35	= $955,900 79
Total,	$2,726,629 41	$1,201,785 34	$1,524,844 07	

To the above amount of net income for the past three years, ($955,900 79,) there should be added the sum of $75,929 96, as appears in the pipe account, as also the amount of bills for pipe which have gone to lien, $83,209 98, every dollar of which is collectable, making a total of profit justly placed to the account of this Department during the present organization, of $1,115,-040 73.

The defects in the ordinances regulating the financial branch of the Department, require your attention. There are no checks upon the Department in regard to the revenue. It is true the Controller audits the books of the Department; but an examination which extends no further than the cash book, ferrule and permit book, leaves the great amount of the revenue without any

adequate check. To secure proper protection, the Department would suggest, that as soon as the register is made up for the year; that is, all the new consumers added, (which could be done early in November,) the Controller should audit the register and charge the Department with the amounts of water rents to be collected from each ward for the coming year. To the amount not paid into the treasury on the first of April, 5 per cent. should be added, as provided by ordinance, approved Dec. 26th, 1854; and to the amount unpaid the first of July, 10 per cent. additional should be added. The Department should keep a blotter explaining every reduction or addition to the water rent that may be made during the year, together with the reasons for the same. By these means the City would have a perfect check upon the Department, so as to preclude any possibility of fraud. As now arranged, your only protection is in the integrity of the officers.

There is also a want of wholesome check in the collection of money from frontage for pipe. As soon as pipe is laid in a street, it becomes the duty of this Department to notify the Survey Department, as per ordinance of January 29th, 1855; who measure the pipe and return bills for each property in front of which the pipe is laid, accompanied with a map of the street having the property marked ont. These documents are immediately entered in books kept for the purpose. The bills are served on the property holders, if possible; if they are not paid within thirty days, interest is charged upon them; and if not paid within four months, they are sent to the City Solicitor to be liened and sued out. Here again the Department would recommend a check in the following manner: When the Surveyor sends bills for water pipe to this Department, he should notify the Controller of the amount of said bills, which should be charged to this Department; and when this Department send bills to the City Solicitor for collection, the Controller should be notified, the Department credited by the amount of the bills, and the City Solicitor charged with the same. This would furnish a check upon this portion of the revenue, and the City would be secured against loss.

It is believed that the revenue could be considerably augmented, if the entire Department were provided with more

suitable accommodations; as in that case the business could be classified and systematised as it has never yet been done. With improved accommodations and one more permanent clerk, all the extra clerks could probably be dispensed with, with the saving of an amount more than sufficient to pay the necessary increase of rent for suitable offices. The Department would then place the books of each district under a special clerk, as we now have a Purveyor and Inspector for each district. This clerk would become familiar with the books and everything pertaining to his district, and could be held accountable for them. He could keep them posted, and prepare the duplicates without any assistance. This arrangement would take four clerks, one for each district into which the City is now divided by the Department. The pipe books should be placed in the hands of a special clerk, as there is sufficient to occupy the entire time of one. And a sixth clerk should be a cash clerk, and receive all money, and receipt all bills, the bills to be made out by the other clerks; by this means there would be a saving in expense, the revenue would be increased, and the public would be better and more satisfactorily served.

The following amounts have been received at the Cherry street office during the year, and paid into the City Treasury:—

Joseph Kiel, for rent of lot on Poplar street,	$60 00
Caleb S. Wright, for rent of wharf at Fairmount,	100 00
Rent of wharf at Schuylkill Works,	65 00
Scrap iron,	719 14
Manure,	1 00
Copper and brass turnings,	173 40
Grass,	49 52
Old barrels,	74 88
Feed,	6 13
Old attachment,	4 00
Amount carried forward,	$1,253 07

Amount brought forward,	$1,253 07
Old gum,	2 00
Cement,	21 25
Rent of lot north of Spring Garden reservoir,	50 00
Putting in fire-plug for Reading R. R. Co.,	83 45
	$1,409 77

EXPENDITURES OF THE DEPARTMENT FOR THE YEAR 1860.

Ordinary Expenses.

Salaries of chief engineer, register, clerks, &c.,			$18,503 47
Office expenses,			2,062 89
Salaries of engineers, firemen, &c., at Works,			16,336 40
Supplies to Works, viz.,			
Coal,	$20,896 13		
Tallow and oil,	1,534 23		
Wood,	132 25		
Small stores,	1,115 24		
		23.677	85
Repairs, viz.,			
Fairmount Works,	$2,969 36		
Delaware "	624 93		
Schuylkill "	2,684 89		
Twenty-fourth Ward,	1,093 47		
	7,372 65		
Buildings, grounds, &c.,	7,181 70		
		14,554	35

Service Mains and Materials.

Iron pipe, fire-plugs and other fixtures, and materials for laying pipes, &c., viz.,			
Iron pipe,	$51,585 55		
Lead,	7,010 14		
Amount carried forward,	$58,595 69	$75,134	96

Amount brought forward,	$58,595 69	$75,134 96
Iron castings,	4,996 83	
Brass do	2,327 83	
Lumber,	722 09	
Gasket,	173 81	
Leather,	174 91	
Wrought iron,	528 73	
Hardware,	337 20	
Blacksmith coal,	116 00	
Stop cocks,	90 00	
Bolts,	555 18	
Powder,	21 00	
Bricks,	57 50	
Wood,	42 00	
Tallow and oil,	83 25	
Wharfage,	160 26	
Tool house,	85 00	
Sundries,	77 07	
		69,144 35

Labor: laying pipe, setting plugs, &c., and for fitting up stop-cocks, fire-plugs, &c., viz.,

Pipe, First District,	$5,425 72		
" Second District,	2,760 75		
" Third District,	5,677 56		
" Fourth District,	5,767 05		
		19,631 08	
Shop,			
Wages,	$5671 03		
Sundry bills,	843 07		
		6,514 10	
Pipe plans,		1,046 00	
Surveyors, for measuring pipe,		2,627 16	
Maps,		180 00	
			29,998 34
Amount carried forward,			$174,277 65

Amount brought forward,			$174,277 65
Keeping pipes, plugs, stops and fixtures in good order, viz.,			
Wages, &c., First District,	$1,330 55		
" " Second "	2,351 19		
" " Third "	2,010 84		
" " Fourth, "	2,037 24		
		$7,729 82	
Hardware,		47 20	
Sundry bills,		190 56	
			7,967 58
Drilling and making new attachments, viz.,			
Wages paid in First District,		$1,345 66	
" Second District,		1,305 85	
" Third District,		1,763 80	
" Fourth District,		1,356 59	
			5,771 90
Grading and planting trees in lot north of Fairmount,			1,999 11
New ascents at Fairmount, viz.,			
Wages,		$1,452 93	
Hardware,		12 54	
Lumber,		4 88	
Lime,		4 40	
Patterns,		24 15	
			1,498 90
Old bills of 1856, 1857, 1858 and 1859,			2,363 96
Grading around stand-pipe and side walks at Twenty-fourth Ward Works,			1,489 58
Overpaid charge on water pipe,			13 50
Public drinking hydrants,			660 75
Notifying delinquents, preparing new duplicates, and assessing water tax,			2,000 00
Testing turbines			26 25
Amount carried forward,			$198,069 18

Amount brought forward, $198,069 18

EXTENSION OF WORKS.

Frankford main,

Sundry bills, ...		227 20
		$198,296 38

PAID FROM WATER LOAN.

(*Item No.* 1.)

Iron pipe, branches, stops, lead, gasket, labor, &c., viz.,

Iron pipe, . .	$13 72	
Damages to D. Carr, .	50 00	
Lead pots, . .	9 00	
Wages, . . .	62	
		73 34

(*Item No.* 2.)

Raising reservoir at Corinthian avenue and Poplar street, viz.,

Bricks, . -	2,086 40	
Lumber, . . .	6 75	
Smith-work, .	19 12	
Hardware, . .	25 04	
Wheelbarrows, .	10 00	
Iron castings, . .	7 36	
Lime, sand and cement,	15 61	
Pointing wall, . .	94 84	
Trees, . . .	37 50	
Screen, . . .	10 00	
Wages, . .	16,419 50	
		18,722 12
	$18,795 46	
Amounts carried forward,		$198,296 38

Amounts brought forward,		$18,795 46	$198,296 38
(*Item No.* 3.)			
Erecting two turbine wheels and four pumps, &c.,			
Machine work, .	$131 52		
Iron castings, . .	30 12		
Hardware, . .	9 50		
Wages, . . .	251 27		
		422 41	
(*Item No* 4.)			
Erecting Mill-house along the Mound dam, viz.,			
Bricks, . . .	$284 60		
Lumber, . .	2,273 72		
Smith-work, . .	151 20		
Machine-work, .	454 93		
Hardware, . .	314 83		
Wrought iron, .	603 07		
Iron castings, . .	214 10		
Leather, . .	18 66		
Wheelbarrows, .	53 00		
Slate, . . .	20 00		
Lime, . . .	156 63		
Cement, . .	1,724 49		
Ropes, blocks and gasket, . .	458 67		
Bolts, . . .	42 58		
Powder, . .	186 85		
Blacksmith's coal, .	15 00		
Anthracite " .	568 90		
Coke, . . .	161 00		
Hammer handles, .	27 00		
Boat, . . .	12 00		
Oar poles, . .	11 50		
Oil, . . .	92 50		
Gas, . . .	47 25		
	$7,892 48		
Amounts carried forward,		$19,217 87	$198,296 38

Amounts brought forward,	$7,892 48	$19,217 87	$198,296 38
Gum hose, . .	59 50		
Gas tubing, . .	119 20		
Gas fitting, . .	72 64		
Stop-cocks, . .	21 50		
Two hoisting engines,	1,160 00		
Two pumping "	800 00		
Two wrecking pumps,	1,660 00		
Rotary pumps, .	220 00		
Wages, . .	22,888 67		
Sundries, . .	97 99		
		34,991 98	
			54,209 85
Total amount expended in 1860,			$252,506 23

REGISTER'S STATEMENT.

DEPARTMENT FOR SUPPLYING THE CITY WITH WATER,
REGISTER'S OFFICE,
January 23, 1861.

H. P. M. BIRKINBINE, ESQ.,
Chief Engineer of the Water Works:

DEAR SIR,—I beg leave herewith to submit a statement of the transactions of this office, for the year 1860.

By a comparison with the receipts of 1859, it will be found that during the past year there has been an increase in the amount received from water rents, of $12,088 41, while upon the amount received in payment of Iron Pipes, a decrease of $5,136 50, leaving an increase on the total amount of receipts, of $8,983 57.

The amount of water rents and water tax outstanding, on the first day of January, 1861, was $22,316 90.

The amount due for Iron Pipes still outstanding, $31,374 51, exclusive of the amount of $26,459 47, sent to the Department of Law for lien in 1860.

Allow me again to call your attention to the serious inconvenience suffered both by the public and the officers and clerks, for the want of proper accommodations for the transaction of the business of the Department. When its receipts were but one half of the present amount, this inconvenience was felt and complained of by my predecessor, and now, it is impossible to discharge with dispatch its constantly increasing business.

Respectfully submitted,

W. J. P. WHITE, *Register.*

No. 11.

Statement of Receipts at the Register's Office, from January 1st to December 31st, 1860.

MONTHS.	Rents of 1858.	Rents of 1859.	Rents of 1860.	Penalties 1860.	Fractional rents.	Iron pipes.	Total.
January,		$2,091 88	$38,392 00		$939 00	$4,291 73	$45,714 61
February,		1,839 54	73,155 00		751 10	2,774 15	78,519 79
March,	$34 75	855 95	252,696 40		2,475 95	2,356 73	258,419 78
April,	5 00	408 37	8,773 50	$284 77	1,729 95	2,647 25	13,847 94
May,	10 00	409 25	8,284 25	272 96	1,887 06	2,447 03	13,310 55
June,		646 51	39,295 50	1,821 86	1,621 40	9,028 79	52,414 06
July,		190 95	2,767 50	309 37	1,726 50	9,430 90	14,425 22
August,		104 85	8,072 50	1,130 50	1,206 80	5,264 30	15,778 95
September,		114 56	9,530 50	1,227 59	1,421 71	3,999 31	16,293 67
October,	5 00	279 97	7,551 25	886 36	1,194 18	7,178 28	17,095 04
November,		471 14	5,370 75	651 56	997 78	6,494 65	13,985 88
December,		360 11	7,947 00	883 29	1,341 45	6,784 42	17,316 27
Total,	$54 75	$7,773 08	$461,836 15	$7,468 26	$17,291 98	$62,697 54	$557,121 76

EXTENSIONS.

RESERVOIR ON CORINTHIAN AVENUE.

The work of raising this reservoir is almost completed; about a month will be sufficient to finish it. The sum of $18,722 12 has been expended during the year. It is hoped that the appropriation necessary to repair and finish it, will be made as early as possible, as the Department is greatly in need of the increase of the storage capacity it will afford. For this purpose an additional appropriation of $7,000 will be required.

The following will show the work done and materials purchased for the reservoir during the year:—

14,221	cubic yards of	gravel embankment.
1,081	" "	black earth embankment.
1,770	" "	of puddling.
4,325	square "	of sodding.
2,541	" "	brickwork, (205,000 bricks.)
442	" "	" taken up and relaid.

NEW MILL HOUSE.

In procuring foundations for the new mill house unlooked for difficulties were encountered, arising from the great amount of water which found its way around the coffer dam, where it joined the mound dam. Excavations were made and the end of the coffer dam carried into the mound dam, as far as it was thought prudent; notwithstanding which the water still flowed through the loose stone composing the dam. This made it necessary to pump a large volume of water; when the tide was full, as much as 100 barrels per minute—a state of things for which the Department were entirely unprepared. They were therefore obliged to procure additional pumping machinery. The entire foundation stands upon piles (300 in number,) driven home to the rock, an average depth of about 23 feet; the earth is excavated to the depth of 18 inches around the heads of the piles, and the excava-

tions filled up with broken stone. Upon this, timbers 12 inches thick are laid, and around the platform thus constructed, sheet piling is driven to the rock. The sheet piling is doubled most of the way. The interstices of the timbers were filled with broken stone, and a good grout of cement and gravel was run in. The platform was then covered with two thicknesses of three-inch plank; and upon this the foundation was laid. The masonry is now above high-water mark, and no further trouble need be anticipated. The mill house can be finished in three months; the south front is shown by plate No. 1. The two wheels contracted for, with Mr. Emile Geyelin of this City, are in a satisfactory state of forwardness, and will be in their places early in the spring. Plate No. 4, shows the wheel and gearing as being constructed. It is hoped that the appropriation for finishing this work will be made at an early day, as it is much needed, and it may be found impossible to supply the City without it during the summer.

Although the outlay upon these Works has exceeded the estimated cost, it will still be less than that of the old Works, which are largely built of perishable material, and none of the difficulties described were experienced in procuring a foundation for them, as they are built upon rock, and the foundations are above low water.

The capacity of the new Works will also be fifty per cent. greater than that of the old ones. An additional appropriation of $15,000 will be necessary to finish the building in the style in which the work has thus far been done. There would have been no difficulty in constructing the Works for a much less sum of money; not, however, in the present substantial manner, nor of such durable material as is now being used. The saving in repairs and renewals will be equal to the difference between the first appropriation and the total cost when finished.

WORK DONE AT THE NEW MILL HOUSE, FAIRMOUNT, DURING THE YEAR 1860.

4,277 cubic yards of excavation.
6,419 " feet of grouting.
27,956 " " of 12 inch logging.
34,236 " " of 3 inch planking.
16,988 " " of 2 inch "
49,500 bricks.
1,488 square feet of ashler, in wheel pits.
192 " " " base course.
2,195 " " " wall and flumes.
223 " " corner stones, (30.)
43 " " window sills.
288 " " ring stones in front arches.
21 " " key stones " "
244 " " window jambs.
7 " " " heads.
2,172 perch laid in walls.
6,000 feet of scaffolding.
4 brackets for platforms.
3 cast iron beams, (6,300 lbs.)
11 wrought iron binders $\frac{3}{4} \times 3$.
300 ten inch hemlock piles, averaging 23 feet.

MATERIALS ON HAND FOR THE NEW MILL HOUSE, JAN. 1ST, 1861.

2 Worthington Pumps.
3 Direct Acting Pumps.
2 Hoisting Engines.
1 Rotary Pump.
2 Pile Drivers.
175 barrels of cement.
2,000 hard bricks.
220 feet of gas pipe.
30 tons of coal.
1,500 feet of scaffolding.

500 feet 1½ first common boards.
3 kegs of nails and spikes.
27 double and single blocks.
2 derricks.
3 winches.
6 coils of rigging, (assorted.)
Set of augers from ⅝ to 2¼ inches.
2 mauls.
2 cross-cut saws.
1,097 square feet of cut ashler.
229 " " 16 inch door jambs.
238 " " corner stones, (32.)
48 " " 12 inch window sills.
174 " " 9 inch window jambs.
24½ " " window heads.

The following report of the sub-committee on the extensions of the Works, now in progress, will exhibit the work in detail—and the report of the sub-committee on the contemplated extension of the Works, will show what extensions are deemed immediately necessary. Their views will receive important confirmation from the opinion of the Board of Health, as appears in the following extracts from their last annual report:—

"The fact is well known to you, that the present capacity of the water supply is inadequate to the demands. At those seasons of the year, too, when its use is most required and most essential for general and personal cleanliness, its deficiency is sometimes alarming, and this scarcity forms a just cause of complaint.

"The free use of the water by citizens, as a preservative of health, demands an increased supply adequate to the wants of the consumers."

* * * * *

"The inadequacy of the present Water Works has been already referred to by the Chief Engineer of the Water Department, as well as by yourself. The necessity for more extended mechanical or other arrangements, to meet the supply that the steady growth of our City suggests, is a subject that should arrest the early at-

tention of councils. Interested, as we are, as a sanitary Department, in all questions of the kind, we cannot refrain from urging upon the City authorities the wisdom of inviting suitable investigations of systems and plans for future improvement."

It will be seen that the outlay on the mill house and reservoirs has already overrun the estimate made for completing them. While the Department regret this, we feel confident that, upon examination, it will be found that the money has been expended to the best advantage, and that the work done fairly represents every cent of the outlay. Care has been taken to construct everything in the most permanent manner. No expenditures have been incurred which have not received the sanction of the committee on water, and which upon examination you would not fully sustain.

Report of the Sub-Committee on the Extension of the Works now in Progress.

PHILADELPHIA, JANUARY 30, 1861.

To the Committee on Water Works:—

GENTLEMEN:—The undersigned, a sub-committee appointed to inquire into, and report upon the expenses of the improvements now in progress at Fairmount, respectfully report, that soon after our appointment we proceeded to Fairmount, and after a thorough review of the whole subject, propounded a series of questions in writing, thirteen in number, to the Engineer in Chief, which we considered covered the whole ground; to which we have received the following reply from that officer. From this statement it appears that the whole work, when completed, will cost $123,500, or $35,500 over the amount appropriated; a sum, as your sub-committee are informed, not exceeding the original cost of the old mill house and machinery; while its capacity for water supply will be fifty per cent. greater. Another very marked feature of this new work is, its permanent character, which is creditable alike to the City and the Chief Engineer under whose immediate auspices the work has been performed. Not a dollar will be

required for repairs in the next fifty years; the whole structure, if finished according to the present plans, will be composed of iron and stone. On the other hand, the outlay for repairs upon the old portion of the work at Fairmount, amounts to $3,000 annually, owing entirely to the perishable materials used in its construction. The additional amount required to complete the new mill house and machinery, will be $35,500. Of this sum, it will be seen by annexed statement, in reply to question fifth, that $21,239 24 was expended entirely in the preparations for foundations for the new mill house. It is well known to the Committee that, whilst the coffer dam remained perfectly water tight, the work was constantly retarded by the influx of water through the foundations of the mound dam, to such an extent as to require the constant operation of four steam pumps. The Chief Engineer now proposes to substitute for the plank roof, originally contemplated, a roof composed of iron joists, connected by brick arches, which will cost $8,000 more than the plank roof; this is a question of policy altogether, and your committee do not hesitate to confirm the views of the Chief Engineer in this respect. We have thus accounted for $29,239 24 of the $35,500 asked for to complete the work. The balance has been absorbed by the increased size of the mill house, which is now 113 feet long.

All of which is respectfully submitted,

WM. BRADFORD,
WM. STOKES,
M. R. MOORE.

To MESSRS. BRADFORD, MOORE AND STOKES—

Sub-Committee on the extension of the Water Works now in progress.

GENTLEMEN:—The following answers I hope will be satisfactory to the several inquiries propounded by you at a meeting at Fairmount, on December 22d, 1860.

First Question. "What amount was appropriated in the first loan, and to what Items, and date?"

First appropriation approved April 8th, 1859, viz:—

Item No. 1. For the purchase of iron pipes, branches, stops, gasket, &c., and to pay for labor and materials connected with the laying of pipe, ... $137,500 00

Item No. 2. For raising the reservoir at Corinthian Avenue, Poplar and Twenty-Second Streets, and building retaining walls, ... 32,000 00

Item No. 3. For erecting two turbine wheels, and four pumps, including mains, stops, connections &c., at Fairmount, ... 35,000 00

Item No. 4. For extending the mill house along the mound dam, ninety feet, ... 17,000 00

Total amount appropriated, ... $221,500 00

Second Question. "What amount was appropriated in the second loan, and to what Items, and date?"

