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A GLANCE AT THE WATER SUPPLY OF PHILADELPHIA.

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[*Read September 23, 1903.*]

INTRODUCTION.

Now that the New England Water Works Association has ventured so far out of its latitude as to hold its convention in a suburb of Philadelphia, it seems not inappropriate that some mention should be made of a water-works enterprise the inception and progress of which have greatly exercised some of the inhabitants of that city.

I have been asked to present a statement of the " progress and present condition " of the Philadelphia filtration plant; but, in order to do this satisfactorily, it may be well to give, first, an outline of the works in general.

With the same object in view, I find myself tempted to volunteer also a bit of the *history* of the Philadelphia water supply, even at the risk of indulging in some personal reminiscences, and thus fighting some of my own battles o'er again.

EARLY CONDITIONS.

The public water supply of Philadelphia has always been drawn either from the Schuylkill River alone or from the Schuylkill and Delaware rivers, the Schuylkill being a tributary of the Delaware and entering that stream at the lower end of the city.

The Schuylkill rises in the anthracite coal regions of Pennsylvania, about 100 miles above Philadelphia, and has a watershed of about 1 900 square miles. The Delaware rises in the southeastern part of New York state, a little north of Port Jervis, where New York, New Jersey, and Pennsylvania meet. Its watershed, above Philadelphia, has about 8 000 square miles, and is about 180 miles long, from north to south, and in general from 20 to 70 miles wide from east to west.

Prior to 1854 the city of Philadelphia covered only about two square miles, being comprised within the nearly rectangular area bounded by the Delaware River on the east, by the Schuylkill

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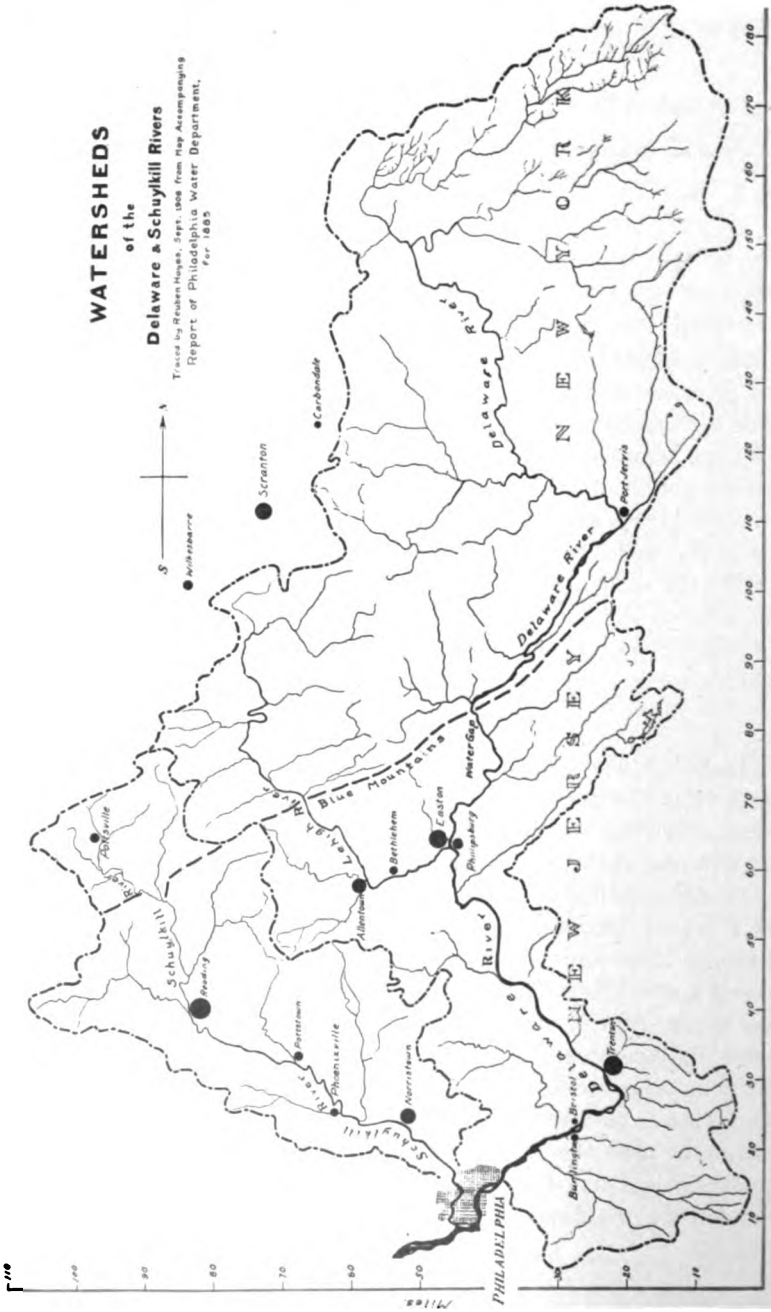

Fig. 1.

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River on the west, by Vine Street on the north, and (appropriately) by South Street on the south. The distance between rivers is about two miles, and the distance between Vine and South streets is about one mile. Beyond these limits lay the "districts" of Kensington, Northern Liberties, Spring Garden, etc., on the north; Southwark, Moyamensing, etc., on the south.

About the close of the eighteenth century, say 1795 to 1800, the city was repeatedly scourged by yellow fever, which drove its well-to-do inhabitants to the adjacent hills or to distant places and left the poor in town to bear it as best they could.

Even in those early days, some connection was suspected between the water supply and the spread of such diseases, for these visitations of yellow fever gave rise to active agitation for an improved and public water supply, the supply hitherto having been taken from wells and cisterns.

Scott's Geographical Dictionary, published in 1805, says: "The water of those parts of the city which are most thickly inhabited . . . had become so corrupt by the multitude of sinks and other receptacles of impurity, as to be almost unfit to be drank."

As in later days, all manner of rival schemes were brought forward and were soon in lively conflict. Among these stood out prominently the proposition of the Delaware and Schuylkill Canal Company, which proposed to tap the Schuylkill River at Norristown, fourteen miles above the city, and to construct a navigation canal from that point down the east bank of the Schuylkill River to Fairmount, and thence across the country, just north of the city, to the Delaware. This concern proposed to tap its main canal at Broad Street and to bring a branch canal, for water supply, to a pond or reservoir to be constructed on "Broad Street extended," at what is now Callowhill Street, just north of the then city limits, whence another canal was to lead down Broad Street, across the city, to South Street, and to supply canals, or at least gutters, on the east and west streets. This was to be a gravity supply, in the true and extreme sense of the word, the citizens being expected to take their supplies by main force from these surface canals. In the canal company's proposition, the introduction of a supply under pressure was reserved for future discussion.

