REPORT

OF THE

WATERING COMMITTEE,

Read in Select Council, November the twelfth, 1818.

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1822.

REPORT, &c.

THE Watering Committee beg leave to report to Councils, that during and since the last summer, when loud complaints were made of a deficiency of a supply of water, they were particularly led to examine into the cause, being well aware that every attention was paid to keeping the engine at work, and the reservoir full, and they were finally led to the conclusion, that the cause was to be found in a want of a sufficient capacity in the mains leading from the reservoir to the city, and to the imperfect plan upon which the pipes were originally laid down.

The Committee were led to seek information also from abroad, which fully confirmed their own and the superintendent's opinion, which he has expressed in the accompanying communication, by which councils will perceive that let the quantity of water, raised by the engine, be what it may, not more than a million of gallons in twenty-four hours can find its way into the city by the present mains; and as experience has shown that during the summer season the health and the wants of the citizens require at least double that supply, the Committee have determined that the only remedy is to put down immediately a large iron main, and that it will comport with true economy to lay one of such size as will, probably, for a great length of time, supply all the wants of the city and suburbs; the health of which latter is as essentially important to us as that of our own members.

In their last report the Committee stated they had written to London for information, and had ordered a parcel of various sized iron pipes, fitted in the manner which experience had pointed out as the best, and they have, through the diligence and care of an engineer of the first respectability, obtained some very useful information, contained in two reports herewith submitted, and a number of pipes constructed upon such principles as will ensure strength and prevent leaks at the joints; and the Committee are decidedly of opinion, they can be laid down at the first cost at as low a price per foot as wooden pipes of the same diameter.

The Committee therefore propose to lay down an iron main of about three thousand eight hundred feet in length, of twenty-two inches diameter, leading from the reservoir to the middle of Schuylkill Front Street and Vine Street; and another leading from thence to the corner of Broad Street and Chesnut Street, of about six thousand two hundred feet, and twenty inches diameter, which will be capable of conveying five millions of gallons in twenty-four hours. To accomplish this work, a sum of money beyond what it would be proper to call for by taxes at the present moment, will be necessary; and however unpleasant the expedient, yet the committee recommend a loan of seventy thousand dollars should be made for the purpose of effecting an object which they believe the public good imperiously requires, and their fellow citizens conceive of too much importance, not to be satisfied with the propriety of its adoption, in order to put the finishing stroke to a work which has already cost so much, and the successful result of which, on an enlarged scale, seems equally necessary to their comfort and their health.

The Committee hand herewith an estimate of the expense of laying down the mains, which are founded upon offers made by manufacturers to contract for them.

The Committee have prepared a bill, which they offer for consideration of councils.

November 11, 1818.

JOSEPH S. LEWIS,
Chairman.

JOSEPH S. LEWIS, Esq.
Chairman of the Watering Committee.

Sir,

In the estimate for the erection of the Water Works at Fair Mount, laid before councils in 1811, is included a cast iron main of fourteen inches diameter, calculated to extend from the reservoir to the Centre square, a distance of 9,704 feet, the cost of which was estimated at 76,249 dollars and 54 cents, or upwards of 7 dollars and 85 cents per foot. After the works were begun, and previous to engaging the iron pipes, doubts arose as to the practicability of obtaining them in time, and a fear existed that by contraction and expansion, leaks might take place, which would occasion the city frequently to be without water. Under these considerations, together with a view of reducing the expenses of the works, five ranges of wooden pipes were substituted in place of the iron main, with the impression that they would be fully adequate for the supply of water to the city; but owing to the unfavourable ground through which they pass, they were found insufficient, when the sixth range was laid, which considerably aided the supply; but I am sorry to state that during the summer months, frequent complaints are made by persons residing on the high grounds, of almost a total want of water. In pipes of so small a diameter, running so great a distance, together with a number of turns at the angles of the streets through which they pass, causes an increase of friction, and checks the velocity of the water far beyond the common allowance in calculation; to these circumstances may be attributed the want of a full supply of water, and not from any deficiency in the engines, which are calculated to raise upwards of 2,000,000 gallons per twenty-four hours, nor from a want of water in the reservoir, the average depth of which has been seven feet. From observation during the summer months the supply has been about 1,000,000 gallons per twenty-four hours, and in the winter about 700,000 gallons; no doubt there would have been a greater consumption in the summer could the mains have issued more water. The supply of water to the city has greatly exceeded the increase of water taken since the erection of the new works, owing chiefly to the additional number of hydrant pumps in the public streets. Under every consideration perhaps it is well that the fourteen inch iron main had not been put down, as the experienced deficiency of water proves that it would have been too small, its area being 153 inches, and rather less than the six ranges of wood pipes now laid; and the method at that time in use of putting iron pipes together with flanch joints, would in all probability have defeated the object by the leakage in that sort of pipes. The same inconvenience, under which we now labour, took place at the New River water works in London; and although they had fifty mains of seven inch bore, still for want of a sufficiency of water they were compelled to abandon them, and substitute large iron mains, some of which are thirty inches diameter; they are cast with the common spigot and fauset joints. The ranges of wooden pipes that now supply the city from Fair Mount are rapidly decaying where the soil is sand or loam; and it is presumed that they will not last in those situations more than four or five years. Were it determined to lay two or three additional mains of wood, to give a greater supply of water, there is not space on the canal bank to receive them, and if carried by any other route the pressure would be too great, independent of their costing upwards of one fourth the expense of an iron main of twenty inches diameter. From these considerations I beg leave to recommend the early attention of the gentlemen of the Watering Committee to the subject of an iron main, which can be had at least per cent. lower than it could have been obtained in 1811 or 12, with the additional advantage of having received correct information from abroad of mains of that dimension answering the purpose satisfactorily. The dimensions of the main required at present is as follows. From the reservoir to the intersection of Schuylkill Front and Callowhill Streets, twenty-two inches clear diameter; from thence along Callowhill to Broad Street, and down Broad to Chesnut Street twenty inches; the distance is not correctly ascertained, but will be about 10,000 feet, and when deemed necessary to extend it to South Street, will require about 2,700 feet additional.