The second appropriation approved July 18th, 1860, viz:

To Item No. 2, of the first appropriation,	$10,000 00
" " " 3, " " "	17,500 00
" " " 4, " " "	23,500 00
" " " 5, for laying a main to connect the new mill house with the stand pipe,	13,000 00
Total amount appropriated, ...	$64,000 00

Third Question. "What amount has been expended on account of each Item?"

The amount expended on Item No. 1, was as follows:—

	1859.	1860.
Iron pipe, . . .	$90,309 60	$13 72
Lead, . . .	8,239 90	
Gasket, . . .	206 36	
Iron castings, . . .	634 20	
Brass castings, . . .	99 88	
Lumber, ...	509 97	
Amounts carried forward, .	$99,999 91	$13 72

Amounts brought forward,		$99,999 91		$13 72
Hardware,		206 46		
Ropes, blocks, &c.,		371 43		
Machine and smithwork,		1,150 32		
Bolts,		67 77		
Damages to D. Carr,				50 00
Lead pots,				9 00
Wages,		25,302 87		62
Amount expended in 1859,		$127,098 76		
Amount expended in 1860,			$	73 34
Total amount expended,				$126,172 10

On Item No. 2, the amount expended was as follows :—

		1859.	1860.
Coping,		$2,811 52	
Iron,		87 60	
Lime, sand and cement,		1,210 00	$15 61
Hardware,		87 68	25 04
Smithwork,		796 18	19 12
Powder and Fuse,		308 25	
Bricks,		129 50	2,086 40
Wheelwright work,		105 98	10 00
Bolts, blocks, &c.,		168 88	
Lumber,			6 75
Iron castings,			7 36
Pointing wall,			94 84
Trees,			37 50
Screen,			10 00
Wages,		30,237 80	16,419 50
Amount expended on reservoir,		$35,943 39	
Stand pipe :			
Plate iron pipe,	$425 08		
Lumber,	320 39		
Hardware,	60 86		
Amounts carried forward,	$806 33	$35,943 39	$18,722 12

Amounts brought forward,	$806 33	$35,943 39	$18,722 12
Tin work,	61 12		
Moulding, &c.,	26 68		
Wages,	662 47		
		1,556 60	
Amount expended in 1859,		$37,499 99	
Amount expended in 1860,			$18,722 12
Total amount expended,			$56,222 11

The amount expended on Item No. 3, was as follows:—

	1859.	1860.
Iron castings,	$1,014 90	$30 12
Brass castings,	242 00	
Machine work,	688 08	131 52
Bolts, &c.,	9 91	
Hardware,		9 50
Wages,	104 25	251 27
Amount expended in 1859,	2,059 14	
Amount expended in 1860,		$422 41
Total amount expended,		$2,481 55

The amount expended on Item No. 4, was as follows:—

	1859.	1860.
Coping,	$657 00	
Lumber,	2,603 69	$2,273 72
Cement,	970 97	1,724 49
Bricks,	347 20	284 60
Iron,	77 01	603 07
Ropes, blocks, &c.,	126 38	458 67
Powder,	162 50	186 85
Blacksmiths' Coal,	18 00	15 00
Anthracite Coal,		568 90
Coke,		161 00
Amounts carried forward,	$4,962 75	$6,276 30

Amounts brought forward,	$4,962 75	$6,276 30
Bolts,	103 54	42 58
Scow,	175 00	
Boat,		12 00
Hardware,	246 40	314 83
Machine Work,	1,047 36	454 93
Wheelwright work,	70 26	53 00
Smithwork,	479 77	151 20
Iron castings,		214 10
Leather,		18 66
Slate,		20 00
Lime,		156 63
Hammer handles,		27 00
Oar poles,		11 50
Oil,		92 50
Gas,		47 25
Gum hose,		59 50
Gas tubing,		119 20
Gas fitting,		72 64
Stop cocks,		21 50
2 hoisting engines,		1,160 00
2 pumping engines,		800 00
2 wrecking pumps,		1,660 00
1 rotary pump,		220 00
Sundries,		97 99
Wages,	13,907 09	22,888 67
Amount expended in 1859,	$20,992 17	
Amount expended in 1860,		$34,991 98
Total amount expended,		$55,984 15
Total amount expended from Loan,		$240,859 91

Fourth Question.—"What amounts have been transferred from one item to another? Include in this item all the transfers that have been made, and strike your balances to each, so as to show the amount remaining to the credit of each item, and the amount ecessary to be transferred."

Loan—Statement of Balances.

The amount expended on Item No. 1, was as follows:—

1859.				
April 8.	Am't appropriated,		$137,500 00	
Nov. 8.	" transferred to Item No. 2, as per resolution,	$6,000 00		
Nov. 18.	Am't transferred to Item No. 4, as per resolution,	4,000 00		
Dec. 31.	Am't expended in 1859,	126,098 76		
			136,098 76	
Dec. 31.	Balance,		$ 1,401 24	
1860.				
Mar. 17.	Am't transferred to Item No. 2, as per resolution,	1,300 00		
Dec. 31.	Am't expended in 1860,	73 34		
			1,373 34	
				27 90

(*Item No.* 2)

1859.				
April 8.	Am't of appropriation,		$32,000 00	
Nov. 8.	Am't transferred from Item No. 1, as per resolution		6,000 00	
			$38,000 00	
Dec. 31.	Amount expended, viz:—			
Stand pipe,		1,556 60		
Reservoir,		35,943 39		
			37,499 99	
	Balance,		$500 01	

	Balances brought forward,		$500 01	$27 90
1860.				
Mar. 17.	Am't transferred from Item. No. 1, as per resolution,	$1,300 00		
" 24.	Am't transferred from Item No. 3, as per resolution,	6,000 00		
June 22.	Am't transferred from Item No. 3, as per resolution,	3,000 00		
July 18.	Am't appropr'ed,	10,000 00		
			20,300 00	
			20,800 01	
Dec. 31.	Amount expended,		18,722 12	
				2,077 89
	(*Item No.* 3.)			
1859.				
April 8.	Am't approp'ed,		$35,000 00	
Dec. 31.	Am't expended,		2,059 14	
	Balance,		$32,940 86	
1860.				
Mar. 17.	Am't transferred to Item No. 4, as per resolution,	2,500 00		
" 24.	Am't transferred to Item No. 2, as per resolution,	6,000 00		
"	Am't transferred to Item No. 4, as per resolution,	6,000 00		
	Amounts carried forward,	$14,500 00	$32,940 86	$2,105 79

Amounts brought forward,		$14,500 00	$32,940 86	$2,105 79
June 22.	Am't transferred to Item No. 2 and 4, as per resolution,	6,000 00		
			20,500 00	
			$12,440 86	
July 18.	Am't appropriated,		17,500 00	
			$29,940 86	
Dec. 31.	Amount expended,		422 41	
				29,518 45

(*Item No.* 4.)

1859.				
April 8.	Am't appropr'ed,	$17,000 00		
Nov. 18.	Am't transferred from Item No 1, as per resolution,	4,000 00		
			21,000 00	
Dec. 31.	Amount expended,		20,992 17	
	Balance,		$7 83	
1860.				
Mar. 17.	Am't transferred from Item No. 3, as per resolution,	$2,500 00		
Mar. 24.	Am't transferred from Item No. 3, as per resolution,	6,000 00		
Amounts carried forward,		$8,500 00	$7 83	$31,624 24

Amounts brought forward,	$8,500 00		$7 83	$31,624 24
June 22. Am't transferred from Item No. 2, as per resolution,	3,000 00			
		11,500 00		
July 18. Amount appropriated,		23,500 00		
		35,007 83		
Dec. 31. Amount expended,		34,991 98		
				15 85

(*Item No.* 5.)

1860.		
July 18. Amount appropriated,		13,000 00
Total amount of balances on Loan,		$44,640 09

The amount necessary to be transferred to the different items to restore their integrity is as follows :

Item No. 1. The work contemplated to be done by this, is completed.

Item No. 2. No transfers from this item.

Item No. 3. The following transfers were made from this to

Item No. 2,	$12,000 00
To Item No. 4,	8,500 00

It will, therefore, be necessary to appropriate $20,500 00 to this item, to restore it to the amount originally appropriated.

Item No. 4. No transfers from this Item.

Fifth Question.—"State in detail the extraordinary expenses incurred in laying the foundation of mill-house and turbine wheels, occasioned by the influx of water by leakage through the dam ?"

The extraordinary expenses incurred in procuring a foundation, resulted, first, from the fact that what the soundings indicated to be solid foundation, upon removing the slight mud covering from it, was found to consist of loose stone, upon a stratum of mud

which averaged twenty-three feet deep. The rock which appeared at low water, at the eastern end of the new mill-house, was found to be nothing more than a narrow spur, with mud upon each side seventeen feet deep; this also increased the cost of the foundations. The whole foundation is now laid upon about three hundred piles, averaging ten inches in diameter, and twenty-three feet long. Upon these are laid timbers twelve inches in thickness, running lengthwise of the building. Around the platform thus constructed, three-inch sheet piling was driven; most of the way of double thickness. Concrete of broken stone and cement was filled in around the heads of the piles, to the depth of eighteen inches. The same was also introduced in the interstices of the timbers. The platform was then planked with two thicknesses of three-inch plank, and upon this the foundations were laid.

A second source of increased outlay was the great amount of water which it was found necessary to pump out of the coffer dam. This was not from any imperfection in the construction of the dam, but from the impossibility of preventing the flow of water around the connection between the coffer dam and the mound dam; it was not deemed safe to excavate the mound a sufficient distance to cut off the leak.

Third, the care necessary, in prosecuting the work, to prevent the possibility of accident to the Dam, and the necessity of keeping constantly prepared for freshets. The following is the amount of labor and material used in the extraordinary work in procuring the foundations, viz.:

Lumber,	$2,273 72
Cement,	862 25
Coal,	583 90
Iron,	402 04
Coke,	161 00
Hardware, nails, &c.,	314 83
Machine-work,	454 93
Smith-work,	151 20
Bolts,	42 58
Amount carried forward,	$5,246 45

Amount brought forward,		$5,246 45
Leather,		18 66
Oil,		92 50
Gas,		47 25
Gas tubing and fitting,		191 84
Stop-cocks,		21 50
Engines and pumps,		3,840 00
Wages,		11,781 04
Total,		$21,239 24

Sixth Question. "Why could not the breast wheels have been removed and turbines substituted in the old mill house?"

This could have been done, and it was in fact the first plan which suggested itself for increasing the capacity of these Works. It was suggested to the water committee by Zebulon Parker, about twelve years ago, and the turbine now in the Works is the result of that suggestion. It is still proposed to replace the breast wheels at some future day with turbines, but it was thought inexpedient to attempt the alteration while so great a part of the City was dependent on these Works alone for a supply of water. The constructing of a coffer dam would be necessary, and the rocks upon which the mill house stands would have to be blasted to the depth of eleven feet below the present floor, to accommodate the turbines; this, it was thought, would destroy a part of the building, and of necessity, stop a number of the wheels, thus rendering it impossible to keep up the water supply After turbines were placed in the old mill house, it would still be necessary to construct the new one, if the City wished to enjoy the whole of the water power of the river, which it purchased at so great a price. The question therefore, was, whether the City would run the risk of altering the old Works first, and afterwards erect the new Works; or whether, by first erecting the new Works and getting them into successful operation, it would ensure a full supply of water under any and all circumstances that might arise in attempting the remodelling of the old Works When this alteration is made, it will be found expedient, if not absolutely neces-

sary, to take down the western wall of the building, before blasting for the wheel pits.

Wheels of sufficient capacity to absorb the entire water power of the river, if erected in the old mill house, could not be supplied with sufficient water through the head arches as they are at present, as they do not furnish sufficient area of water way. To enlarge the water way, it would be necessary to stop all the wheels in the Works, which would deprive a large part of the City of water, while the enlargement was in progress.

Seventh Question—"What addditional loan do you deem necessary to complete the mill house and turbines, and what would be the amount required for each?"

It will require an appropriation to Item No. 3, to restore it to the original amount, on account of transfers made from it, the sum of $20,500 00

It will require an appropriation to Item No. 4, to complete the mill house, of . . 15,000 00

Making the total amount of appropriation necessary to complete the mill house and machinery of $35,500 00

Eighth Question.—"What was the contemplated size of the mill house under the first loan, and what is its present size?"

The original estimate was fifteen thousand dollars for a mill house sixty feet long, furnishing accommodations for two wheels and four pumps; this was altered in the ordinance creating the loan, to ninety feet and seventeen thousand dollars. The mill house as now being constructed is one hundred and thirteen feet long, and furnishes ample room for three turbines of the largest class, and six double acting pumps. The maximum pumping capacity of these Works will be eighteen million gallons per day.

Ninth Question.—"What additional expense has been incurred by departing from the original plans?"

It was at first intended to build a mill house of material, workmanship and appearance similar to that of the old one, excepting the roof, which was to be flat and covered with plank; but when the large annual expense of repairs to wood work, plastering,

painting, &c., was taken into consideration, (about $3,000,) the building was commenced, and has been thus far constructed, of most durable material; cut stone-work has been substituted for rubble work, and there is not a piece of timber in it except that in the foundations under water, where it will never decay; nor is there any other work that will require renewal or repairs. The three gates are of iron, working upon iron frames; both the surfaces of the gates and frames are faced with brass, and fit perfectly water tight; they cost, when in their places $2,500, while wooden ones would have cost but $1,200, but would, however, have required renewals at least every fifteen years.

If sufficient appropriation is made, it is proposed to finish the whole work in the same manner, which in the end will be found more economical than if plaster, wood, and other perishable material had been used, at an apparent reduction in the first cost. The mill house, if finished as thus far completed, will cost fifty-four thousand dollars above the amount first estimated. The interest of this sum will be saved in repairs and renewals, that would have been necessary if the building had been constructed as at first proposed.

Tenth Question.—"State what the total cost of the mill house and turbines will be when completed?"

The mill house will cost when completed, . .	$71,000 00
The three turbines, gearing, and six pumps with stops and connections will cost when completed and in operation, ...	52,500 00
Total cost of mill house and machinery, . .	$123,500 00

It may not be out of place to remark that this is considerably less than the old mill house and machinery cost, with the large amount of perishable material used in their construction and rock foundations above low water to build upon, while in the new Works no perishable material is used; the foundations are upon piles, twelve and a half feet below City datum, and the pumping capacity will also be fifty per cent. greater than that of the old ones.

Eleventh Question.—"What will be the value of the machinery and materials on hand when this work is completed?"

It is difficult at this time to estimate the value of the machinery, tools, and materials that will be left after the work is done; should the Department have immediate use for them they will be as valuable as when first purchased.

Twelfth Question.—"What will be the total cost of the work done in raising the Corinthian Avenue reservoir?"

The amount expended to January 1st, was	$56,222 11
Amount of appropriation unexpended,	2,077 89
Additional appropriation required to finish it,	7,000 00
Total cost of reservoir when finished,	$65,300 00

Thirteenth Question.—"What amount was expended in laying the 30 inch main to First Ward?"

This main and its connections cost one hundred and twenty-six thousand one hundred and seventy-two dollars and ten cents.

Yours, respectfully,

HENRY P. M. BIRKINBINE,
Chief Engineer Water Department.

January 22d, 2860.

Report of the Sub-Committee on the Further Extension of the Water Works.

PHILADELPHIA, FEBRUARY 5, 1861.

To the Committee on Water Works:—

GENTLEMEN:—The sub-committee, to whom was referred the report of the Chief Engineer upon the extension of the Water Works, and the petitions of sundry citizens for a better supply of water,—

Respectfully report that, after a thorough examination of the subject, they think that the interest as well as the necessities of the City require an increase of the pumping capacity of the Schuylkill Works, and of the facilities for distributing the water generally. The improvements now in progress at Fairmount,

will, when completed, be amply sufficient to supply all the water that will be required from that point for some time to come. The time is not far distant, however, when, if we continue to use the water from the Schuylkill, we may find it necessary still further to increase the pumping capacity of these Works. This can readily be done by removing the breast wheels from the old mill house, and substituting therefore the Jonval turbines, similar to those now being erected in the new mill house, by which means we should double the present pumping capacity. We would recommend, however, that a connection of the thirty-inch pumping main from Fairmount Works, with the thirty-inch distributing main from the Schuylkill Works, or Spring Garden reservoir, (a distance of only 250 feet on Twenty-second Street,) be made with the least possible delay. This will be the work of but a few days, after which we shall be able to pump directly from the Fairmount Works into the Spring Garden reservoir. By this means we shall save for the City, at least twenty dollars per day, in the article of coal alone, as we can then dispense with three steam engines at the Spring Garden Works, during the winter and early spring, when the quantity of water required for consumption, and the demands upon the Fairmount Works are greatly reduced.

The Schuylkill Works are of equal, if not greater importance than those at Fairmount; the latter, from their mode of construction, although decidedly the most economical, are also much more liable to accidents; and although they have been in operation for forty years, and in that time sustained no serious injury, yet we have no guarantee that the first ice freshet may not sweep away a portion of the dam, and leave the City entirely dependent upon the Schuylkill Works, a false and perhaps fatal security. An injury to the dam of only a limited character, under our present arrangements, would probably paralyze for months all our efforts to keep up a supply; an extended drought would be attended with like results. The effects upon a population of over half a million of inhabitants may probably be conceived but not described, and at the same time the millions of property entrusted in a measure to our care, would be exposed to the ravages of fire,

without the necessary means to stay its progress. A wise policy and the true interest of the City should prompt the authorities to be vigilant in providing against contingencies, by which we are liable to be overtaken both in winter and summer. It is our duty as well as interest to contemplate these liabilities, involving as they do, our health, safety and comfort to so large a degree, and to see that they are properly guarded against.

To be prepared for such contingencies, there are no means so readily available, and at so small an expense, as the erection of a Cornish engine of the largest class at the Schuylkill Works, with a pumping capacity of ten million gallons per day; and although the cost of an engine of this character may startle the propriety of some, it is clearly demonstrable, that it would be of very great importance in an economical point of view. The present cost of raising 1,000,000 gallons of water into the reservoir at the Kensington Works, for running expenses alone, is $13 26, and including the interest on the cost of the Works $23 63 per million gallons. At the Schuylkill Works the cost of raising one million gallons, for running expenses alone, is $9 49, and including interest on the cost of the Works, $12 90; showing a difference in favor of the latter of $3 77 per million gallons, without interest, and $10 73 per million gallons, including interest on the cost of the Works. The quantity of water pumped at the Delaware Works during the year 1859, was 868,567,100 gallons, which, at the difference in cost of pumping the same quantity at the Schuylkill Works as at present arranged; taking the running expenses only of both Works into the account, namely, $3 77 per million gallons, will show a difference of $3,272 36 per annum in favor of the latter Works; and if we take into consideration the interest on the cost of the Works, which properly enters into the calculation, we shall find a more striking difference in the result. This, as above shown, is $10 73 per million gallons, or $9,313 64 per annum, equal to about 45½ per cent. in favor of the Schuylkill Works. This statement, however, shows but a portion of the saving that would be effected by the introduction of the Cornish engine. It has been ascertained by a careful experiment recently made at the Schuylkill Works, that the best reciprocating

engine there in use, with a consumption of one ton of coal, raised into the reservoir 626,682 gallons. The Cornish engine, now in those Works, with the same consumption of fuel, raised into the reservoir 987,761 gallons; showing a difference in favor of the latter of 58 per cent., thus proving beyond a doubt, its vast superiority for pumping purposes.

The whole district, composed of the 17th, 18th, 19th and 23rd Wards, which are now very indifferently supplied from the Delaware Works, both as to quantity and quality of water, could draw their supply in abundance, and of a superior quality from these Works, and at a reduction in cost to the Department of nearly 60 per cent. The Delaware Works could then be dispensed with, and the pumping main could be used as a distributing main to that portion of the City which is now greatly in need of a better supply. This main is 13,260 feet long; to lay such a main would cost the City $47,825. The necessity for the conversion of this pumping into a distributing main, will appear more fully in a subsequent part of this report. The engines, pumps, buildings, and wharf property connected with the Works could probably be sold to realize to the Department $60,000.

The necessity for a reservoir in the Twenty-fourth Ward, as recommended by the Chief Engineer in his last annual report, has become still more evident. The stand pipe from its meagre capacity—17,000 gallons, or but one half hour's average supply for the ward—cannot be considered as a reservoir; and until this deficiency is supplied by a basin of some considerable capacity, the Works will continue to be operated as they have been heretofore, at a very serious disadvantage in an economical point of view; and will fail entirely in fulfilling the object for which they were designed. The supply is so precarious that improvements are greatly retarded, both in dwellings and manufactories. In case of fire, an accident to both the pumps would preclude all supply, to the great danger of the surrounding property; wells continue to be dug and used; and many citizens refuse to take the water in this uncertain state of supply.

