Surveys, Plans, Estimates,
and Reports made and
Construction Superintended.

Compliments of

L. E. CHAPIN,

ASSOC. M. AM. SOC. C. E.,

CANTON, OHIO.

CONSULTING ENGINEER

FOR WATER WORKS,
SEWERAGE,
SEWAGE DISPOSAL
AND STREET IMPROVEMENTS.

NIMISHILLEN CREEK.

The outlet of the Canton Sewer is under the bank, as shown at the extreme left of the picture. It is for the protection of this beautiful stream from pollution that the city has built sewage disposal, or purification works on the adjacent farm, which is the property of the city.

CITY OF CANTON, OHIO.

REPORT OF THE BOARD

OF

SEWER COMMISSIONERS

FOR THE PERIOD COMMENCING OCTOBER 30, 1880,

AND ENDING APRIL 1, 1893,

COMPRISING

THE CONSTRUCTION OF A MAIN SEWER, OF LATERAL

AND STORM WATER SEWERS,

AND OF

SEWAGE DISPOSAL WORKS.

Press of The Repository Printing Company, Canton, Ohio.

044

(Extract from minutes of the proceedings of the City Council of the City of Canton, Jan 30, 1893.)

"Resolution by Mr. Campbell—

WHEREAS the Sewer Commission is about to present a report which will necessarily be quite extensive, we have therefore thought it best to have the same put in pamplet form. Therefore, be it

Resolved, That said Sewer Commissioners are hereby instructed to proceed with said work in manner as they see proper.

Adopted unanimously."

BOARD OF SEWER COMMISSIONERS.

From June 5, 1882 to February 6, 1888:

WILLIAM DANNEMILLER, President.

DANIEL PARR.

E. O. PORTMAN.

W. A. LYNCH.

JOSIAH HARTZELL, Clerk.

From February 6, 1888, to the date of this Report:

WILLIAM DANNEMILLER, President

DANIEL PARR.

E. O. PORTMAN.

W. R. DAY.

JOSIAH HARTZELL, Clerk.

CITY GOVERNMENT.

CITY OFFICERS DURING THE EXISTENCE OF THE BOARD OF SEWER COMMISSIONERS.

1882.

WILLIAM J. PIERO, Mayor.
E. M. Grimes, City Clerk.
John C. Welty, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

R. S. Shields, President.
Matthew Bast.
John C. Stinchcomb.
John Werner.
William H. McCammon.
William H. Wyant.
George Rex.
Henry T. Warner.
Arvine C. Hiner.
Abram D. Coldron.
John Murray.
Johnson Sherrick.
John P. Rauch.
Jacob P. Fawcett.

1883.

WILLIAM J. PIERO, Mayor.
E. M. Grimes, City Clerk.
John M. Myers, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

R. S. Shields, President.
Matthew Bast.
Arvine C. Hiner.
Stephen Wagner.
William H. McCammon.
John Class.
Alexander Howenstine.
Henry T. Warner.
H. W. Haines.
John H. Werner.
John Murray.
William H. Wyant.
John P. Rauch.
J. P. Fawcett.

1884.

WILLIAM J. PIERO, Mayor.
E. M. Grimes, City Clerk.
John M. Myers, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

R. S. Shields, President.
John H. Piero.
Michael Adler.
Augustus Gachatte.
John Murray.
John Webb.
David Swanger.
Henry T. Warner.
Harry W. Haines.
Stephen Wagner.
Henry A. Weaver.
John Class.
Alexander Howenstine.
J. P. Fawcett.

1885.

GEORGE REX, Mayor.
E. M. Grimes, City Clerk.
John M. Myers, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

J. P. Fawcett, President.
Ignatius G. Maline.
William Miller.
Henry Voglegesang.
Benjamin F. Rohrer.
Charles R. Frazer.
Matthew E. Meek.
John H. Piero.
Michael Adler.
Augustus Gachatte.
John Murray.
John Webb.
David Swanger.
Samuel J. Roberts.

1886.

GEORGE REX, Mayor.
E. M. Grimes, City Clerk.
John M. Myers, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

Charles R. Frazer, President.
John W. Walser.
William Volkman.
Augustus Gachatte.
Albert Ringle.
Matthew E. Meek.
Samuel J. Roberts.
Ignatius G. Maline.
William Miller.
Henry Voglegesang.
A. W. Conger.
Louis Loichot, Jr.
John E. Dine.
B. F. Schweier.

1887.

JOHN F. BLAKE, Mayor.
E. M. Grimes, City Clerk.
Atlee Pomerene, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

Daniel Worley, President.
William Volkman.
Augustus Gachatte.
Albert Ringle.
Louis Loichot, Jr.
John E. Dine.
Benjamin F. Schweier.
John W. Walser.
Henry G. Schaub.
Henry Voglegesang.
Jules Py.
O. A. Essig.
Charles H. Henderson.
William L. Alexander.

1888.

JOHN F. BLAKE, Mayor.
Henry G. Schaub, City Clerk.
Atlee Pomerene, City Solicitor.
John H. Holl, City Engineer.

COUNCIL.

Daniel Worley, President.
E. J. Donze.
Henry Voglegesang.
Jules Py.
O. A. Essig.
Charles H. Henderson.
W. L. Alexander.
Joseph H. Dumoulin.
William Volkman.
Gustave A. Fries.
Albert Ringle.
Louis A. Loichot, Jr.
John J. Adams.
Paul Field.

1889.

JOHN F. BLAKE, Mayor.
Henry G. Schaub, City Clerk.
Atlee Pomerene, City Solicitor.
John H. Holl, City Engineer, to Sept. 8.
R. R. Marble, City Engineer, from Sept. 8.

COUNCIL.

Louis A. Loichot, Jr., President.
Paul Gschwend.
E. J. Donze.
Orville L. Slentz.
Jules Py.
J. J. Adams.
Paul Field.
J. H. Dumoulin.
William Volkman.
Gustave A. Fries.
Albert Ringle.
O. A. Essig.
John Duffy.
Frederick Lied.

1890.

JOHN F. BLAKE, Mayor.
Henry G. Schaub, City Clerk.
Atlee Pomerene, City Solicitor.
R. R. Marble, City Engineer.

COUNCIL.

J. H. Dumoulin, President.
Martin Henry.
Gustave A. Fries.
J. A. Russell.
Nicholas Guirlinger.
F. Joseph Wagner.
W. E. Sefton.
E. J. Donze.
O. L. Slentz.
Jules Py.
O. A. Essig.
John Duffy.
Frederick Lied.
Paul Gschwend.

1891.

JOHN F. BLAKE, Mayor.
George W. Yohe, City Clerk, to June 23.
Wm. Lichtenwalter City Ck, from June 23.
Thomas F. Turner, City Solicitor.
R. R. Marble, City Engineer, to Sept. 8.
L. E. Chapin, City Engineer, from Sept. 8.

COUNCIL.

W. E. Sefton, President.
Joseph A. Linville.
Anthony Francis.
David L. Miller.
George W. Trump.
A. Best.
William B. Dager.
J. H. Dumoulin.
Martin Henry.
Gustave A. Fries.
John A. Russell.
Nicholas Guirlinger.
F. Joseph Wagner.
J. M. Campbell.

1892.

JOHN F. BLAKE, Mayor.
William Lichtenwalter, City Clerk.
Thomas F Turner, City Solicitor.
L. E. Chapin, City Engineer.

COUNCIL.

J. A. Linville, President.
Anthony Francis.
David L. Miller.
George W. Trump.
Andrew Best.
William B. Dager.
J. M. Campbell.
Henry T. Warner.
Ed. Sexauer.
G. Eicher.
W. C. Dahinden.
F. Joseph Wagner.
H. W. Detmering.

REPORT.

To the Honorable Mayor, and President and Members of the City Council of the City of Canton:

It has been deemed best that a statement should be made by the Board of Sewer Commissioners descriptive of the sewer system, and of the more important events affecting its construction. We therefore beg leave to submit the following report:

The census of 1880 gave Canton a population of 12,258. The three or four last years of the preceding decade had been characterized by unusual activity. Each year witnessed a larger addition to the population, and improvements, both public and private, were assuming proportions of greater importance. The city water works had already been in operation for ten years.

The subject of sewers was beginning to engage the attention of reflecting citizens. In the absence of sewers the advantages afforded by the water supply were largely curtailed. The influx of water without drainage, imposed heavy burdens. The retention of house wastes on the thickly settled areas was a menace to health. Certain large enterprises, and permanent street improvements, could be intelligently undertaken only after a sewer system had been introduced.

The needs of our situation were diligently urged upon the public attention; the arguments in favor of sewer drainage were also combatted with assiduity. The first tangible result of this agitation appeared in a successful effort to obtain an opinion from Col. George E. Waring, Jr., in regard to a sewer system for Canton. Col. Waring visited the city in the fall of 1880, and subsequently presented his report. The portions of the report that were most directly applicable to the problem of Canton sewerage were as follows:

COL. WARING RECOMMENDS THE SEPARATE SYSTEM.

To the Mayor and Common Council of the City of Canton:

There has been a modification in the size, and a vast improvement in the construction of sewers within the past thirty years—or since the introduction of earthenware pipes; but the old custom is still almost universal—the use of pipes has only modified it—and instances of the separation of surface water and household waste are very recent.

My own idea is that not only should surface water and household waste be removed by separate means, but that their removal should be considered, or may be considered as quite distinct problems.

It is evident from an examination of your streets that an argument to spend money for construction of engineering works to get rid of the surface water which falls in Canton would make no converts. I believe that the number is very large of those who consider the introduction of some system by which the filth of the town may be properly removed the most important question now before the public. I propose to treat this latter question without involving it in any way with the former. That is to say, I advise leaving the storm water question to take care of itself, and consider the removal of foul sewage without the least reference to it.

I send herewith a tracing of the map of the city, with sewers laid down as accurately as the information in my possession as to the slopes of the ground will allow. These slopes were constructed, as shown by the blue lines on the tracing, from levels received before my visit. They have been somewhat modified according to the corrected lines, but these were not transferred to the tracing, as it was not thought worth while at this time to go to the additional expense.

Accurate surveys, made with a view to the execution of the work, would doubtless modify the direction of some of these sewers, but not in such a manner as to make any material difference in the general plan, or in the cost of its execution.

The main outlet of the sewer is 15 inches in diameter from the dam up to the junction of the Poplar street and Plum street system.

From this junction along the railroad to Cherry street it is 12 inches in diameter, that size having been continued to Cherry street, in order to provide an outlet for the eastern part of the town when it shall be sewered.

The sewer in Walnut street is 10 inches in diameter.

The rest of the material is mainly of six-inch pipe—eight inch being used where a number of laterals come together.

The streets in which the sewers are laid have been selected with very much less information than would be necessary for the final plan ; it is quite likely that some streets are included that ought to have been omitted, and that some are omitted which ought to have been included. The only object aimed at has been to give an intelligent idea of the manner in which it is proposed to do the work, and to furnish a basis for a somewhat accurate estimate of its cost. It will be easy to judge the cost of any necessary alterations."

Col. Waring then quotes from a statement made by him before the American Public Health Association at Nashville in 1879, showing the manner in which his system is applied, as follows :

"The discussion between the advocates of the combined and the separate systems of sewerage, especially in England, has long been active. The issue between them seemed doubtful until the matter of agricultural or chemical purification of the effluent became prominent.

The arguments in favor of the exclusion of storm water from the sewers proper seems to me so conclusive that I no longer hesitate to accept such separation as essential to the best sanitary sewerage.

Sewers large enough to remove storm water, according to the usual formula, are open to several serious objections :

1. The question of cost is so often the controlling question, even in improvements of most vital importance, that the expense entailed by the construction of storm water sewers constitutes an insuperable obstacle in the case of many a small town where sewerage is not necessary. Even in the larger cities the expenditure in this direction might sometimes, if not always, be economized for the benefit of other necessary work.

2. The larger the sewer the more difficult becomes the matter of its ventilation.

3. Cases are extremely rare where sewers of the storm water size are not, at least during the hot and dry season, sewers of deposit to such an extent as to have their air made most foul by the decomposition of their sediment.

4. Where the question of final disposal has been important, the admixture of storm water with the sewage leads to the constant embarrassment of the system, whether the process be chemical or agricultural.

The carrying of surface water to a depth of ten or fifteen feet below the surface seems to be at least unnecessary. Street wash can be safely admitted to sewers only after passing through settling basins, and these are sure to accumulate an offensive and dangerous amount of decomposing filth.

I believe that one of the most important improvements that we are destined to see is the removal of storm water, as far as possible, by surface gutters—carrying away the greater accumulations through very shallow conduits ; largely, perhaps, through covered gutters, easily accessible for cleansing and flushing.