With great respect,

Your humble servant,

FREDERIC GRAFF,

Superintendent of the Water Works.

October 28, 1818.

SIR,

In the estimate for the cast iron main, the interlaps of the joints were omitted.

The estimate, handed the Committee, was for the neat length of the main when put together, consequently is deficient the depth of the joint, which is six inches in each pipe.

Will you have the goodness to state the omission to the gentlemen of the Watering Committee, that it may be corrected previous to its being laid before Councils.

The estimate without the allowance for the joints is as follows:

	Dolls.	Cts.
3,738 feet of 22 inch pipe and laying, at 6 dollars and 73 cents . . .	25,156	74
6,380 feet of 20 inch pipe and laying, at 5 dollars and 98 cents . . .	38,152	40
	63,309	14

Loss in joints to be added,

	Dolls.	Cts.	Dolls.	Cts.
415 pipes of 22 inches, six inches in each joint, 207 feet at 5 dollars and 75 cents	1,190	25		
709 pipes of 20 inches, six inches in each joint, 354 feet at 5 dollars	2,070	00		
			3,260	25
			66,569	39

The course which the pipes is to pass, not being decided. perhaps some deep cutting and filling may be required, to comply with the levels of the streets. In order to cover all incidental occurrences, I beg leave to suggest an alteration in the estimate, by adding 5,000 dollars to the sum agreed on by the Committee.

With great respect,

Your humble servant,

FREDERIC GRAFF.

November 4, 1818.

JOSEPH S. LEWIS, Esq.

Chairman of the Watering Committee.

Finsbury Square, London, 6th April, 1818.

Dear Sir,

I have taken some pains in complying with the request of your correspondent abroad, and I hope that I shall not be blamed if I have exceeded the strict letter of the instructions, for if you compare it with the list of things sent out, you will see that I have not confined myself exactly to the order, but I have sent out in addition, such articles as are in use here in the most improved works where the expense was not considerable, so as to give your friends a more general and better idea of the business generally, than I could have done by description only.

The articles themselves, and the invoice which accompanies them, render it unnecessary to repeat all the things sent out, and I shall therefore proceed to examine the questions submitted by your correspondent in the order he has stated them.

His first enquiry regards "the pipes of conduit, with information how they are connected; if by spigot and fauset joints, how deep the joints overlap each other, the thickness of the joint, and what proportion of the joint is caulked with oakum, and what part the lead occupies, as well as how the joints are finished, whether by the common method of caulking, or by any other means?"

In reply to these enquiries, I would observe that the pipes which are found on the whole to be the most convenient and best, are the spigot and fauset pipes. The joints are more easily made, as well as more easily renewed or repaired in case of leakage. The depth and width of the fauset end, for the different diameters of pipes, will be seen by those sent out; the spigot end is laid so as to go as far in or give as much interlap as the fauset will admit and blocked up so as to give nearly an equal width of joint all round, excepting where a small turn is intended, which is effected by an inequality of the joint, and which may be done safely, if, at the most confined part, sufficient width is left for the lead to meet round the pipe in a state of fusion, and to caulk the joint; care should be taken to give the pipe a solid bed upon the ground, before the joint is made. There are two ways of making the joint: the first is by lead, the other is by cement. The first operation in making the lead joint, is to drive in a ring of dry hemp about an inch in length, to prevent the melted lead from getting round the spigot end into the pipe; after this, some clay well wrought is put all round, between the outer end of the fauset and the spigot pipe, the inside of the clay being kept as nearly as possible, to correspond with the outer end of the fauset, and being formed into a cap at top into which the melted lead is run, and if properly managed, a ring of lead about two to two and a half and three inches, according to the size of the pipes, is formed all round the pipe, being stopped from wasting by the clay at the one end, and the hemp at the other.