There can be no question, but that the increased income from this ward would pay the interest on the cost the first year after

the construction of the reservoir, and the following year would produce a considerable profit to the Department, over and above the interest on the whole cost of the Works. The engines now in use are amply sufficient to perform the work required of them; and after the basin is completed, either one of them will furnish more water than is now supplied by both, in a given time through the stand pipe, and at a large reduction in cost. The greater economy of pumping the water into a basin, will be readily understood when we consider the fact, that, while the quantity stored in the stand pipe can never exceed one half hour's supply, the engines are necessarily idle when it is full, although they are required to be in readiness to pump at all hours of the day and night; and consequently, the fires must be kept up at all times, whether the engines are at work or not. Thus, one third of the time is lost by the engines remaining idle when the pipe is full; although all other expenses of the Works are the same as if they were fully employed; whilst in case of fire, or any unusual demand for water, the engines are necessarily worked at a speed much beyond their capacity, to the serious detriment of the machinery. On the contrary, if the engines pumped directly into a basin, where a supply for two or three weeks could be stored, it is quite probable that one engineer and one fireman could be dispensed with altogether, and the quantity of coal consumed be reduced one half; which would reduce the running expenses of the Works at least $2,500 per annum, whilst the supply would be regular and abundant. This would offer inducements to the citizens to take more freely of that which is a prime necessity, which they have hesitated to do heretofore, because of the uncertain supply.

In calling your attention to the Twenty-first Ward, we must be permitted to say, that the citizens of that Ward have the strongest claims upon our sympathy and action. They are entirely without a supply of water, other than that obtained from wells; and when we consider how densely that portion of the Ward, embraced within the limits of Manayunk, is populated, the impure character of the water thus obtained can readily be imagined; in fact the water has become so impure, that many of those living upon

the main street, fronting the canal, have laid water pipes connecting with it, impure as it is known to be at that point, and conveyed the water into their dwellings. They are without the means of extinguishing fires, and a very large amount of valuable property is constantly exposed to the ravages of the devouring element, with none but the most primitive means of arresting its progress. Another urgent reason for the consideration of your body is the fact, that the Twenty-first Ward has a very large proportion of working population, who add greatly to our production and wealth; and any interruption to the regular demands for employment would take away their means of subsistence, and render them unwilling dependents. The wants of this ward deserve prompt and immediate action. Their improvements are retarded and prosperity is checked for want of a sufficient supply, which affects no part of our community more unhappily than the industrial. We have every reason for prompt action, and none for delay, as $100,000 would, in our opinion, be ample to build a works sufficient for the supply of the ward, including engine, engine house, and reservoir at Flat Rock, and also a main extending from that point into and through Manayunk. A site for the reservoir can be procured at Flat Rock, within one thousand or fifteen hundred feet of the river, and at an elevation of two hundred and thirty feet above tide. From these Works we could readily supply the Twenty-second Ward, whenever their population may require an increased supply over that now furnished by the private Works in operation there.

Having thus, as briefly as the nature of the case permits, and much more so than than the importance of the case demands, called your attention to the general extension of the Works, which we consider actually necessary, we will now ask your attention whilst we point out the necessity of increased facilities for distributing the water in various parts of the City. This is so obviously necessary, and the increased receipts which would accrue from thence, are so clearly demonstrable, that the measure would seem to be a plain and essential duty. With our present pumping facilities we could give a full and ample supply to all our water-takers, during a great part of the year, if we had the proper means

of distribution. It is in vain to erect pumping apparatus, if corresponding distributing facilities are not simultaneously provided. That for which we now ask appropriations to perform, ought to have been executed during the past season. We shall have doubled our pumping capacity at Fairmount on the completion of the improvements in progress there, at a cost of some $100,000, and shall receive no adequate return, until we lay the pipes necessary for the proper distribution of the water. Your Committee fully believe that, if the distributing facilities recommended by the Chief Engineer and the majority of the Committee on Water Works, of the last year, had been carried out, a return of ten per cent. upon their cost might very reasonably have been looked for during the present year; instead of which, nearly one year's interest will be lost on the whole investment for increasing our pumping capacity. There are much stronger reasons for expecting a large return from the extension recommended in the third and fourth districts, than there were from the thirty-inch main laid on Broad street, to supply the first district. Improvements are advancing more rapidly in the districts in which we contemplate laying mains; our railway conveyances are tempting many to occupy more space; and all the tendencies indicate a more rapid growth in the northern and north-eastern districts than in the lower part of the City—though we make this remark with no invidious design. The increased receipts in the first district, since the laying of the thirty-inch main, are equal to about twenty per cent. on its cost.

In conclusion, we urge upon you the importance of putting this work in hand at the earliest possible moment; believing, as we do, that nothing can be done that will more rapidly and certainly advance the interests of the districts and increase the receipts of the Department, than the work to which we are calling your attention. Before leaving the subject, we would call your attention to the great injustice which has been practised towards a portion of the fourth district. This district pays the largest water and manufacturing tax of any in the City, and yet a portion of the water takers are compelled to draw their supplies in the morning to consume through the day; and, as for water to extinguish fires

or protect property in the middle of the day, it is not to be had. Such a course in business would be ruinous to individual operators, and it is certainly not very reputable in the City to enforce payment for that for which she does not give value. Early and prompt action in this matter is so clearly for the best interests of all, that we trust it cannot fail to receive the most prompt and favorable consideration of your body, leading to the immediate appropriation of the necessary amount.

The following statement will show the sources from which the various Wards now draw their supplies, and the sectional area of present mains for their supply in square inches, and proposed additions to each :—

The first, second, third and fourth Wards are now supplied from the Corinthian avenue reservoir, by a thirty-inch main extending along Poplar street to Ridge avenue, along Ridge avenue to Broad street, and along Broad street to Washington avenue, at which point a twenty-inch branch is taken from it down Washington avenue to Tenth street, where it is reduced to a sixteen-inch main, and continued down to Fifth street of that size, where at present it terminates. We now propose to extend this sixteen-inch main to Front street, to supply that portion of the City lying south of Washington avenue, and along the river front, which is now fast filling up with manufactories of various kinds, and the population which necessarily accompanies them.

The present population of these wards is 103,784, which pays a water-rent, by private consumers, of	$86,804
By manufactories,	3,223
Total water-rent,	$90,027

Sectional area of supply mains, 706.86 square inches.

The fifth, sixth, seventh, eighth, ninth and tenth Wards, are supplied from the Fairmount Works by one thirty-inch main, one twenty-two inch main, and one twenty-inch main, to which we propose to add one twenty-inch main, from the reservoir at Fairmount, laid down Callowhill street to Twenty-second street, and along Twenty-second street to Chestnut street; at this point, to

reduce it to a sixteen-inch main, and extend it along Twenty-second to Locust, where it will join a main already laid to Pine street; then to extend the twelve-inch main from Pine to South street; this extension will supply all that portion of the City lying west of Twenty-second street, and south of Callowhill street. The population of these wards is 138,176, who pay a water-tax, by private consumers, of $173,461

By manufactories, 12,582

Total water rent, $186,043

Sectional area of supply-mains, 1335.18 square inches.
To which we propose to add, 314.16 " "

The eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteenth and twentieth Wards, are supplied from the Spring Garden reservoir, by one thirty-inch, and three sixteen-inch mains. The whole quantity of water supplied by this thirty-inch main is not absorbed at present by the distributing pipes. It supplies two ten-inch, one twelve-inch, and one sixteen-inch, mains. We now propose to attach a twenty-inch main to it, and connect it with two sixteen-inch mains from the same reservoir, the capacity of which is now absorbed by branches, before reaching the point where we propose to connect. The population of these wards is 160,671, who pay the Department for water rent, by private consumers, $174,319

By manufactories, 15,807

Total water rent, $190,126

Sectional area of supply-mains, 1,310.05 square inches.
" " proposed addition, 314.16

The seventeenth, eighteenth, nineteenth and twenty-third Wards, are supplied from the Kensington reservoir, by one eighteen-inch main, only, running to Frankford road and Norris street. In his last Annual Report, page 104, the Chief Engineer says: "The nineteenth Ward is greatly in need of a supply-main; there being now but one of eighteen inches, passing through only a portion of it, along Norris street to Frankford avenue. This is the

only main leading from the Kensington reservoir, and its capacity is almost exhausted before it reaches Frankford avenue. The twenty-third Ward will also receive its supply through this main, and will require a large amount of water for numerous manufactories and dwellings being built in it." From this statement of the Chief Engineer, it is plain that the supply of water to the Wards above named must be very inadequate to the demand; and if his argument in reference to the short supply in the nineteenth Ward is correct, which we do not doubt, how entirely inadequate must be the supply to the twenty-third Ward, which receives only what little there may be left, after the seventeenth, eighteenth and nineteenth Wards are supplied. The whole supply received by the twenty-third Ward is now carried through a ten-inch main, with a head of only thirty-seven feet at Frankford. The consequence is that, at times, not a drop of water is furnished.

We propose now to lay a thirty-inch main from the reservoir at Poplar Street, to Broad and Columbia Avenue, *via* Poplar Street, Corinthian Avenue, Girard Avenue, and Broad Street; from this point to continne a twenty-four inch main down Columbia Avenue to Sixth Street, and up Sixth Street to Germantown Road, and there connect with the eighteen-inch main from the Kensington reservoir; also a twenty-inch main from the Kensington reservoir to Frankford Road and Lehigh Avenue; also a twelve-inch main from Kensington Avenue and Lehigh Avenue to Frankford Road and Westmoreland Street; also a sixteen-inch main from Frankford Road to Richmond Avenue, on Lehigh Avenue.

The population of these Wards is, 107,162, who pay a water rent, by private consumers, of $62,429
Manufactories, ... 7,288

$69,717

Area of supply mains from reservoir, 254.47 square inches.
" " proposed addition, . 452.19 " "

A table showing the Districts into which the City is divided by the Department, and the Works from which they are supplied, Diameter of Supply Mains, Population, Amount of Water Rents received for Private Use and Manufacturing Purposes, together with area of Supply Mains.

WARDS, AND THEIR SOURCE OF SUPPLY.	Water Districts.	Dia. of Supply Mains.	Population	Amount of Water Rents paid for private use.	Amount of Water Rents paid for Manufactories.	Total amount of Revenue from Water rents paid	Area of Supply Mains, in square inches.
1st, 2d, 3rd, and 4th Wards, supplied from Fairmount Works, ...	1	30 in	103,784	$86,804 00	$3,223 00	$90,027 00	706.86
5th, 6th, 7th, 8th, 9th and 10th Wards, sup. from Fairm't Works	2	30 " 20 " 20 "	138,176	173,461 00	12,582 00	186,043 00	1,335.18
11th, 12th, 16th and 13th, 14th, 15th and 20th Wards, supplied from Schuylkill Works,	4	30 " 16 " 16 "	160,671	174,319 00	15,807 00	190,126 00	1,310.05
17th, 18th, 19th and 23rd Wards, supplied from Delaware Works,	3	16 " 18 "	107,162	62,429 00	7,288 00	69,717 00	254.47
24th Ward, supplied from Works in the Ward, ...	2	12 "	23,791	7,054 00	1,793 00	8,847 00	113.09
			535,584				
Part of 21st Ward, no supply, ...			17,164				
22nd Ward supplied from Private Works, ...			17,286				
			568,034	$504,067 00	$40,693 00	$544,760 00	3,719 65

The following statement shows the proposed extensions of the mains, and their estimated cost in detail. First—a thirty-inch main, to connect the pumping main from Fairmount with the thirty-inch distributing main from the Spring Garden reservoir on Twenty-second Street. This will require 250 feet of thirty-inch main with the necessary stops and branches, $4,000 00

Second—a twenty-inch main, to connect the thirty-inch main from Spring Garden reservoir, with the two sixteen-inch mains at Ridge Avenue and Poplar Street, on Poplar Street. This will require 700 feet of twenty-inch main, with the necessary stops and branches, ... 4,000 00

Third—a thirty-inch main from the reservoir on Poplar Street, to Broad and Columbia Avenue, on Poplar Street, Corinthian Avenue, Girard Avenue, and Broad Street. This will require 7,000 feet of thirty-inch main, with the necessary stops and branches, ... 60,000 00

Fourth—a twenty-four inch main from Broad Street at Columbia Avenue, to Sixth Street and Germantown Road, on Columbia Avenue, to connect with the eighteen-inch main from the Kensington reservoir. This will require 5,500 feet of twenty-four-inch main, with the necessary stops and branches, ... 37,000 00

Fifth—a twenty-inch main from Kensington reservoir to Frankford Road and Lehigh Avenue. This will require 6,100 feet of twenty-inch main, with the necessary stops and branches, . . 31,000 00

Sixth—a twelve-inch main from the crossing of Kensington Avenue and Lehigh Avenue to Frankford Road and Westmoreland Street. This will require 6,500 feet of twelve-inch main, with the necessary stops and branches, ... 16,000 00

Seventh—a sixteen-inch main from Frankford Road to Richmond Avenue, on Lehigh Avenue. This will require 4,500 feet of sixteen-inch main, with the necessary stops and branches, . . . 16,000 00

Amount carried forward, $168,000 00

Amount brought forward,	$168,000 00
Eighth—a sixteen-inch main from Fifth to Front Street, on Washington Avenue. This will require 1,900 feet of sixteen-inch main, with the necessary stops and branches, ...	7,000 00
Ninth—a twenty-inch main from Fairmount reservoir to Twenty-second and Chestnut Streets, on Callowhill and Twenty-second Streets. This will require 5,000 feet of twenty-inch main, with the necessary stops and branches, ...	25,000 00
Tenth—a sixteen-inch main from Chestnut Street to Locust Street, on Twenty-second Street. This will require 1,000 feet of sixteen-inch main, with the necessary stops and branches, ...	4,000 00
Eleventh—a twelve-inch main from Pine to South, on Twenty-second Street. This will require 700 feet of twelve-inch main, with the necessary stops and branches, ...	2,000 00
Twelfth—a reservoir and twenty-inch main for Twenty-fourth Ward Works, including real estate. This will require for excavation, puddling, and lining, a reservoir to contain 20,000,000 gallons, ...	40,000 00
11,250 ft. of twenty-inch main, with the necessary stops and branches, ...	50,000 00
Real estate, ...	10,000 00
Thirteenth—a Cornish engine, and forty-eight inch pumping main for Schuylkill Works, and the necessary alterations to the engine house:	
A Cornish engine to pump 10,000,000 gallons per day, ...	50,000 00
Alterations in engine house, ...	10,000 00
3,250 feet of forty-eight inch main, with stops,	33,000 00
Amount carried forward,	$399,000 00

Amount brought forward,	$399,000 00
Fourteenth—a works at Flat Rock, to supply the Twenty-first Ward, as follows :—	
Real estate, 15 acres, at $300, . . .	4,500 00
Engine house, ...	5,000 00
Cornish engine to raise 1,000,000 gallons per day,	17,500 00
Reservoir to contain 10,000,000 gallons, .	25,000 00
Pumping main, twenty-inch diameter, . .	10,000 00
Distributing main, 12,000 feet, sixteen and twelve inch, ...	35,000 00
Contingent fund to cover extraordinary expenses,	29,000 00
	$525,000 00

The necessity for the above extensions is so self-evident that the committee do not think the subject demands a lengthy argument. They have been careful to recommend nothing but what the present necessities of the City demand, and what they believe will be largely remunerative, by the increased revenue that will follow their completion. These have, to a large extent, been recommended and urged upon the consideration of councils, by both committees, preceding the present watering committee, (see appendix to Journal of Select Council for 1858–9, folio 23; and for 1859–60, folio 115; and the reports of his honor, the Mayor, and the Chief Engineer for 1859–60.)

The map accompanying this report, shows the position of the supply mains now laid, marked with red lines; the proposed mains are dotted in red, and the pumping mains are marked with blue lines. For the purpose of making the above extensions and improvements the Committee would recommend that a loan of $525,000 be created.

In conclusion, we have presented authoritative statistics, showing the population, the area of mains for water supply in square inches, and the income from the various Districts, now supplied by the City with water, which show at a glance, their exact and relative conditions. From these statistics we gather facts which are very important as a guide for our present and future action; among the most important of which is, that as the supply increases, the receipts will be proportionably greater. The second District, (the old City proper,) with 138,176 inhabitants, with an

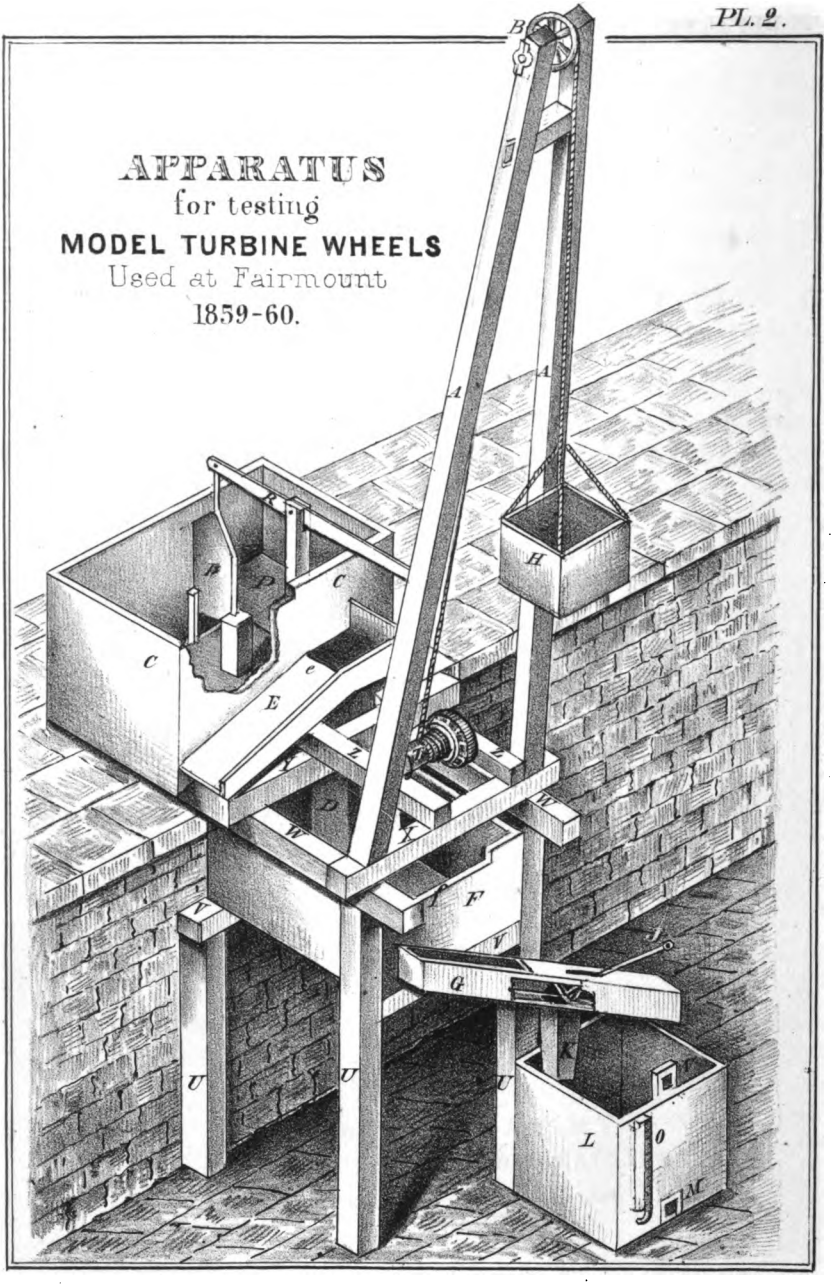
area of supply mains from reservoirs, of 1,335 square inches, pays a water rent of $186,043; while the fourth District, with a population of 161,000 inhabitants, and an area of supply mains of 1,310 square inches, pays only $190,126; a result which is no doubt produced by a want of proper distributing facilities, as the ability to consume water is one-sixth greater in the fourth than in the second District. The receipts should be increased in proportion to the greater number of inhabitants, and probably would be, if the District could be as fully supplied. It is the inability to supply, and not the want of demand, which causes the small proportionate receipts. In the third District, there is a population of 107,000, and an area of supply mains of 254 square inches, and the net income from all sources is only $69,717. This result, as in the fourth District, arises from the want of supply, and not from deficiency of demand; with increased distributing facilities the receipts would be proportionably greater. Thus we have endeavored to present the facts connected with this important subject, and also the prominent and most obvious reasons for our recommendations. Before closing, however, we wish to call your particular attention to the fact, that during the year 1859, the net profit of this Department—paid into the treasury—amounted to $326,098 05; this, we think, ought to be sufficient to justify the united action of your committee in thus urging the importance of the proposed extensions, at the earliest practicable period. We trust they may strike the minds of the committee as forcibly as they have the minds of your sub-committee, and that they will receive your favorable consideration and cordial approval and support.

W. W. Smedley,
Wm. Stokes,
Charles F. Iseminger,
M. R. Moore,
George W. Simons,
Jos. Megary.

Further remarks upon the extensions are not deemed necessary after the above full report of your committee.

Respectfully yours,
Henry P. M. Birkinbine,
Chief Engineer.