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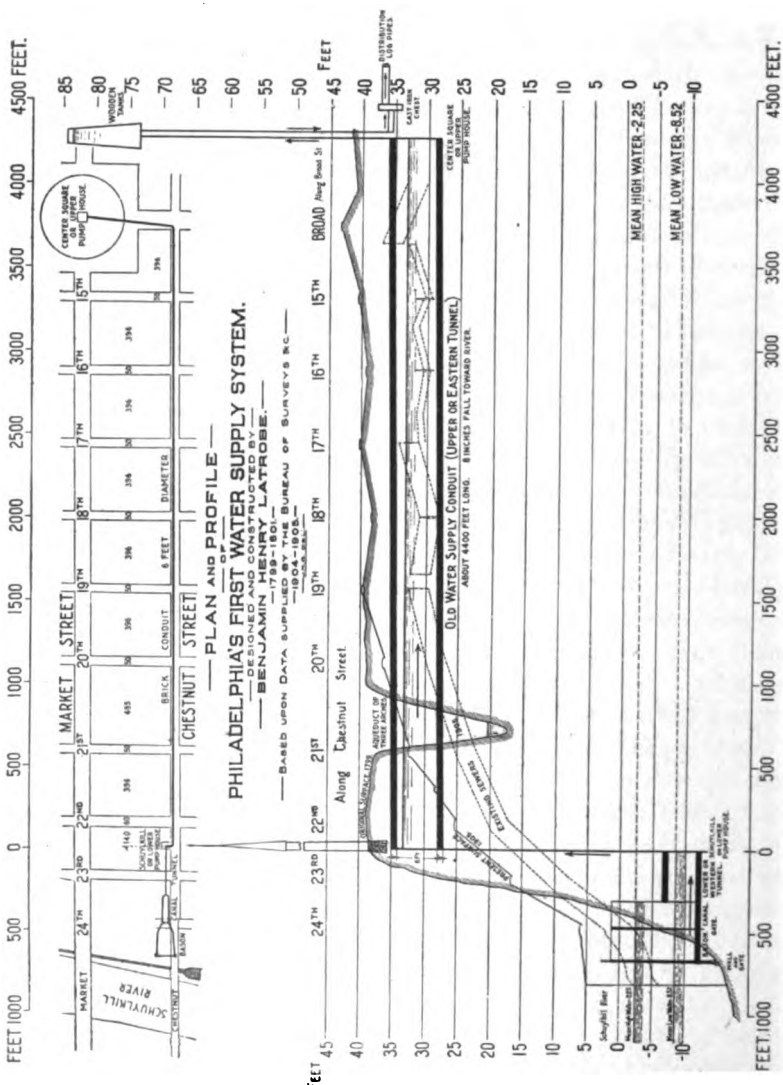

FIG. 2. PHILADELPHIA'S FIRST WATER SUPPLY SYSTEM.
Devised and Constructed by Benjamin Henry Latrobe, 1799-1801.
PLAN AND PROFILE.

Another prominent project was that of Benjamin Franklin, who left a sum of money to be expended in bringing the waters of the Wissahickon Creek to the city.

Finally, however, the project of Benjamin Henry Latrobe (who

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refers to himself as being " the only successful architect and engineer " in America at that time) prevailed and was carried to execution in 1801. (See portrait, Plate I.)

The Schuylkill was tapped on the east side, at Chestnut Street, and its waters were led, by gravity, to the pump well of a steam station located upon the site of a British redoubt, on high ground on the north side of Chestnut Street, just west of Twenty-Second Street, or about one block east of Chestnut Street bridge. (Plate II, Fig. 1.) Here the surplus power of the engine was rented out to run a rolling and slitting mill in an adjacent building.

This station lifted the water into a six-foot brick conduit, which ran along the north side of Chestnut Street to Broad Street, and there turned abruptly and ran northward to a second station in Center Square, the site of the present City Hall. Here the water was again pumped, this time into overhead tanks, whence it flowed through log pipes to the distribution. (See Fig. 2, and Plates II and III.)

West of about Seventeenth or Eighteenth Street, the grading down of Chestnut Street has removed the old conduit, but east of Seventeenth Street it is still in place. During comparatively recent years it has been used for purposes of sewerage, a low dam being constructed across it, about the middle of each block, and false bottoms placed in it, sloping each way from the dams to the sewers on the north-and-south streets at the ends of the block, as shown in Fig. 3. The conduit (so much as remained of it) was thus made to serve as a series of short feeders to the sewers running north and south. In April, 1906, the old conduit was cut through, where the City Hall looks down South Broad Street, by the excavations for the subway since constructed.

In a report to the American Philosophical Society, in 1803, Latrobe mentions the two engines of the Philadelphia system, two in New York, and one in Boston, five in all, as being " the only engines of any considerable powers which, as far as I know, are now at work in America." This enables us to form some idea of the prodigiousness of the work involved in the tiny first waterworks of Philadelphia.

The earliest boilers were of wood, but these were shortly followed by cast iron, and afterward by plate iron boilers. The prin-

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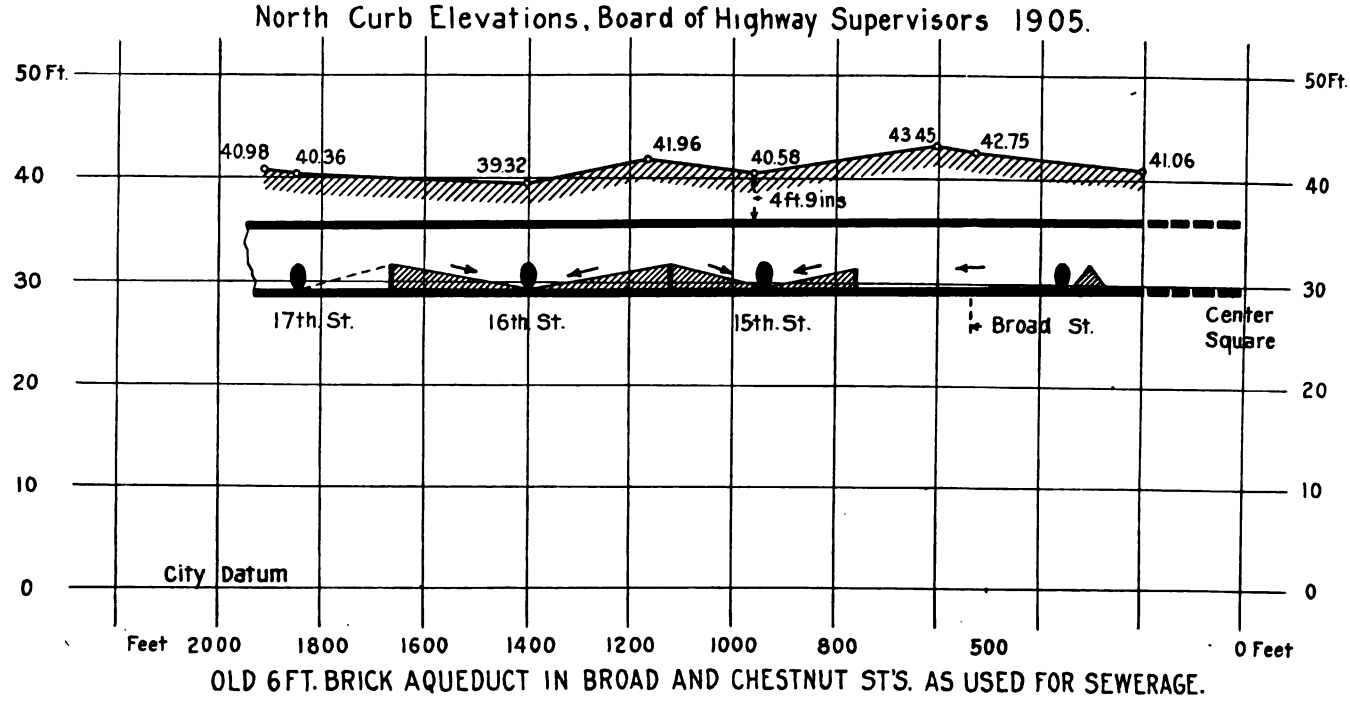

OLD 6 FT. BRICK AQUEDUCT IN BROAD AND CHESTNUT ST'S. AS USED FOR SEWERAGE.