When the lead is cooled, the clay is removed, and as the lead is contracted in cooling, it has to be caulked, or as it is here called *upset*, by a hammer and chissel, and the joint is complete. The cement joint is formed by laying the pipes in the same manner as the other, and using in place of the lead a mixture of two pounds of sal ammoniac, with one hundred pounds of borings of iron. A little sulphur is also used sometimes to quicken the progress of corrosion, but is not absolutely necessary. When the workman is about to make the joint, he puts a sufficient quantity of the above into a small tub, and applies to it a quantity of water; he then puts some hemp into the tub which he works round in the mixture so as to make it take up as much of the iron and sal ammoniac as he can, and he caulks this into the joint. The salt by means of the water acts upon and oxydizes the iron, and in a short time the mixture becomes extremely hard, and quite impervious to water; of the two plans however, the lead has been found to answer by far the best, and with the exception of one company, is now universally in use. The cement joint is as good as any that can be made, when it is horizontal, but when otherwise, or when the distribution of materials is not seen, it is apt to be defective; and the fear is, that the oakum, in place of being a vehicle for the cement, forms so large a proportion of the bulk that it is the oakum and not the cement that forms the joint; and if this is the case, the joint will remain water tight only so long as the oakum remains good and fresh. I have had a lead joint, in the common way, made in one of the six inch pipes, and by pulling it assunder, any deficiencies in my description of the mode of making them, will be fully compensated for. More pains than common has been probably taken in making this joint, but if so, the fault is on the right side, as much trouble is saved by good joints. In London the making of them is generally left now to the most handy of the excavators, who are found to be able to do the business well enough for the purpose.

Your correspondent's second enquiry is as to "the thickness and length of pipes in proportion to their diameters, and the weight of each sort, say from two to twenty inches diameter."

In regard to those points, I may state generally, that three-fourths of an inch is quite sufficient for a pipe of twenty inches diameter; and as the tendency to burst decreases as the diameter, pipes of smaller sizes can hardly be cast too thin if they are sound; three-eighths of an inch being upon the above principle sufficient for a ten inch, and three-sixteenths for a five inch pipe, which is less than they can be cast with ordinary metal. Ample allowance is at the same time to be made for defects and inequalities in casting, but almost all accidents that have happened, have been through faults in the pipes, and not from their thinness. The pressure upon the square inch of a pipe, with a head of 140 feet, is about sixty-two pounds, which is much less than one tenth of pressure which a good casting of one foot diameter, and a half an inch thick, is capable of resisting; the tenacity of a square inch of the best cast iron, having been found by experiment to exceed 20,000 pounds. The best preventive to accidents is to prove the pipes, particularly the large mains, before they are put down, which is easily done by means of a hydraulic press; the first expense of which is from thirty to forty pounds. All the cocks and pipes which have been sent out, have been proved by a pressure equal to a column of 300 feet of water by this means.

The following is, I believe, a correct list of the average weights, and of the prices, at present, of pipes of different diameters:

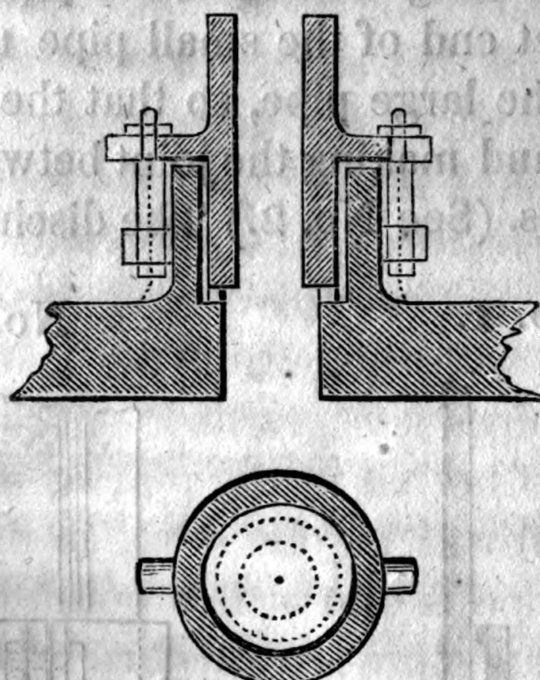
Diameter.	Weight per running Yard.			Present price per Yard.	
Inches.	Cwt.	Qrs.	lbs.	s.	d.
2	0	1	2	3	0
3	0	1	16	3	9
4	0	2	4	5	0
5	0	2	25	7	0
6	1	0	0	9	0
7	1	0	24	10	6
8	1	1	21	14	0
9	1	2	9	16	0
10	2	0	8		
11	2	1	9		
12	2	2	18		
16	3	2	0		
18	4	1	9		
20	5	0	0		
30	8	2	18		

And by adding thirty-five pounds per yard, for every additional inch in diameter, the weight of any greater size may be obtained. The prices of pipes have been as low, in this country, as eight pounds per ton. The price of iron is advanced, but they may still be furnished at very considerably lower prices than have been charged for those sent out, if any considerable quantity were wanted, and time were given to receive tenders for country castings. I suppose a fair price per hundred weight, at present, to be about ten pounds per ton.

The ordinary lengths are nine feet for all sizes, the same as all that have been sent out, excepting the two inch, which are only six feet lengths.