APPARATUS
for testing
MODEL TURBINE WHEELS
Used at Fairmount
1859-60.



DEPARTMENT FOR SUPPLYING THE CITY WITH WATER.

REPORT

ON THE

EXPERIMENTS

WITH

TURBINE WHEELS,

MADE 1859-60,

AT

FAIRMOUNT WORKS,

PHILADELPHIA,

BY

HENRY P. M. BIRKINBINE,

CHIEF ENGINEER.

PHILADELPHIA:
WILLIAM F. GEDDES, PRINTER,
NO. 320 CHESTNUT STREET.
1861.

EXPERIMENTS

WITH

TURBINE WATER WHEELS.

The importance attached to the experiments made by the Department upon turbine wheels, appears, from the numerous applications which have since been made for the results. These experiments were made in 1859-60, at Fairmount Water Works, but on account of the agitation of the subject in Councils, the Department did not feel at liberty to give details of the result to the public. The whole subject is now disposed of, and the action of the Committee on Water, and of the Department have been fully sustained.

In presenting this Report the Department do not propose to enter into the theory of turbine wheels—for this has already been done by those better qualified for the work—nor to offer any theory or scientific explanation of the differences in the forms of the wheels, or per centage yielded, but simply to give the results of actual experiments with the differently constructed wheels, under various loads, and running at different velocities. The practical man will, no doubt, find suggestions in the tables worthy his attention, and facts which may assist in the construction of wheels, or in the selection of the wheel best adapted to a given location, work, &c. The experiments were undertaken with great reluctance, not for want of interest, but of the time necessary to conduct them with the care and deliberation which the importance of the subject demands. Our object in these experiments, therefore, was simply to ascertain the co-efficient of useful effect that would be produced with different loads, the amount of water that would be vented when the wheel was kept stationary, the velocity the wheel would acquire, and the amount of water vented, when left to

run free, without a load. The wheels were all tested under the same head and fall: viz., six feet. The apparatus was of the most simple kind, and, so far as the experiments were prosecuted, they may be relied upon as correct. The proportion and peculiarities of each wheel experimented upon, are given with the tables annexed. As partial results have been placed before the public, from time to time, by those interested, and, in some instances, erroneous impressions conveyed, every experiment made in public has been given in detail in the tables, from which all interested may draw their own conclusions. The Department, never, in any way, conveyed the idea, that the model producing the highest coefficient of useful effect in these experiments, would, under all circumstances, entitle the maker of it to the contract for building the wheels to be used in the extension of Fairmount Works. Such an arrangement would betray a want of practical knowledge in the Department. Models, particularly when of such considerable dimensions as those experimented upon, would, of course, give the best idea of the wheels that could be gained in any way, except by the full-sized wheel itself, in actual operation. A peculiar service will be required of the wheels in the Fairmount extension, namely, pumping, and that, under a varying head and fall of from six to fourteen feet. Nevertheless, models would exhibit in the best manner the motors which would be best adapted to our use, and the experiments made with them would show their efficiency, and furnish the best guide within reach, in making a selection suited to the wants of the Department.

The maker of the wheel was allowed to put it up according to his peculiar views, and to run it at the velocity and load which he chose to select as best calculated to exhibit its efficiency, only restricting the head and fall to six feet, which is the *minimum* head and fall at Fairmount. In making this restriction, perhaps the Department did not do full justice to some of the wheels, whose peculiar excellence was claimed to be in the fact, that the useful result would be little affected by changes of head and fall. The small appropriation and want of time, compelled the limitation of the experiments to a uniform head and fall, under the belief that vary-

ing the load upon the wheels would produce nearly the same results.

It would not be safe to make these experiments themselves a final test of the efficiency of the wheels, or to conclude that those which produced the highest co-efficient are the best calculated for all purposes or circumstances; or that the makers of the *models* which produced the highest co-efficient, were, in every respect, the persons best qualified to build wheels for actual service. All we wish to assert is, that such experiments furnish certainly one of the best means of judging of the wheel and the ability of the maker in the absence of full-sized working wheels. It will be seen that all the parties who engaged in a second series of experiments, effected improvements in their wheels, as a result of information gained by the first series; and, in experiments not reported, improvements of even more marked character, were made. Indeed, it is probable, that even in cases where the makers of the wheels had previously enjoyed an extensive experience, they derived some valuable suggestions from the experiments. Many forms of wheels in general use in this country, including some of those more highly esteemed, as the Fourneyron and the Scotch motor or Whitelaw, were not represented. There is no country in which so great a variety of wheels has been invented or made, or where wheels of superior efficiency have been produced.

The wheels through which the water passes in a vertical direction, such as the Jonvals, gave the highest useful effects. The wheels venting centrifugally or from the centre, were next in efficiency; and the wheels venting towards the centre or centripetally, gave the lowest results in this series of experiments.

Care has been taken in preparing the tables, &c., to make the subject intelligible to all. The calculations by which the results were reached, are therefore explained, and examples given, which will enable any person acquainted with the simplest mathematical processes to follow them. Illustrations of all the different wheels experimented upon, would no doubt have made the report more intelligible and interesting.

The Department are under obligations to Messrs. O. H. P.

Parker, William B. Bement, and Charles Close of this City; and to Mr. James Millholland of Reading, for valuable assistance, and suggestions in connection with these experiments.

There were but few of the builders of the wheels exhibited, who were not fully conversant with their business, and well qualified to construct this valuable class of motors; and the Department cannot refrain from expressing the pleasure derived from intercourse with so many mechanics of more than ordinary abilities, and desire to acknowledge the valuable help and useful information gained from them, as well as through the experiments themselves. If injustice has been done to any of them, or to the experiments, in this report, it would be a matter of sincere regret to the Department.

The Committee on Water passed resolutions at several different times, directing the experiments to be stopped, on account of the delay which they occasioned in perfecting the plans for the new Works; but were induced to extend the time by the owners of wheels, who were anxious to have them tested. When the results were reported to the Committee there were three wheels, which in efficiency and other respects were found to be about equal, (see the experiments in detail.) These were the wheels constructed by Mr. J. E. Stevenson; that of Mr. Emile Geyelin, and that of Messrs. Andrews and Kallbach. The peculiarities of these wheels are shown by plate No. 3. After a patient discussion of the subject, the Committee on Water directed the Department to procure estimates from these persons, and also from Levi Smith, the maker of the Parker wheel. The bids will be found in the appendix. Mr. Emile Geyelin of this City, was the lowest bidder, and the contract was therefore allotted to him for two of the wheels; no appropriation having at that time been made for the third. The wheel, as now being built, is shown in plate No. 4.

DESCRIPTION OF APPARATUS USED FOR TESTING THE MODELS OF TURBINE WHEELS.—PLATE NO. 2.

The large box C, forms a reservoir for supplying the models with water; it communicates with the penstock D, by way of

the trunk P, and has a waste notch adapted to it, for preventing overflow of the box. The valve *p*, operated by the lever R, having its fulcrum in the post S, opens and closes the communication with the trunk and reservoir, at the pleasure of the operator.

The models to be tested, were placed in the box F, which served as a wheel pit, with their inlet water-ways connected directly to the side of the penstock D. Those wheels which had no gates of their own, were provided with one at the opening of the penstock into the inlet of the wheel. After the water had performed its work in the wheels, it flowed into the box F, and escaped through the notch *f*, into the trough G, by which it was either conveyed from the apparatus into the river, or conducted into the measuring box L, through the spout K.

When the discharge valve J was open, any water passing down the trough fell into the measuring box; but when the valve was shut, the water passed over its back and was delivered outside. This valve was operated by the rod *j* extending through a slit in the top of the trough, the side of which is removed to show the arrangement.

The measuring box L is emptied through the opening M, by drawing the slide N, and has a graduated glass tube O fitted to its side, for exhibiting the exact depth of the water within.

To the top of the penstock D was fitted an overflow spout E, for carrying off any excess of head of water from the models, it being important to maintain an unvarying head over them. The perpendicular distance between the summit *e*, of the overflow E, and the notch *f*, was six feet.

The shaft of each model was connected by suitable gearing to the shaft of the drum T. Upon this drum was wound a rope, which, passing over the sheave B, revolving in bearings at the tops of the posts AA, lifted the weight box H.

The posts AA, were held in position by guys, which extended back and were fastened on the upper level of the wall.

The whole apparatus was supported on and connected with the framing UU, VW, XY, and Z.

The box C received a constant supply of water, through pipes connected with one of the pump mains.

The measuring box was five feet every way, inside.

The apparatus is Isometrically represented to a scale of one-eighth of an inch to the foot.

The height of the wall against which the apparatus stood is fifteen feet.

OPERATION.

After the model to be tested was properly connected with the penstock D, and drum shaft T, the reservoir C was filled with water, and kept constantly supplied to the point of overflow.

The weight box H was then charged and carefully weighed, and the valve J thrown upon its seat, to pass the water outside the measuring box. This valve was operated by an assistant, whose business it was to open and close it promptly, when the signals were given.

An assistant was stationed at the lever R, to control the valve *p*, and keep the water in the penstock, during the experiment, just at the point of overflow.

The rope was well stretched before it was used, and during the course of the experiments two pieces of tape were fastened around it, at a convenient distance apart for observation, (usually 25 ft.) which distance was measured when the whole weight of the loaded box was suspended. Before trial, the box was raised and lowered several times by running the wheel, to ascertain that all the machinery was properly adjusted, and to give the rope every opportunity of becoming fully stretched for the trials. The distance between the tapes was again measured, and frequently also during the trial, to enable the operators to eliminate every possibility of error from the stretching or contracting of the rope.

When the wheel was fully under way, and at the moment the first tape was passing a fixed point, a signal was given to open the discharge valve and direct the tail water into the measuring box; when the second tape was passing the same point, another signal was given to close the valve, and conduct the tail water away from the apparatus; after which the wheel was stopped and the weight box allowed to run back to the place of starting.

If the depth of overflow from the top of the penstock varied in any experiment, or in different experiments, the operator at the inlet valve noted the amount of variation from observations made at the summit of the spout, and allowed for it accordingly.

An adjustable slide was fitted to the notch *f*, to enable the operator to maintain a uniform overflow of the tail water from the wheels. Upon the surface of the water in the wheel box F rested a float, from which projected a rod vertically, to the top of the penstock; this rod exhibited to the operator above the level of the water in the wheel box, and served as a check to any neglect of duty on the part of the operator at the adjustable notch *f*. For wheels which vented water more rapidly than others, the adjustable notch and float indicator were necessary to ascertain the actual difference of level of the head and tail water, during every trial; which difference is the *true* head or fall, acting on any water wheel.

It will be noticed, that the amount of water which escaped from the wheel during the experiment, into the measuring box, was only that which was used to raise a *known weight* a *measured height, after* the wheel had attained a uniform speed.

It is reasonable to assume that the amount of water required to start different wheels, may vary very considerably; and it is possible that a wheel which gives a higher ratio of useful effect while in motion, may require more water to get it under way than one which gives a lower ratio. It is also certain, that at the commencement of the trials, the rope would be drawn to different tensions; perhaps, in some instances, it would hang loosely from the sheave, in which case the wheel would vent a great deal of water before the weight would be lifted at all. It was to avoid errors from these sources that the apparatus was constructed in the manner described; to ascertain the useful effect of each wheel, *only while in motion and during the performance of its work;* omitting altogether, the uncertain conditions of starting and stopping.

The different parts of the apparatus were so disposed that the observer at the penstock overflow could see the level of the water in the wheel box, as indicated by the float rod; and the observer

stationed to signal the passage of the tape over the measuring point could, by his ear, note the time of closing and opening the discharge valve, and make allowance, if necessary, for any fore or after movement, which might unavoidably occur while closing it. This observer was at the same time within sight of the float rod and penstock overflow, and in the interim of tape transits, could detect, at a glance, the height of head under which the wheel was working. In this manner, one observer could watch the performances of the others, and act as a check to any neglect of duty on their part; and any person interested in the correct testing of the wheels, could see the ropes, water-levels, and discharge valve, from one station point, and thus observe for himself the faithfulness of the operators and the progress of the trials. The time required for each wheel to perform its work was taken by an observer, who stationed himself on the upper platform, at a point favorable for observing the exact moment of transit of the tapes.

During the whole course of the experiments the same persons gave the same signals and operated the same parts of the apparatus, and no pains were spared in securing the greatest degree of exactness in every manipulation of the machine.

The amount of weight to which the box was loaded was varied in different experiments; these weights, together with all the essential data of the trials, appear in the tables which are given under the head of each wheel. A correct platform scale for weighing the box, was kept at the apparatus during the whole time of the experiments, and any person who wished to be satisfied of its correctness before trying his wheel, could have it tested upon making that wish known.

EXPERIMENTS.

The following is a description of the wheels, with statements and tables of the experiments.

GEYELIN'S DOUBLE JONVAL WHEEL ON A HORIZONTAL SHAFT.

Geyelin's first series of trials was made with two wheels, secured on a horizontal shaft. The head-water was admitted

between the fixed wheels, and escaped horizontally outwards through the movable wheels into discharge tubes, which were submerged in the tail water in the same manner, and for the same purpose as in the case of the single wheel hereafter described. The arrangement and general design of the wheels and cylinders, and the curvature of the guides and buckets were similar to those of the single wheel on a vertical shaft.

Table No. 1 exhibits the results with this arrangement.

A high percentage was not claimed for the double Jonval wheel; the trials with it were regarded altogether as experimental in their nature, with a view to ascertain the comparative merits of the two systems, when wheels, in every way similar to each other, were used under similar circumstances; that is, two wheels on a horizontal shaft compared with one wheel, of about the same power, on a vertical shaft, and under the same head.

JONVAL TURBINE BY GEYELIN.

The sketch fig. 5, plate 3, represents a vertical section of the principal parts of the Jonval model, by Geyelin, drawn to a scale of three-quarters of an inch to a foot, in which A is the movable wheel, B the fixed wheel, and C the casing which contains them. Plate 4, will give a general idea of the wheel and gearing. The buckets were fastened in the movable wheel, at D, to the central part, or hub, and were bound around their outer edges by a wrought iron band.

The wheel thus constructed was secured to the shaft F, turned off truly on its upper face and outer edge, and fitted to run freely under the fixed wheel, and within the cylindrical part of the casing C. The guides were firmly secured to the outer face of the fixed wheel B, at E, and fitted closely against the conical sides of the upper part of the casing C. The shaft F revolved freely through the top plate of the fixed wheel. The part of the casing in which the fixed wheel rested, and the cylindrical part in which the movable wheel turned, were bored out truly, and the under edge of the hub B, where it meets the corresponding rim of the movable wheel, was faced off, so that the movable wheel could run nearly in contact with it.

No. 1.

GEYELIN'S FIRST SERIES OF TRIALS.

NOTES OF TRIALS OF JONVAL TURBINE (DOUBLE VERTICAL,) BY E. GEYELIN, NOV. 9, 1859. HEIGHT 25 FT. HEAD 6.04 FEET.

No.	Weight raised.	Water in box.	Time in seconds.	Ratio of useful effect.
1	700 lbs.	3.31 ft.	20	.5633
2	800 "	3.52 "	22	.6054
3	900 "	3.76 "	24	.6376
4	1,000 "	4.02 "	25½	.6626
5	1,100 "	4.31 "	28	.6799
6	1,200 "	4.72 "	30	.6772
7	700 "	3.283 "	21	.5680
8	600 "	3.126 "	20	.5112
9	500 "	2.966 "	19	.4490
10	wheel held fast	3.42 "	20	
11	" runn'g free	3.335 "	20	

Ratio of gearing,
Bevel 50 to 144, } 25 to
Spur 6 " 24, } 288.
Area of orifices in both fixed wheels, 42.6 sq. in.
Area of orifices in both movable wheels, 42 sq. in.
Number of buckets in each fixed wheel, 9.
Number of buckets in each movable wheel, 28.
Note.—In trial, No. 11 the drum made 13½ revolutions.

No. 2.

GEYELIN'S SECOND SERIES OF TRIALS.

NOTES OF TRIAL OF JONVAL TURBINE, (HORIZONTAL,) BY E. GEYELIN, FEB. 29TH, 1860. HEIGHT RAISED 25 FT. HEAD AND FALL, 6 FT.

No.	Weight raised.	Water in measuring box.			Average.	Time in seconds.			Ratio of us'ful effect
1	900 lbs.	2.96 ft.	3.02 ft.	2.96 ft.	2.98 ft.	22	25	21	.8099
2	950 "	3.18 "	3.06 "	3.10 "	3.113 "	25	24	25	.8183
3	1,000 "	3.25 "	3.32 "	3.23 "	3.266 "		26	26	.8210
4	1,050 "	3.54 "	3.46 "	3.46 "	3.486 "	27	28	27	.8077
5	1,100 "	3.67 "	3.60 "	3.63 "	3.633 "	26	27	28	.8119
6	1,150 "	3.84 "	3.73 "	3.82 "	3.80 "	30	29	30	.8124
7	1,200 "	4.02 "	4.05 "	4.01 "	4.03 "	31	31	31	.7993
8	1,250 "	4.25 "	4.32 "	4.21 "	4.26 "	32	33	33	.7868
9	1,300 "	4.51 "	4.39 "	4.56 "	4.49 "	34	33	34	.7771
10	1,000 "	3.87 "				30			.6928
11	Wheel held fast,				4.52 "	30			
12	" running free,				3.98 "	30			

Ratio of gearing,
Bevel, 1 to 2½ } 7 to 60.
Spur, 7 " 24 }
Area of orifices through guides, 44.6 square inches.
" " wheel, 37.7 " "
Number of buckets in fixed wheel, 10.
" " movable " 26.
Notes.—In trial 12, the wheel made 20 revolutions.
In trial 10 the gate was only partly raised.

The head water flowed freely into the chamber over the fixed wheel, whence it passed into the chutes formed by the guides, and acted upon the buckets at D of the movable wheel, the curves of which being in reverse order, received the most effective blow and pressure of the discharging water. After the water had performed its work in the wheel, it escaped downwards through the discharge tube, which was a continuation of the cylinder C. This tube was enlarged immediately below the wheel, to give the escaping water an unobstructed flow, and was submerged in the tail water, to secure the power of the suspended column of water below the wheel, forming a draft tube.

This wheel, in common with all wheels where the draft tube is used, occupies a mid-position between the head and tail water; when the former was shut off, the suspended column of water sunk to a level with the latter, and left the wheel in a favorable position for examination and repairs.

Should any solid body pass between the buckets and guides, which would endanger the breakage of either, while the wheel is in motion, the guide-wheel, being fitted loosely in the conical part of the casing, would be raised and let the obstruction pass out without doing injury. This peculiarity also permits the raising of the movable wheel, when the step, or any of its parts, needs repairing, and obviates the necessity of taking the wheel apart.

In the upper part of the diagram fig. 6, plate 3, will be found the dimensions of the template which was fitted to the guides of the model, against the outer circumference of the hub B, and the ordinates to the curve at every tenth part of the whole space occupied by the curve, equal to 8.55 inches.

In the lower part of the diagram are given the ordinates of the bucket curve of the movable wheel for every tenth part of the whole curve space. The template from which the bucket curve was taken, was formed to suit the curve of the bucket against the inner surface of the ring which encircles the whole wheel. The guides and buckets project radially from the hubs of the wheels.

The model was very nicely and truly fitted up. The cylinder, gate, base-plate and wheel centers were made of cast iron; the shaft, of two-inch wrought iron, running on a steel step, about five-eighths of an inch in diameter; the guides and buckets were made of sheet brass, correctly and uniformly shaped to the proper curves; the former were about one-eighth, and the latter one-sixteenth of an inch in thickness. Its proportions and finish were well designed and executed, and leave nothing to be desired to make it a perfect model of this type of turbines.

Table No. 2 exhibits the results of trials with this model. The average useful effect given by this series of trials is .8049.

JONVAL TURBINE, BY COLLINS.

Collins's first wheel, the results of which are given in table No. 3, was of the Jonval form, with several improvements. It had an adjustable circular plate over the hub of the wheel, to defend it from the pressure of the head-water, and a throttle-ring below the wheel, which could be raised or lowered at pleasure; when close to the wheel, the issues were reduced to one half their full area. The maker says, "This improvement is much valued where it is adapted to wheels which are are driven by small fluctuating streams."

The step of this wheel was not adjustable, but should the "toe" wear laterally on it, the wheel could not rub the cylinder in which it runs, for this had a horizontal flange fitting into a corresponding recess in the casing of the wheel, larger in diameter than the ring, thus allowing lateral motion of both wheel and ring, without leakage at either joint. The step is made of *lignum vitæ*, and is very large compared with that of other wheels. This model was made to operate under a varying head, and this peculiarity the makers claimed to be its excellence. It is to be regretted that the testing apparatus was not adapted to exhibit this feature of the wheel.

No. 3.

COLLINS'S FIRST SERIES OF TRIALS.

NOTES OF TRIALS OF JONVAL TURBINE, BY J. P. COLLINS, FIRST WHEEL. HEAD AND FALL, 6.1 FT.