FIG. 3.

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BENJAMIN HENRY LATROBE,
Engineer of Philadelphia's first Water Works, 1799–1801.

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FIG. 1. SCHUYLKILL PUMPING STATION, PHILADELPHIA.
BUILT 1799–1801.

(From a water-color sketch by Mumford.)

FIG. 2. CENTER SQUARE PUMPING STATION, PHILADELPHIA.
Built 1799–1801, on site of present City Hall, Broad and Market streets. Removed 1827.

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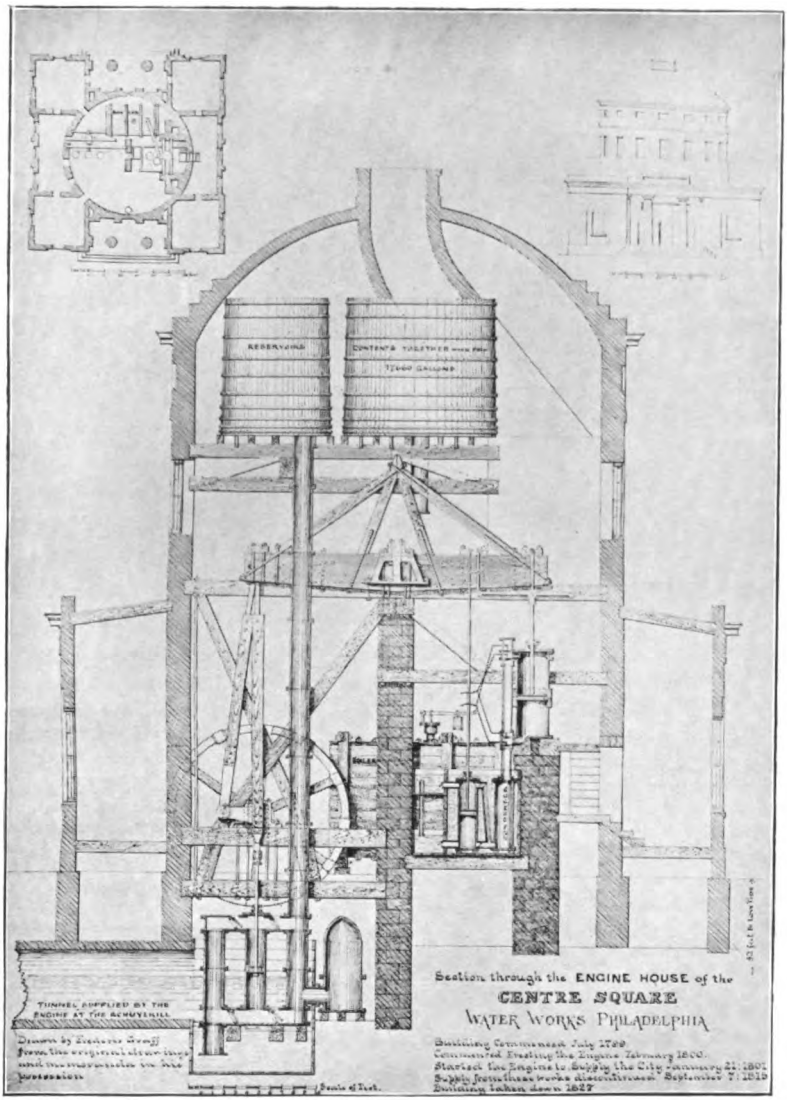

CENTER SQUARE PUMP HOUSE, PHILADELPHIA. 1799–1801.
VERTICAL SECTION.

(The distortion of the two upper figures is due to unavoidable difficulties in photographing.)

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cipal rods, beams, and shafts of the engines were also of wood, as were also the tanks, and, as we have seen, the distributing pipes. Some of the details of these boilers and engines are shown in Fig. 4.

The contractor for the engines was Nicholas I. Roosevelt, of Soho, N. J., a brother to President Roosevelt's grandfather. Nicholas, who afterward married Latrobe's daughter, was evidently a heavy loser through the contract, and the city suffered correspondingly, the " Watering Committee " finding it impossible to keep him up to time with his work. In particular, Mr. Roosevelt undertook to provide the Schuylkill engine with an " index " (probably a revolution counter). One annual report after another remarks that this " index " is not yet in place, and finally the mention of it is dropped. (See portrait, Plate IV.)

On the other hand, the city councils, then as now, found it possible to act the part of a thorn in the flesh of the engineer. Nicholas was practically bankrupted by delays in payments, and in one of his letters Latrobe writes, " First the sub-committee of the Watering Committee must assent to an agreement, then comes the Watering Committee itself, then the Common Council and the Select Council, — all avaricious, unjust, ignorant, and proud."

These first water works were completed and put in operation in 1801, but they gave most unsatisfactory service; and, the conditions having become intolerable, the old pumping stations and the conduit were abandoned in 1815, and the same distribution system was supplied by steam pumps (including one by Oliver Evans) at Fairmount, which pumped into a reservoir on the top of the rocky Fairmount hill. This reservoir, since greatly enlarged, but still one of the smaller reservoirs, and the old steam pump house, are still standing.

About 1820, a dam and breast wheels were constructed at Fairmount and the steam engines at that point abandoned.

The Fairmount works were constructed by Fred. Graff, Sr. (see portrait, Plate IV), who had been Latrobe's assistant from the beginning, and who was for many years in charge of the water works, as was his son, Fred. Graff, Jr., after him.

At the time of their completion, the Fairmount water works were one of the wonders of the world, and most of my contemporaries

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Figures accompanying "First Report of Benjamin H. Latrobe, to the American Philosophical Society, held at Philadelphia; in answer to the enquiry of the Society of Rotterdam, 'Whether any, and what improvements have been made in the construction of Steam-engines in America.'"

American Philosophical Transactions
Vol. 6, pp. 89 &c
May 20, 1803.