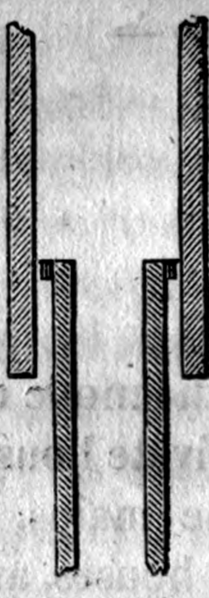
3d. It is asked if the "mains or service pipes are drilled for private insertion, previous to their being laid, or drilled afterwards?" and the next question is connected with this, viz. "the manner in which the private pipes are attached?"

In some, if not all of the pipes sent out, a small circular swell will be observed, in the side of the pipe. The pipe is thin at this point, and it is here that the private pipes are attached by drilling, which is not done until the water is ordered to be laid on, at the house to be supplied. The simplest and most usual way of attaching the private pipe, is by driving a tapering brass, like the end of a common brass cock, into the hole that has been previously drilled, with the first length of lead pipe soldered to it, much in the same manner in which the private pipes are attached to the wooden pipes. Another way, by which there is less chance of leakage, is by having two ears cast upon the opposite sides of the point where the pipe is to be drilled, and a ring of about two inches high round the same place, of greater diameter than the private pipes to be attached; a cast iron lid, with a piece of pipe cast on each side of it, is screwed down upon the ring, and rendered water tight, in the same manner as the common stuffing box. The following sketch will show nearly what is meant.

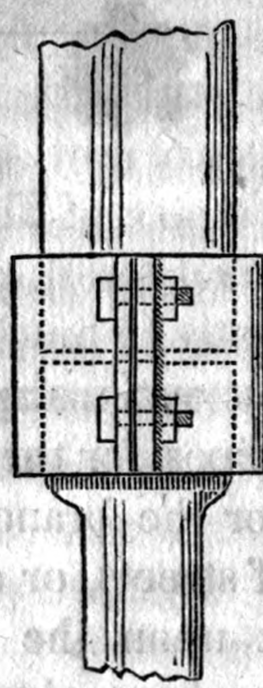


These observations apply only to the mode of fixing the lead pipes, for the supply of private houses. The outlets for the branches from the mains, for the supply of streets, or a number of houses, are generally cast upon the main, and the water works companies have always pipes ready, with outlets of different sizes cast upon them. If the outlet is considerably larger than the proposed branch pipe, a short taper pipe is introduced, which is the best way of diminishing the size; but there are other ways, in which it may, and is frequently done, as by converting the spigot end of the large pipe, to form the fauset for the small pipe, (See No. 1.); or which is preferable, by fixing a circular hoop or plate of sufficient length, and cast in two semi-circles screwed together, (called in the invoice "half sockets,"*) round the large pipe, letting one half of it overhang the end of the pipe, then bringing the fauset end of the small pipe up to the spigot end of the large pipe, so that the hoop covers the joining, and making the joint between the hoop and the pipes. (See No. 2.) The discharge by those

No. 1.



No. 2.



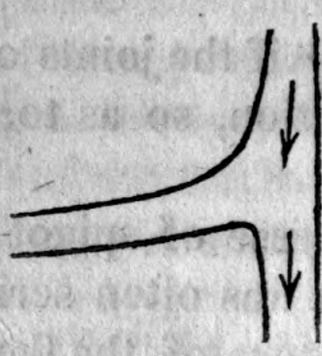
small pipes depends much upon the way in which

* Half sockets of different lengths are used also in repairing the defects of pipes, or when pipes are cut across to be taken out for any purpose of repair.

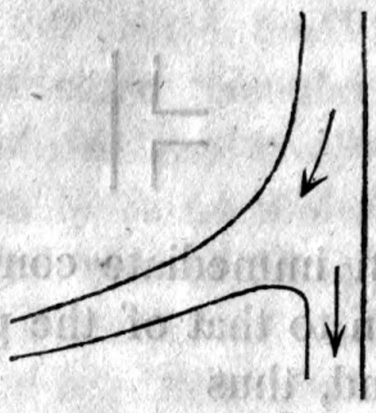
the entrance to them from the main is formed. A sudden turn with an angle thus

is very bad. An immediate contraction from the size of the main to that of the pipe, with a curve, or quarter round, thus

is preferable. The first is the way in which, until lately, the outlets were made; the latter is that in which they are now done. But this sudden contraction to the size of the small pipes, is also objectionable; and the discharge with such an opening, will evidently be much less than where the entrance is an easy curve, and at the same time larger at the junction with the main, in a funnel shape, thus



and if the first length were made tapering, thus



the entrance would be still more complete. The importance of what is here suggested, will be evident to all who are acquainted with the motion of fluids; it is illustrated by almost every running stream, and has been fully proved by every experiment on the subject, particularly by those of Bossut and Buat, which were made to a great extent. To give your friends a correct idea of my meaning, I have had one of the eight inch pipes cast, with a four inch outlet, intended to be according to what I have explained above. I did not see it before it was sent off, but I have little doubt of its being according to what I wished.

4th. It is asked "if the joints of pipes were ever injured by contraction, so as to occasion leaks in time of frost?"