In my judgment a perfect system of sanitary sewerage, for a small town or a large one, would be something like the following :

No sewer should be used of a smaller diameter than six inches: (a) because it will not be safe to adopt a smaller size than four inch for house drains, and the sewer must be large enough surely to remove whatever may be delivered by these; (b) because a smaller pipe than six inch would be less readily ventilated than is desirable; (c) and because it is not necessary to adopt a smaller radius than three inches to secure a cleansing of the channel by reasonably copious flushing.

No sewer should be more than six inches in diameter until it and its branches have accumulated a sufficient flow at the hour of greatest use to fill this size half full, because the use of a larger size would be wasteful, and because when a sufficient ventilating capacity is secured, as it is in the use of a six inch pipe, the ventilation becomes less complete as the size increases—leaving a larger volume of contained air to be moved by the friction of current or by extraneous influences, or to be acted upon by changes of temperature and of volume of flow within the sewer. The size should be increased gradually and only so rapidly as is made necessary by the filling of the sewer half full at the hour of greatest flow.

Every point of the sewer should, by the use of gaskets or otherwise, be protected against the least intrusion of cement, which in spite of the greatest care, creates a roughness that is liable to accumulate obstructions.

The upper end of each branch sewer should be provided with a Field's flush tank of sufficient capacity to insure the thorough daily cleansing of so much of the conduit as from its limited flow is liable to deposit matters by the way.

There should be sufficient man-holes, covered by open gratings, to admit air for ventilation. If the directions already given are adhered to, man-holes will not be necessary for cleansing.

The use of the flush tank will be a safeguard against deposit. With the system of ventilation about to be described, it will suffice to place the man-holes at intervals of not less than 1,000 feet.

For the complete ventilation of the sewers it should be made compulsory for every house-holder to make his connection without a trap, and to continue his soil-pipe to a point above the roof of his house. That is, every house connection should furnish an uninterrupted ventilation channel four inches in diameter throughout its entire length. This is directly the reverse of the system of connection that should be adopted in the case of storm water and street wash sewers. These are foul, and the volume of their contained air is too great to be thoroughly ventilated by such appliances. Their atmosphere contains too much of the impure gases to make it prudent to discharge it through house drains and soil pipes.

With the system of small pipes now described, the flushing would be so constant and complete, and the amount of ventilation furnished, as compared with the amount of air to be changed, would be so great, that what is popularly known as sewer gas would never exist in any part of the public drains. Even the gases produced in the traps and pipes of the house itself would be amply rectified, diluted, and removed by the constant movement of air through the latter.

All house connections with sewers should be through inlets entering in the direction of the flow, and these inlets should be funnel-shaped so that their flow may be delivered at the bottom of the sewer, and so they may withdraw the air from its crown; that is, the vertical diameter of the inlet at its point of junction should be the same as the diameter of the sewer.

All changes of direction should be on gradual curves, and, as a matter of course, the fall of the head of each branch to the outlet should be continuous. The reduction of grade within these limits, if considerable, should always be gradual.

So far as circumstances will allow, the drains should be brought together, and they should finally discharge through one, or a few main outlets.

The outlet, if water-locked, should have ample means for the admission of fresh air. If open, its mouth should be protected against the direct action of the wind.

It will be seen that the system of sewerage here described is radically different from the usual practice. I believe that it is, in all essential particulars, much better adapted to the purposes of sanitary drainage. It is cleaner, is much more completely ventilated, and is more exactly suited to the work to be performed. It obviates the filthy accumulation of street manure in catch-basins and sewers, and it discharges all that is delivered to it at the point of the ultimate outlet outside the town, before decomposition can ever begin. If the discharge is of domestic sewage only, its solid matter will be consumed by fishes; if it is delivered into a water-course, its dissolved material will be taken up by aquatic vegetation.

The limited quantity and the uniform volume of the sewage, together with the absence of dilution by rain-fall, will make its disposal by agricultural or chemical processes easy and reliable.

The cost of construction, as compared with that of most restricted storm-water sewers, will be so small as to bring the improvement within the reach of the smaller communities.

In other words, while the system is, in my judgment, the best for large cities, it is the only one that can be afforded in the case of small towns."

Col. Waring concludes his report in regard to proposed sewers for Canton as follows:

"The flush tanks referred to in this paper as being placed at the heads of the laterals, are on this plan 37 in number. They would be supplied from the public water-works with a trickling stream sufficient to fill them (about 112 gallons each) in from fifteen to twenty-four hours. When filled they would discharge themselves very rapidly and wash the whole system clean.

As Schriver's run furnishes an abundant supply of water for the purpose I have thought best, in order to insure an effective flushing of the whole main line, to build a tank of ten thousand gallons capacity at the crossing of Walnut and North streets to be supplied from this stream, to discharge as often as may be thought necessary. There is no reason why this may not be daily.

I estimate the total cost of the work to be as follows:

6,900 feet sewer costing		$6,713.00
1,900 feet sewer costing		1,349.00
3,350 feet sewer costing		2,178.00
4,450 feet sewer costing		2,136.00
38,950 feet sewer costing		15,969.00
55,550	Total	$28,345.00
1 large flush tank		600.00
37 small flush tanks		1,850.00
35 fresh air inlets		2,100.00
Iron pipe across creek at outlet		1,000.00
Total		$33,895.00
Add for contingencies ten per cent		3,390.00
Total		$37,285.00
Engineering, inspection and superintendence		5,593.00
Grand total		$42,878.00

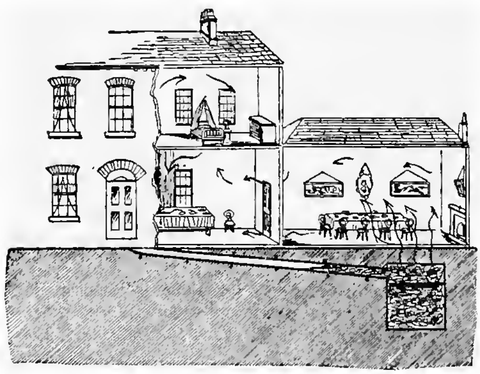
Although the allowances on this estimate are doubtless larger than are required, as there is no probability of rock being encountered, still, to make the estimates amply large, it may be best to fix the whole cost at $45,000.00.

Very respectfully yours,

GEO. E. WARING,

Newport, R. I., October 30, 1880. Consulting Engineer."

The Canton Sewers, as finally constructed, exhibit considerable deviation from Col. Waring's recommendations; but these changes apply only to collateral details. The system he proposed was generally adhered to. As a matter of fact the city's population had almost doubled between the date of Col. Waring's visit and the time when sewer connection commenced, in 1888. He anticipated these changes, as is seen by his statement that his plan is based upon "Very much less information than would be necessary for the final plan." He says also that "The only object aimed at has been to give an intelligent idea of the manner in which it is proposed to do the work."



Locate cess-pool as far from kitchen as possible. If a sewer is available abolish the cess-pool and make a safe connection with the sewer without delay.

A BOARD OF SEWER COMMISSIONERS IS CREATED.

No action was taken by the Council in regard to Col. Waring's report. The need of sewers, and their advantages, and the rapidly increasing foulness of the city, and the dangers of delay, were pressed upon public attention through the newspapers with considerable vigor. At length the Council, on

June 5th, 1882, took action looking to the creation of a Sewer Board by the passage of the following ordinance:

AN ORDINANCE Authorizing Five Persons to Constitute the Board of Commissioners of Sewers of City of Canton and Prescribing their Duties:

WHEREAS, In the opinion of the City Council of the city of Canton, Ohio: That many and manifest reasons, especially the health of the inhabitants of said city, demand that a system of sewerage and drainage be provided for said city, and in order to establish proper sewer districts in said city, therefore,

SECTION I. Be it ordained by the City Council of the city of Canton. O.: That there be appointed by the Mayor of said city subject to the confirmation of the City Council of said city, five persons, one of whom shall be appointed for one year, one for two years, one for three years, one for four years and one for five years, and yearly thereafter one shall be appointed to serve for a term of five years, to constitute the Board of Commissioners of Sewers, and they shall serve without compensation.

SEC. II. That it shall be the duty of the said Board of Commissioners of Sewers of said city to fix the boundary lines of each sewer district in said city according to the natural drainage, and that said board shall, as soon as convenient for them report to said Council of said city, plans, specifications and estimates of a main sewer, which shall be properly located looking to the drainage of that part of said city needing immediate sewerage.

SEC. III. That if, in the opinion of said Council, said main sewer shall be built as reported by said Board of Commissioners of Sewers after the cost thereof has been estimated and reported, said Council shall provide that the necessary means to construct said main sewer shall be collected under and by virtue of the special assessment plan which provides that the entire expense of sewerage of each sewer district shall be paid by each of said sewer districts except what is in excess of the amount necessary to build an ordinary street sewer of sufficient capacity to drain or sewer said street on which said main sewer is located. Such excess shall be paid by general taxation on all property in said city as required by law, and that the expense of all lateral sewers to be paid by the owners of property abutting on said street where such lateral sewers shall be located, and by owners of adjacent property benefitted thereby. The necessary means to construct said main sewer to be provided for in advance of the contract to build said sewer, as the Council hereafter may direct.

SEC. IV. That the Mayor shall appoint said members of the Board of said Commissioners of Sewers subject to the confirmation of the City Council on or before April 1, 1882, and one member yearly thereafter to serve as in this ordinance provided.

SEC. V. That this ordinance shall take effect and be in force from and after its passage and due publication. Passed March 6th, 1882.

The Mayor, Wm. J. Piero, appointed the following as Sewer Commissioners:

William Dannemiller for five years;

Josiah Hartzell for four years;

William A. Lynch for three years;

E. O. Portman for two years;

Daniel Parr for one year;

The appointments were confirmed by the Council.

The Board was organized by the election of William Dannemiller as President, and Josiah Hartzell as Clerk.

There were no funds available for sewer. work, either in possession or anticipation. The efforts of the new Board were therefore restricted to the preliminary duty of carefully considering the subject with a view to determining upon the wisest course of proceedure.

The first practical step was to select a Consulting Engineer under whose supervision detailed maps, plans and specifications could be prepared. If the choice of a large proportion of our citizens was to have weight, an engineer who would provide the city with a combined sewer built of brick, would have been preferred.

On the other hand the more modern plan, the small pipe sewers, for house wastes only, had its adherents.

The employment of an engineer was, of itself, an act which, to all intents and purposes, decided the question as to which system of sewers Canton was to have. Such was the view taken by the Board of Sewer Commissioners. The Board decided to adopt the Separate System.

REASONS FOR ADOPTING THE SEPARATE SYSTEM.

Inasmuch as the city had delegated to the Board of Sewer Commissioners the important duty of deciding these questions, upon which health, taxation, and the future prosperity of the city would depend, and inasmuch as this decisive action of the Board was unfavorably commented upon, both at the time and subsequently, it is proper here to present some of the reasons which supported their conclusion. And in glancing over these facts it is well to bear in mind that facts and experiments in support of such action were by no means so abundant ten years ago as now. It is, however, a source of congratulation to know that the history of the art of sewer-building during all these years has been a continuous and irrefragable vindication of the action of the Board.

SIGNIFICANT EXPERIMENTS.

Pipes of stoneware are said to have been first used in London, about 1846, being inserted in place of brick and stone sewers for the purpose of decreasing the diameters sufficiently to make them self cleansing.

In view of the results obtained a distinguished sanitary engineer said: "Every sewer as formerly made is an elongated retort; the sewage is the organic compound from which the foul gases are generated, and the drains which convey the sewage into it from the openings in the sinks and the closet pans are the necks from it, carrying the gases up into the sewer openings, from which they pass into the houses."

Several of the earlier experiments were described, as follows:

"The sewer in upper George street, London, is five and one-half feet high by three and one-half feet wide, draining a built area of 44 acres. In the bottom of this sewer was laid a 12-inch pipe 560 feet long, and a dam was built at the upper end, thus forcing the sewage of the whole area to pass through this pipe. The velocity of the water in the pipe was found to be four and one-half times greater than on the bed of the old sewer and its drainage power twenty times that of the old sewer in proportion to its size. In one trial a quantity of sand, brick-bats and stone was thrown into the head of the pipe and the whole of this was passed through the pipe and deposited some distance from the lower end. 'It was found that this 12-inch pipe was of ample size to drain the 44 acres, and indeed, it was rarely ever more than half full at its head, though the sum of the cross sections of the house drains delivering into this half-full 12-inch pipe was equal to a circle 30 feet in diameter.'