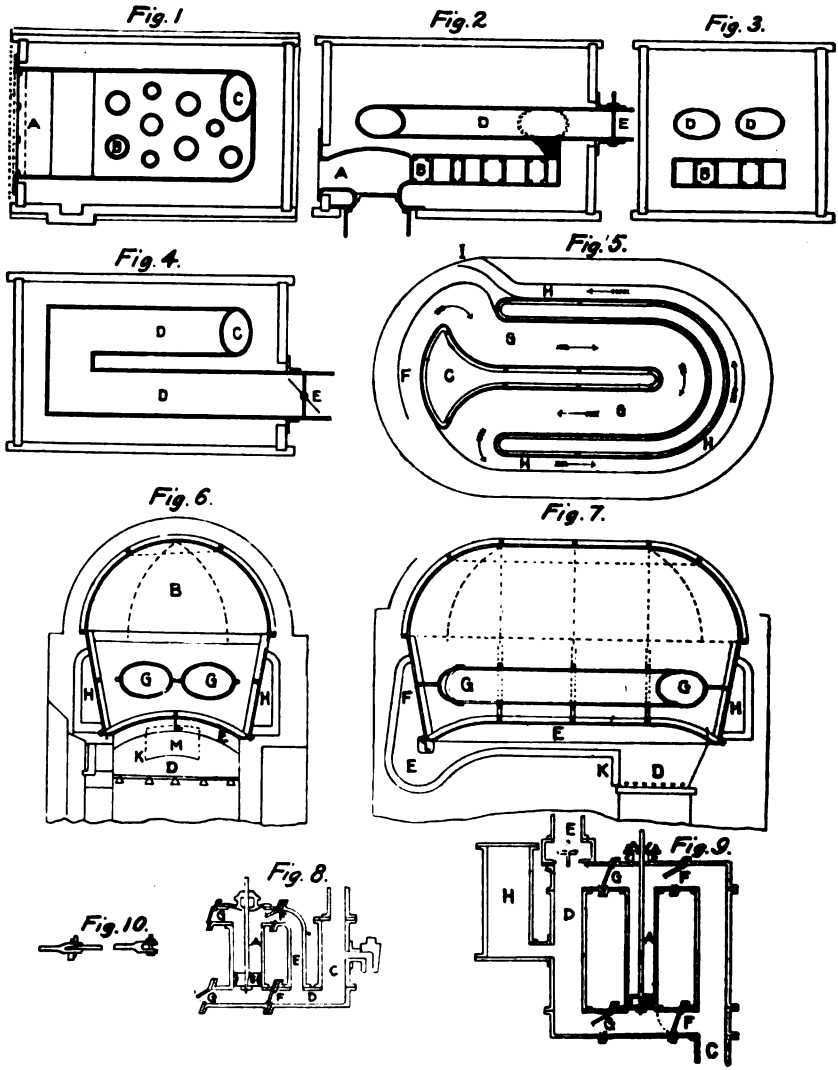

FIG. 4. BOILERS AND ENGINES, PHILADELPHIA'S FIRST WATER WORKS, 1799–1801.

(See opposite page for description of figures.)

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will remember how they figured, along with Girard College, in the descriptions of Philadelphia in the school geographies, even as late as the fifties.

In 1851 the first turbine was constructed at Fairmount, and this remained the only turbine until 1867, between which and 1874 all the breast wheels were abandoned and succeeded by six new turbines, making seven in all. This Fairmount plant supplied the entire city proper between Vine and South streets, and, under contract, some portions of the adjacent districts.

In 1854 the city increased its area from 2 to 130 square miles (its present dimensions) by taking in the outlying "districts" and all the rest of Philadelphia County, making the city and county coterminous.

In the meantime, the adjacent districts of Kensington and Spring Garden had constructed steam pumping stations of their own, the Kensington works taking water from the Delaware, and the Spring Garden works from the Schuylkill. With consolidation, these works were taken over by the city, and thereafter the water supply system of the consolidated city grew rapidly.

RECENT CONDITIONS.

Prior to the inauguration of the present filtration system, that is to say, about ten years ago, the works consisted of six pumping stations, five on the Schuylkill and one on the Delaware, those on the Schuylkill being located on the east, or left, bank of the river, except the Belmont station, which supplied that portion of the city lying west of the river. About 90 per cent. of all the water pumped was then taken from the smaller stream, the Schuylkill.

DESCRIPTION OF SMALL FIGURES MAKING UP FIG. 4.

FIGS. 1, 2, 3, 4. Wooden Boilers.
- Fig. 1. Horizontal section through A B, Fig. 2.
- Fig. 2. Vertical longitudinal section at A, Fig. 1.
- Fig. 3. Vertical cross section at D, Fig. 2.
- Fig. 4. Horizontal section through D, Fig. 2.

FIGS. 5, 6, 7. Cast Iron Boilers.
- Fig. 5. Horizontal section through G, Fig. 7.
- Fig. 6. Vertical cross section through G, Fig. 7.
- Fig. 7. Vertical longitudinal section through B D, Fig. 6.

FIG. 8. Air Pump, double acting.
FIG. 9. Main Pump, water end, double acting.
FIG. 10. Braces for cast-iron boilers.

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All of the stations, except the one at Fairmount, were operated by steam, and all pumped normally to open, elevated reservoirs, whence the water flowed, by gravity, into the distribution.

It frequently happened, however, that the pumps were unable to keep the reservoirs supplied against the enormous draft (due partly to the use of water, but much more largely to waste), and at such times it became necessary to cut off the reservoirs and to resort to direct pumpage. The dirty river water was then sent direct into our dwellings, without even the benefit of a day or two of sedimentation.

There were also three or four high-service stations, pumping to standpipes, and supplying small districts at elevations too high to be reached by the main pumping stations or supplied from the reservoirs.

The Roxborough station, that farthest up the Schuylkill, raised its water to an elevation of about 400 feet; the Fairmount, or lowest station, about 100 feet.

The Schuylkill river flows through prosperous agricultural and manufacturing districts, with numerous large and thriving manufacturing towns along its banks; so that, although cut off, by the Fairmount dam, from the major part of the city's own pollution, its waters had, long before the present filtration works were designed, become wholly unfit for household use, to say nothing of the fact that each flood in the river brought down, first, the new red shale mud from the districts near the city, and, a day or two later, the anthracite coal dust which had been stored in the navigation dams in the upper portion of the stream.

The Delaware, on the other hand, a larger stream, and flowing through a less densely populated district, was unprotected, by any dam, from the city's own pollution, which traveled upstream with every flood tide.

Notwithstanding this, no attempt at purification of the water had been made. The entire city was supplied with the same fluid which is now furnished to the central business and residence districts. With my apologies to those good people who hold that we should speak only good of our own town, I venture to assert that the conditions were ripe for improvement.

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NICHOLAS I. ROOSEVELT, BROTHER OF PRESIDENT ROOSEVELT'S GRANDFATHER, AND BUILDER OF THE TWO STEAM PUMPING ENGINES OF PHILADELPHIA'S FIRST WATER WORKS.

FREDERICK GRAFF, ASSISTANT TO B. H. LATROBE, AND AFTERWARD CHIEF ENGINEER OF PHILADELPHIA WATER WORKS.

He designed and built the steam-power, and, later, the water-power works at Fairmount.