No.	Weight raised.	Height.	Water in box.	Time in seconds.	Ratio of useful effect.
1	1,200 lbs.	16	4.723 ft.	36	.4289
2	1,100 "	16	3.970 "	30	.4677
3	1,000 "	18	4.030 "	31	.4712
4	900 "	23	4.613 "	34	.4734
5	800 "	23	4.193 "	28.6	.4630
6	700 "	23	3 920 "	28.5	.4333
7	Wheel held fast,		3.830 "	30	
8	" running free,		4.165 "	30	

Ratio of gearing. Bevel 16 to 38 } 56 to
Spur 7 " 21 } 76.
Diameter of fixed wheel outside of guides, 20 inches.
Diameter of movable wheel, 20 inches
Width of buckets, 2.75 inches.
Depth of wheel, 3 75 inches.
No. of buckets, 21.
Area of orifices 39 square inches.
No. of guides in fixed wheel, 18.
Depth of guides in fixed wheel, 3.75 in.

Area of orifices in fixed wheel, 40 square inches.
Note. In trial No. 8, the drum made 14½ revolutions.

No. 4.

COLLINS'S SECOND SERIES OF TRIALS.

NOTES OF TRIALS OF JONVAL TURBINE, BY J. P. COLLINS, HEAD, 6 FT. SECOND WHEEL.

No.	Weight raised.	Height.	Water in measuring box.			Average.	Time in seconds.			Ratio of useful effect
1	900 lbs.	25 ft.	3.63 ft.	3.58 ft.	3.58 ft.	3.596 ft.	30	30	31	.6716
2	800 "	25 "	2.93 "	2.87 "	2.85 "	2.883 "	25		25	.7440
3	700 "	25 "	2.48 "	2.52 "	2.53 "	2.51 "	22	22	22	.7478
4	600 "	25 "	2.34 "	2.34 "	2·30 "	2.326 "	21	21	21	.6915
5	850 "	25 "	3.22 "	3.15 "	3.17 "	3.18 "	28	27	28	.7168
6	1,000 "	25 "	3.79 "	3.67 "	3.66 "	3.706 "	31	31	31	.7235
7	1,100 "	25 "	4.39 "	4.32 "	4.30 "	4.336 "	36	37	36	.6802
8	1,200 "	23 "	4.85 "	4.91 "		4 88 "		40		.7662
9	900 "	25 "	3.20 "	3.13 "	3.12 "	3.15 "	28	27	28	.7221
10	1,000 "	25 "	3.78 "	3.71 "	3.65 "	3.713 "	31	32	31	
11	Wheel held fast,					4.05 "		30		
12	" running free.					4.12 "		30		

Ratio of gearing,
Bevel, 2 to 1, } 48 to 7.
Spur, 24 " 7, }

Area of orifices through guides, 35.4 sq. inches. Area of orifices through wheel, 31.35 sq. inches. Number of buckets in movable wheel, 19. Number of buckets in fixed wheel, 13. Depth of movable wheel, 4.35 inches. Depth of fixed wheel, 7 inches. Width of buckets in fixed wheel at top, 3.25 inches. Width of buckets in fixed wheel at bottom, 2.25 inches. Width of buckets in movable wheel at top, 2.10. Width of buckets in movable wheel at bottom, 1.65. Diameter of fixed wheel at top, 22.4 inches. Diameter of fixed wheel at bottom, 20.4.

Collins's second series of results, which are given in table No. 4, was obtained by a Jonval form of wheel, differing from the first in having a conical water-way through both guides and buckets, which, in the first, was cylindrical. The rims of the hubs of both wheels was cylindrical, 15.9 inches in diameter. The chutes, where the water entered them had a radial breadth of 3.22 inches, and the issues, at the bottom of the wheel, had a radial breadth of 1.65 inches. The vertical depth of the chutes was 7 inches, and of the buckets 4.35 inches. There was a space of about one inch between the fixed and movable wheels.

JONVAL BY STEVENSON.

No. 5.

STEVENSON'S FIRST SERIES OF TRIALS.

NOTES OF TRIALS OF JONVAL TURBINE, BY J. E. STEVENSON.

No.	Weight raised.	Height.	Water in meas. box.	Time in seconds.	Head and fall.	Ratio of useful effect.
1	900 lbs.	25 ft.	3.520 ft.	26	6 02 ft.	.6833
2	1,000 "	"	3 816 "	29	"	.7004
3	1,050 "	"	3.926 "	29	"	.7148
4	1,100 "	"	4.053 "	30	"	.7254
5	1,150 "	"	4.190 "	31	"	.7335
6	1,200 "	"	4.420 "	33	"	.7256
7	1,250 "	22 "	4.076 "	30	"	.7213
8	1,300 "	22 "	4 346 "	32	"	.7035
9	1,350 "	20 "	4.166 "	31	"	.6929
10	Wheel held fast,		4.58 "	30	"	
11	" running free,		4.39 "	30	"	
					Average,	.7112

Ratio of gearing.
Bevel, 17 to 69, } 187 to 1406.
Spur, 44 " 96, }
Area of orifices through guides, 41.25 square inches.
" " " wheel, 30.9 " "
Outside diameter of wheel, 21 inches.
Inside " " 15.5 "
Number of buckets in movable wheel, 18.
" " fixed wheel, 12.
Depth of movable wheel, 5.25 inches.
" " fixed " 5. "
In trial 11, the drum made 18 revolutions.

Fig. 1.

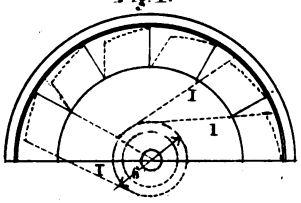


Fig. 2

Stevenson

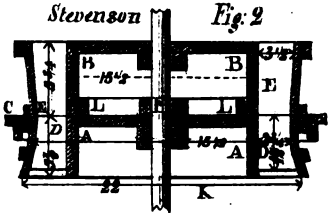


Fig. 3

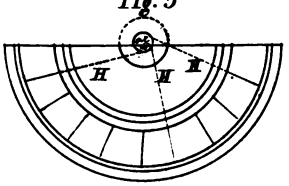
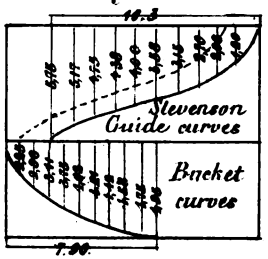


Fig. 4.



Scale of Wheel details,
3/4 in. to a foot.
Scale of Guide curves,
1/10 of full size.

Geyelin Fig. 5.

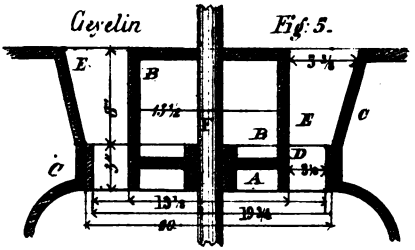


Fig. 6.

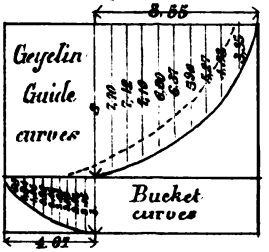
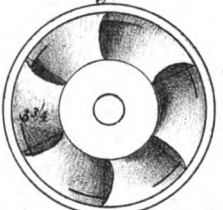


Fig. 7.



Andrews & Kalbach.

Fig. 8.

Fig. 9.

(First Model.)

In Stevenson's first model, the guides were not bent down at their lower ends, as shown in the description of the second, (see plate 3, fig. 4,) but the lower edge of the band of the movable wheel was flared; and the water-ways in the fixed wheel narrowed to the point of discharge. The movable wheel had eighteen buckets, the fixed wheel twelve guides, and the forebay had a partition projecting from one side to near the shaft, to prevent gyration of the head-water, which entered the forebay in a radial direction towards the centre of the wheel-shaft.

The results of the trials are shown in table No. 5.

(Second Model.)

This Jonval model, by Stevenson, was similar to Geyelin's in principle, but different in the arrangement of its details. Fig. 2, plate 3, represents a vertical central section of the movable and stationary wheels, as arranged when it gave the second series of trials, in which A is the movable, B the fixed, wheel, and F the shaft to which the former is secured, and which runs freely through the latter; D represents the place occupied by the buckets, which were bound to the hub by a thin wrought iron band, as in Geyelin's, and were additionally secured by two small square bands outside. A flange, L, projected from the movable wheel, within the rim of the fixed wheel, and formed against it a water-tight joint.

The position of the guides is shown at E; they were doubly bound to the hub of the fixed wheel, in the same manner as the buckets of the movable wheel. The fixed wheel was secured in a groove turned in the floor, C, of the forebay, into which it projected.

The step-box was adjusted laterally by radial screws, which passed through lugs on the centre-plate of the spider beam, and rested on a ring which was fitted into the central aperture of the latter. This ring was adjusted vertically by a large taper key, which extended under it and across the central aperture. If the radial screws were slackened and the key withdrawn, the ring and step-box could be lowered through the central aperture, and re-

paired, without raising or disturbing the wheel, after which it could be replaced with little trouble.

A circular chamber bolted fast to the centre-plate of the spider beam surrounded the step-box and extended above the bearing; a spout led from the side of the discharge tube into this chamber, for the purpose of keeping the chamber constantly filled with water.

This wheel had a discharge or draft-tube extending beneath the surface of the tail water, in the same manner as Geyelin's, and was fitted with a gate, which consisted of a circular disc of the same diameter as the tube, supported on a horizontal axis, by which it was operated from the outside.

Beneath the floor, C, of the forebay, projected a flange, within which the upper band of the movable wheel freely revolved. This flange, and the flange L, allowed the movable wheel to be lowered without loss of water at the joints of the flanges with the wheel. This arrangement permitted experiments to be made with the wheel at different distances from the guides.

The head-water entered the forebay in the direction of a tangent, thus favoring gyration in its motion over the chutes or guide curves, which, in the first model, was prevented by a partition in the forebay.

Diagram fig. 4, plate 3, represents the guide and bucket curves of the model, drawn to a scale of one-tenth the full size. The dimensions were taken from templates fitted to the guides and buckets on the inner surfaces of the bands which encircle them.

In the fixed wheel there were twelve guides, and in the movable wheel nineteen buckets. The top edges of the guides were radial lines, and the lower edges were tangent to a circle 6 inches in diameter, concentric with the wheel, as shown by the lines I, fig. 1. The top edges of the buckets were tangent to a circle $1\frac{1}{2}$ inches in diameter, shown by the lines H, fig. 3, and the bottom edges were radial lines; all the tangents were on the same side of the axis.

The lower edge of the band which encircled the buckets of the movable wheel was flared outwards, to give the water (in the opinion of the maker) "a free discharge from the wheel, and at

the same time diminish friction, secure the action of centrifugal force upon the incline of the band, and give thereby additional power to the wheel."

It will be noticed in the diagram, fig. 4, that the guide curve is bent downwards at its lower end, causing the space between the curve and the dotted line, (which latter is a guide curve advanced on the wheel) to widen towards the point of discharge.

It will also be noticed that this change of curvature deflects the direction of the discharge at a greater angle with the plane of the wheel.

These were strong, practical working models, 22 inches in diameter, with brass buckets, well finished. Every part was well and truly fitted; the "toe" of the shafts revolved upon *lignum-vitæ* steps about two inches in diameter, the same as that of their shafts; all of the machine work was done in the best manner.

It will be noticed in table No. 6, that the model gave its highest result in the twelfth trial, the first one made after the wheel was lowered from the guides; but in the next two trials, it shows a decided *loss* when compared with the third and fourth trials, which were made under like circumstances, or nearly so, before the wheel was lowered from the guides.

It further appears, that on the next day, when three trials were made, the second of which was under circumstances precisely similar to those of the twelfth trial on the day previous, a falling off of 3.4 per cent. occurred, and the third trial failed, by 1.6 per cent., to equal the fifth, with the same weight to lift as on the previous day, when the wheel ran close to the guides.

Reference to Stevenson's first series of trials, table No. 5, will show an average ratio of useful effect of .7112, which is considerably below .8485, the average of the second series. The average of both series taken together is .7798.

No 6.

STEVENSON'S SECOND SERIES OF TRIALS.

NOTES OF TRIALS OF JONVAL TURBINE, BY J. E. STEVENSON, MARCH 9, 1860.
THE WEIGHTS WERE ALL RAISED 25 FEET.

No.	Weight raised	Water in measuring box.			Average.	Time in seconds.			Head and fall.	Ratio of useful effect
1	750 lbs.	2.36 ft.	2.40 ft.	2.36 ft.	2.373 ft.	20	20		6 ft.	.8475
2	800 "	2.57 "	2.53 "	2.46 "	2.52 "	20	20½	20	"	.8512
3	850 "	2.72 "	2.64 "	2.61 "	2.656 "	22	22	21	"	.8582
4	900 "	2 83 "	2.78 "	2.78 "	2.796 "	23	23	23	"	.8632
5	950 "	2.97 "	2.90 "	2.98 "	2.95 "	25	25	25	"	.8635
6	1,000 "	3.17 "	3.12 "	3.10 "	3.13 "	26	26	26	"	.8567
7	1,050 "	3.50 "	3.34 "	3.58 "	3.456 "	27	28	28	"	8147
8	1,100 "	3.79 "	3.77 "	3.71 "	3.756 "	30	30	30	"	.7853
9	1,050 "	3.31 "	3.28 "	3.26 "	3.283 "	26	27	27	"	.8372
10	1,000 "	4.81 "			4.81 "	40			"	.5575
11	975 "	3.15 "	3.05 "	2.98 "	3.06 "	26	25	25	"	.8544
12	925 "	2.78 "	2.83 "	2.87 "	2.826 "	23	24	24	"	.8777
13	900 "	2.88 "	2.79 "		2.835 "	23	23		"	.8513
14	875 "	2.73 "			2.73 "	22			"	.8593
15	wheel held.	4.29 "			4.29 "	30			"	
16	" free.	4.51 "			4.51 "	30			"	

NOTE.—IN THE LAST FIVE EXPERIMENTS THE WHEEL WAS LOWERED 1⅛ IN. FROM THE GUIDES.

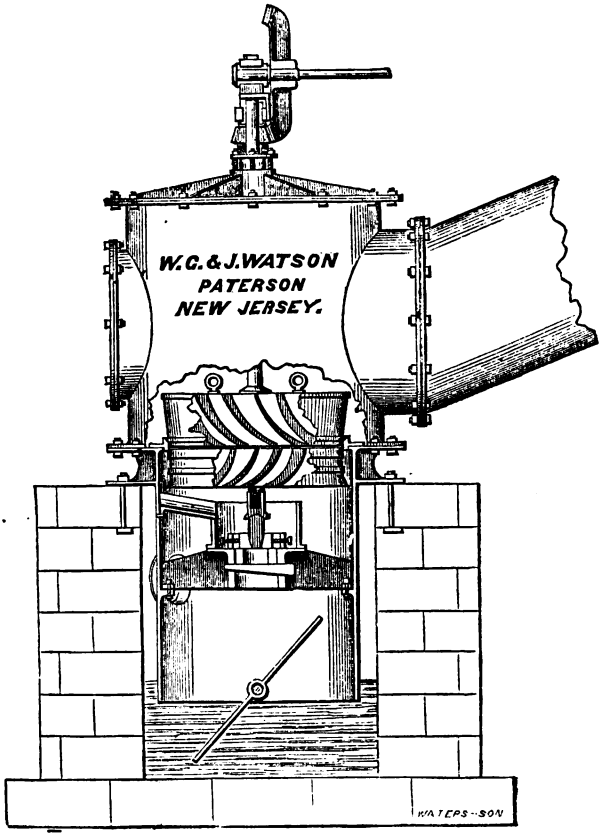
MARCH 10th, 1860.

1	900 lbs.	2.76 ft.	2.82 ft.	2.79 ft.	2.79 ft.	23	23	24	6 ft.	.8650
2	925 "	3.01 "	2.91 "	2.90 "	2.94 "	24	24		"	.8437
3	950 "	3.04 "	3.00 "	2.98 "	3.006 "	24	24	24	"	.8475
4	wheel held	4.20 "				30			"	
5	" free.	4.22 "				30			"	

Omitting the 10th trial, the average is .8485

Ratio of gearing. { Bevel, 17 to 69, / Spur 60 " 96, } 85 to 552.
Area of orifices through guides, 42 square inches.
" " " " wheel, 32 " "
Number of buckets in movable wheel, 19.
" " fixed " 12.
Depth of movable wheel, 5.125 inches.
" fixed " 5.75 "
Depth of buckets in movable wheel, 4.937 inches.
" " fixed wheel, 5.75 "
Mean diameter of movable wheel at lower edge, 18¾ inches.
Top edges of buckets of movable wheel are tangent to *a*; circle, 1½ inches diameter.
Bottom edges of buckets in movable wheel are radial lines.
Top edges of buckets in fixed wheel are radial lines.
Bottom " " " " tangent to a circle 6 inches diameter.
In trial No. 10, the gate was partly closed.

W. G. & J. Watson, of Paterson, N. J., who claim to be the designers, makers and owners of the Stevenson models, have furnished a cut of their wheel, which is here inserted.



The descriptions of Stevenson's models given above apply to this cut, it being a representation of the wheel experimented upon. A letter from the Messrs. Watson is here inserted :—

PATERSON, N. J., FEBRUARY 4, 1861.

To H. P. M. BIRKINBINE,

Chief Engineer, Water Department, Philadelphia:

DEAR SIR:—Reverting to the experiments on turbine water wheels, made at your Works at Fairmount, we beg to assure you that the models exhibited by J. E. Stevenson, were constructed by us at our expense and upon our own plans; they were also erected at our own cost, and that he acted in the matter only as our agent.

* * * * * *

We are anxious to be fairly represented in your forthcoming report, and also to have the merit of our model certified to by you, as was your original intention, but which unfortunately, a faithless agent perverted and appropriated to his own uses, by securing the testimonial in his own name.

We are, most respectfully yours,

W. G. & J. WATSON.

ANDREWS,' AND ANDREWS AND KALBACH'S WHEEL.

The results of the experiments with a wheel by Andrews, will be found in table No. 7. It differed from the wheel of Andrew's and Kalbach, described below, in the curvature of the buckets and in having smaller issues.

Fig. 7, plate 3, represents a top view: fig. 8, a side elevation, and fig. 9, a bottom view of Andrews and Kalbach's wheel, which ran over a scroll or helical chute, common to many wheels. The model was made of soft metal, and was very roughly finished. It had the least amount of machine work on it, and in appearance was most unpromising.

Table No. 8, will show its performances, and table No. 9, another series of trials when the chute or scroll over which the wheel was placed was enlarged.

No. 7

ANDREWS' SERIES OF TRIALS.

NOTES OF TRIALS OF ANDREWS' UPWARD DISCHARGE WHEEL. DECEMBER 23rd, 1859. FIRST MODEL. HEAD 6 FT.

No.	Weight raised.	Height.	Water in box.	Time in seconds.	Head and fall.	Ratio of useful effect.
1	1,300 lbs.	18 ft.	4.55 ft.	35	6 ft.	.5516
2	1,250 "	20 "	4.54 "	37	"	.5906
3	1,200 "	20 "	4.37 "	33	"	.5891
4	1,150 "	20 "	4.05 "	32	"	.6084
5	1,100 "	20 "	3.81 "	25	"	.6193
6	1,050 "	20 "	3.63 "	23	"	.6205
7	1,000 "	20 "	3.52 "	20	"	.6094
8	900 "	20 "	3.20 "	23	"	.6033
9	800 "	20 "	2.97 "	23	"	.5743

Ratio of gearing,
Bevel 4 to 1, } 7 to 6.
Spur, 7 " 24, }
Diameter of wheel outside of buckets, 15¼ inches.
" " " inside " 8¼ "
6 issues, having an area of 26 square inches.

No. 8.

ANDREWS AND KALBACH'S FIRST SERIES OF TRIALS.

NOTES OF TRIALS OF ANDREWS AND KALBACH'S UPWARD DISCHARGE WHEEL. DECEMBER 27th, 1859. WEIGHTS RAISED 25 FT. HEAD 6 FT.

No.	Weight raised.	Water in measuring box.			Average.	Ratio of useful effect.
1	650 lbs.	2.28 ft.	2.26 ft.	2.35 ft	2.296	.7591
2	675 "	2.45 "	2.50 "		2.475	.7313
3	700 "	2.58 "	2.57 "		2.575	.7290
4	725 "	2.60 "	2.61 "		2.605	.7463
5	750 "	2.90 "	2.75 "	2.71 "	2.786	.7219
6	775 "	2.91 "	2.85 "	2.89 "	2.883	.7226
7	800 "	2.96 "	2.94 "		2.950	.7272
8	825 "	3.14 "	3.04 "		2.090	.7159
9	850 "	3.23 "	3.18 "		2.205	.7112
10	875 "	3.48 "	3.49 "		3.485	.6733
11	900 "	3.89 "			3.890	.6204

Ratio of gearing.
Bevel, 4 to 1, } 96 to 11.
Spur, 24 " 11, }
Opening into scroll 8¼ inches wide, and 10¾ inches high.
True opening inside of scroll, 3¾ inches wide, and 12 inches high.
Which = 45 square inches.
Six issues having an area of 31 square inches.

No. 9.