"Another experiment was made with the Earl street sewer, which took the drainage from 1,200 average size London houses, occupying a paved or covered surface of 43 acres. The sewer had a sectional area of 15 feet, and an average fall of 1 in 118, and the soil deposits from 1,200 houses accumulated 6,000 cubic feet per month. A 15-inch pipe was placed in this sewer with an inclination of 1 in 153, and it was kept perfectly clear of deposit. 'The average flow from each house was about 51 gallons per day, and apart from the rainfall the 1,200 houses could have been drained by a 5-inch pipe.'"

Says one writer: "Only a few years ago it was estimated that the sewage proper of London might be discharged through a sewer three feet in diameter, yet there is scarcely a town of 5,000 inhabitants whose officers would be satisfied with one of less size."

Col. Geo. E. Waring, who was the first to recommend for Canton the system which is now put in, gives an example of the capacity of small pipes in a case where a six-inch pipe was used to drain one detached house. "One after another as new houses were built new drains were connected with the same pipe, until after a time it was found to be clean and in perfect order, though carrying all the drainage for 150 houses."

A similar set of experiments was made in St. Louis, in the summer of 1880, by Sewer Commissioner Moore, with the following results:

"The first sewer experimented on was seven and one-quarter feet in diameter, draining an area of 440 acres, upon which 1,370 houses were inhabited by 11,000 people. A dam was built across the sewer and a 12-inch pipe inserted. The greatest depth of flow was six and one-half inches. The second sewer drained an area of 155 acres, being in size 3½ by 4½ feet. This was treated in the same manner, with the exception that a nine-inch pipe was inserted. The greatest depth of flow here was also found to be 6½ inches. These results indicate a consumption equal to 80 gallons of water per day for each inhabitant."

GENERAL OPPOSITION TO SEPARATE SEWERS.

As has been already intimated, the early innovations of the smaller bore sewers had to be built under protest. An early departure in this respect was undertaken by Col. Waring at Saratoga, N. Y., in 1875. The main sewer was not very small, being three feet in diameter. Mr. Waring says: "From the very beginning of the work it encountered the most violent opposition on the part of many citizens who believed the sewer would be entirely inadequate. We were constantly reminded that one hotel had a main drain 18 inches in diameter; another one 2½ feet in diameter, and that it was madness, with these drains as our guide, to attempt to accomplish the whole work with a three-foot sewer."

It is needless to say that when the sewer was completed, and these same landlords and respectable fossils saw that all the sewage flow in the morning, at the hour of the largest flow, might have been discharged through a 2½ inch pipe, they changed their tune.

Col. Waring adds, speaking of this Saratoga sewer: "I can excuse my course in recommending so large a sewer as one of three feet only by the fact that, in the state of public opinion then, it would have been impossible to secure the making of anything smaller."

THE MEMPHIS SEWERS.

In the entire history of sewer building no event called forth such general comment as the new Memphis sewers, built under the supervision of Col. Waring, in 1880. The distinctive features of that system were:

1. The small pipes used. In Memphis the largest sewer (brick) is only twenty inches in diameter. The pipes from the houses to the street connections are uniformly four (4) inches and are glazed sewer tiling with cemented joints. The next sizes are 6, 8, 10, 12 and 15 inches.

2. At the end of each extension there is a flushing tank with a capacity of 120 gallons of water, which empties itself automatically at stated intervals.

3. All surface water, street washings, and even the roof and house-yard water is excluded from the drains.

4. All sewage, liquid or solid, kitchen and laundry slops, and factory liquid refuse is admitted.

5. There are no man-holes, nor catch basins, and the pipes are ventilated by shafts in connection with each house.

6. The sewage and all liquids entering the pipes, owing to the small size of the pipes, is carried on so rapidly, especially by the copious and systematic flushings, that the pipes are kept perfectly clean, and no decomposition or fermentation of the sewage takes place before it finds its way to its place of disposal.

7. The cost of construction and maintenance is about one-tenth of the old combined system, where storm water and all surface water must be provided for in some sewer.

The actual cost of construction was $187,000. For the sewerage of the same area by the combined plan the estimates ranged from $800,000 to $2,225,000.

This experiment engaged the attention of engineers throughout the world. In November, 1880, a report on the Memphis plan was presented to the American Society of Civil Engineers. After full discussion this conclusion was reached:

"With the results already achieved by this small-pipe system of sewerage, it seems safe to predict that a new era has been inaugurated, and that the coming years will witness great modifications in the prevailing methods of sewerage."

The "Social Statistics of the Cities of the United States," Tenth Census, contains the report of an examination of the Memphis Sewers, of which this is the last paragraph:

"Neither in removing obstructions, in cleansing the main sewers, nor in connecting house drains is the odor of sewer-gas ever observed."

The following letter is self-explanatory:

U. S. ENGINEER'S OFFICE,
MEMPHIS, TENN.,
October 9, 1880.

To the Mayor and Common Council, City of Newport, R. I.:

Having been requested to give my opinion in regard to the system of sewerage adopted for the city of Memphis, I desire to state that I have closely observed the work from its very inception and have made frequent inspections in order to observe the workings or the different parts. While the entire work has not been completed—though nearly so—I am perfectly satisfied that the success or the system is assured. The sizes of the pipes adopted and their arrangement are amply sufficient to carry off all the flow, and the addition of the flush tanks assures at all times a freedom from accumulated matter. Everything works admirably.

Very respectfully,
[SIGNED.] W. H. H. BENYAURD,
Major Engineers.

Dr. J. F. Kennedy, Secretary of the Iowa Board of Health, made a personal visit of inspection, and as the result, recommended the separate system for use in the cities of that State. The same course was pursued by other health officers.

The weight of English authority, comprising the most eminent engineers, preponderated heavily on the side of the separate system.

The Government Chronicle (London) after a careful review of the new Memphis experiment, and its workings up to September, 1880, put one of its conclusions into these words:

"In short, it seems clear that a sufficient case has been made out to cause any sanitary authority which is proposing to adopt a system of large storm-water sewers, to pause and enquire whether small sewers for the reception of sewage only, carefully laid, and periodically flushed by means of proper flush-tanks, would not be better and cheaper, and at the same time healthier. The large sewers in dry seasons are only too likely to become sewers of deposit; to leak and give off offensive odors; whereas the smaller ones, if properly laid and regularly flushed, may be kept equally clean the whole year around."

Already, in 1883, a portion of Paris, France, had been sewered by the Waring plan. In his report M. Pontzen, the engineer in charge, states the following conclusions:

"The first application of sewerage according to Waring's system, made in Paris in 1883, in a quarter where all of the unfavorable conditions are combined, has been a complete success.

"The establishments drained by Waring's system leave nothing further to be desired in a sanitary point of view, and the *ensemble* of the drainage work has not, during the five months it has been in operation given rise to the least complaint.

"The establishment and maintenance of a system of sewers according to Waring's system has in all cases the advantage of being economical.

"PARIS, May, 1884."

A direct inquiry, addressed to the Memphis Board of Health, brought the following response :

OFFICE OF THE BOARD OF HEALTH,
MEMPHIS, TENN,
May 21, 1882.

Josiah Hartzell, Esq., Canton, O.:

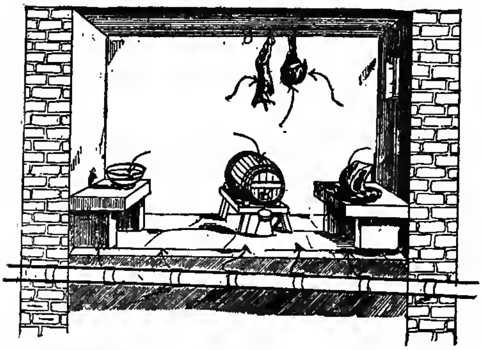
DEAR SIR :—Your inquiry in regard to the Waring system of sewerage has remained unanswered longer than I had intended it should, and I herewith apologize for the delay.

So far the Waring system has fulfilled all that was expected of it. By all observers it is declared a success. It is an utter impossibility for the sewers to cause an increase of the mortality, for there is a stream of water continually flowing through the pipes, and there is no accumulation of effete material anywhere. It is carried off and emptied into the river. There is no formation of sewer gas throughout the course of the pipes, and in opening a man-hole in any portion of the city, not the faintest odor can be detected. Probably our death rate was some larger last year than the year before, but that may be accounted for by an increase of our population. The authorities here are highly pleased with the sewers, and think them to be quite an advantage to our city.

Very truly yours, J. H. BURNELL,
Secretary Board of Health.

The last official report of the City Engineer of Memphis, published in 1891, says :

"The system in the main has so far worked admirably and has given entire satisfaction."



The Canton ordinance requires iron soil pipe to be placed under houses. One of the reasons for this is made plain by the above picture.

KEENE, N. H.

The city of Keene, N. H., was sewered on the Memphis plan in 1882. Inquiries as to the workings of the system were responded to by the Mayor as follows :

(1882.) "So far as completed it worked well. No arrangements were made for carrying off surface water; this took the old channels.

(1883.) "Has worked with perfect success like clock work. There has been no trouble with the flush-tanks, the water in them has not frozen.

(1884.) "It seems to me also that the construction of our sewers is as nearly perfect as can be, from the fact that no impediments to a steady flow have been discovered from the beginning, and I have not heard that any one of the forty-four flush-tanks has failed at any time to perform its duty with accuracy. There has not been a single stoppage of the pipes."

WEST TROY, N. Y.

West Troy, N. Y., was sewered by the separate system. An inquiry was thus responded to by Geo. H. Kimberly, a prominent business man :

"The whole sewer system has worked well thus far, and given satisfaction. The parties who were *sure* the pipes were *too small* and that they would fill up, will have to wait longer to see their prediction fulfilled."

LENOX, MASS.

Mr. William D. Curtis, Chief of the Dist., Com. of Lenox, Mass., replied to an inquiry as follows :

"*Josiah Hartzell, Esq.:*

"DEAR SIR :—Our sewers, put in by Col. Waring, of Newport, R. I., work very satisfactorily. The small pipe system has the advantage of being easily flushed and kept sweet and clean."

OMAHA, NEB.

Mr. D. H. Goodrich, Superintendent of Water Works, Omaha, Neb., responded as follows, March 15, 1883 :

"*Josiah Hartzell, Esq., Canton, O.:*

"DEAR SIR :—I have your favor of the 13th inst., in relation to the Waring sewer system. We have nothing to do with sewers in this office directly, but of course I feel deeply interested in their development.

"After much opposition the Waring system was adopted for the larger portion of the city. It has so far been a decided success. In connection we have with this, however, a system of storm water sewers which are necessary in nearly all cities. These are very costly as compared with the Waring. There is probably no doubt as to this latter being the best, at the least cost, and for the largest number."

The following extracts from the last annual message of the Mayor of Omaha, Neb., explains itself : "The health of the city depends in a great measure upon its supply of water and upon its system of sewerage. It is gratifying to know that our city is free from the odious gases and odors that in most other cities are emitted from sewers at every corner of their streets. According to the report of the sewer inspector there was but $2,285.09 expended for salaries and in keeping our system in good working condition. This is certainly a very small sum. There can be no doubt that the Waring system of sewerage is, for sanitary purposes, the best ever devised. It is not intended for storm water or waste water from elevators, and in the business portion of the city other means will have to be provided for the overflow from the latter."

YOUNGSTOWN, OHIO.

At a convention of the Ohio State Sanitary Association, held in Mansfield, February 24, 1883, Dr. John McCurdy, a prominent citizen of Youngstown, said : "The Youngstown people are using the large brick sewers which have cost them nearly $200,000, and notwithstanding this great expense the system is a failure from a sanitary point of view."

In the general discussion which followed the small pipe sewer, which could be easily flushed, was unanimously considered the best.

OPINION OF THE ENGLISH HEALTH BOARD.

This Board was composed of the most widely known and authoritative Sanitary Specialists. Their "General Conclusions," after a thorough investigation of the whole subject of sewerage, were embodied under five heads. Number 4 reads as follows:

"That brick and stone house drains are false in principle, wasteful in cleaning, construction, and repairs. That house drains and sewers, properly constructed of vitrified stone-ware, detain and accumulate no deposit, emit no offensive odor, and require no additional surplus of water to keep them clean."

ENGLISH ENGINEERING OPINION.

In 1881, James T. Gardiner, C. E., Director of the New York State Survey, was employed to make a report to the State Board of Health on the methods of sewerage for cities. On page 6 of this report is this paragraph:

"I visited in London the sanitary department of the Local Government Board which has general supervision of the sanitary affairs of England. The Chief Engineer, Mr. Robert Rawlinson, C. E., and the principal medical inspectors, Dr. Ballard and Mr. Radcliffe, are perfectly agreed that the combined sewer system is radically defective from a sanitary standpoint. In this opinion Dr. Richardson, and other prominent sanitarians concurred. At the meeting of the British Association for the Advancement of Science in York, the leading civil engineers whom I met had abandoned their belief in the 'combined system' of sewers, being convinced that it could not be made healthful."