Previous to the use of spigot and fauset pipes, the injury by frost was often serious from the unaccommodating nature of the flange joints. I have heard that of a principal main of one of the water works here, breaking at the flange, and leaving an opening of upwards of an inch. Where flange pipes have been continued in use, this evil has been remedied by introducing occasionally, a spigot and fauset joint; but now that the flange joints may be said to be exploded, an accident from contraction is almost impossible, and the motion at each joint is so small that no leakage is likely to arise from it, particularly if the joint is of lead, as the variation even between summer heat (80°), and freezing (32°), in a piece of iron nine feet long does not exceed one fortieth of an inch.

5th. The question next put is "if any regular depth of laying the pipes in the earth is established?"

I reply, that the depth is to be regulated by the country generally, and the particular situation in which the pipes are to be laid. The two principal things to be attended to are, to lay the pipes low enough, that the water may not be frozen in them during the winter, and that the joints may not be disturbed by heavy carriages passing over them. In England, and countries in the same latitude, about eighteen inches may be taken as sufficient to prevent the effects of frost; but in roads and more particularly in paved streets, they ought to be considerably lower. Two feet of clear distance between the bottom of the paving and the top of the pipes is generally sufficient, and the ground should be rammed firmly under the pipes and over them.

6th. It is enquired "if the stop cocks are formed with slide valves, or in what manner they are made?"

The screw cocks sent out are those which experience has proved to be the best, and which are now most in use; a valve cock is also sent along with the others, which plan is found to answer well enough, when the diameter is small, say under eight inches, and the head not greater than is mentioned by your correspondent. The cocks sent out are all as well made as any in use in this country, and they have all been proved by a pressure much beyond any they can ever be subject to. One of the cocks is attached to a pipe to show completely how this is done, and a wooden pipe is sent out to be placed over the screw of the cock to guide the key in opening it, the opening of which is to be placed over the head of the screw, and the top to reach to the level of the street. I have sent also a key for turning the screw, also a fire plug and its appurtenances, and a stand pipe and cock which are used for the supply of water during severe frosts, when the water in the private pipes is frozen: in such cases the fire plug is driven out, the stand pipe is fixed in the place of it, and the inhabitants of the streets supplied by this means. The screw cocks sent out are all brass faced, and they are preferable to the iron facing; but by this facing an extra expense is incurred. When it is necessary occasionally to prevent the water passing either way, the cocks are made "double faced" and both faces are of brass. I do not apprehend that the double faced cocks can be required in the works described to me, and therefore, I have not ordered any of them. The parts liable to corrode in the articles sent out have been covered with tallow; but this is not commonly done, if they are to be used near where they are made, although it might be better if they were so treated. The cocks not much in use should be opened and shut occasionally, to prevent the rust from gathering upon them. I have thought of having the screws of the cocks made of a *hard* brass, or mixed metal, as a preventive to corrosion; but this would increase the expense, and if the cocks are much in use, the brass thread would wear out sooner than the iron, and thus one evil would only be substituted for another.

The following is nearly correct as to the retail prices of the different sizes and kinds of cocks by the best makers.

SIZE.		*Screw Cocks.*					
		Iron Faced.		Single Brass Faced.		Double Brass Faced.	
		£	s.	£	s.	£	s.
3	inch	5	10	6	5		
4	do.	6		7			
5	do.	6	15	7	16		
6	do.	7	15	9			
7	do.	8	16	10	5		
8	do.	9	17	11	10		
9	do.	11		13			
10	do.	12	8	15	10	17	17
12	do.	15	15	18	18	21	
15	do.	21		25		30	
16	do.	24		30		34	
18	do.	32		38	10	44	17
21	do.	45		56		66	
30	do.	—		90		100	

7th. The next question, viz: "if the cocks on the large mains are similar to those used on the service pipes?" has been answered in considering the last question.

8th. The enquiry respecting the distance from "each other at which the stop-cocks are placed in the mains or service pipes," is properly introduced here; but it is impossible to give any particular answer to the question without knowing the nature of the district to be supplied. The use of a stop-cock upon a main is, that when it is shut and another cock opened, the water may be turned to supply the district in which the cock then open is placed; and again, the use of a cock upon any branch from the main is, that when the quarter to which that branch leads is supplied, the cock upon it may be shut to prevent the water going to waste in that direction; and the cock upon the main being at the same time opened, the water is forced down the main to the next cross street, or a number of cross streets together, when the same operation is repeated until those places are supplied in their turn. The number of stop-cocks upon the mains, depends therefore upon the number of streets and houses in the line of them, and the knowledge of the one will easily decide the other—the object being to give every customer a fair supply, and not to open such a number of pipes of supply at one time as thereby to prevent the water rising to the proper height, or issuing with the proper velocity. After the district is supplied, it is desirable that all the cocks on the mains be opened; and that the principal mains be always kept full of water in case of fire. An inconvenience arising from this is that if *ball-cocks* in the houses which are supplied directly from the mains are not attached, or are not kept in repair, a great waste of water is the consequence; as the water is laid on to the houses throughout the whole of the day. To remedy this it is not unusual to run a pipe of supply parallel to the main, with communications and stop-cocks at proper distances between the main and it; and to let all the private pipes communicate with the smaller pipe only. The water is thus laid on to the houses in the streets through which the main runs, for a limited time only, in the same manner as in the cross streets; and the main is not allowed to be broke into for private pipes.