ANDREWS & KALBACH'S SECOND SERIES OF TRIALS.

NOTES OF TRIALS OF ANDREWS & KALBACH'S UPWARD DISCHARGE WHEEL, MARCH 23D, 1860, SECOND MODEL.
WEIGHTS ALL RAISED 25 FT.

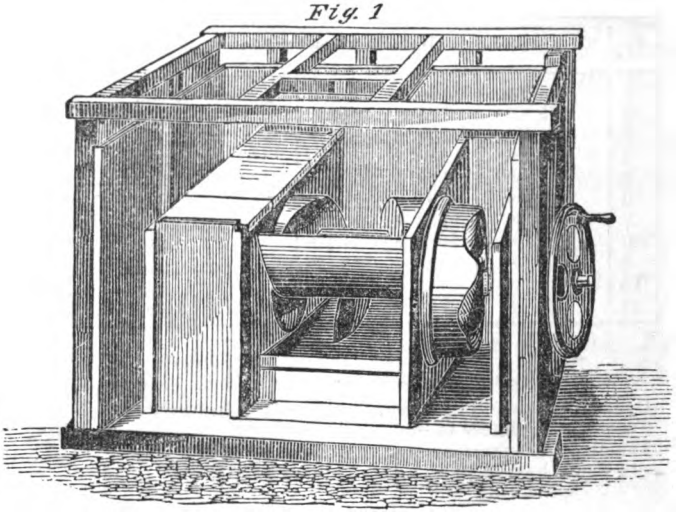
No.	Weight raised.	Water in measuring box.			Average.	Time in seconds.			Head & fall.	Ratio of useful effect.
1	950lbs.	3.71 ft.	3.58 ft.	3.56 ft.	3.616 ft.	27	27	27	6 ft.	.7045
2	900 "	3.36 "	3.17 "	3.17 "	3.233 "	24	23	23	"	.7465
3	850 "	3.15 "	2.90 "	3.00 "	3.016 "	25	23	21	"	.7446
4	825 "	2.93 "	2.77 "	2.79 "	2.82 "	23	22	21	"	.7845
5	800 "	2.73 "	2.66 "	2.65 "	2.683 "	19	20	20	"	.7996
6	775 "	2.63 "	2.55 "	2.52 "	2.566 "	21	21	21	"	.8099
7	750 "	2.49 "	2.46 "	2.44 "	2.463 "	19	19	20	"	.8165
8	725 "	2 41 "	2.35 "	2.41 "	2.390 "	19	18	19	"	.8134
9	700 "	2.32 "	2.30 "	2.25 "	2.290 "	19	19	18	"	.8197
10	650 "	2.17 "	2.12 "	2.10 "	2.130 "	17	17	18	"	.8183
11	600 "	2.075 "	2.075 "		2.075 "	16	16		"	.7754
12	Wheel held fast.				3.96 "	30			"	
13	" running free. Drum 22 rev.				3.52 "	20				

Ratio of gearing, { Bevel, 4 to 1 / Spur, 24 to 11 } 96 to 11.

This wheel is the same as that tried on December 27th, 1859, with the exception of an enlargement of chute to $3\frac{3}{4}$ by $13\frac{3}{4}$ inches, which = 51.56 square inches area.

Messrs. Andrews and Kalbach have furnished cuts of their wheels, which are here inserted. Fig. 1 represents an arrange-

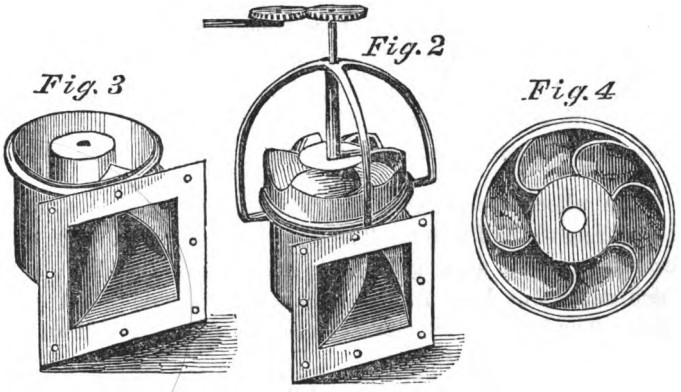
Fig. 1



ment of two wheels on a horizontal shaft; the head water passing between the wheels and into the scrolls, and thence through the wheels into the tail boxes outside.

Fig. 2 represents a single wheel on a vertical shaft placed in working position on the top of the scroll, and connected with gearing above.

Fig. 3 represents the scroll with wheel and shaft removed, and fig. 4 shows a bottom view of the wheel; the curves indicating the shape of the buckets at their lower edges, where the water from the scroll strikes them. These represent the wheel as experimented with.



PARKER WHEELS, BY SMITH.

The model of Parker's single wheel had a diameter from centre to centre of orifice, of 18.375 inches, and six buckets having a combined area of 37.5 sq. inches; it revolved immediately over a double scroll, which delivered the head water under the wheel at diametrically opposite points, thus equalizing the wear on the step. The depth of water-way in the scroll was seven inches, and the whole area of the same 49 sq. inches.

The buckets had lips or short bends on their inner ends, against which the water from the scroll acted to turn the wheel; from these bends the water was deflected outwards through the issues, reacting in its passage from the wheel.

Mr. Smith thus describes the double wheel:—"The wheels are small in diameter, and to get the required amount of water a number of small rims are placed in pairs on a horizontal shaft, to suit different heads of water and different powers, as occasion may require; and the water is conducted into the wheels by double helical guides, placed between concentric cylinders surrounding the shaft, (similar to Andrews and Kalbach's wheel, fig. 1, page 24.) The shaft passes horizontally through the centre of the inner cylinder, and the wheels face up to the ends of the outer or largest cylinder.

"The gate is so placed as to form the upper curve of the funnel-mouthed chute or inlet to the circular helical guides, which are so arranged as to impinge the water on the wheels in its circular motion around the shaft, in a direction coinciding with the revolution of the wheels; which gives a full and perfect combination of the *percussive* and *reactive* forces of the water.

"The wheels are placed in the 'draft boxes' at any convenient height from the tail water. The shaft passes out through peculiarly constructed stuffing boxes in the sides of the draft boxes, which cause but little friction, and are not liable to get out of order. The journals are elevated above back water, and are easy of access at all times."

This model was made in exact proportion to a full sized working wheel, such as the maker would recommend for the New Mill House at Fairmount, and was about one-fifth the size.

The results of this wheel are given in Tables No. 10, 11 and 12.

No. 10.

SMITH'S PARKER'S SECOND SERIES OF TRIALS.

NOTES OF TRIALS OF PARKER'S OUTWARD DISCHARGE DOUBLE VERTICAL WHEEL, BY L. SMITH. DEC. 5, 1859.

No.	Weight raised.	Height raised.	Water in measuring box.			Average.	Time in seconds.			Ratio of useful effect.
1	1000lbs.	20 ft.	3.42 ft.	3.46 ft.	3.47 ft.	3.45 ft.	24	23	24	.6208
2	1050 "	20 "	3.58 "	3.54 "	3.60 "	3.57 "	25	25	24	.6294
3	1100 "	20 "	3.68 "	3.68 "	3.71 "	3.69 "	26	26	26	.6384
4	1150 "	20 "	3.83 "	3.84 "	3.80 "	3.82 "	28	27	27	.6442
5	1200 "	20 "	4.00 "	4.03 "	4.01 "	4.01 "	29	29	29	.6404
6	1250 "	20 "	4.11 "	4.09 "	4.09 "	4.09 "	31	30	30	.6535
7	1300 "	20 "	4.31 "	4.32 "	4.29 "	4.30 "	32	32	32	.6465
8	1400 "	16 "	3.73 "	3.75 "	3.73 "	3.74 "	29	28	28	.6419
9	1500 "	16 "	4.23 "	4.20 "	4.24 "	4.22 "	33	33	34	.6085
10	1250 "	20 "	3.96 "	3.97 "	4.01 "	3.98 "	30	30	30	.6726
11	1300 "	20 "	4.25 "	4.19 "	4.19 "	4.21 "	33	33	32	.6613
12	1350 "	20 "	4.32 "	4.32 "	4.30 "	4.31 "	34	33	33	.6703
13	Wheel held.		2.83 "	3.23 "	3.18 "	3.08 "	31	30	30	
14	Wheel free.		3.09 "	2.95 "	2.97 "	3.00 "	15	15	15	

Ratio of gearing,
Bevel, 6 to 24
Spur, 23 to 144
} 23 to 576.

In the 14th trial, the drum made 9 revolutions.
Head and fall, 6.01 feet.
Diameter of wheels, 9.375 inches.
Diameter between centres of discharge orifices, 8.5 inches.
Breadth of wheels, 3.5 inches.
Orifices in each wheel, 8.
Size of orifices, 3 ins. by .75 = 36 sq. ins. area.
Size of chute, 16 ins. by 2.5 = 40 sq. ins. area.

No. 11.

SMITH'S PARKER'S THIRD SERIES OF TRIALS.

NOTES OF TRIALS OF PARKER'S OUTWARD DISCHARGE SINGLE TURBINE, BY L. SMITH.

No.	Weight raised.	Height raised.	Water in box.	Time in seconds.	Ratio of useful effect.
1	1200 lbs.	25 ft.	4.556 ft.	23.3	.7063
2	1150 "	"	4.416 "	22.3	.6983
3	1100 "	"	4.176 "	21.3	.7063
4	1050 "	"	4.09 "	20.6	.6884
5	1000 "	"	4.033 "	20.0	.6649
6	900 "	"	3.883 "	18.6	.6296
7	1100 "	"	4.246 "	21.0	.6947
8	1150 "	"	4.383 "	21.6	.7036
9	1200 "	"	4.506 "	22.6	.7139
10	1250 "	"	4.64 "	23.3	.7224
11	1300 "	22 "	4.163 "	21.3	.7869
12	1350 "	22 "	4.266 "	22.	.7467

Ratio of gearing,
Bevel, 18 to 77 } 33 to 308.
Spur, 11 to 24 }
6 discharge orifices.
Area of do., 1.5625 by 4 = 37.5 sq. ins.
In this series of trials, the buckets had lips or short bends, 2.25 ins. long, into which the water from the chutes was projected.

No. 12.

SMITH'S PARKER'S FOURTH SERIES OF TRIALS.

NOTES OF TRIALS OF PARKER'S OUTWARD DISCHARGE SINGLE TURBINE, BY L. SMITH.

No.	Weight raised.	Height raised.	Water in box.	Time in seconds.	Ratio of useful effect.
1	1350 lbs.	22 ft.	4.233 ft.	22	.7526
2	1300 "	"	4.053 "	20.3	.7569
3	1250 "	25 ft.	4.516 "	22.3	.7439
4	1200 "	"	4.410 "	22	.7294
5	1150 "	"	4.290 "	22	.7188
6	1100 "	"	4.183 "	20.3	.7051
7	1050 "	"	4.110 "	20	.6849
8	Wheel free.		2.52 "	10	
9	Wheel held.		4.73 "	30	

Ratio of gearing,
Bevel, 18 to 77 } 33 to 308.
Spur, 11 to 24 }
In trial No. 8, the counter shaft made 17 revolutions.
In this series of trials, the bends of the buckets were one inch long.

LITTLEPAGE'S WHEEL.

Littlepage's model was an outward discharge wheel, two feet in diameter, placed over a scroll having a water-way depth at issues of 3.4 inches; the area of all the issues, twelve in number, being 50 sq. inches.

The wheel revolved over the top of the scroll, in the same manner as Andrews and Kalbach's single wheel. The area of water-way in the scroll, where the water first meets the wheel, was 9 inches deep by 7 inches wide=63 sq. inches.

Mr. Littlepage says, of his wheel:—"Instead of the water striking the wheel from the side or top, it strikes it from the bottom through a spiral water passage, filling all the buckets at the same time. Upon the old plan, the lower journal or pivot of the wheel had to bear the weight of the wheel, shaft, &c., and all or part of the column of water bearing on the wheel, while at the same time that pivot is not accessible for lubrication.

"In my arrangement the water more than sustains the wheel, shaft, and attached gearing, and requires a top screw on the shaft to keep the wheel down in its place." This is the case with all wheels placed over a chute. The diameter of the wheel upon which the water from the scroll directly acts is 18 inches; outward from this the reactive power only of the water assists in turning the wheel. The buckets are spirals, and are arranged similarly to the guides of Fourneyron's wheel, except that the water strikes them from below, and then rises into the issues and escapes outwardly.

The results of this wheel are given in table No. 13.

No. 13.

LITTLEPAGE'S SERIES OF TRIALS.

NOTES OF TRIALS OF OUTWARD DISCHARGE TURBINE, BY LITTLEPAGE.
NOV. 22D, 1859. HEAD, 6.05.

No.	Weight raised.	Height raised.	Water in box.	Time in seconds.	Ratio of useful effect.
1	1200 lbs.	18 ft.	4.636 ft.	25	.4956
2	1300 "	15 "	4.083 "	26.6	.5080
3	1350 "	15 "	4.213 "	23	.5113
4	1400 "	15 "	4.310 "	23.6	.5183
5	1450 "	15 "	4.016 "	23	.5377
6	1500 "	14 "	4.126 "	23.6	.5414
7	1550 "	14 "	4.263 "	24.3	.5415
8	1600 "	14 "	4.400 "	25	.5415
9	1650 "	14 "	4.616 "	26	.5323
10	1100 "	14 "	3.140 "	16.6	.5217

Ratio of gearing, Bevel, 14 to 60 } 77 to 720.
Spur, 11 to 24 }
Area of orifices in wheel, 50 sq. ins.

BLAKE'S WHEEL.

In Blake's model, the head water was admitted to the wheel in a single external scroll, and while pressing against the buckets moved towards the centre of the wheel. From the issues it was discharged against the inverted cone of the hub, and escaped downwards on the sloping edges of a conical base.

Mr. Blake says:—"The discharging apertures of the wheel are so large, compared with many other wheels, and also according to quantity of discharge, that there is not the least possibility of clogging by drift or other floating substances."

There were twelve buckets in the wheel, each 6 inches long; and they formed tangents to a circle 12 inches in diameter, concentric with the wheel, the water acting against the exterior surface of the tangent. The whole diameter of the model was 18 inches. The "toe" on the shaft, revolved on a wooden step centrally fixed in the base plate of the scroll, which latter was supported on the base plate by four pillars.

The results of this wheel's performances are shown in table No. 14.

No. 14.

BLAKE'S SERIES OF TRIALS.

NOTES OF TRIALS OF INWARD DISCHARGE TURBINE, BY L. W. BLAKE, JANUARY 20TH, 1860.
WEIGHTS ALL RAISED 25 FEET. HEAD AND FALL, 6 FEET.

No.	Weight raised.	Water in measuring box.			Average.	Time in seconds.			Ratio of useful effect.
1	900 lbs.	3.40 ft.	3.49 ft.	3.53 ft.	3.473 ft.	28	29	28	.6949
2	875 "	3.35 "	3.31 "	3.32 "	3.326 "	28	28	28	.7055
3	850 "	3.30 "	3.28 "	3.18 "	3.250 "	27½	27	27	.7020
4	925 "	3.46 "	3.46 "	3.46 "	3.460 "	28	28	29	.7169
5	950 "	3.65 "	3.59 "	3.60 "	3.613 "	29	29	29½	.7051
6	975 "	3.69 "	3.66 "	3.63 "	3.660 "	30	30	30	.7143
7	1000 "	3.76 "	3.75 "	3.78 "	3.763 "	30	31	30	.7125
8	1025 "	3.87 "	3.86 "	3.84 "	3.856 "	31	31½	31	.6966
9	800 "	3.27 "	3.29 "	3.28 "	3.280 "	28	28	28	.6540
10									

Ratio of gearing,
Bevel, 4 to 1 } 11 to 6.
Spur, 11 to 24 }
Area of inlet to wheel, 37.4 sq. ins.
" discharge through the buckets, 52.59 sq. ins.

TYLER'S WHEEL.

Tyler's model wheel was surrounded by a scroll 6 inches deep in the clear, and 5.75 inches wide where the water first meets the wheel, giving a water-way of 34.5 sq. inches; the diameter of the wheel was 18 inches; it had ten buckets.

The buckets were arcs of a circle, the radius of which was one-third greater than that of the wheel; they were arranged in the wheel as tangents to a circle of one third the diameter of the wheel, and concentric with it. The maker says:—"The buckets have therefore a curved form, the water acting against their convex surfaces in such a manner as to operate equally on or near the end of each and every bucket at the same time, thereby keeping the pressure of the water on the outer end of the bucket, and running easier when passing by the spout than if straight; the outer end of the bucket being nearly parallel with the current of water and moving in the same direction and not running as fast as the water by one-third, its movements are not obstructed by

sluggish water. The lower edges of the series of buckets are connected with one another at their lower and outer edges, by means of a flat scalloped rim which extends inward in contact with the convex surface of each bucket, about three-sevenths of the length of said surface, and from that point curves outward and downward to a narrow connection between said rim and the outward extremity of the concave surface of the next bucket.

"The object of giving the aforesaid shape to the rim is to conduct the water in a compact body from the water-way against the convex surface of each bucket, and then as soon as it has performed its propelling function, allowing it freely to fall out of the wheel and not react upon the back of the buckets.

"The object of giving the curving or dish-shape to the wheel, is to enable the water, as it enters the wheel, to exert a lifting action upon it, thereby materially lessening the friction on the step. It also causes the water to be kept in a compact mass, and to pass so rapidly and cleanly through the wheel that there can be no loss from the reaction of water between the buckets."

The wheel, as was the curb or scroll, was cast in one piece, and of a form imparting great strength and durability. The cap or dome terminated in a bearing and packing box, through which the shaft of the wheel extended. The step was adjustable, and rested upon the base-plate. The gate-box was formed for easy bolting to the flume, and contained a nicely fitting gate. The wheel was very compact and portable.

The results of trials with this wheel are given in table No. 15.

No. 15.

TYLER'S SERIES OF TRIALS.

NOTES OF TRIALS OF INWARD DISCHARGE TURBINE, BY JOHN TYLER, DEC. 19, 1860. HEIGHT RAISED, 25 FEET. HEAD AND FALL, 6 FEET.

No.	Weight raised	Water in measuring box.			Average.	Time in seconds.			Ratio of useful effect
1	500 lbs.	2.45 ft.	2.36 ft.	2.43 ft.	2.413 ft.	21	21	20½	.5556
2	600 "	2.71 "	2.62 "	2.65 "	2.66 "	22	21	22	.6048
3	700 "	2.89 "	2.79 "	2.86 "	2.846 "	23½	23	24	.6595
4	800 "	3.11 "	3.06 "	3.02 "	3.063 "	25	25	25	.7004
5	825 "	3.12 "	3.09 "	3.11 "	3.106 "	26	25½	25	.7123
6	850 "	3.28 "	3.27 "	3.28 "	3.276 "	26	27	26½	.6957
7	862 "	3.29 "	3.30 "	3.33 "	3.306 "	27	27½	27½	.6992
8	875 "	3.48 "	3.47 "	3.47 "	3.473 "	28	28	28	.6756
9	900 "	3.74 "	3.75 "	3.66 "	3.716 "	29½	29	30	.6494

Ratio of gearing,
Bevel, 3 to 1 } 72 to 11.
Spur, 24 " 11 }
Diameter of wheel, 18 inches.
Area of inlet, 34.5 square inches.
" discharge about 103 square inches.

MERCHANT'S GOODWIN WHEEL.

The Goodwin model was surrounded by a horizontal scroll, through which the head-water had access to the wheel.

The wheel was thirty inches in diameter, and the sixteen buckets occupied an annulus six inches in width, which left a centre vent area of eighteen inches in diameter.

The patentee claims the form of bucket, "commencing in a true circle, at a tangent to the outer periphery, and terminating in a straight line, fifteen degrees in length at the inner curve, and at a tangent thereto"

The height of water-way in the scroll and wheel was five and five-eighths inches, and width of same in scroll, seven inches, giving a clear area of 39.375 square inches.

Each bucket was semi-circular in form, with the exception of the short straight part at the point of issue, and they were set in the annulus, with the diameter of the semi-circle coincident with the radial lines. The current of water from the scroll was directed into the hollow of these buckets.

This model was built rather strong and heavy, and was too large for satisfactory experiments.

Table No. 16 gives the results.

No. 16.

MERCHANT'S (GOODWIN WHEEL.) SERIES OF TRIALS.

NOTES OF TRIALS OF INWARD DISCHARGE TURBINE, BY N. R. MERCHANT & CO., JANUARY 12, 1860.