SEWER SYSTEMS FOR NEW YORK STATE.

In the document last named we read Engineer Gardiner's conclusion, on page 14, as follows:

CONCLUSION:

"In obedience to the resolution of this Board I have endeavored, by the examination of foreign and American experience, to determine what method of sewerage we ought to recommend to the towns and cities of this state applying for advice. I am convinced that both in England, and America at large, combined sewers, for carrying storm-water and sewage are, and necessarily must be, constant and powerful sources of disease, and that for most towns, they are a very costly method of removing sewage.

I am of the opinion that the separate system of small sewers avoids in a great measure the inherent sanitary difficulties of the combined plan; and that it is an efficient and economical method of removing the sewage of towns. I therefore recommend the State Board of Health to advise the adoption of the separate system of sewerage in those towns which have asked for information on this subject.

Very respectfully yours,

JAMES T. GARDINER,

Director of the New York State Survey."

At the quarterly meeting of the State Board of Health held at Albany, February 8th, 1881, the following action was taken:

"The costly plan of large combined sewers for carrying sewage and storm-water together has proved a sanitary failure both in England and in this country; while the 'separate system,' when properly constructed, avoids in great measure the evils from sewer air now so common, and is much less expensive for most towns. Therefore the use of the 'Separate System of Sewers' with flushing tanks is hereby recommended for general use in this state."

KALAMAZOO, MICH.

The cost of combined sewers is variously estimated as being from five to ten times greater than that of separate sewers.

In the village of Kalamazoo, Mich., which had about 10,000 inhabitants in 1883, there were in that year, 5.89 miles of sewers, which had cost $40,184.75, or 1, 29 per foot, or $6,811 per mile. The smallest are 4-inch and the largest 12-inch pipes. This information is taken from the report of George H. Pierson, C. E., made April 11th, 1883.

COST OF CLEANING SEWERS.

Many cities are sewered partially on the Separate plan, and thus afford ready means for showing the comparative cost of maintenance. An example of this is given by City Engineer Towle, of New York, in his report for 1871, where the comparative cost of cleaning brick and pipe sewers is given for the 5 years previous. It shows that the cost for brick drains was 125 times more than for pipe drains. This report contains the following: "In all cases where pipe sewers have required cleaning or repair, their failure to work has been traced to error, or unfaithfulness, in their construction."

SEWER VENTILATION.

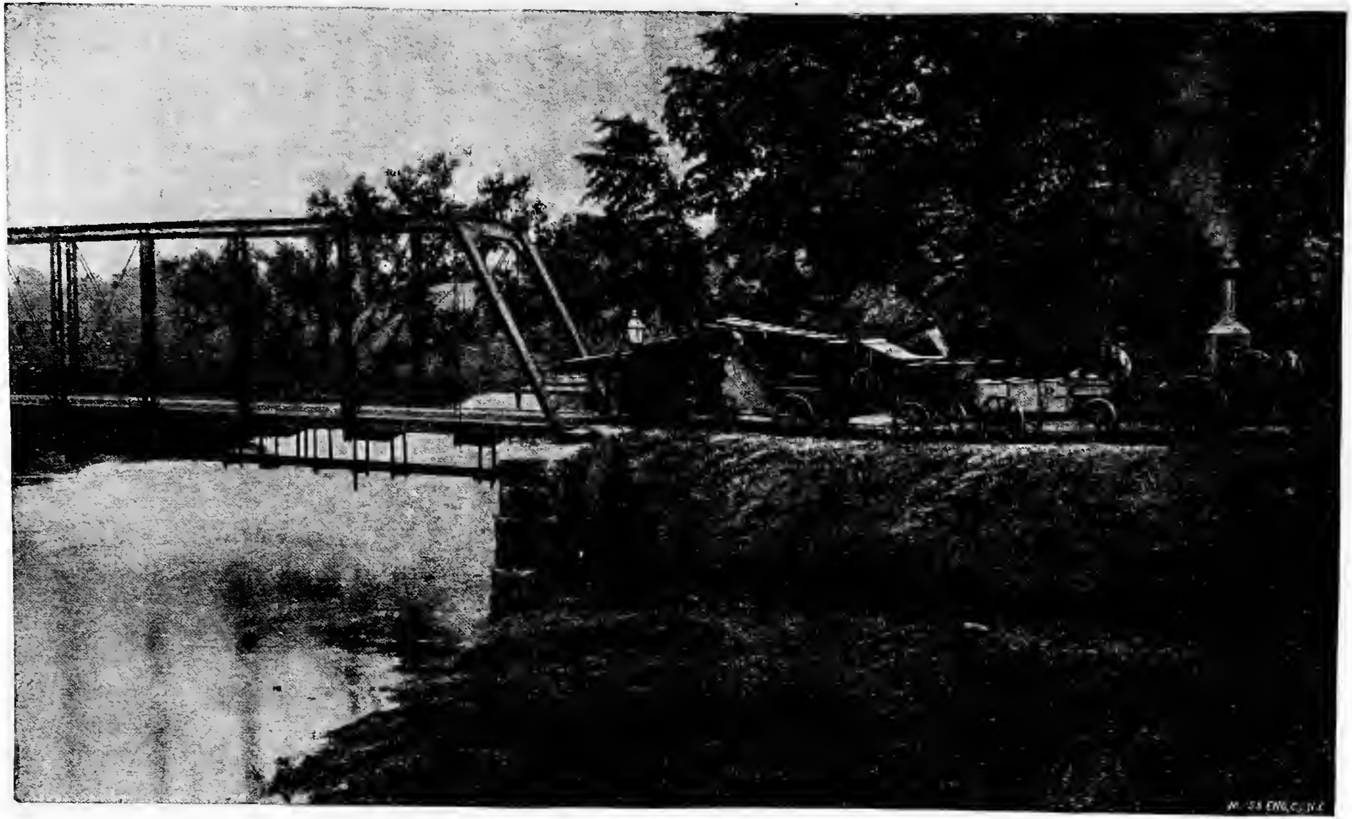
Combined sewers were advocated on the ground that resultant gases could be confined to the sewers. That was shown to be impossible. The dangers of the plan manifested themselves. Baldwin Latham, the English engineer said: "Unventilated sewers are far more dangerous than steam boilers without safety valves." Speaking of the ventilation used in connection with pipe sewers he said: "In my opinion this plan is decidedly the best system that can be adopted."

OPINION OF ENGINEER LATROBE.

A document which had great weight with the Canton Board was the report on a "Plan of Sewerage, made to the City Council of Baltimore," by C. H. Latrobe, chief engineer of the Baltimore and Ohio Railroad. With a view to building sewers, that city obtained the opinion of this eminent engineer. The report appeared in August, 1881.

The pages of this document show that the examination of the entire subject of sewers was made without prejudice. It is an important study. The advantages, and disadvantages, of the Combined system are pointed out. The merits and weaknesses of Separate Sewers are fully set forth. The testimony and authorities comprise the history of sewer building in Europe and America. After a most lucid presentation of the subject Mr. Latrobe concludes thus.

"To sum up: It would seem that the combined system has reached its fullest and most perfect development, and that no material improvement can be expected to take place in its application in the future, from the simple fact that it is called upon to perform two incompatible offices—one the sewage drainage, constant and small; the other, the storm water drainage, intermittent and larger. On the other hand, the separate system seems to be capable of fulfilling accurately the constant and small, though most important office, of the disposal of the sewage proper; whilst the intermittent rush of storm waters can be provided for otherwise."



ALLEN STREET BRIDGE (BY THE KINDNESS OF C. AULTMAN & CO.)
This view shows the temporary sewer suspended to the bridge; also the embankment necessitated by the sewer south of the bridge.

A visit to Memphis was part of the preparation for this report. After getting his impressions in regard to the work of Col. Waring, then recently completed, Mr. Latrobe says:

"In summing up my impressions as to the separate system as developed at Memphis, I would say that it is well planned and well executed, and fully answers the purpose for which it was intended, and which I conceive to be primarily the object of all sewerage, viz.: to carry off human and industrial waste with rapidity and cleanliness to its ultimate destination."

The fruit of all of Engineer Latrobe's investigations is summed up in these words:

"The separate system is, therefore, the one which I would respectfully recommend to your honors as the best adapted to our present and future needs."

THE ACTION OF THE CANTON BOARD.

The above chapter on recorded opinions and experiments might be made longer—much longer. But enough has been said to convince fair-minded citizens that, in adopting the separate system, the Canton Board of Sewer Commissioners, acted in conformity with the best interests of the city, and the examples presented have no other object than that. The conclusions arrived at comprise the following as the

ELEMENTARY REQUISITES OF GOOD SEWERS.

First—The sewer must have a continuous grade from the starting point, or points, to the outlet.

Second—The velocity of the flow must be sufficient to make the sewer self-cleansing.

Third—The size must be adapted to the work it has to perform.

Fourth—It must be thoroughly ventilated.

Fifth—It must be impervious.

These general principles were to be adhered to as to grade, velocity, size, ventilation and construction.

As to shape, Col. Waring says: "A perfectly round pipe, accurately laid at the joints, will deliver under the same circumstances, fifty per cent. more water than one of distorted form and ill-fitting joints."

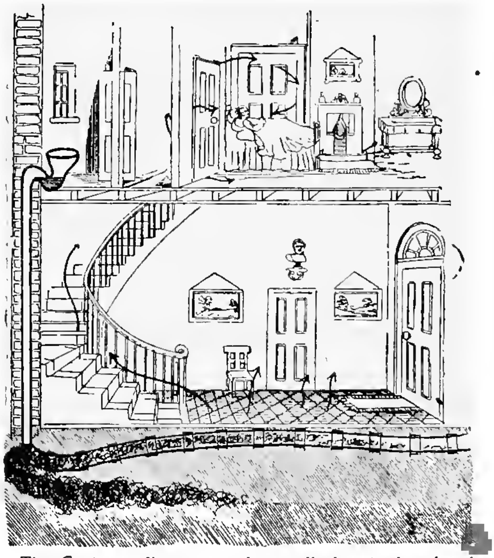
Concerning the effect produced on the flow by the material of which the sewer is made, the tables prepared by Barzin, the French engineer, are regarded as most reliable. The velocity, under the same circumstances, were found to be: In stone masonry, 3.5; in brick masonry, 6.1; in smooth pipes, 7.8. Smoothness increases velocity so that sectional area can be diminished and the cost reduced.

ALL SEWER WORK SHOULD BE IN HARMONY WITH ONE GENERAL SYSTEM.

Another qnestion to be decided was whether the part of the city in most urgent need of sewers should be drained in the quickest and least expensive manner, or in a manner conforming to, and constituting only part of a general plan which should ultimately comprise the entire area of the city. The opinion prevailed that the method last named would be the part of wisdom. In fact the experience of other cities left no doubt on that subject. For example, page 4, report of 1881, Kalamazoo, Mich., (famed for excellence of sewers) says:

"Should a place at first require sewers in a few streets only, a complete survey would be an economical investment, in order that there might be perfect harmony with all the succeeding sewers, and that all funds be judiciously expended."

The city of Philadelphia had recently created a loan of several millions of dollars, a liberal slice of which had been appropriated for the construction of sewers. In his inaugural address, referring to the use of this borrowed money, President Smith, of the Common Council, made this assertion:



The Canton ordinance requires soil-pipe to be placed against the wall, not in it; also that drain under the house be of iron; also that the fall from house to sewer be, at no point, less than one-half an inch to the foot. All these provisions are violated in the case presented in the picture.

"Never had there been a time when our citizens were more willing to submit to reasonable and necessary charges, but that they would insist upon the wise and honest expenditure of their money. This we believe, but we are constrained to say that, while the money devoted to sewers has been honestly appropriated, we cannot feel that it is wisely expended. The fact is that none of our large cities have any real system of sewers; they have accumulated in patchwork style, as occasion demanded, but there is no system, properly speaking about them. Hence do we feel that money expended to extend and enlarge this unscientific network of sewers is not money wisely expended. We must begin at the beginning and go all over the work in a proper and scientific way, and the sooner we begin the better and cheaper it will be. Let our small and growing cities profit by the predicament of their elder brethren and start their sewerage on a scientific basis, sufficiently comprehensive to meet all possibilities of future growth."

It was resolved that the plan for Canton, particularly having reference to the main sewer, should be such as would, as additional drainage areas were added, afford relief to the entire plat of the city.

ENGAGEMENT OF MAJOR HUMPHREYS.