PLATE IV.

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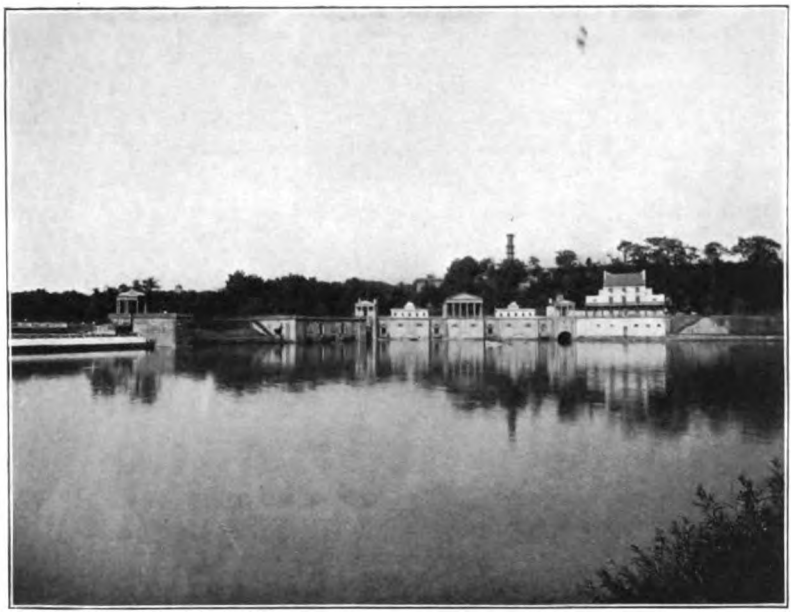

FIG. 1. FAIRMOUNT WATER WORKS, PHILADELPHIA.

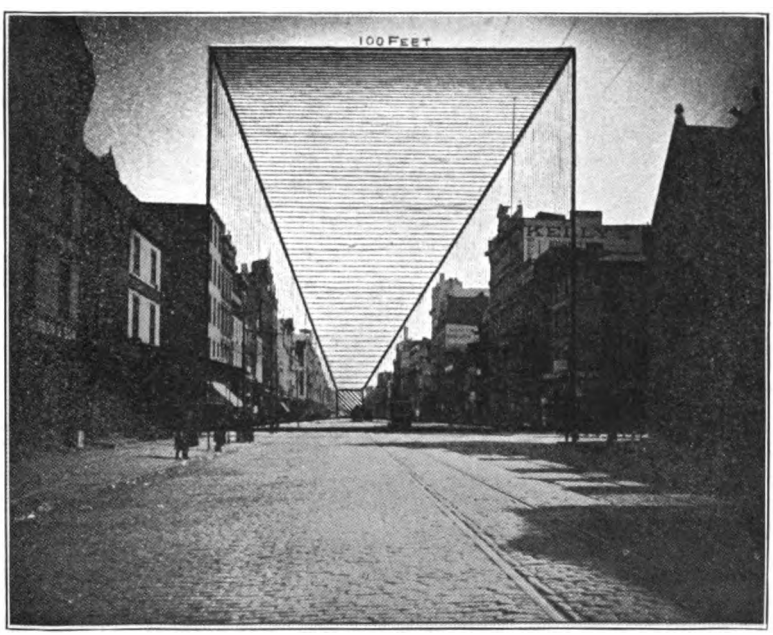

FIG. 2. 250 MILLION GALLONS.
(100 feet square, 3,300 feet long.)
MARKET STREET, LOOKING EAST FROM SEVENTH STREET TO DELAWARE RIVER.

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Not only was the quality of the water atrocious, but the supply was ridiculously inadequate, and that solely because the people gloried in throwing away, unused, at least two thirds of all the water pumped.

With the greatest water-pumping plant on earth, running night and day, straining itself to the point of destruction, and pumping something like two hundred gallons per capita daily, a large portion of the city was constantly complaining (and with excellent cause) of the insufficiency of the supply, — the pressure, over much of the area, being insufficient to carry the water above the second floor; and all because one man in five was robbing the other four, and the four insisted that the robber should not be interfered with.

The average pumpage, deduced from plunger displacement and no doubt considerably exaggerated, was about 250,000 000 gallons per day. Even allowing for exaggeration, it probably approximated at least 200 000 000 gallons.

Market Street is one hundred feet wide between house-lines; and 250 000 000 gallons would fill Market Street, to a depth of one hundred feet, from the Delaware river to 7th Street, forming a square prism one hundred feet square and three thousand feet long, as shown on Plate V, Fig. 2.

During the agitation respecting the method of improvement of the water supply, a certain homeopathic physician, apparently well informed on many subjects, remarked, in one of his discourses in eulogy of the scheme in question, that " the people of Philadelphia would never submit to having their water doled out to them by the pint."

In order to show what ballast there was in this learned remark, I had three cubical frames prepared, covered with white muslin, and photographed. The largest of these frames was a 10-foot cube, containing, therefore, 1 000 cubic feet, which the city was then selling, by meter, for " thirty cents "; the next contained 1 000 gallons, or four cents' worth, while the smallest contained 1 000 pints, or one cent's worth. These 1 000 pints will furnish six comfortable baths.

In those degenerate days, our city fathers, and the statesmen who controlled the city's operations, were intent chiefly upon

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obtaining and holding the control of things, and the sanitary condition of the city was a matter of quite secondary importance.

Although communities all about us were loudly proclaiming the benefits to be derived from the use of the water meter, our people were so densely and persistently ignorant of the matter that those who were most actively but unofficially interested in the improvement of the water supply, were ready to suppress abruptly any one who mentioned the water meter, and thereby threatened to arouse public opposition to the whole scheme of water improvement.

Under the circumstances, it is not strange that there was lively agitation for improvement. Commission after commission had studied the subject and made recommendations, most or all of which were ignored; and, as happened a hundred years before, all manner of rival schemes were actively advocated.

At this juncture, the writer found himself in charge of the Bureau of Water. He gave careful study to the subject of the improvement of the supply, both as to quantity and as to quality.

As to quantity, the result of course was that he persistently advocated the use of the water meter, and thereby not only alienated the politicians, who saw their welfare rather in the construction of unlimited pumps and "resavoys," but also lost the sympathy and coöperation of the public-spirited people who were forming themselves into associations for water improvement, and who were fearful lest all projects for improvement would be dashed by the mention of the ominous word "meter"; and this notwithstanding the fact that the city's finances at that time were (or were given out to be) such that the city could not possibly find means for the construction of works for the purification of the enormous quantities then used and wasted.

As to quality, the writer's studies had impressed him most forcibly with the facts (1) that filtration was the indicated solution of our problem; and (2) that the science of water purification was then in its infancy, that each supply must, to a great extent, be a law unto itself, and that each community must work out its own salvation with fear and trembling, and without relying slavishly upon the experiences of other communities.

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He recognized, too, that the Philadelphia system lent itself admirably to just such experimental work as was required in its case, where the supply was taken from two rivers of quite different characteristics.