No.	Weight raised.	Height raised.	Water in measuring box.			Average.	Time in seconds.			Ratio of useful effect
1	1100 lbs.	20 ft.	4 32 ft.	4.40 ft.	4 38 ft.	4.366 ft.	32	33	32	.5405
2	1150 "	20 "	4.50 "	4.53 "	4.49 "	4 506 "	33	34	33	.5475
3	1200 "	20 "	4.60 "	4.70 "	4 68 "	4.660 "	34	34	34	.5524
4	1250 "	20 "	4.78 "	4 80 "	4.77 "	4.783 "	34	35	35	.5607
5	1300 "	18 "	4.38 "	4.45 "	4.40 "	4.410 "	30	31	31	.5692
6	1350 "	18 "	4.50 "	4 55 "	4.55 "	4.533 "	32	32	32	.5750
7	1400 "	18 "	4.64 "	4.63 "	4.66 "	4.643 "	33	32	32	.5822
8	Wheel held.				3 39 "	3.390 "	20			
9	Wheel free; made 10 revolutions.				2.55 "	2.550 "	30			
10	900 lbs.	25 ft.	3.93 ft.	3 96 ft.	3.94 "	3.943 "	27			.6120
11	950 "	25 "	4.08 "	4.12 "		4.100 "	28			.6213
12	1050 "	25 "	4.43 "	4 44 "		4.435 "	30			.6348
13	1100 "	25 "	4.62 "	4.58 "		4.600 "	32			.6412

Ratio of gearing,
Spur, in trials 1 to 9, inclusive, 7 to 24 } 7 to 48.
Bevel, ... 1 " 2 }
Spur, in trials 10 to 13, inclusive, 11 " 24 } 11 to 48.
Bevil, ... 1 " 2 }

RICH'S WHEEL.

Rich's model was an inward discharge wheel, fifteen inches in diameter, with eleven buckets, occupying an annulus two and one eighth inches in width. The wheel was surrounded by a scroll, having a clear water-way, at the point where the water strikes the wheel, of 10.25 inches wide, and 5 inches deep. The depth of water-way in the wheel was 3 inches.

The curvature of the buckets was peculiar: The outer ends were curved to a radius of 2.75 inches, tangent to the outer circumference of the wheel, and had their convex faces set against the current of water from the chute; the inner ends were slightly concave to the current of water, and were tangent to the outer end of the bucket as well as to the inner circumference of the annulus.

The shaft was supported above and below the scroll by triple-footed brackets, the lower one having a step, and the upper one a journal bearing. Every part of the wheel and scroll was made of iron, and was well fitted.

The results of trials with this wheel are given in table No. 17.

Just before the testing apparatus was taken down, another model of this wheel was tried, which gave much higher results, the notes of which were mislaid.

No. 17.

RICH'S SERIES OF TRIALS.

NOTES OF TRIALS OF INWARD DISCHARGE TURBINE, BY R. RICH, OCT. 20, 1859. WEIGHTS RAISED 25 FEET. HEAD 6.1 FEET.

No.	Weight raised.	Water in box.	Time in seconds.	Ratio of useful effect.
1	750 lbs.	3.226 ft.	33	.6132
2	700 "	3.080 "	32	.5997
3	650 "	2.900 "	31	.5912
4	600 "	2.836 "	30	.5580
5	800 "	3.656 "	40	.5771
6	wheel held fast.	3.850 "	60	
7	" free.	2.480 "	30	

Ratio of gearing, Bevel 17 to 69, } 119 to
Spur 7 " 24, } 1656.
In the seventh trial the drum made 13 revolutions.
Number of discharge orifices in wheel, 11.
Area of discharge orifices, 33 square inches.

MASON'S SMITH WHEEL.

Mason's model of Smith's wheel was 18 inches in diameter, and consisted of four blades or buckets, curved spirally around a cylinder 8 inches in diameter and 12 inches long. The upper half of the wheel revolved in a scroll which surrounded it; the lower half revolved freely in a cylinder, the lower end of which was entirely open.

The entrance to the scroll was 6 inches square. The working faces of the buckets were tangent to a circle 5 inches in diameter and concentric with the axis; the line of face from the point to the heel falling back of the motion, thus giving the water a tendency to slide towards the periphery of the wheel.

The inventor calls this model, "Smith's Improved, Direct, Reaction, Ventilated, Scroll, Cylinder, and Surface Discharge Water Wheel," and says it secures the most important combination of

"a complete ventilation and the freest discharge." The cylinder on which the buckets were secured was hollow, and extended through the cover of the wheel into the air above; it was open at its upper end and had an aperture at the bottom; a valve on the hub just beneath the cover opened against the water "to secure ventilation to the wheel in case of back water." The upper half of the wheel received the direct action and the lower half the reactive force of the water.

The performances of this wheel in the first series of trials are given in table No. 18; in the second series, a few weeks afterwards, when an enlargement of the chute was made, this wheel gave a higher result, as indicated in table No. 19.

No. 18.

MASON'S SMITH WHEEL. FIRST SERIES OF TRIALS.

NOTES OF TRIALS OF VERTICAL DISCHARGE TURBINE, MADE BY A. P. MASON. JANUARY 9, 1860. WEIGHTS ALL RAISED, 25 FEET. HEAD, 6·05 FEET.

No.	Weight raised.	Water in measuring box.			Average	Time in seconds.			Ratio of useful effect
1	850 lbs.	4.01 ft.	4.02 ft.	4.09 ft.	4·04 ft.	33	33	33	·5621
2	800 "	3.79 "	3.71 "	3.73 "	3·74 "	31	30	30	·5684
3	775 "	3.61 "	3.62 "	3·65 "	3·62 "	30	29	30	·5684
4	750 "	3.45 "	3.50 "	3·51 "	3·48 "	29	29	30	·5721
5	725 "	3.44 "	3.32 "	3·37 "	3·37 "	28	28	29	·5711
6	700 "	3.25 "	3.23 "	3·20 "	3·22 "	28	29	28	·5778
7	650 "	3.05 "			3·05 "	27			·5670
8	900 "	4.21 "	4.18 "	4·17 "	4·18 "	34	34	34	·5718
9	950 "	4.59 "	4.50 "		4·54 "	36	36		·5560
10	875 "	4.05 "	4.10 "		4·07 "	33	34		·5762
11	Wheel held.	3.45 "	3.70 "	3·76 "	3·63 "	30	30		
12	Wheel free.	2.89 "	3.00 "		2·94 "	30	30		

Ratio of gearing,
Bevel, 4 to 1, } 96 to 11.
Spur, 24 " 11, }
In the twelfth trial the drum made 15.5 revolutions.

No. 19.

MASON'S SMITH WHEEL. SECOND SERIES OF TRIALS.

NOTES OF TRIALS OF VERTICAL DISCHARGE TURBINE MADE BY A. P. MASON, MARCH 16, 1860. WEIGHTS ALL RAISED 25 FT. HEAD, 6.05 FT.

No.	Weight raised.	Water in measuring box.			Average.	Time in seconds.			Ratio of us'ful effect
1	1,000 lbs.	4.74 ft.	4.78 ft.		4.76 ft.	39	38		.5635
2	900 "	4.05 "	4.05 "	4.00 ft.	4.03 "	32	32	32	.5984
3	850 "	3.80 "	3.79 "	3.79 "	3.79 "	30	30	30	.6009
4	800 "	3.59 "	3.55 "	3.55 "	3.56 "	29	29	29	.6021
5	750 "	3.28 "	3.19 "	3.16 "	3.21 "	28	28		.6265
6	700 "	3.07 "	3.08 "	2.99 "	3.04 "	27	27	27	.6162
7	750 "	3.20 "	3.16 "	3.18 "	3.18 "	28	27	27	·6324
8	Wheel held.	3.81 "			3.81 "	30			
9	Wheel free.	3.01 "			3.01 "	30			

Ratio of gearing,
Bevel, 4 to 1
Spur, 24 " 11 } 96 to 11.

In the ninth trial the drum made 18 revolutions.

In this series of trials, the inlet of scroll was enlarged to 5 inches wide by 7.25 inches deep = 36.25 square inches.

MONROE'S WHEEL.

Monroe's model was an inward discharge turbine of 17.75 inches diameter, having twenty-eight buckets occupying an annulus of $2\frac{7}{8}$ inches in width, and 4 inches in depth in the clear.

The wheel was surrounded by a scroll which had a clear water-way of 44 sq. inches, being 11 inches wide by 4 inches deep. Eleven guides or "conductors" were fixed in the scroll to give the water tangential direction where it strikes the buckets; the spaces between the points and heels of these guides were each half an inch wide; the whole area of water-way to the wheel from the scroll was thereby reduced to 22 sq. inches. The point of one conductor was on the same radial line as the heel of the next.

The centres of curvature of the buckets all lie in the outer circumference of the wheel. The radius of curvature is equal to the breadth of the annulus; the curve of the bucket is therefore tangent to the inner circumference of the annulus, and starts at right angles, or nearly so, to the outer.

The result of this wheel's performances are given in table No. 20.

No. 20.

MONROE'S SERIES OF TRIALS.

NOTES OF TRIALS OF INWARD DISCHARGE TURBINE, BY A. MONROE. OCT. 7, 1859.

No.	Weight raised.	Height.	Water in box.	Ratio of useful effect.
1	900 lbs.	25 ft.	4.526 ft.	.5332
2	850 "	22 "	4.253 "	.5359
3	800 "	25 "	4.070 "	.5271
4	750 "	25 "	3.845 "	.5230
5	700 "	25 "	3.630 "	.5171
6	500 "	25 "	2.940 "	.4560
7	1,000 "	20 "	4.415 "	.4859
8	Wheel held fast,		7.160 "	
9	" running free,		4.300 "	

Ratio of gearing.
Bevel 17 to 69 } 187 to 1656.
Spur 44 " 96 }

In trial 9 the drum made 28 revolutions in one minute.
In trial 8 the duration was one minute.

DIMENSIONS OF WHEEL.

Outside diameter, $17\frac{3}{4}$ inches.
Inside " 12 "
Distance between the top and bottom shrouding of wheel, $4\frac{1}{8}$ "
Number of buckets, 28.
Width of discharge orifice, $\frac{1}{2}$ inch.
Area of " " 57.75 sq. in.

DIMENSIONS OF SCROLL.

Distance between top and bottom plates, 4 in.
Width of inlet, 11 "
Area of " 44 "
Number of conductors, 11
Width for passage of water between conductors, $\frac{1}{2}$ "
Area of water through conductors, 22 sq. in.

REMARKS ON THE TABLES.

Under the head of "Weight raised," will be found the actual load in pounds (avoirdupois) suspended by the rope, including of course, the "weight box" and contents.

In the columns over which is written "Water in box," or, "Water in measuring-box," will be found the quantity of water which was delivered in the measuring-box during the time of each and every experiment. The figures give the depths in feet and decimals, as indicated by the graduated tube on the outside of the measuring-box.

Usually three trials were made without change of weight; the depth of water in the measuring-box was accurately ascertained

every time; the average depth, in feet and decimals, of the three trials, under the same circumstances, is given in the column headed "Average."

The duration of each and every trial, in seconds, will be found under the head of "Time in seconds."

The first column of every table headed "No.," indicates the order in which the trials were made.

In table No. 1, opposite trial No. 10, will be found the words: "Wheel held fast;" this experiment shows that by holding the wheel stationary during the period of 20 seconds it discharged 3.42 feet depth of water in the box. The measuring-box was nearly 5 feet square; by actual measurement the area of the bottom was 24.86 feet; this quantity was the multiplier constantly used for obtaining the cubic contents of the discharges.

Opposite the trial No. 11, it will be found that when the wheel was allowed to run free, without any load whatever, except that of itself and shaft, during the time of 20 seconds it discharged 3.335 feet depth of water in the box.

Under the heading, "Height raised," which will be found in some of the tables, is the vertical distance in feet through which the weight was raised during the time of the trials. When this column is not to be found in the tables, the "Height raised," as well as the "Head and Fall," is put in the heading of the tables.

Under the heading, "Ratio of useful effect," are the quotients, which are found by dividing the product of the *weight in box* and *height raised*, by the product, *weight of water discharged* and *height of head and fall*.

The following example will show the process by which the ratio of useful effect is obtained.

Take the third experiment in table No. 2.

The area of the bottom of the box was constantly 24.86 sq. ft.

A cubic foot of water was taken at 62.5 lbs. avoirdupois.

Then $1{,}000 \times 25 = 25{,}000$.

And $24.86 \times 3.266 \times 62.5 \times 6 = 30447.285$.

And $\frac{25000}{30447.285} = .8210$ = ratio of useful effect sought for.

It will be noticed that the quantity 30447.285, which expresses in pounds the whole possible effect, or mechanical power of the water used in the above experiment, is greater than the quantity 25,000, which expresses in the same terms the amount of work done by the wheel. The difference between them indicates the loss of power by the use of the wheel and attached machinery.

The following proportion will express the *percentage* of power utilized by the model wheel, when acting under the circumstances given in the table: 30447.285 : 25000 : : 100 : 82.10.

The tables are numbered in the order of arrangement shown in table No. 21.

If the models were arranged according to the ratio of useful effect which they gave, beginning with the highest, the following list would indicate the order:

Stevenson's 2d wheel,	.8777
Geyelin's 2d wheel,	.8210
Andrews & Kalbach's 3d wheel,	.8197
Collins's 2d wheel,	.7662
Andrews & Kalbach's 2d wheel,	.7591
Smith's Parker's 4th trial,	.7569
" " 3d "	.7467
Stevenson's 1st wheel,	.7335
Blake,	.7169
Tyler,	.7123
Geyelin's (double) 1st wheel,	.6799
Smith's, Parker's 2d wheel,	.6726
Merchant's Goodwin,	.6412
Mason's Smith,	.6324
Andrews' 1st wheel,	.6205
Rich,	.6132
Littlepage,	.5415
Monroe,	.5359
Collins's 1st wheel,	.4734

It will be noticed by reference to the tables that the *highest* ratio obtained is given in the above list, and not the average of

each series. The figures present, therefore, the best work done by each wheel.

Taking into account the fact that each and every wheel was tried under an unvarying head, and that whatever error there might be in the precise relations which should obtain between the diameter of the wheel, the number and area of its issues, and weight to be raised, to make the experiment a perfect one; it was perhaps compensated for by the opportunities offered to alter the model, change the ratio of gearing and the weights to be raised. For these reasons, the results of the experiments may be considered the fairest show of the merit which the models possessed.

In table No 21, the wheels are classified according to the direction of discharge from the issues of their buckets.

The first class includes those in which the discharge was vertical. Geyelin's 2nd, Collins's 1st and 2d, and Stevenson's 1st and 2d were all Jonval wheels, and all discharged downwards, while Andrews' and Andrews & Kalbach's discharged upwards.

The second class includes the outward discharge wheels. The head water passed into these wheels between their hubs and the inner ends of the buckets, and thence outwards, centrifugally from the periphery of the wheels.

The third class includes the inward discharge wheels. They were all surrounded by scrolls, and the head water entered all of them and was discharged from the issues toward their axes, except Mason's which discharged downwards. The power of the head water was directed by the scroll around the wheel, but its motion through the wheel was centripetal.

The figures in the fourth column were found by the process explained above.

The figures of the fifth column were found by dividing the number of cubic feet of water discharged, by the number of seconds which elapsed during the discharge. For example, take the third trial of table No. 2.

$$\frac{24.86 \times 3.266}{26} = 3.122$$ the amount of discharge sought for.

The figures in the sixth and seventh columns were obtained from actual measurements of the models.

No. 21.

SUMMARY OF EXPERIMENTS WITH MODEL TURBINE WHEELS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NOTE.—In the trials marked (*), the diameters and circumferences given are *means*, measured at the centres of discharge orifices.			Ratio of useful effect.	Cubic ft. of water discharged per second.	Area of orifices between guides.	Area of orifices in wheel.	Velocity of water through guides.	Head and fall.	Ratio of velocity of water through guides to theoretic velocity.	Velocity of water through wheel in feet per second.	Ratio of velocity of water through wheel to theoretic velocity.	Revolutions of wheel per min.	Velocity of circumference of wheel in ft. per second.	Ratio of circumferential to theoretic velocity.	Diameter of wheel.	Load upon wheel at the circumference.
					sq. in.	sq. in.	ft. pr sec	ft.							Inches.	lbs.
Jonval and vertical discharge.	1	*Geyelin 2d	.8210	3.122	44.6	37.70	10.08	6.	.5129	11.92	.5929	191.4	13.9	.7074	16.62	69.29
	2	*Collins 2d	.7662	2.837	35.4	31.35	11.54	6.	.5871	13.03	.6479	144.2	11.06	.5629	17.55	73.79
	3	*Stephenson 1st	.7335	3.353	41.25	30.90	11.70	6.02	.5941	15.62	.7931	169.7	13.32	.6717	18.25	70.21
	4	*Geyelin 1st	.6799	3.911	42.6	42.	13.22	6.04	.6703	13.41	.6799	222.9	12.66	.6423	13.	79.06
	5	*Collins 1st	.4734	3.372	40.	39 5	12.14	6.10	.6126	12.29	.6203	129.3	9.75	.4920	17.25	55.73
	6	*Stevenson 2d	8777	2.976	42.	32.	10.2	6.	.5204	13.39	.6831	152.	12.41	.6331	18.75	79.00
	7	*Andrews & Kalbach 3	.8197	3.065	51.5	31.	8.57	6.	.4361	14.23	·7241	297.	15.34	.7806	11.75	61.3
	8	*Andrews	.6205	3.116	45.	26.	12.55	6.	.6387	21.73	1.1020	276.9	14.22	.7236	11.75	53.73
	9	*Andrews & Kalbach 2	.7591	3.298	45.	31.		6.							11.75	
Centrifugal or outward discharge.	10	*Smith's Parker's 4	.7569	4.963	49.	35.	14.58	6.	·7420	20.52	1.0380	235.9	18.74	.9533	18.25	75.30
	11	* " " 3	.7467	4.820	49.	35.	14.19	6.	·7206	19.85	.9860	216.7	17.29	.8790	18.25	78.20
	12	* " " 2	.6726	3·298	40.	35.	11.87	6.01	·6035	13.56	.6897	396.8	14.74	.7493	8.50	57.94
	13	Littlepage	.5415	4.375	63.	50.	10.00	6.05	·5066	12.60	.6380				24.00	
Centripetal or inward discharge.	14	Blake	7169	3.039	37.4	52.6	11.70	6.	.5953	8·32(	.4233	179.1	14.08	.7166	18.	58.10
	15	Tyler	.7123	3.431	34.5	103.0	14.32	6.	.7121	4.797	.2440	149.	11.72	.5965	18.	69.09
	16	Merchant's Goodwin	.6412	3.573	39.3	123.0	13·09	6.	.6661	4.183	.2128	79.17	10:38	.6649	30.	82.91
	17	Rich	.6132	2.430	50.	33.0	7.00	6.10	.3531	10.65	.5384	244·8	16·59	.8370	15.5	34.30
	18	Mason's Smith	.6324	2.928	36.25		11.63	6.05	.5894			187.6	14·72	.7410	18.	47.13
	19	Monroe	.5359	2.711	22.68	57.7	17.21	6.	.8756	6.775	.3441	131·9	10·22	.5085	17.75	42.28

The "velocity of water through guides" in feet per second, will be found in column 8, and is obtained as follows:—

As above, the cubic feet of discharge per second is 3.122. The area of orifices through guides is 44.6 square inches, which is $\frac{44.6}{144} = .3097$ foot; and the quantity discharged in feet per second, divided by the area of discharge, gives the velocity of discharge.

Therefore, $\frac{3.122}{.3097} = 10.08 =$ velocity in feet per second.

Column 9 gives the heights of head and fall in feet, which were taken by measurement of the distance between the levels of head and tail-water, during the time each and every trial was made.

The ratios of actual to theoretic velocity of the water through the guides are given in the tenth column, and are found thus:— The theoretic velocity of water issuing from an orifice under pressure, is equal to that of a falling body at a height equal to the head which gives said pressure.

Therefore, $\sqrt{6 \times 64.33} = 19.65 =$ theoretic velocity in feet per second.

The actual velocity is 10.08, found in column 8.

Hence, $\frac{10.08}{19.65} = .5129 =$ ratio sought for.

The figures in column 11 are found in the same manner as those in column 8, by substituting the areas from column 7 for those of column 6; and the figures of column 12 are found by the same process as those of column 10, by substituting the velocities of column 11 for those of column 8.

The "revolutions of wheels per minute" in column 13, were deduced from the ratios of gearing and velocity of drums. Thus, the actual diameter of drum was 9 1-16th inches; the diameter of rope was $1\frac{1}{4}$ inches, but the effective circumference of the former was 2.5836 feet.

Then $\frac{25}{2.5836} = 9.6763 =$ revolutions of drum in 26 seconds.

And $\frac{9.6763 \times 60}{26} = 22.33 =$ revolutions of drum per minute.

Therefore, $\frac{22.33 \times 60}{7} = 191.4 =$ revolutions of wheel per minute, as in table No. 2.

Having the revolutions of the wheels per minute, the "velocities of the circumferences of the wheels" in feet per second in column 14 are easily found.

Column 16 contains the diameters of the model wheels, which were obtained by actual measurements of the same.

To get the velocity of circumference in feet per second, we have the diameter in inches = 16.62. Table 21, No. 1.

Then, $\frac{16.62 \times 3.1416}{12} = 4.35 =$ circumference of wheel in feet.

And $\frac{191.4 \times 4.35}{60} = 13.876 =$ the velocity sought for.