Having adopted the Separate Sewer System the Board deemed it advisable to confer with Col. Waring as to the proper steps to be taken in order to obtain a plan of the work. The following correspondence ensued:

LETTER FROM COL. WARING.

NEWPORT, R. I., March 16, 1883.

Josiah Hartzell, Esq., Clerk of Board of Sewer Commissioners, Canton, O.:

DEAR SIR:—I am very glad to have your letter of March 13, and to know that your board is slowly working its way to success.

One of the best men in the country for your purpose is Maj. J. H. Humphreys, who had charge of the construction of sewers at Memphis for about four years, who has been in charge of the Norfolk sewers for a year past, and who is just now living there temporarily during a suspension of the work. I am writing him to send you his address and let you know if he is free. If he is not, I can send one of my own men after a short time.

I think it extremely important that you should have the assistance of a man who is well accustomed to such work.

Very truly yours,

GEO. E. WARING, JR.

LETTER FROM MAJOR HUMPHREYS.

OFFICE OF THE
BOARD OF SEWER AND DRAIN COMMISSIONERS,
NORFOLK, VA., March 20, 1883.

Mr. Josiah Hartzell, Clerk of Sewer Board, Canton, O.:

DEAR SIR:—I have received a letter from Col. Waring, of Newport, R. I., in which he tells me your city desires to employ an engineer and requests me to send you my address, etc. My engagement has terminated here and I am at present free to make another.

Yours respectfully,

J. H. HUMPHREYS.

Learning that Maj. Humphreys had also been employed at Little Rock, Ark., an inquiry brought the following response:

LETTER FROM LITTLE ROCK, ARK.

LITTLE ROCK, ARK., June 12, 1882.

Josiah Hartzell, Esq., Clerk Board Sewer Commissioners:

DEAR SIR:—Your letter of the 7th was delivered at the City Clerk's office and handed to me yesterday.

Maj. J. H. Humphreys was employed by our Board of Sewer Commissioners to come to Little Rock and give us the benefit of his knowledge and experience in building Sewers on the Separate System after we had decided to build sewers of that kind.

I believe Maj. Humphreys a very capable engineer and his experience at Memphis and Norfolk in building that kind of sewers will make him a valuable engineer for you to employ.

We built about two miles of sewers last year which is in fine working order. We believe it has many advantages over the old system and can be built at small cost.

Yours truly,

G. H. MEADE,
Secretary Board of Improvement and Manager of Sewers.

EXTRACTS FROM THE MINUTES OF SEWER COMMISSION, MAY 9, 1883.

"Sewer Commissioners met in conference with the City Council and recommended to the latter the employment of Maj. J. H. Humphreys for the purpose of furnishing to the city a plan, map, and specifications of a sewer system for the city of Canton. Subsequently, the same evening, the City Council called a meeting, separately and by unanimous resolution, authorized the Sewer Commissioners to send for Major Humphreys, of Memphis, Tenn."

Major Humphreys arrived in Canton May 16, 1883. Although the primary purpose in engaging the services of Major Humphreys was to furnish sewer plans, the majority in the Council had other problems for which they demanded a solution prior to commencement of operations on the house sewer enterprise. These related principally to the drainage of storm water. It will therefore conduce to a better comprehension of the drainage system of Canton if this branch of the present report be taken up and disposed of before entering upon the subject of house sewers proper.

STORM-WATER SEWERS OF CANTON.

While sewers for the removal of house wastes were urgently needed, there was another problem which, right at the beginning, confronted the Board. This was the disposal of storm water. The Board was agreed as to the superior advantages of separate sewers for sewage. Therefore the concentration of water from rainfalls would have to be otherwise provided for.

After heavy rains, or thaws, the collection of water in the lower lying part of the Second ward assumed the proportions of a small lake, inflicting serious injury on lot owners.

The drainage from large areas in the northern part of the city was through Shriver's Run and Walnut street. As the surface drain of the most thickly settled area, Walnut street often became highly offensive. Petitions for relief from these embarrassments were addressed to the Council, and these were, in turn, referred to the Sewer Commission. With a view to taking measures to obtain the needed relief the Board, on November 3d, 1882, requested the City Civil Engineer to furnish estimates as follows:

1st. The cost of a sewer through Walnut street to drain the waters tributary to that channel.

2d. The cost of a sewer through Walnut street of sufficient capacity to carry the water tributary to that channel, and, in addition, the storm flow of Shriver's Run.

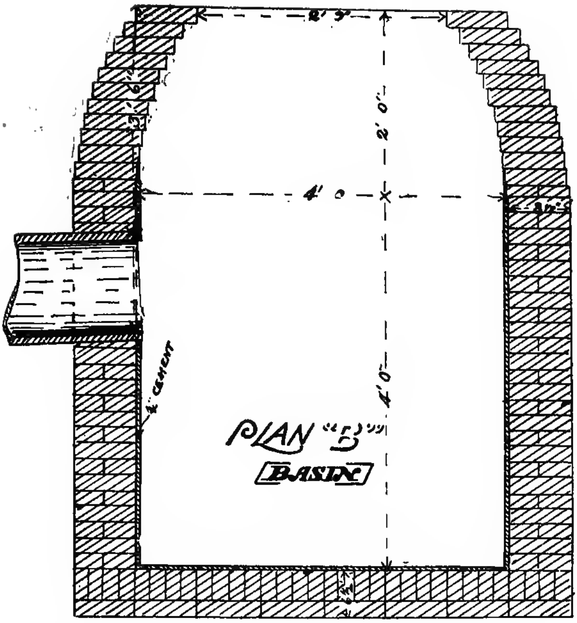
3d. The cost of a sewer of sufficient capacity to convey the waters of Shriver's Run, and of the low grounds of the Second Ward, eastwardly, to the creek.

On November 10th the Engineer presented a report in which it was assumed that the territory north of Summit street could be drained westwardly into the creek at a moderate expense. As a matter of fact the territory referred to has since been drained westwardly through Lake street.

The Engineer, therefore, very properly, rejected said area, which he fixed at 48.8 acres from his estimate. Upon this basis his estimate for the sewer contemplated by inquiry No. 1 was $16,250; for the sewer in response to inquiry No. 2 it was $26,879; for the sewer No. 3, the estimate was $8,879. For the drainage of the Second Ward storm water, alone, his estimate was $3,250.

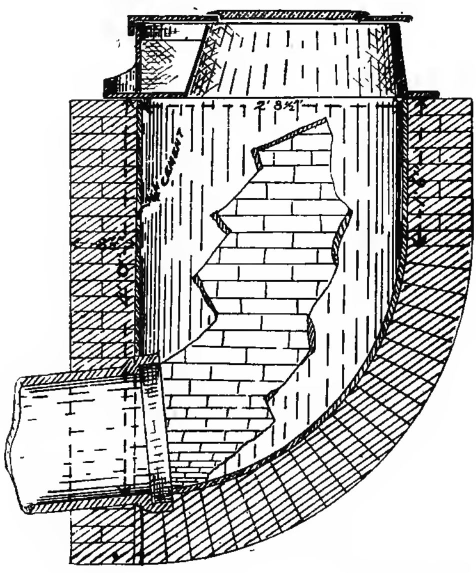
THE PENNSYLVANIA AVENUE SEWER.

The disposal of storm waters for the areas to which reference has been made, which was the most pressing, continued to be made the subject of investigation. The last report in regard to the flooded district of the Second Ward, submitted to the Board June 18, 1883, was as follows:



CATCH BASIN, STORM-WATER SEWERS.

When the sediment reaches the height of the outlet the lid is removed and the basin cleaned out.



PLAN OF INLET INTO STORM-WATER SEWERS.

To the Sewer Commissioners of the City of Canton:

With reference to the drainage of the basin east of the run, between Pennsylvania avenue and Washington avenue, observations made by Mr. Holl, City Engineer, show that during the flood of last February there was a continuous sheet of water from the high ground near Mahoning street on the east to Cherry street on the west, and that the water from this territory and the run flowed down along the streets and across lots as far south as Tuscarawas street. The first step necessary to prevent the recurrence of this would seem to be the deepening Shriver's Run sufficiently to prevent its overflow into this basin. This accomplished, I think the three-foot brick conduit, of the cost of which Mr. Holl has furnished you an estimate, would provide for the storm water of the area under any consideration. City Engineer Holl's report, referred to, is as follows:

"In the matter of providing a better outlet for the flood water in the late overflowed district in the Second ward, and in order that damage by future floods may be avoided, the present sewer pipe drain in Pennsylvania avenue should be replaced by a brick sewer of circular shape, 3 feet in diameter, and beginning at the intersection of Gibbs street and Pennsylvania avenue and extending eastwardly along said avenue to Nimishillen creek, a distance of 1,550 feet, which can be constructed with a fall of 2½ inches per 100 feet, and would have 5 8-10 times the capacity of the present drain, and the top can be covered without interfering with the street grade.

For a wall of one thickness of brick, this sewer would require 75 brick per lineal foot, or for the entire length, 116,250 brick, and the cost of the same would be approximately as follows:

116.250 brick at $15 per M laid in cement	$1,763 75
Excavating, average cut 8 feet at 30 cents per cubic yard	744 00
Ten catch basins at $25 each	250 00
Two man-holes at $45 each	90 00
Total	$2,847 75

JOHN H. HOLL, City Civil Engineer.

This report was approved by Major Humphreys, who added the following suggestion:

"But I am of the opinion that the low ground in this basin should be raised by filling to some extent, by which both the drainage and sewerage of the area would be greatly facilitated. Respectfully submitted,

"J. H. HUMPHREYS."

The above was approved by the Sewer Commissioners and certified to the City Council, as follows:

"It is the opinion of this Board that the plan proposed by Engineers Humphreys and Holl will afford entire relief and, if carried out, will avert all danger of flooding in the Second Ward in the future. Respectfully submitted,

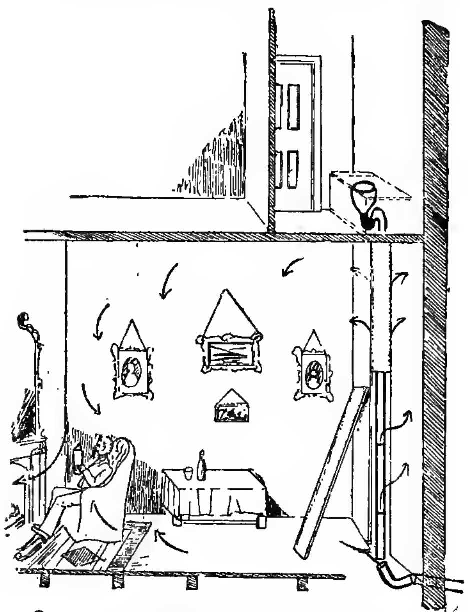
WM. DANNEMILLER,
President.
JOSIAH HARTZELL,
Clerk of the Board.

THE WALNUT STREET STORM-WATER SEWER.

The Pennsylvania Avenue sewer was constructed in accordance with the above plan and has proven to be an ample remedy for the vexations arising from collections of storm water in the low lying grounds of the Second ward.

In regard to the storm-water sewer on Walnut street, the estimate of City Engineer Holl has already been given. A farther investigation of the subject led Mr. Holl to reduce his first estimate to the extent of $1,500. This report was received Nov. 27th, 1882.

After the arrival of Major Humphreys his opinion on this subject was obtained, and is contained in the report submitted by him June 18, 1883. It was as follows:



Our ordinance says that soil-pipe in the house, as well as under the house, must be of iron well leaded at the joints, and it prohibits double traps. If these provisions are neglected dangers may be set loose to fly about as freely as the arrows in the picture.

"For the disposition of the surface water of Walnut street and Shriver's run it would seem best to take the water from the run at Saxton street and Pennsylvania avenue to Cherry street; thence along Cherry street to North street, thence along North street to Rex street, thence along Rex street to Shriver's run, south of the P., Ft. W. & C. R. R., a distance of 4,000 feet. This sewer should be six feet in diameter at the upper end, and 7 feet at North street and 7½ feet south of Tuscarawas street. It is proposed in connection with this to deepen and widen Shriver's run from Pennsylvania avenue to Washington avenue. Estimated cost of above:

4,000 feet of brick sewer at $8	$32,000
1,000 feet of Shriver's run deepened and walled at $5.50	5,500
Add for contingencies 10 per ct.	3,750
Total	$41,200

Respectfully submitted,
J. H. HUMPHREYS."

The feasibility of a third plan had been considered by the Board, viz: making the sewer last named of sufficient depth to receive house sewage, making it a combined sewer so far as the main sewer was concerned. Maj. Humphreys' report, in response to the request of the Sewer Commissioners, was as follows:

CANTON, OHIO, June 4th, 1883.