9th. The next question is, "what distance from each other are the air cocks placed, and which is the most approved sort?"

I have sent, as an answer to the last part of this question, one of our most approved safety valves. It will be easily understood, that when the main is full of water the cork is floated in it, and raised so as to keep the valve close shut; but that when the air takes the place of the water, the cork sinks down and the valve remains open until the air has all escaped. The small pipe over the air valve will require an additional length to be added to it to bring it above the surface of the ground, where it may be protected from injury by being let into one of the road posts, or into the recess of any building so covered up as to prevent the orifice being stopped. Air cocks are much less used here than they were at the commencement of the new water works, or than they ought to be. There is, however, no stated distance at which they can be directed to be placed, without having sections of the streets. The general rule is, that where air is likely to accumulate in the pipes, there an air valve ought to be placed; and that, therefore, this should be done at the summit level of every street and rising ground, and before beginning the descent to any lower level; as the air being specifically lighter than water, is sure to rise to that point.

It remains for me now only to add the observations which occur to me, as to the proper size of the mains and the points connected with the supply of the city, which is the last enquiry made by your correspondent, whose description is perfectly intelligible, and who has himself presented obstacles to any thing like accurate calculation, which I have no means of overcoming, so as to give a very accurate calculation of the main, necessary to give a discharge of a quantity equal to, and not exceeding that named by him. He states the unfavourable nature of the ground, with the many turns, as the causes which render the present pipes hardly sufficient to the supply of 900,000 gallons in twenty-four hours. To ascertain the magnitude of those obstacles, I have taken the data given by your correspondent, viz: Five six inch mains, and one four and a half main with a head of fifty-six feet, and a length of a quarter of a mile, and have calculated what the discharge ought to be, from a formula deduced from the most accurate experiments, and I find that they should give upwards of 1,800,000 gallons per twenty-four hours, or twice what they actually do give. There are perhaps other impediments, which are not noticed, arising partly from the air being confined in the pipes, and partly from the moving cylinder of water being contracted, or having its circular shape converted into a parrallelogram, by injudiciously constructed cocks; and from the way in which your correspondent puts his question, I am sure he is aware that if the water way is contracted in any point, the discharge cannot exceed what is due to the part so contracted, and that it is comparatively of little consequence of what size every other part of the quarter of a mile main is. I conclude from what is stated, that the pipes which go from the chest at Centre Square, are sufficient to take all the water, that is brought into the chest by the mains, and that the discharge ought to be calculated upon a head of fifty-six feet. Still as my calculation is taken from experiments, made upon a straight continued pipe of uniform diameter, I confess that the difference between it and the actual discharge, is not greater than I expected, taking into consideration the different circumstances I have noticed above, and the vastly greater difference that has existed between the calculations, and the actual discharge in other cases, where the greatest care, and the best mathematicians have been employed, both in the construction of the works, and in the calculation of the discharge to be expected from them.

In regard to the size of the new main, I would observe, that it is desirable in all cases, to have it *large enough*, and that the only objection to the increase of size, is the increase of the first expense of the pipes. In every other point of view, the larger the main is, the better; there is (if the main is laid as I would propose,) less friction to overcome, and therefore less work for the engine to do. The branch pipes are all better supplied, and the capability of the works every way increased to meet any unforeseen increase of the city or any other demand for water. A saving in the size of the main, has, therefore, always turned out to be a short sighted economy. One of the new water companies, who at the commencement of their works, (about eight years since,) laid down a twenty inch main, are now about laying another along side of it, and this is no uncommon case. Had they at first put down a main of twenty-eight inches diameter, it would have given a larger supply than the two of twenty inches, and the expense would have been less by about one third of what it will now be, supposing the thickness of metal, in both sizes of pipes, to be the same. I should be therefore inclined to leave out of consideration the improvements by easy turnings, circular cocks, &c. and to lay the new main, of such a size, as with some of the defects of the present ones, it may be adequate to the supply of the quantity which your correspondent names, viz. 5,000,000 gallons per twenty-four hours.

The following are the calculated discharges, per twenty-four hours, of pipes of the diameter stated, having a head of fifty-six feet, and the length one quarter of a mile, without allowing for turnings, &c.

18 Inches . . .	5,600,000	Gallons.
20	7,600,000	do.
22	9,402,000	do.
24	11,700,000	do.

Of these sizes, I would recommend the eighteen inches as the minimum, and the twenty-two inches as the maximum, of what ought to be adopted.

In regard to the sizes of the service pipes, your correspondent does not give me any particular data for calculation, and it would be the work of much time, to calculate for all the different cases of level, demand, &c.; but if the distance and fall from the reservoir, to the point at which the different service pipes branch off, and the number of houses, or quantity to be supplied by each service pipe is given me, I will give the size of pipe necessary for the purpose as nearly as I can.

In examining the plan of the city, and the description given me, the following observations occur to me, with which I shall conclude this report.