Column 15 gives the "ratios of circumferential to theoretic velocity." In the process for obtaining the ratios in column 10, it was shown that the theoretic velocity of discharge of water under the given head, was 19.65 feet per second.

Then, $\frac{13.9}{19.65} = .7074 =$ ratio sought.

Column 17 gives the "loads in pounds at the circumference of wheels," which are found by the following process:—

Above, it is stated that the revolutions of wheel and drum per minute are respectively 191.4 and 22.33, and in this experiment the load on drum was 1000 lbs.; therefore—

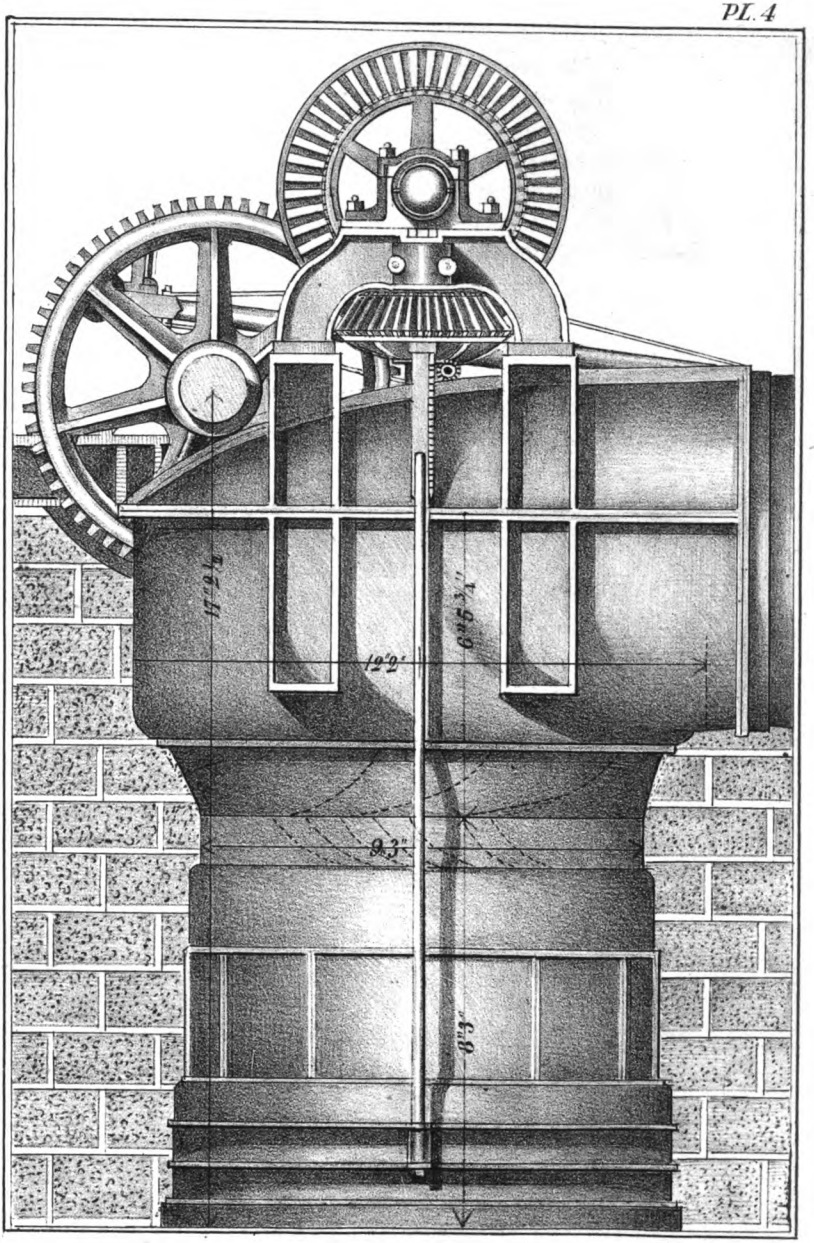
$$191.4 : 22.33 :: 1000 : 116.66,$$

which latter is the load on the wheel. Now the diameter of the wheel is 16.62 inches, and the circumference in feet corresponding to this is 4.35, as above, while the circumference of drum is 2.5836 feet.

Therefore, $4.35 : 2.5836 :: 116.66 \times : 69.24$, which latter is the load at the circumference of the wheel in lbs.

The lengths of ordinates of the guide and bucket curves are given in diagrams, Figs. 4 and 6, Plate 3, but they are very indistinct. The following table gives them in a more readable form:

PL. 4



STEVENSON'S.		GEYELIN'S.	
Guide curves length 10.5 ins.	Bucket curves, length 7.90 ins.	Guide curves, length 8.55 ins.	Bucket curves, length 4.67 ins.
1.20 ins.	2.25 ins.	3.35 ins.	0.93 ins.
2.08 "	2.96 "	4.53 "	1.54 "
2.70 "	3.41 "	5.27 "	1.95 "
3.15 "	3.75 "	5.90 "	2.26 "
3.58 "	4.02 "	6.37 "	2.46 "
4. "	4.21 "	6.80 "	2.63 "
4.38 "	4.42 "	7.10 "	2.75 "
4.75 "	4.58 "	7.42 "	2.85 "
5.17 "	4.75 "	7.70 "	2.95 "
5.75 "	4.95 "	8.00 "	3.05 "

NOTE.—The lengths of curves given above are the distances on the peripheries occupied by the curves.

DESCRIPTION OF TURBINES,

For the new Mill House at Fairmount in process of construction.

Plate 4 represents a side elevation of one of the turbines designed for the New Mill House at Fairmount. It is drawn to a scale of one-fourth of an inch to a foot. It stands in a pit 15 feet wide by 20 feet long, the floor of which is 4 ft. 4 in. below mean low tide, and 10 ft. 4 in. below mean high tide.

The mouth of the casing from which the tail water issues is 21 in. below low tide line; it is quite certain, therefore, never to be open to the air, but will secure to the wheel the whole effect of the suspended column within, through all the fluctuations of the tides.

The centre of the wheel is 2 ft. 8 in. below the surface of an ordinary flood tide of 6 ft.

The gate consists of a short cylinder fitted for sliding over ribs on the outside of the casing or discharge tube, as shown, which latter is supported by stands resting on the base ring; these guide the gate while closing the mouth of the tube. This form of gate has the advantage of being partly balanced by the current of water passing outwards beneath its lower edge. When the gate is shut as represented, it fits water tight on the base ring, and against the mouth of the discharge tube: when raised it exposes the whole open mouth of the discharge tube.

The gate is lifted by two rods, (one of which is shown in the plate,) connected with the small shaft across the top of the cover by racks and pinions; this pinion shaft is operated by an endless screw and reducing gear arrangement, the worm shaft of which terminates above in a hand wheel, not shown.

The head water is conveyed from arches in the north front of the Mill House, joining the dam, to the chamber over the fixed wheel by an elliptical tube 36 ft. in length, having a horizontal diameter of 12 ft. 10 in., and a vertical diameter of 7 ft. 2 in., affording a clear water-way of over 70 sq. ft. of section.

This inlet tube is shown in the plate, as opening partly into the casing of the chamber, and partly into the cover; the latter is strongly ribbed on the outside to sustain by means of a bracket, arching over the bevel pinion, one end of the counter shaft which transmits the power of the wheel from the bevel pinion on the top of the turbine shaft, to the great mortice spur wheel on the crank shaft.

The water passes from the inlet tube or flume into the case, down through the guide curves, and gives motion to the movable wheel. This is 9 ft. in diameter, and is made of wrought iron cast to an iron centre or nave, bound around the outer edges by a wrought iron rim, and turned up true. The buckets and guide curves are ground smooth.

Each wheel is calculated to make an average speed of 35.5 revolutions per minute, which is reduced by the gearing to 13 revolutions per minute of the crank shaft.

Two eighteen inch pumps, each having 6 ft. stroke will be worked by this shaft, one from each end; one crank pin being a quarter of a turn in advance of the other.

CONCLUDING REMARKS.

The Department are aware that this report of experiments, which were full of interest, and which furnished many valuable results, is yet, in many respects, defective and open to criticism. It is difficult to make the peculiarities of the different wheels intelligible, without diagrams of each, and much more detailed description. If time allowed, they would gladly revise it and

render it still more complete; but the multiplicity of our duties limits us absolutely to such a use of the results as our immediate practical exigencies demand. Meanwhile, we hope that the statements will prove intelligible, and that some one with better opportunities and better qualifications for the work, will be induced to develop and perfect the results of these experiments. We would especially call attention to table No. 21, as presenting many valuable suggestions; such as the best relative velocity of water through the wheels, load upon the periphery, &c. These comparisons could doubtless be extended to other elements with profit.

HENRY P. M. BIRKINBINE,
Chief Engineer.

APPENDIX.

Report of the Chief Engineer of the Water Works.

To the Select Council
of the City of Philadelphia:—

GENTLEMEN:—In answer to your resolution of May 31st, 1860, the Department would submit the following general report upon the experiments made with turbine wheels at Fairmount Works:—

The experiments were made in obedience to a resolution of the Committee on Water, and under an appropriation of five hundred dollars, made by councils. See resolution appended, marked "A." An advertisement was inserted in the *Scientific American*, calling attention to these experiments. See copy appended, marked "B." See also appended a copy of a letter addressed to the wheel makers, in answer to inquiries, marked "C." If a detailed report is thought desirable by your honorable body, an appropriation of three hundred and fifty dollars will be necessary to print in pamphlet form, with the necessary diagrams and tables to make it fully intelligible and useful.

An experimental apparatus was constructed at Fairmount Works for the purpose of testing such turbine water wheels as

might be presented. The Department entered reluctantly into these experiments. First, for want of time to conduct the investigations with the care and detail which their importance demands. Second, on account of the limited appropriation made to carry them out. Third, the delay in completing the plans and details of the Works, consequent upon the experiments, and also the difficulty felt in making deductions from model experiments, which would guide us in the selection of wheels of the great power required for these Works. So far, however, as these experiments have been prosecuted, they have been carefully done. The tests were made simply for the purpose of ascertaining what proportion of the power employed would be utilized by the different wheels, or their co-efficient of useful effect. The wheels were tested under a head and fall of six feet, and weights of from five hundred to sixteen hundred pounds were raised from fourteen to twenty-five feet.

Nineteen different wheels were tested and one hundred and twenty-two experiments made with them. Several of the wheels were removed without submitting them to a public test; of these no accounts have been kept. The accompanying table marked "D" exhibits the best results obtained from some of the wheels. Mathematical accuracy was not aimed at, but the experiments may be relied upon as practically correct. The apparatus was of the most simple character, and the arrangements such that no mathematical formula was required to ascertain the amount of water used or result produced, but these elements were actually weighed and measured.

It was necessary to refuse to test a number of the wheels, as the appropriation was all exhausted, and the completion of the plans for the wheels could be no longer delayed, and the Department was so fully occupied with the extension of the Works, that time could not be found to pay them the proper attention. Valuable assistance was rendered in these experiments by the Chairman of the Water Committee, O. H. P. Parker, Esq.; James Millholland, of Reading; Wm. B. Bement, and Charles S. Close of this City.

Among the wheels which produced the best results, and

to the makers of which certificates have been given, as shown in the accompanying paper marked D, the highest co-efficients of useful results were produced by the Jonval wheels made by J. E. Stevenson, of Paterson, New Jersey, and E. Geyelin, of this City, and a modification of the Parker wheel, made and patented by Andrews & Kalbach, of Bernville, in this State. The majority of the wheels worked very satisfactorily, and the makers of them were mechanics of more than ordinary ability. It is believed that no country could produce from the same number of wheels promiscuously collected, as satisfactory a series of experiments.

The best result was procured from the Jonval wheel, made by J. E. Stevenson, of Paterson, New Jersey, which gave an actual useful effect of the power employed of nearly ninety-one per cent. The wheel of Andrews & Kalbach, of Pennsylvania, is remarkable for its simplicity, and had it been constructed with the same amount of care and finish as that of some of the others, it is believed that the co-efficient of useful effect would not have been surpassed by any. Two of these wheels placed upon a horizontal shaft might make a most desirable arrangement for our new Works; but the Department is not prepared to recommend their adoption, as it might involve a risk or a failure, and we are averse to making any experiment at so great an expense and loss of time as might have resulted to the City. We have been unable to find any wheels now in operation, arranged in the above manner, of the aggregate power that we shall require, or under circumstances such as exist at Fairmount.

The Department, therefore, see no reason to change the plans of the Works, and will adopt the Jonval Turbine, arranged and geared similar to the one now in use at Fairmount.

In coming to the above decision, and recommending the Jonval wheels, the Department have been influenced by the following considerations:—

First—They have always been esteemed among the most efficient wheels, and although other forms of wheels have been removed to give place to Jonval Turbines, the Department does not know an instance where this Turbine has been taken out to

introduce another form. Our experiments upon the Turbines have also proved them the most effective, giving the highest co-efficient of useful effect. See table appended marked D.

Second—They are the best adapted to our particular situation, on account of the comparatively small fall at Fairmount, the large amount of power required for each wheel (a mean of one hundred and twenty-five horse power,) and the low velocity at which they run, as compared with other Turbines, making a less reduction of speed by means of gearing, necessary.

Third—Their durability, and the facility with which repairs and renewals can be made.

Fourth—They can be constructed and connected to the pumps at as small cost as any other form of Turbine wheel. No objection can be urged against the Jonval wheel, arranged as proposed, except that involving mere mechanical arrangement, unless against the step and bevel gearing. Practically, these are not objections; the step of the present wheel at Fairmount Works has required but one renewal since it was erected, which is the only repair found necessary to the wheel; and as regards the bevel gearing, or reducing the velocity for the proper speed of the pumps by two or four wheels, there is only an apparent additional loss by friction, but none in reality, as a little reflection will demonstrate.

Fifth—The favorable experience the City has had with the wheel of this kind at Fairmount, built by Emile Geyelin, which has been in constant use since December, 1851.

The reasons for rejecting the plan of two wheels upon a horizontal shaft, as recommended by the former chairman of the Committee on Water, are as follows:—

First; our minimum head and fall is but eight feet. To produce one hundred and twenty-five horse power by two wheels, it would be necessary for each of them to be fifty inches in diameter, and they would occupy so large a proportion of the head and fall that the co-efficient of useful results would, of necessity, be low.

Second—The experiments made by the Department at Fairmount proved, that two wheels arranged upon a horizontal shaft, will not give as good a result as one on a vertical shaft. Two

Parker wheels arranged upon this plan, gave but a co-efficient of sixty-seven per cent., while one Parker wheel by the same maker on a vertical shaft, gave a co-efficient of seventy-five per cent. Two Jonval wheels upon a horizontal shaft gave a co-efficient of but sixty-eight per cent., while one Jonval wheel by the same maker, on a vertical shaft, produced a co-efficient of eighty-two per cent.

Third.—The velocity of the wheels would be so great, (from seventy to ninety-six revolutions per minute with the two wheels, while the one Jonval wheel upon a vertical shaft will make but from thirty-one to forty-two revolutions per minute,) that the necessary reduction of the speed, by means of gearing, to the speed of the pumps would involve much greater loss by friction, than could possibly be the result of the plan adopted for the gearing of the Jonval wheel.

In obedience to a resolution of the Committee on Water, the Department addressed letters to J. E. Stevenson, of Paterson, N. J.; E. Geyelin, of Philadelphia; Andrews & Kalbach, of Bernville, Pa.; and Levi Smith, of Reading, Pa. (See copy appended marked E.) In answer to these, the following propositions were received and opened by the Committee on Water, April 24th:—

From Emile Geyelin, of Philadelphia, for three turbine wheels, ...	$6,900 00
Gearing for the same, ...	16,500 00
Total,	$23,400 00
From J. E. Stevenson, of Paterson, N. J., for three turbine wheels, ...	$15,000 00
Gearing for the same, ...	14,500 00
Total,	$29,500 00
From Levi Smith, of Reading, Pa., for each turbine wheel, ...	$4,130 00
Gearing for each wheel, ...	4,360 00
	$8,490 00
Total,	$25,470 00

And at a subsequent meeting of the committee, May 22d, a proposition was received from Hunsworth, Eakin & Co., of this City, for three turbine wheels and gearing, $26,566.80.

Care has been taken by the Department not to commit the City either in the advertisement, (appended marked "B,") or in letters addressed to makers of wheels, in such a manner as to give the maker of any wheel which might be presented for test, a claim upon the City. This was done that the Department might not be embarrassed in considering simply the interest of the City, in the selection and construction of the wheels. In regard to the form of wheel recommended, none of the Jonvals tested claimed any patent or peculiarity of construction, but simply differed in proportion and mechanical finish.

At the recommendation of the Committee on Water, the Department has made arrangements with Emile Geyelin, of this City, to construct two Jonval turbines for the works.

Respectfully yours,

HENRY P. M. BIRKINBINE,

Chief Engineer.

June 7th, 1860.

(A.)

Resolved, That the Chief Engineer of the Water Works be, and he is hereby authorized and instructed to notify by letter or otherwise, all competitors for building turbine or other water wheels, to be placed in the proposed new mill-house at Fairmount, hat they will be required to furnish the said Engineer with "an exact working model of their wheel or wheels" according to the size and scale adopted by said engineer, under the direction of the Committee on Water Works. And that the said Engineer is hereby authorized and directed to make the necessary preparation and arrangements for testing the said model wheels, so as to determine the per centage of power produced by each wheel respectively, and he is also required to examine into the mode of construction, with a view of ascertaining which wheel will be best adapted for propelling the pumps, in the most simple and durable manner, and to make a full report of his examination to this Committee.

(B.)

From the Scientific American, June 4th, 1859.

The Committee on Water Works of the City of Philadelphia are about to erect two additional turbines at Fairmount Works. They have directed that a test of the comparative value of the different wheels be made by models, at their Works, commencing June 7th. For further information, address H. P. M. Birkinbine, Chief Engineer, Water Department, Philadelphia, Pa.

(C.)

DEPARTMENT FOR SUPPLYING THE CITY WITH WATER.

Philadelphia, July 23d, 1859.

DEAR SIR:—The experiments upon "Turbine Water Wheels," directed by the "Watering Committee," will be commenced the first of August. Models must be constructed to discharge about two hundred cubic feet per minute, and work under a head and fall of from six to twelve feet. A drawing must accompany each model, and a description of the peculiarities of the wheel. These experiments are undertaken to determine the "wheel" that will be best adapted (all things considered,) for our "Fairmount Works." Two of the wheels approved of will be ordered immediately. They will be about one hundred horse power each, and intended to work under a head of from six to twelve feet, varying with the tide. Each wheel will be required to work two "double acting pumps, chambers 18 inches diameter and 6 feet stroke, and make from 10 to 16 strokes per minute, pumping into a reservoir 115 feet above the surface of the dam."

Yours, respectfully,

H. P. M. BIRKINBINE,
Chief Engineer.
Per J. H. YOCUM, JR.

(D.)

	Weight raised in pounds.	Height raised in feet.	Cubic feet of water discharged.	Head, in feet.	Time, in seconds.	Ratio.	Date of Trial.	Address.
Monroe & Bartlett,	.850	25	105.72958	6	39	.5359	Octb'r 7, 1859	Worcester, Mass.
Reuben Rich,	750	25	80.19836	6.1	33	.6132	" 20, 1859	
J. Littlepage,	1600	14	109.384	6.05	25	.5415	Nov. 22, 1859	Austin, Texas.
J. Tyler,	825	25	77.21516	6	25.5	.7123	Dec. 19, 1859	West Lebanon, N. H.
N. R. Merchant,	1100	25	114.356	6	32	.6412	Jan. 12, 1860	Guilford, N. Y.
L. W. Blake,	925	25	86.0156	6	28.3	.7169	" 20, 1860	East Peperell, Mass.
Collins, Haydock & Wildman,	900	25	78.309	6	27.6	.7662	Feb. 9, 1860	Troy, N. Y.
L. Smith,	1300	22	100.75758	6	20.3	.7569	" 21, 1860	Reading, Penn'a.
E. Geyelin,	1000	25	81.19276	6	26	.8210	" 29, 1860	Philadelphia, Penn'a.
J. E. Stevenson,	925	25	70.25436	6	23.6	.8777	March 9, 1860	Paterson, N. J.
A. P. Mason,	750	25	79.0548	6	27.6	.6324	" 16, 1860	Buffalo, N. Y.
Andrews & Kalbach,	700	25	56.9294	6	18.6	.8197	" 23, 1860	Bernville.

(E.)

Philadelphia, April 10th, 1860.

DEAR SIR:—The Committee on Water have requested me to procure from you an estimate of the cost of three turbine wheels and gearing suited for our new Works, each wheel to work two pumps, each eighteen inches diameter and six feet stroke of piston, raising water one hundred and twenty-five feet high, and making from ten to sixteen strokes of each pump per minute, with from eight to fourteen feet head and fall.

Please state the price of the wheels and gearing separately; also, state the space the wheels and gearing will occupy.

The Department will not consider itself obliged to accept your proposition, even should it be the lowest, but will make such disposition of it as may appear to be the interest of the City. Please let me hear from you before Tuesday next, the 17th inst.

Yours, respectfully,

H. P. M. BIRKINBINE,
Chief Engineer.

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