To the Sewer Commissioners of the City of Canton:

GENTLEMEN:—In compliance with your request I submit the following report with reference to a combined sewer which shall provide for the storm water of Shriver's run and Walnut street, and the house sewerage of the territory tributary to them. This plan would combine in a single work a provision for sewerage and storm water, and would be less objectionable than such sewers usually are in consequence of the continual flow through it of the waters of Shriver's run. It would however cost more than a sewer for storm water only, in consequence of the lower grade neceesary, and the increased amount of sub-soil water encountered in its construction. Should it be found necessary to discharge the sewage into the creek below Raynolds' dam it would entail the necessity of increasing the section of a sewer for this purpose at least as much as would provide for the ordinary flow of Shriver's run, the storm water being provided for by overflow into the creek. This plan would, I think, eventually cost more than that by which the storm water sewerage would be provided for separately. The following is an estimate of the cost of the combined sewer from the Fort Wayne railroad to the creek:

4,000 feet of section equal to a circle 8 feeet in diameter, cost $14 a foot	$56,000.00
Previous estimate for part above Ft. W. R. R......................	41,000.00
Total	$97,000.00

Respectfully submitted,

J. H. HUMPHREYS.

It will be observed that this report by Major Humphreys confirms the correctness of the principle adopted by the Sewer Board, viz: Sewage to separate sewers, and rain water to special storm-water conduits. It was decided to build the Walnut street storm-water conduit as planned by City Engineer Holl, viz: A round sewer of brick having a diameter of 44 inches where it enters Shriver's Run and 3 feet at North street. Its length is about 3,500 feet. This work was accordingly recommended to the City Council at a meeting held May 4, 1884, and after preliminary steps had been taken, the following ordinance was passed:

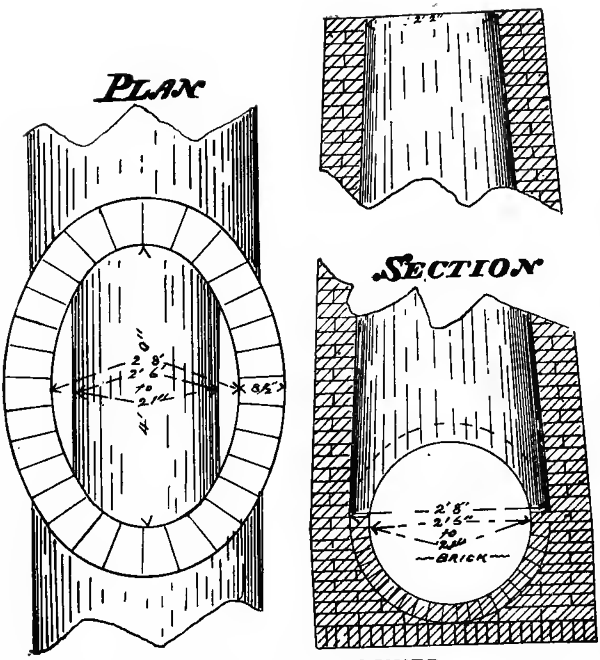
"SECTION I. Be it ordained by the City Council of the city of Canton (two-thirds of all the members elected thereto concurring), That Walnut street, in Central Sewer District No. 1, of said city, be improved and drained, between North street and the Pittsburgh, Ft. Wayne & Chicago Railway in said city, by locating and constructing therein in and along the gutter on the west side thereof a good, substantial brick storm water sewer in such manner as to drain that part of said street and its abutting lots, of surface water. The same to be located, established and constructed in accordance with the plans and specifications on file in the office of the City Civil Engineer.

SEC. II. The cost and expense to be incurred in making the contemplated improvement mentioned in Section 1 of this ordinance, shall be paid for and the means therefor provided in the manner stated in the next succeeding section of this ordinance.

SEC. III. That the sum of $2.500, now in the city treasury and certified to by the clerk and entered on the journal of this Council, be and the same is hereby appropriated toward the payment of the sewer out of the sewer fund now in the treasury; the estimated cost of such sewer being $12,000, which amount of $2,500 hereby appropriated shall be and is set apart for that purpose and shall be used for no other.

SEC. IV. That the sum of $3,000, which in the opinion of this Council would be required to construct an ordinary street storm water sewer to drain the lots bounding and abutting upon said sewer in said district, be assessed per foot front upon the lots and lands bounding and abutting upon such proposed sewer by an assessing ordinance to be passed by the City Council in accordance with the laws and ordinances relating to the subject.

SEC. V. That to pay the remainder of the estimated cost of said sewer, viz: $6,500, the Council shall provide by ordinance at the time of making their next annual levy for all purposes by levying by special levy a sufficient amount on all the real and personal property in Sewer District No. 1 of said city, whereby to realize a sum sufficient to pay the residue of the cost, viz: $6,500.



STORM-WATER SEWER.

Plan and Section of Man-Hole on Storm-Water Sewer. Sewer of single ring of brick.

SEC. VI. That as soon as the levy has been made, as authorized by law and section 5 of this ordinance, the Council shall and is hereby empowered to provide by ordinance for the issuing and sale of the city's bonds in anticipation of the revenue to be derived from the levy on all property in said Sewer District, and the assessment so made upon such abutting property. The proceeds realized from the sale of such bonds, and the $2,500 hereby appropriated, shall be used and applied to the payment of the contract price of said sewer and to no other purpose. And the amounts realized by said levy and the said assessments shall be applied in payment of the bonds issued therefor as the same become due.

SEC. VII. That the assessments herein provided for shall be a lien on the abutting property of the respective owners, and on failing to pay their said assessment at the time provided for in the assessing ordinance, then the City Clerk shall certify the same to the County Auditor to be entered on the tax duplicate and collected by the Treasurer as other taxes are collected with the lawful penalty.

SEC. VIII. That this ordinance shall take effect and be in force from and after its passage and legal publication.

Passed September 15, 1884."

POWERS OF THE SEWER BOARD DEFINED.

Upon the creation of the Board of Sewer Commissioners it was generally supposed that the Board would have direct control of the erection of the works authorized by it, and approved by the Council; that in fact the same methods would be observed, and the same powers exercised, as by the Water Board and Health Board. The duties of the Sewer Board, in these respects are, however, limited by a State law, in these terms :

(FROM THE OHIO STATUTES.)

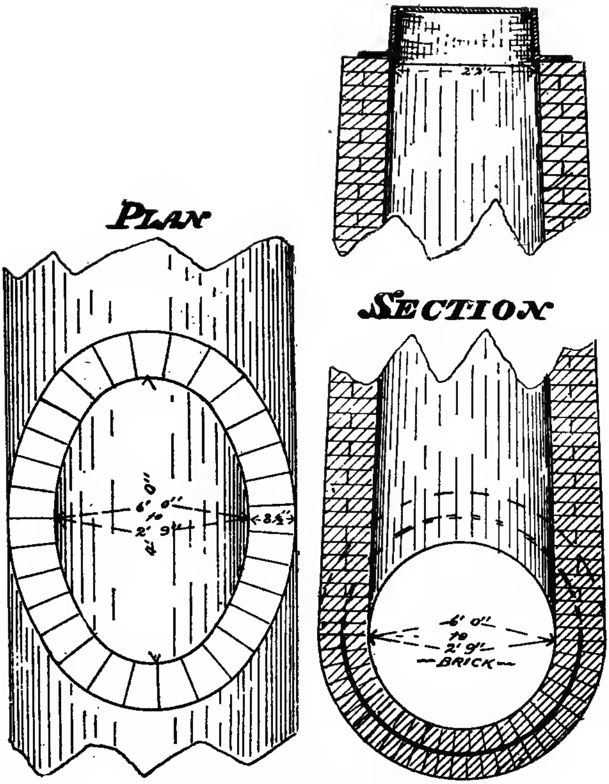
An Act to Provide for the Construction and Repair of Sewers in Cities of the Second Class.

SECTION 8251-2. " The Council, on recommendation of the Board, shall cause such sewer or sewers, specified in the plan, as may be designated by the Board, to be constructed."

By the terms of the law, therefore, the duties of the Board of Sewer Commissioners are ended when maps, plans and methods of construction have been specified and authorized. All contracts and expenditures are made directly under the supervision of the City Council.

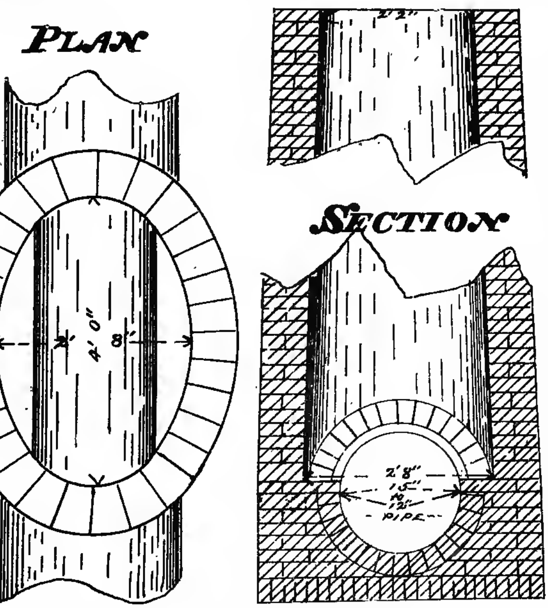
FINANCIAL ENTANGLEMENTS.

In the course of construction of the Walnut street storm-water conduit several unlooked for embarrassments were encountered.



STORM-WATER SEWERS.

Plan and Section of Man-Hole on Storm-Water Sewer. Brick, two rings. Man-Hole Cover.



STORM-WATER SEWER.

Plan and Section of Man-Hole of Storm-Water Pipe Sewer.

The first of these was an injunction, obtained upon the application of the Whitman & Barnes Manufacturing Company, restraining the city from building the sewer through that company's premises. The route of the sewer, as planned by the Engineer, followed the old water course of the Walnut street open drain. This route took the sewer, by a curve, from the centre of Walnut street, eastwardly, through the Whitman & Barnes' grounds, and under the Fort Wayne tracks, directly into Shriver's Run. After a hearing of the case in the Court of Common Pleas the injunction was made perpetual.

The course of the sewer was then projected southward on Walnut street to, and across the Fort Wayne railroad tracks, and thence south-eastwardly across the premises of C. Aultman & Co., to Shriver's Run.

C. Aultman & Co. donated the right of way. The additional cost to the city, over that of the proposed outlet through the Whitman & Barnes' property, was $1,482.80. This extension was formally authorized by the action of the Sewer Board, August 3, 1885, and the work was completed in conformity with this amended plan.

It will be seen that in this ordinance, as passed, "Sewer District No. 1" is mentioned as the district in which the sewer was located. This should have been "Sewer District No. 3," and the ordinance was accordingly also rectified in this respect.

A more serious objection to the ordinance was its taxing feature. That there should have been some bungling legislation in the commencement of this work is not surprising. Before the completion of the sewer, however, the justice and injustice of the taxing clauses of the ordinance had been well canvassed both in and out of the Council. The movement in the Council took shape by the introduction, on November 17, 1885, of the following resolution:

"RESOLVED, That the City Solicitor be and is hereby instructed to prepare and present to the City Council an ordinance providing that bonds issued for the construction of the Walnut street storm water be paid when due from the general sewer fund, raised by general taxation, and repealing existing ordinances providing that the cost of constructing the same be assessed upon sewer district No. 3 and upon property fronting on Walnut street."

Concerning the reasons for the proposed change we quote the language of Councilman Roberts, who spoke in support of the resolution introduced by him as follows:

"The Walnut street storm water sewer is now substantially completed, the expense of the same having been about $13,000, of which there is yet due Mr. Adams in round numbers $2,600. Under the ordinance providing for the construction of this sewer, and subsequent resolutions of the Council, this amount is raised by a special assessment of $3,000 on the Walnut street property fronting on the sewer, $6,500 by special aseessment upon the property of Sewer District No. 3, and $4,000 by appropriation from the sewer fund, raised by general taxation. A levy of one and two-tenths mills has been made upon all the property in sewer district No. 3, which is now due upon the tax duplicate at the Treasurer's office; the assessing ordinance raising $3,000 from Walnut street property owners will soon have to be passed; and the balance of $4,000 has already been appropriated and paid out of the general sewer fund. Bonds have been issued, running two years, in anticipation of the collection of $6,500 from Sewer District No. 3, and this amount has been paid over to Contractor Adams. The collection of the $3,000 special assessment would leave a balance of $400 to be returned to the general sewer fund, after paying the contractor the balance of $2,600 yet due him. This in a nutshell shows the expense and financial status of the Walnut street sewer.