Much power appears to be lost, by raising all the water into the reservoir, by which the lowest districts require the same application of power, as the highest. It appears that some of the streets are only fourteen feet above the river, and that the average of the whole is thirty-three feet, yet in all cases the water is raised ninety-eight feet. Besides this, if the main that raises the water into the reservoir, is not continued down again without interruption, in other words if the water is all pumped into the reservoir, the greatest height, to which the city can be supplied, can never exceed the height of the reservoir. Both those disadvantages may be removed by carrying a main from the engine upon the low ground, and forcing the water through an air vessel, directly into it.

The line of Ferry road and Callowhill, appear to be suitable for this purpose, and at the upper end of Callowhill this main may join that from the reservoir; the reservoir being kept full chiefly in cases of fire, or to supply the city, in case of any repair of the works. If the water is at all foul, or muddy, when it comes from the river, a reservoir upon the level of the river may be requisite, to allow it to settle before it is pumped into the pipes.

In laying a new main, it appears to me from the plan, that many of the present turnings may be avoided. The fewer there are of these, and the larger the circle or sweep, with which the turns are made, the better. Every change of shape in the main should be avoided, as well as every increase or decrease; for which reason I consider the *chest* in Centre Square, to be very injurious.

In London the use of iron pipes is now universal. Whenever the old wooden mains begin to decay, it is thought better to take them up altogether, and to substitute iron, than to continue repairing them; and if the substitution of iron should be resolved upon in the city to which your correspondent refers, I shall be ready to give you any further information in my power. I believe that the calculations I have given you are generally correct; but as my limited time will not allow me to examine them so carefully at present as I could wish, I must take another opportunity of doing this, and shall not fail to inform you, if I detect any error.

I am, dear sir,

Your obedient humble servant,

J. WALKER.

35 *Finsbury Square, London,*
6th April, 1818.

To ALEXANDER GLENNIE, Esq.

Gentlemen,

Since receiving your last communication, I have carefully considered the plan proposed by (I presume) the engineer to the Water Works Company, for the sizes and direction of the iron mains. The local knowledge of this gentleman must give him such advantages, that what I have to say on the subject should be considered only as hints for his consideration.

His idea generally I approve; it is "to divide the present improved parts of the city into four districts by bringing a twenty inch main from the reservoir to the corner of Broad Street and Vine Street, and from thence extending down Broad Street to South Street, then carrying two smaller mains down High Street, one down Vine Street, and one down South Street."

I beg to submit, 1st, The propriety of a twenty-two inch main from the reservoir as far as Front Street, with a branch pipe at this point; one of the branches being intended to form a continuation of the principal main of twenty inches towards Broad Street, the other branch being intended for a ten or twelve inch main in the line of Front Street.

The additional expense by this alteration, being only about ten per cent. upon the cost of the pipes, will not be considerable. The advantages of it consist in the increase of the capability of supply from the reservoir, amounting to twenty per cent., which may be applied, when wanted, by a continuation of the smaller main, to the western part of the city near the Schuylkill; or in cases of any alterations or repairs being wanted to any part of the twenty inch main, the water may be shut off from that part by a cock at each end, and by the smaller main joining the other at Centre Square, or at any other point, the Northern and Southern Districts may be kept supplied while the work of repairs is on hand. At a convenient part of the main, near the foot of the reservoir, it would be well to have a pipe with an opening to receive a main from the engine without going over the reservoir, which would save much trouble and expense when the low-service system is carried into effect.

I would suggest the propriety of decreasing the size of the main after passing High Street. The district north and east of Centre Square appears to be populous, and if a twenty inch main is sufficient before arriving at Centre Square, the same size does not appear requisite after the reduction caused by the supply of the main in High Street and the streets north of it. A seventeen inch main will convey about three fourths of the twenty inch one, it appears to me therefore to be sufficient after passing Centre Square.

Your letter expresses a request to me to send a plan of a London district as now supplied, to which

I could have no possible objection, but that it would take considerable time, and be of very little use. Indeed, when made it would only show that the pipes which have been laid down at first, have almost all in works of long standing been altered since, and are continuing to be altered as errors have been discovered, or as districts have become more populous, and would prove, what I doubt not the engineer is already sensible of, the necessity of setting out and acting upon a general scientific principle, making a proper allowance for an increase of demand, as the best way of avoiding an infinite deal of future trouble and expense.

From the drawing I have received of the present engine, I conclude it to be what is called a double engine, and that the pump is also double, that is, that it forces the water in both directions of its motion. One of the papers sent to me, states the diameter of the cylinder at forty-five and five eighths inches; in the drawing it is written forty-three and three fourths. Supposing it to be forty-five inches with six feet stroke, and to make twenty double strokes per minute, the power of the engine is what is commonly reckoned at sixty-six horses, and the quantity of water raised to the height of ninety-eight feet should be about 3,000,000 gallons in twenty-four hours: the number of strokes, and the pressure upon the piston I have assumed, those particulars not having been communicated to me. The engine is stated to be calculated to raise

2,100,000 gallons in twenty-four hours, which is equal to about forty-four horses; a horse's power being taken in this case at 150 pounds raised 220 feet high, or thirty-three thousand pounds raised one foot high per minute.