The single pumping plant on the Delaware was of moderate dimensions, as were two of those upon the Schuylkill, and he urged that the first step toward the filtration of the entire supply should be the construction of a filtration plant or plants in connection with one or two of these smaller stations, said plants to contain installations of each of the systems then best and most favorably known, in order that these might be tested in actual use and in competition with each other, and that the effects of filtration upon the public health might be tested in those limited districts.

It is needless to say that this scheme, like that for the restriction of waste, found no favor with the politicians in charge, and but little, if any, with the benevolent people who were agitating for improvement, and who insisted that the supply for the whole city must be purified at once. Experiment was taboo, for it meant postponement of completion, which, by the way, has not yet been brought about.

We were told that, if a beginning were made with one or two districts, all the others would be up in arms; yet that is exactly what has been done, and no revolution has resulted. We were asked whether filtration had not then " passed beyond the experimental stage."

Among the various schemes then claiming public attention was a large and well-assorted collection of water-snakes, in the shape of benevolent corporations, each with its champions in the city councils, and each kindly proposing to bring the impoverished city out of its water difficulties.

Notable among these was the Schuylkill Valley Water Company, which proposed filtering Schuylkill water, taken below Reading, and which was getting on swimmingly in councils, with every prospect of going through, when an inconsiderate member threw the fat in the fire by announcing that he had been offered a substantial sum for his vote in favor of the company's ordinance.

That such a trifle could block a scheme of this sort shows that the harmony, which has since reigned in the councils of the domi-

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nant political party in our midst, had not then been completely established. Nowadays, any reptile cage placed before councils for approval, contains *but one* specimen, and every councilman knows what are his orders from "the front." In those days, however, the administration found itself opposed by an active and powerful faction, which ruled that all improvement of the water supply must await the inauguration of the succeeding administration which they hoped to, and which they eventually did, control.

The result of this policy is seen in the following comparison of estimates for extensions and improvements, and the corresponding appropriations, during the writer's term of service:

	Estimates.	Appropriations.
For 1896.....	$2,484 150	$0
,, 1897.....	3 339 450	0
,, 1898.....	3 735 050	0

Our boilers and engines were strained to the utmost, night and day, and in some cases disabled; there was no opportunity for thorough repairs; we dared not stop pumping during seasons of muddy water; in spite of all manner of pitiful expedients, we were compelled to cut reservoirs off from the distribution and resort to direct pumpage, in order to avoid emptying the reservoirs completely; and from all sides came loud and well-grounded complaints from citizens who paid for a water supply and did not get it.

Nevertheless, as we have seen, the Schuylkill Valley snake came within an ace of getting its appropriation of fifty millions.

During this time the city fathers passed a resolution providing that chiefs of bureaus should devote the whole (only the whole) of their time to the duties of their offices; and the practice of their honorable bodies seemed to be, when they became apprehensive lest the chief of the water bureau might not be earning his salary, to call for plans and estimates for the filtration of the city's supply. These plans and estimates were furnished, to the best of the bureau's abilities, which, at that time, were represented by an engineering force consisting of the chief draftsman and two or three subordinate draftsmen.

One of these requests for enlightenment mentioned "all the water used by the city," and the writer took advantage of the presence of the word "used" to lay before their honorable bodies

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comparative estimates of the cost of filtering (1) all the water used, and (2) all the water used *and wasted*, with results as follows:

ESTIMATED COST OF IMPROVEMENT, 1898.

	For Water Used.	For Water Used. and Wasted.
Extensions.....	$1 000 000	$5 000 000
Filtration plants ..	2 500 000	7 500 000
Meters.....	1 000 000	0
	$4,500 000	$12 500 000

THE PRESENT TRANSFORMATION.

With the advent of the Ashbridge administration, in 1899, the scene shifted. A reassessment of real estate values was made, and the city was said to be in position to borrow practically any sums which might be needed for the improvement of the water supply.

Mayor Ashbridge called in an expert commission, consisting of Messrs. Rudolph Hering, of New York; Samuel M. Gray, of Providence, R. I.; and Joseph M. Wilson, of Philadelphia, who, according to the resolution providing for their appointment, were " to act in conjunction with the chiefs of the Bureaus of Survey and Water."

These gentlemen were, of course, given all needed assistance in their studies, and, after some summer months of hard work, including several all-night sessions by Mr. Hering, their report was published, recommending " the adoption of that project by which the waters of the Schuylkill and Delaware rivers, taken within the city limits, are purified by filtration."

In the body of their report the experts said, " We earnestly recommend the introduction of meters for the city of Philadelphia"; but in their résumé and conclusions the meter was not mentioned, and the deficiency in quantity of supply was ascribed to " the lack of effective pumping machinery and to the insufficient capacity of the distributing system."

The works have cost at least double what would have been required for a lavishly ample supply under proper regulation, and it costs correspondingly to operate them.

Mayor Ashbridge had expressed the wish that the works might

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be such as to supply the city for fifty years to come, a view perhaps pardonable in a layman, who could hardly be expected to picture to himself what would be our plight to-day if *our* ancestors of fifty years ago (with the knowledge at their command) had constructed works sufficient for our present supply.

In brief, the report of the experts recommended the retention of all the existing Schuylkill pumping stations and of all but one or two of the smallest reservoirs, the adoption of rapid filtration at East Park reservoir, and of slow filtration for all the rest of the supply, the construction of a large slow-filtration plant and pumping station at Torresdale, and the abandonment of the Lardner's Point pumping station.

Plans were submitted, showing the proposed arrangements at each station and reservoir, and the relations of the several plants to each other and to the entire system.

Like the plan proposed by the experts, that now being carried out follows " that project by which the waters of the Schuylkill and Delaware rivers, taken within the city limits, are purified by filtration." In fact, the report of the experts may be said to form the basis upon which the plant is being constructed; but the two plans differ in certain important details.

The plan now being carried out involves in brief, the abandonment of the Fairmount pumping station, on the Schuylkill, and the construction of the great Delaware pumping station at Lardner's Point, instead of Torresdale; the old works at Lardner's Point to remain in service, this station being supplied with filtered water from the Torresdale filters by the celebrated Torresdale conduit, which formed no part of the plan recommended by the experts. Rapid filtration is discarded, and all the filters are of the covered slow type. The largest reservoir, East Park, will be used chiefly for emergency storage of raw water, and the largest of the old pumping stations, Spring Garden, which supplies East Park reservoir, will be held in reserve.

The long period of storage in the large upper Roxborough reservoir being deemed sufficient, preliminary filters are not used there. They are used, however, at Lower Roxborough and at Belmont, and they will be used at Queen Lane and at Torresdale.

The first preliminary filters, or " scrubbers," built in Philadel-

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phia were those at Lower Roxborough reservoir. In them the water flows vertically upward, first through coke and then through sponge.

The next were those at Belmont for the West Philadelphia supply. In these the water flows first horizontally, through coke passing a 2.5-inch mesh; then horizontally again, through coke, passing a 1-inch mesh; then upward through sponge, and finally downward through coke breeze ranging in size from dust to $\frac{3}{8}$ inch.