"And now to return to the resolution introduced last evening. I have all along been of the opinion that the taxing of the people of Walnut street and Sewer District No. 3, for the construction of a purely storm-water sewer or drain was a rank injustice, the more so when it is considered that a year or two ago the city constructed exactly the same kind of a sewer on Pennsylvania avenue, and paid for the same by taxing every dollar of taxable property in the city. There was no suggestion of assessing the property owners upon that street so much per foot front, or that the cost should be saddled upon some sewer district; but it was very properly paid by the entire city. It was not designed expressly for the relief of Pennsylvania avenue, but for half a score of tributary streets draining into it, and was in every way a public necessity and a general improvement.

"Now I take the same ground concerning Walnut street. If it was necessary to build a storm water sewer it certainly was not to merely dispose of the rain water falling on that street, but because it is used to drain a very large portion of the city. Surface and underground drains are constructed at the city's expense to carry water from distant streets into Walnut street, and then we levy an enormous assessment upon property owners of that street to carry it away. We use their streets as a natural drain or water course, and then charge them a good, round sum for the privilege we enjoy. But this is not the only injustice. A special levy to raise $6,500 is made upon Sewer District No. 3, which largely comprises property and thoroughfares which can never by any system of engineering be drained into Walnut street. The boundaries of this district have been frequently published, and every citizen who is familiar with the sewerage question knows how unjust it is to tax all the property owners included in the district to construct a sewer which many of them can never expect to use.

"If it was right to tax the entire city for the construction of the Pennsylvania avenue sewer, regardless of the district drained, it is just as right that the Walnut street sewer should be paid for by general taxation. Of course in the case of a house sewer the premises are entirely different, and the same conclusions cannot be drawn. It is but right that each street should be assessed for house sewers constructed thereon, as they are more in the nature of local improvements, the entire city of course bearing a portion of the expense of main sewers.

"Under existing ordinances property owners of Walnut street are subjected to three different forms of taxation in paying for the same: First, there is $4,000 taken from the sewer fund, raised by general taxation; then $6,500 to be raised by a special levy upon Sewer District No. 3, in which Walnut street is located; and finally $3,000 to be assessed per front upon all property fronting or abutting on Walnut street. This is certainly an injustice that should be righted, and now is the time to do it.

The repeal of the existing ordinances would work no hardship to any property holder. In addition to the $4,000 already appropriated from the sewer fund the city at large would be called upon to pay $9,500 now provided for by special assessments, but this will not necessitate any increased levy upon any property in the city, as the bonds outstanding can be paid as they mature out of the general tax collection."

The view of the case taken by Mr. Roberts prevailed and the resolution above quoted, passed by the Council November 23, 1885, was carried into effect.

SMALLER STORM WATER DRAINS.

One of the arguments used in favor of a change of the taxing feature of the Walnut street ordinance, as first passed, was that quite a number of drains had already been built, the payment, in each instance, having been made from the general fund. The principal drains to which reference was thus made were as follows:

The Pennsylvania avenue sewer, 1,515 feet long and 3 feet in diameter, built in 1883, of which mention has been made on a previous page:

A 24-inch drain 520 feet long, from the Valley tracks to the creek, on West Tuscarawas street.

A 24-inch drain 250 feet long, draining a portion of East Tuscarawas street into East Creek.

An 18-inch drain on East Fifth street from Market to Walnut streets.

Also drains on East Seventh and East Eighth, from Market to Walnut.

A 24-inch drain on West Tuscarawas street, from High to Newton, a distance of 1,150 feet.

Drain pipes on North street, from Cleveland avenue to Walnut; also 18-inch drains 400 feet long on North Plum and Elizabeth streets.

As will be seen by the table printed on page 36, the use of a portion of these drains has been abandoned, the need of them having been superseded by the construction of the storm-water drains known as the Northwest and Southwest systems. These sewers were authorized by action of the Sewer Board, July 29th, 1889. For the route of these sewers we refer the reader to the map accompanying this report. Material, name of contractor, and cost are given in the table on page 36.

Storm water drainage is a problem whose permanent solution is sometimes attended with considerable difficulty. City improvements deflect water from their natural channels. The grading of streets, and the paving of streets, increase activity of flow, and consequent quick collection of waters, inflicting damages over areas not previously liable to such visitations.

The inadequacy of the Walnut street storm-water drain after occasional rainfalls of exceptional abundance is partially due to the above named influences. Also partially to the quick influx into it of the waters from the side streets which are improved and frequently freshly dug up. These swift currents scour up the loose earth and, once delivered into the conduit with more sluggish grade, their heavier portions fall as sediment and choke up the sewer.

The frequent clogging and considerable repair-bills which attend the maintenance of the Walnut street sewer furnish a sgnificant object-lesson to the advocates of combined sewers. For contrasts between present inconveniences, and the perplexing conditions that would be inevitable if the volume of sewage flow was contributed to the contents of the sewer, must readily present themselves. Increased diameters could afford only temporary relief, for the sewer never was built, with no greater fall than the ground over Walnut street admits of, in which sedimentation from the same causes which now afflict that sewer could fail to occasionally fill it up, and necessitate large expense in its maintenance.

NEED OF ADDITIONAL STORM WATER DRAINS.

Looking to further improvements in this direction, City Civil Engineer L. E. Chapin said in his last annual report to the Council on the subject that it was his intention to present a plan for permanent relief in the near future. The same was foreshadowed by his observations on the Schriver Run problem, in the following language:

"This valley should constitute a storm water sewer district, having a drainage area of about 800 acres. From Lawrence avenue to Charles street the bottom of the run is at most not over six feet below grades of crossing streets, and as the gradients of such streets are usually quite flat, high water in the run usually results in the backing up of storm waters over an extended area of closely built up and valuable property, causing much damage.

"The improvement of this run, either by straightening and deepening and walling up, or by constructing a covered-in sewer at a depth of say ten feet below grade of streets, would result in lowering the ground water to that extent, besides bettering the surface drainage of all the flat adjacent territory. This improvement I regard of much importance, and steps should be taken to begin such improvement. This would result in a free outlet to the Walnut street sewer and I think almost entirely relieve it from its oftentimes surcharged condition, due to obstructed outlet. A large proportion of the benefits of this improvement being local, it might be possible to provide for a portion of the total cost by assessments of property so benefitted."

PROPOSED CONDUIT FOR SHRIVER'S RUN DISTRICT.

The plan of Engineer Chapin was more fully outlined, and estimates given, in his report to the City Council on January 30, 1893, as follows:

In the early part of 1892, by resolution of the Council, I reported an estimate of cost for the brick conduit sewer, located on present route of the Shriver's Run, and extending from North street to Charles street. And during the past year, having had time to become better acquainted with the problem, I am of the opinion a better route can be had by following Saxton street from North street to the P. Ft. W. & C. Ry., thence across those tracks to Liberty street, and thence down Liberty street to the East Creek.

The advantages of this route are:

1. City owns entire right of way of ample width from North street to the creek except about 150 feet only, across the Ft. Wayne tracks.

2. Entire absence of trees, timber, bridges and other obstructions.

3. Avoidance of danger of injury to the main house sewer, which owing to its location close to run, would be endangered by the excavations and be expensive to protect.

4. A decreased length of sewer, the route being about 3,000 feet shorter from North street to creek, saving about 600 lineal feet of work over former plan which ended at Charles street, while present route contemplates improvement running to the creek.

5. A better outlet to the sewer, it, on Liberty street, discharging in the direction with the flow of the creek.

6. A lower grade of the sewer, resulting in its adaptability for local drainage to a much greater distance laterally and permitting the thorough drainage of the flat streets lying immediately east of the run.

WATER SHED.

The area of water shed contributing to flow of the run is approximately 1,090 acres, and the volume of water from it and reaching the stream in times of heaviest rainfall is 260 cubic feet per second, based on a rainfall of one inch per hour on the entire surface, assuming the future development, when built up, to result in an average of 24 per cent. of the area to be pavements, buildings and such other impervious surfaces.

GRADES AND DIMENSIONS.

Starting at south line of North street at elevation 67.30 for the bottom of sewer, a uniform fall of 25-100 feet per 100 feet can be secured for the entire distance of 5125 feet to the creek, resulting in elevation of invert at mouth of sewer of 54.50 or 7-10 feet above mean water level of the creek. With this grade, and to carry a maximum of 260 cubic feet of water per second a sewer 6½ feet in diameter will be required. And its capacity by Kutter's formula will be 268 cubic feet per second, which is the size recommended.

WALNUT STREET SEWER.

The above dimension contemplates the extension of the present 3-foot sewer in North street by a 4-foot sewer from Walnut street to the new improvement in Saxton street, thus relieving the Walnut street sewer from all storm water on territory north of North street and also that reaching North street from North Market street and North Cleveland avenue.

Having removed this quantity of storm water from the Walnut street sewer, and diverted the Shriver Run water from its present course to the proposed route, would result in a free discharge of the Walnut street sewer into the bed of the run. But to effectually remove any possible nuisance from this source, it is proposed to continue the present Walnut street sewer by a 4-foot sewer to a point below Charles street. This work requiring but little excavation and being of comparatively small diameter would not interfere with any existing improvements and be done at small expense.

Provision has been made and allowed for the future construction of lateral sewers on Eighth street, and also for the territory adjacent to the Malleable Iron Works.

ESTIMATED COST.

Main sewer, 6½ feet in diameter	$59,137 50
Inlet at North street, outlet and man-holes	1,100 00
Extension of North street sewer	3,510 00
Necessary changes to existing house sewers	2,000 00
Painting, inspecting and contingent costs	1,252 50
Total	$67,000 00
Extension of Walnut street sewer	8,000 00
Total estimated cost	$75,000 00

A long time bond at low interest rate could be floated, perhaps a 30-year at 4 per cent, which would make an annual interest charge of $3,000, necessary to insure the complete drainage of this portion of Canton in which are located the many manufacturing plants, the success of which has contributed to the growth of our city, and which have been put to serious disadvantage and much annual expense by the lack of passable streets during one-third of the year, permanent street improvements being impossible without the essential of perfect drainage."

It was resolved to adopt the plan presented and to commence work on the sewer as soon as the needed legislation had been obtained and the legal preliminaries had been complied with.

COMMON S TRAP BACK VENTED.

STORM WATER SEWERS.

SHOWING LOCATION, SIZE AND COST OF ALL BUILT TO MARCH 17, 1893. PREPARED BY L. E. CHAPIN, C. E.

	BRICK.—FEET DIAMETER.														PIPE. INCHES DIAM.				NO. OF MANHOLES	NO. CATCH BASINS.	CONTRACTOR	COST.
	5	6	5¼	4½	3¾	3½	3¼	3	2¾	2⅔	2½	2¼	2	1¾	20	18	15	12				
Second St , from Cleveland to Walnut													524	452			12	15	2	3	Jac McKinney	$1 337.12
North St., from Cleveland to Walnut											534		325				54		2	4	Jac. McKinney	1,297.75
Central, Southwest and Branches							1904	1114	720		855		2237	955			1412	772	13	35	Jac. McKinney	24,645.74
Northwest and Branches	1664	1278	808	826	617	1996	668			1262		900	538	1510			804	271	11	20	Adams Bros.	59,604.71
West Tuscarawas St. and Branches						1262		591				690	482	1016			64	376	9	19	A.G. Pugh & Co	13,510.32
East Tuscarawas St., Young to Creek										1104									4	8	Frank Riley	2,337 09
West Tus. St., Creek to Lincoln						450		465											2	6	Frank Riley	3,804.49
Mulberry St., Liberty to Shriver's Run																350			1	3		
Pennsylvania Ave., Gibbs to Creek								1515											3	11		2,973.69
Seventh St., Market to Walnut																220		220		1		
Eighth St., Market to Walnut																540				2		
Rex St., South to Shriver's Run																300	200		1	5		
Elizabeth St., Plum to Poplar																1000						
Walnut St., North to Shriver's Run					2875			700											10			13,479.28
* North St., Poplar to Walnut																2 Pipe 1040			4	4		
* West Tus. St., Creek Eastward													Pipe 540							2		
* West Tus. St., Cassilly to Newton								600					600							1		
* East Tus. St., Creek Westward													Pipe 250						1	2		
* North St., Market to Walnut																530				2		
* Fifth St., Piedmont to Walnut																	240					
Eighth St., Cleveland to Plum																487	160		1	4	Berry & Davis.	669.08
Cleveland Ave., Williams to Raynolds																	350		1	2	Berry & Davis.	266.00
Tuscarawas St., Market to Walnut																	480	20	1	10	Berry & Davis.	372.00
Brown Ave., Tus. to Collins and Fifth															374		142		1	4	City	655.26
Tuscarawas St., Plum to High																480	112		1	3	City	743.94
Miscellaneous Sewer Work																290	222	232	14	31	City	------
TOTAL FEET	1664	1278	808	826	2992	3708	2578	4975	720	2466	1389	1590	4096	2334	374	3667	4012	1866	76	171		

* Abandoned.