Your correspondent refers to a publication containing the work of different engines, and is naturally desirous of knowing the cause of one engine doing twice the work of another. The accuracy of those tables ought to be very fully proved, before we take much trouble in investigating the cause which produces so great a difference. My own opinion is that no engine will, *for a continuance*, raise either forty-seven or fifty-one millions of pounds by a bushel of coals; and if experiments are made by workmen, or by persons interested in the result, they ought to be cautiously received. An engine upon Woolf's principle, was erected at a large manufactory in London several years since, and flattering accounts were given of its work. Four engineers were appointed to compare accurately its work with a condensing engine erected by Boulton and Watt at another manufactory—and their opinion was, in point to the consumption of fuel, in favour of the latter. The other engine was afterwards taken down, and a condensing engine is now substituted for it.

I believe that since that time considerable improvements have been made upon Mr. Woolf's engines, but by no means such as, in my opinion, to justify any thing like the difference stated in the list to which your correspondent refers.

I have seen one a few days since which is applied to a corn mill, and has been in use for, I think, about four years:—the owner states, that it works three pair of four feet stones, and grinds and dresses 200 quarters of corn per week, (say in 152 hours) and that, *when in good repair*, it burns three fourths of a bushel of coals per hour. The engine therefore, according to this statement, does the work of a ten horses engine with three fourths of the usual allowance of fuel. From my informant introducing the words "good repair," I was led however to conclude that the average expense of coals was somewhat about what he stated, but even supposing it otherwise, this work is much under what is stated in the Magazine to be done in pumping water: and in referring to the statement of work done by the two engines in Cornwall (referred to by your correspondent) in the evidence before the House of Commons in 1817, I find the work to be much less than it is in the statement which is made in the late Magazine:—without asserting, however, that those statements are not correct, it is not too much to say, that they are very subject to error. The accounts are taken by a person who goes round to the different engines in the county, Cornwall, and makes a monthly return of the work done, and of the coals expended, in doing which he must depend very much, or rather altogether upon the honesty, as well as the accuracy of the man who works the engines. The engines at Whealvor, and at Wheal Abraham, are both upon Mr. Woolf's principle; the principal features of which are, 1st, That the steam is first used in a small cylinder at high pressure, and then passed into a larger cylinder at low pressure, so that it combines the principles of both high and low pressure engines; 2dly, That the force of the fire acts principally upon two small tubes, from which the high pressure steam is passed into the boiler, or rather in this case the steam reservoir, by which a greater surface is exposed to the action of the fire, and when compared with other high pressure boilers, greater security from explosion is certainly obtained; and 3dly, That the piston of the cylinder is formed of metallic segments, with a spring from the centre, which is firmly fitted to the surface of the cylinder, so as to render packing unnecessary.

It would be useless to your purpose to go into the improvements and objections caused by those alterations. I believe, that in some respects, they may be fairly called improvements; but they are improvements chiefly upon *high* pressure engines, to which it is probable your friends may have objections; and for the particular situation and purpose for which they want an engine, I would certainly advise the low pressure engine upon Boulton and Watt's principle in preference to any other; and when I say "for your particular situation and purpose," I do not mean to infer that those particulars only give it the preference; for I believe that for any situation where *security* and *constant* work are desirable, that engine is in no respect inferior to any other; and this opinion is entitled thus far at least to respect, that it is given by one who has no interest in recommending one engine above another, and no connexion with any manufactory or trade of any kind.

For a Water Works Company, I consider the single engine and pump to be superior to the double; its advantages consist in its simplicity, and in being consequently less subject to be out of order.

The new engine should be of such power as to raise about three millions of gallons in twenty-four hours: this, with the present engine, will make five millions, which is stated as the greatest probable demand. And the adopting of my suggestion of supplying the city by a main, round the foot of the mound or reservoir, will give a much greater power of supply, should it ever be wanted.

I consider that the engine now to be erected, will be perfectly sufficient if its maximum of power is such as I have stated, and I think it ought not to be less. A single engine fifty-four inches diameter will do, and I find that this size may be made to suit very well the present engine house without alteration, supposing the foundations to be sufficient. The boiler house, though its shape is not the very best for two boilers, will also do without alteration. The cost for such an engine, including two pumps, boilers, air vessel, &c. will be somewhat about £5000, and the expense of fuel equal to about six bushels of coals per hour.

Your correspondent is correct in stating that improvements have, of late years, been made in the engines and pumps erected in London; and probably there is no new one put up, which does not contain improvements, or additional facilities, not possessed by its predecessor.

I have ordered a proving engine to be made; it acts, as your correspondent intimates, upon the principle of Bramah's Hydraulic Press.

The heights of the building are not marked upon the drawing sent; those will be required to be known, and the plan and sections had better be drawn to scale, with the principal dimensions figured.

I am, Gentlemen,

Your most obedient servant,

J. WALKER.

35 *Finsbury Square*, *London*.
25th August, 1818.

To Messrs. A. GLENNIE & SON.