Both of these plants were designed and built by Mr. P. A. Maignen, and both are working satisfactorily, materially reducing the load on the main filters and permitting a higher rate of filtration through them than would otherwise be compatible with safety.

At Torresdale and at Queen Lane the preliminary filters will consist simply of a series (120 at Torresdale) of rectangular "mechanical" filters, operated without coagulant, and cleansed by reversal of current, and jets of compressed air, as in the filter plants at Little Falls, N. J., and Harrisburg, Penn.

Apart from filtration, the prominent feature of the changes now being made is a reversal of the relation of the Delaware and the Schuylkill as sources of supply, the Delaware being now made the principal source, while the Schuylkill is to be altogether subordinate. Instead of 90 per cent., the new system will take only one third of its supply from the Schuylkill.

For Queen Lane, the experts proposed utilizing the north basin and the larger portion of the south basin for sedimentation, while the remainder of the south basin was to be converted into a clear-water reservoir, and slow filters were to be built upon ground lying just north of the reservoir.

Later, the administration proposed to remove the Queen Lane pumps to the Lardner's Point (Delaware) pumping station and to use the Queen Lane reservoir for the storage of filtered water from Torresdale.

Finally, however, it has been decided to retain the Queen Lane pumping station and to strengthen the foundations of the pumps, to use the entire south basin of the reservoir for sedimentation, and to construct preliminary and slow filters over the north basin, the filtered water to be collected in the lower part of the north

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basin immediately under the filters. There will be no pumpage at the reservoir, the water passing by gravity first from the sedimentation basin to the scrubbers, then to the filters, then to the clear water basin, and finally to the distribution. The filters and scrubbers will be supported by concrete columns, piercing the

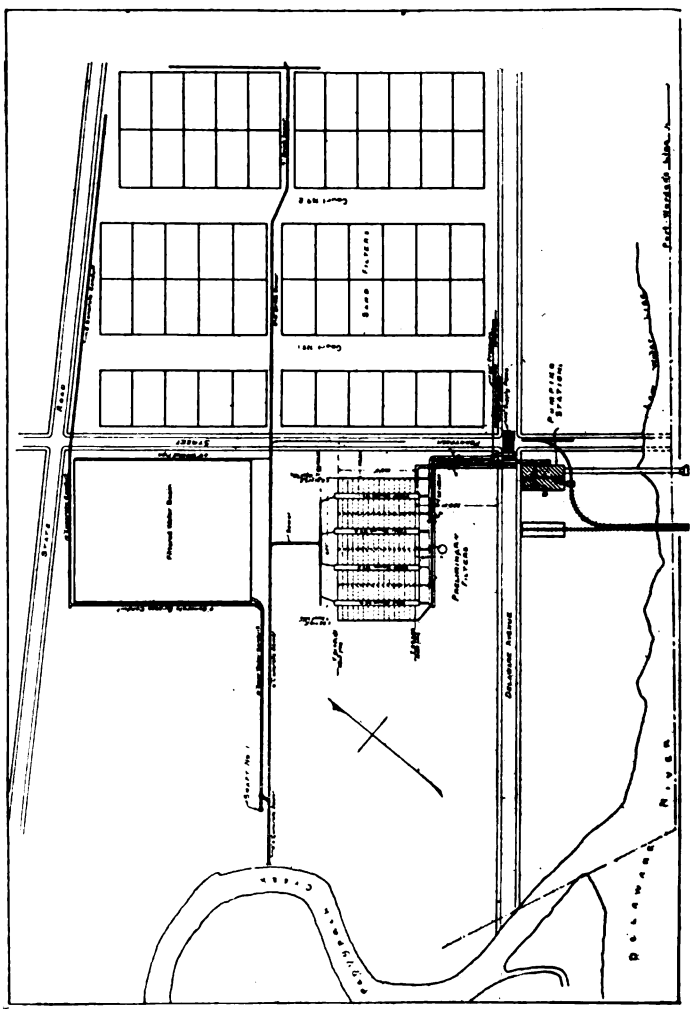

FIG. 5. PLAN OF TORRESDALE FILTER PLANT, SHOWING PUMPING STATION, PRELIMINARY FILTERS, 55 OF THE 65 SLOW FILTERS, FILTERED WATER BASIN, AND BEGINNING OF TORRESDALE CONDUIT.

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concrete and clay puddle which form the present floor of the north basin, and resting on rock foundation.

On the Delaware, at Torresdale, two and one-half miles above the former intake at Lardner's Point, a slow filtration plant, believed to be the largest in the world, is now practically completed (see Fig. 5). Here the Delaware water is first lifted by centrifugal pumps to the filters, whence it flows to the adjoining clear water basin, and thence, through the Torresdale conduit, 10 feet 7 inches in diameter and 100 feet below the surface, to the Lardner's Point station, which has been enlarged to many times its old capacity, and which, under the new system, will form by far the largest station for the city's supply, and, it is believed, the largest high-duty pumping station in the world. The new portion of this station will contain twelve new twenty-million gallon pumping engines. When completed, the Torresdale plant will contain 65 filter beds, with a total filtering area of nearly 50 acres, and a preliminary filter plant of 120 rectangular mechanical filter tanks.

Practically, the supply from Lardner's Point will be by direct pumpage of filtered water.

The old Delaware works had but one reservoir, and that a small and defective one, and the great projected Delaware system has also but one small reservoir, and this acts merely to counterbalance the expected inequality between the day and the night demand.

Connected with the Delaware system is one high-service station constructed some ten years ago.

At the risk of advertising an old friend, I will mention that this Wentz Farm high-service station contains one of the few existing d'Auria pumps, another being in operation at the Pleasantville plant which supplies Atlantic City. These pumps are unique in their means for securing high-duty, viz., an oscillating or reciprocating body of water, which acts as a liquid balance-wheel, reversing its direction of motion at each stroke of the pump. The expensive crank and fly wheel are thus dispensed with. The Philadelphia d'Auria was purchased by the Water Bureau in an emergency, and it has since had a checkered career, having been moved about from one station to another and forced to operate generally under unfavorable conditions for which it was not designed. Some years ago it found a resting-place at this little Wentz Farm

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station, where it ran for years without a condenser. This lack has been supplied, and Mr. Dunlap tells me that the pump is running well.

It may not be uninteresting to compare Mr. Hill's great Torresdale aqueduct of 1900 with Latrobe's Chestnut Street aqueduct

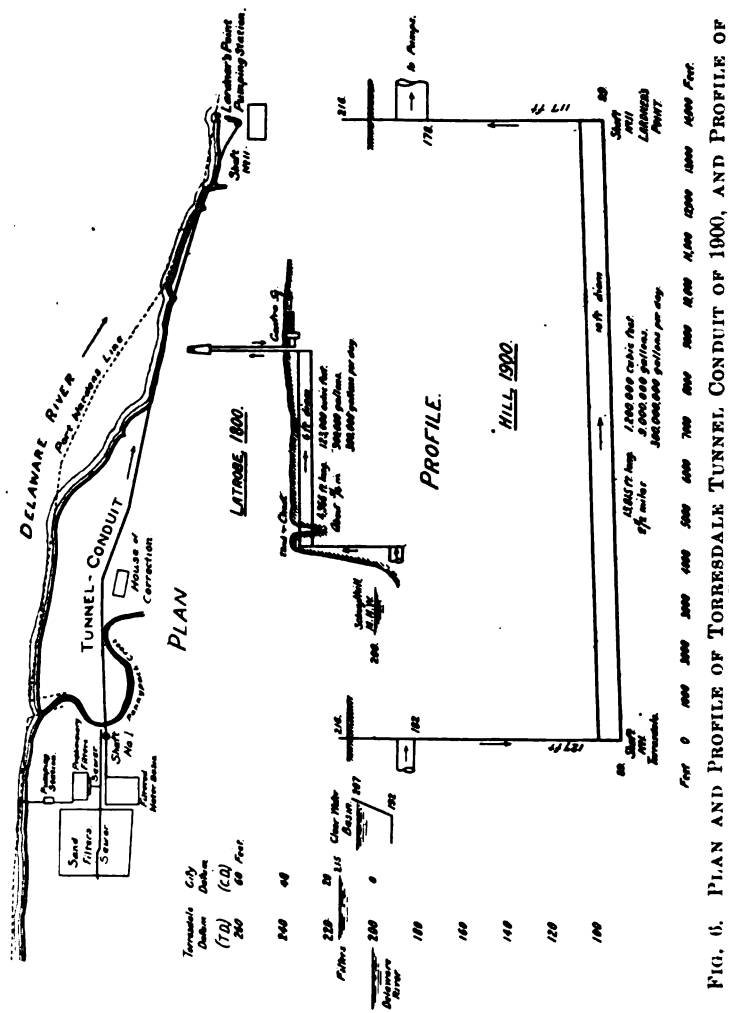

FIG. 6. PLAN AND PROFILE OF TORRESDALE TUNNEL CONDUIT OF 1900, AND PROFILE OF CONDUIT OF 1800.

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of 1800. See the accompanying illustration, Fig. 6, which shows both structures at their relative elevations.

	Latrobe.	Hill.
Date	1800	1900
Diameter, feet	6	10
Length, feet	4 366	13 815
Contents, cubic feet	123 000	1 200 000
Capacity, gallons per day	300 000	300 000 000

For convenience of flushing, both aqueducts were given a gentle inclination downward toward their points of beginning. In the Latrobe aqueduct, the flow was by gravity; the slope of the water surface of course producing the flow, notwithstanding the slope of the aqueduct itself in the opposite direction. In Mr. Hill's tunnel, the flow is under pressure, and is caused by the difference in elevation of water surface in the shafts at its two ends.

In 1905 our quiet city was convulsed by a political upheaval. The politicians aroused popular resentment by undertaking a modification of the gas-works lease. Reformers, anxious for improvement, and would-be's, anxious for power and place, seized the opportunity. Mayor Weaver threw in his lot with the new party, threw out his Directors of Safety and of Public Works, and appointed Major Cassius E. Gillette chief of the Bureau of Filtration, to succeed Mr. John W. Hill. Major Gillette, in conjunction with Mr. J. Donald Maclennan, since deceased, reported that, in various ways, the city had been defrauded of some $6 000 000 by the contractors. Thereupon work was stopped for some time, but was afterward resumed, under Major Gillette's charge. With the advent of the present administration, Major Gillette was succeeded by the present chief, Mr. Fred C. Dunlap.

The average daily consumption, during 1907, based largely upon plunger displacement, was 300 000 000 gallons.

The total daily capacity of the works when completed may be stated as 340 000 000 gallons.

The Belmont plant, which supplies all of Philadelphia west of the Schuylkill, has a total nominal capacity of 40 000 000 gallons per day. It has been supplying all, or a part, of this district with filtered water since 1904.

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The two Roxborough plants have a combined capacity of 25 000 000 gallons per day. They have been supplying their district with filtered water since 1903.

The Torresdale filter (as yet without scrubbers) in conjunction with the Lardner's Point pumping station (not yet completed) is already supplying the northeastern portion of the city, or say that portion east of Broad Street and north of Spring Garden Street.

The portion of the city not yet supplied with filtered water may be called the central and southern portion, or say the district east of Broad Street and south of Spring Garden Street, and that west of Broad Street and south of Allegheny Avenue.

The works are now filtering from 170 000 000 to 180 000 000 gallons daily. This is about half their intended final capacity and is more than an ample supply for nearly double our present population, but, as we are now wasting at least 100 gallons per capita per day, and using possibly from 50 to 70, I presume that only about one million persons, or about two thirds of our population, are at present supplied with filtered water, while the final supply, of 340 000 000 gallons daily, ample for 5 000 000 people, will be short rations for our one and a half millions.

The important works still to be completed are the preliminary filters at Torresdale, six high-duty pumps at Lardner's Point, and the Queen Lane filters. The preliminary filters at Torresdale are to be completed during the current year, and the Lardner's Point pumps early in 1909, or say ten years after the advent of the Ashbridge administration. The Queen Lane filters have not yet been advertised, and the date of their final completion must depend, to some extent, upon councilmanic appropriations, and these, in turn, of course, upon the grace of his reigning majesty, the Boss.

In round numbers, including engineering and incidental expenses, but exclusive of land damages and experimental and administrative expenses, the changes in the system since 1899, thus far completed or under contract, have cost 26 million dollars, and the work still proposed, but not yet under contract, is estimated to cost 2¼ million more, making a total of 28¼ million, of which 7 million are being expended upon the Schuylkill and 14¼ million

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upon the Delaware, 5½ million upon distribution, and 1½ million upon repairs to pumps and stations.

As it will soon be nine years since the writer was officially connected with the Philadelphia water works, he need hardly say that, for most of the information here presented respecting the status and prospects of the works, he is indebted to the present chief of the Bureau of Water, Mr. Fred C. Dunlap, who has extended, to those taking part in this convention, an invitation to visit and inspect the works under his charge.

Any account of the water supply system of Philadelphia would be incomplete without mention of its high-pressure fire service, consisting of a pumping station, at foot of Race Street, Delaware River; four lines of mains, on Race, Arch, Market, and Walnut streets; connecting lines on Second, Fifth, Eighth, and Eleventh streets; and the requisite fire hydrants. Additional connecting lines are now being laid on others of the cross streets. The system extends from the Delaware River to Broad Street. All the mains are of flanged cast-iron pipe.

On Market Street the main is 16 inches in diameter; on Race, Arch, and Walnut streets, 12-inch; and on the cross streets, 8-inch. Chestnut Street was found already so encumbered by underground structures that no attempt was made to lay a fire main there.

The pumping station contains 9 pumps, 7 of 300 horse-power each, and 2 of 150 horse-power each, driven by a gas engine, supplied with gas from the mains of the United Gas Improvement Company.

The maximum fire pressure maintained is 300 pounds per square inch.

The system has been in service for about five years.

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