HOUSE SEWER SYSTEM.

Wishing to dispose of one branch of Canton's sewer system before taking up the other we have, in describing the city's storm-water drains, proceeded considerably beyond the practical inauguration of house sewers, in point of time.

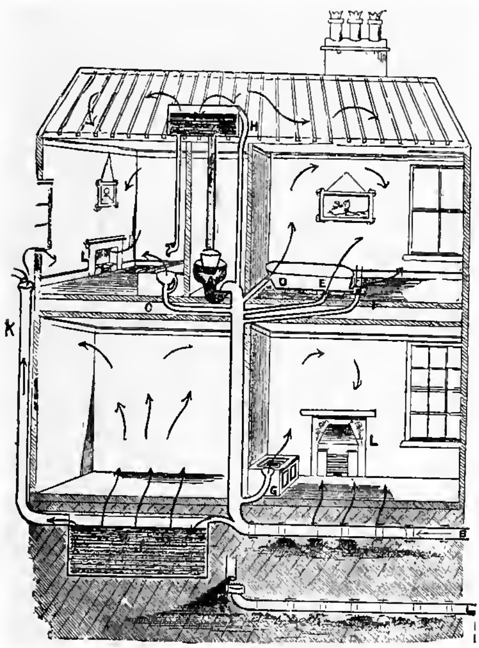
As before stated, Major Humphreys, who had been engaged to prepare plans, reached Canton on May 16, 1883. After the necessary topographical examination had been made he and City Engineer Holl furnished the information in regard to storm water conduits which had been requested of them. He then gave his attention to the house sewer system. His first report was as follows:

To the Sewer Commissioners of the City of Canton:

GENTLEMEN:—In compliance with your request I have made some examination of your city with reference to a sewer system, especially as to the location and approximate estimate of the cost of a main sewer which would remove the sewage from the business and most thickly populated portions of the city. I find a route already suggested by Col. Waring on Walnut and South Market streets which would discharge near the confluence of the two creeks. My estimate of the cost of this sewer is $17,500.

I have also partially examined a route down Walnut street to the Fort Wayne railroad, thence through private property, and near Shriver's Run to the East Creek. This I think may be built for about $13,000. A further examination of the two routes is necessary before a choice between them should be made.

Respectfully,
J. H. HUMPHREYS.



In this case pretty much all is wrong. A vent pipe, instead of going above the roof, stops under a window. Another vent pipe is too small. No traps, no tight joints, no iron soil pipe under the house, no fall to the sewer. Rain water cisterns above and below communicate directly with the sewer. It is an extreme, and an extremely bad case. Yet all these things have occurred.

After making further surveys he reported again as follows:

To the Sewer Commissioners of the City of Canton:

GENTLEMEN:—In obedience to your instructions, the main sewer on Walnut street and along Shriver's Run, from North street to Nimishillen Creek, has been located.

A profile of this route, and specifications of the work required to construct the sewer, together with a map showing the location of the main sewer, and such laterals as may be drained into it, is herewith submitted. The main sewer is designed 20 inches in diameter from Nmishillen Creek to Douglas street, 18 inches from Douglas to Ninth street, 15 inches from Ninth to Third street, and 12 inches from Third to North street. The construction of the sewer is estimated to cost $16,000.

A profile for the preliminary survey for the extension of the main to a point below Raynold's dam on Nimishillen Creek is also submitted. This extension would cost about $8,000.

Respecectfully submitted,
J. H. HUMPHREYS.

CANTON, O.. June 30th, 1883.

The profile, specifications and maps referred to in the above report constitute the basis of the sewer system of Canton as it is in operation to-day. Very few deviations were made in the lateral sewers.

The route of the main sewer proposed by Major Humphreys was changed. Instead of going directly south to the creek, its course is south only to a point just south of the C., C. & S. railroad track, thence southwestardly, along the railroad track to Allen street, thence south, on Allen street to a point near the creek, which is now the sewage farm. The route is shown on the map accompanying this report.

The diameters of the main sewer were adhered to, as specified, with the exception that the portion from Third to North streets was made 15 inches instead of 12 inches in diameter.

The specifications prepared by Major Humphreys also ultimately underwent some minor changes, owing to the change in diameters and the changed route of the main sewer. They will be presented later on.

Major Humphreys, at the request of the Sewer Commissioners, also presented a preliminary report on the subject of the disposal of the city's sewage by absorption. The plan did not, however, recommend itself sufficiently to warrant any action.

He also made a survey for the purpose of fixing the boundary of Sewer District No. 3 in compliance with the following ordinance:

SECTION NO. 324 OF THE REVISED ORDINANCES.

Ordering the Division of the City into three Sewer Districts.

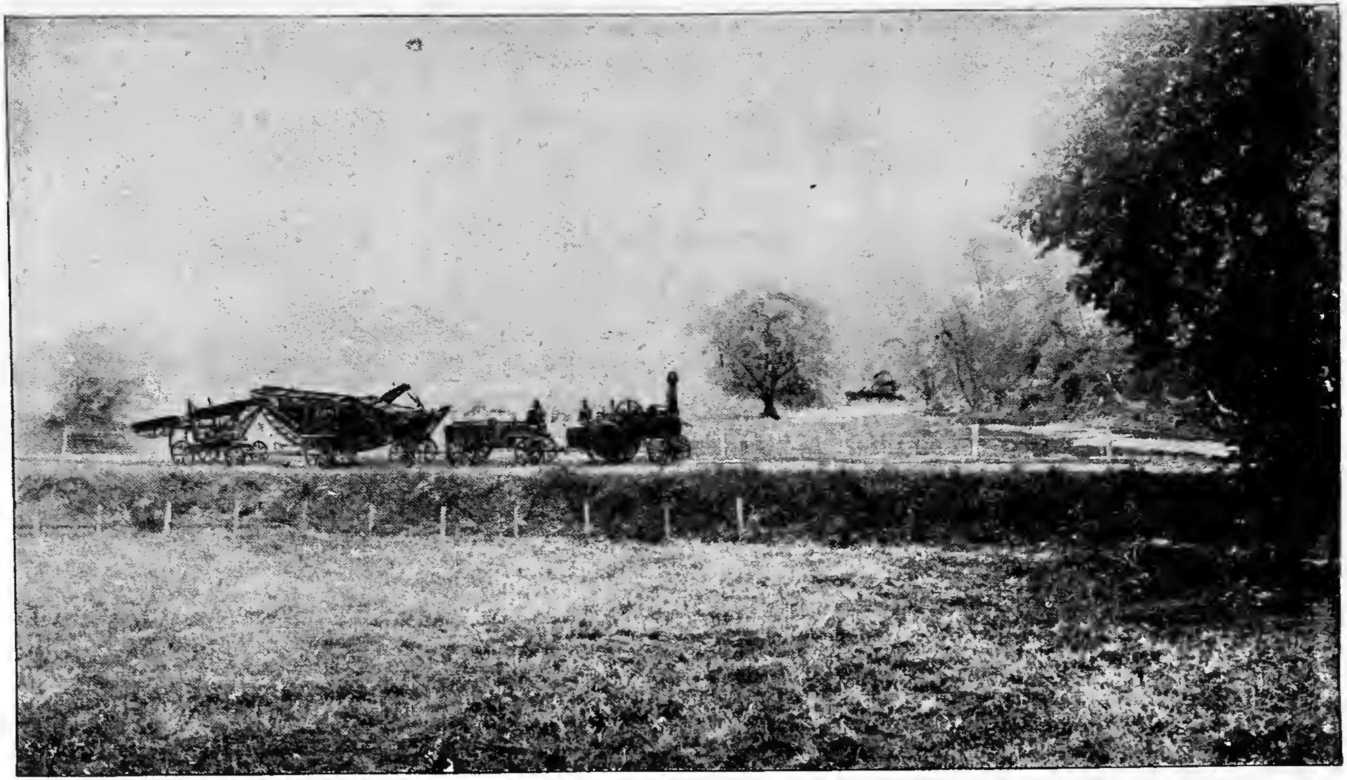
For the purpose of draining the city of Canton with water and house sewerage, suitable and proper sewers shall be constructed from time to time whenever deemed expedient by the Council and in accordance with such general plan, to be adopted by the Commissioners of Sewers and approved by the Council of the city. And for the purpose of taxation to build, construct and maintain the same or any part or portion of it, the said city shall be, and the same is hereby divided into three (3) several and separate sewer districts, named and numbered respectively as follows: East Sewer District of the city of Canton, and numbered one (1); also West Sewer District of the city of Canton and numbered two (2); and Central Sewer District of the city of Canton and numbered three (3).

SECTION NO. 325 OF THE REVISED ORDINANCES.

Fixing the Boundaries of Sewer District Number Three.

The limits and boundaries of the sewer district to be known as the Central Sewer District of the city of Canton No. 3, be and the same are hereby fixed as follows, to-wit:

Beginning at the point where the main sewer crosses the Connotton Railroad near Shriver's Run; thence eastward with said track to Liberty street; thence northwardly with Liberty street, including the lots fronting on the east side of same to Mulberry street; thence in an eastwardly direction with Mulberry street (including the lots fronting on the south side of the street) to Ninth street; thence north to the Pittsburg, Ft. Wayne & Chicago Railroad; thence northeastwardly with track of said railroad to a point in the line with Herbruck street (produced); thence northward with said line and Herbruck street to Second street; thence westward with Second street, including lots fronting on north side of Second street to the line of Correll street (produced); thence northwardly with that line and Correll street, including the lots fronting on the east side of that street to Washington avenue; thence westwardly with that street, including lots fronting on the north side of that street, to Spring street; thence northward with Spring street including lots fronting on the east side of that street, and abutting thereon, to the north corporation line; thence westward with said line to Cleveland avenue; thence southward with said avenue including lots fronting on west side of same to Summit street; thence westward with Summit street to Plum street; thence southward with Plum street, including the lots fronting on the west side of the street to Third street; thence westward with Third street including the lots fronting on the north side of that street to Shorb street; thence southward on Shorb street including the lots fronting and abutting on west side of same to Fifth street; thence westward with Fifth street including lots fronting on north side of same to the line between the lots Nos. 1598 and 1600; thence south with said line



EMBANKMENT BETWEEN C., C., & S. R. R. TRACK AND ALLEN STREET BRIDGE. (BY THE KINDNESS OF C. AULTMAN & CO.)

The fence at the foot of the embankment shows the original level of the ground, The bottom of the sewer is two feet above the old ground level, and the road surface is four feet above the top of sewer.

between lots Nos. 1617 and 1618, to Tuscarawas street; thence westward with said street including lots fronting on the south side of it to the alley on west side of out lot No. 101; thence southward with that alley to Eighth street; thence east on Eighth street including lots fronting on south side of same to Marion street; thence southward with Marion street to Tenth street; thence eastwardly with Tenth street including lots fronting on south side of same to High street; thence south on High street including lots fronting on the west side of the street to South street; thence eastwardly with South street (south side of same) to Plum street; thence south with Plum street including lots fronting and abutting on west side of same to Cedar street; thence eastward with Cedar street including the lots fronting on south side of same to Market street; thence southward with Market street including the lots fronting on west side of said street to Valley Railroad track; thence southward with said track to the Connotton Valley Railroad; thence eastward with the last named track to the beginning. (Sept. 17, 1883.)

SECTION NO. 326 OF THE REVISED ORDINANCES.

Leaving Exact Boundaries of East and West Sewer Districts to be Established when deemed Expedient.

That the exact boundaries and limits of the east sewer district of the city of Canton numbered one (1), as well as that of the west sewer district of the city of Canton numbered two (2), shall be fixed and established by an ordinance to be passed by the Council for that purpose, whenever deemed expedient by the Council of that city.

With this report, fixing the boundary of Sewer District Number 3, Major Humphrey's term of service was brought to a close. The work done by him amply confirmed the recommendations that preceded his coming. In fact the controlling recommendations of our city sewer system are largely due, in part to him, and in part to his more distinguished predecessor, Col. George E. Waring.

The minutes of the Sewer Board, July 5, 1883, contain the following memorandum:

"It was deemed expedient to dismiss Major Humphreys for the present.

"First—Because he has fixed the route of the sewers, mapped and districted the area of the city, made necessary profiles and specifications, and done all that can and will be accomplished before the actual work of building the sewers is commenced, and

"Second—Because, in the opinion of the City Council, money for the purpose of building the sewers cannot be provided before September 1st; and perhaps a longer time will elapse before the required funds are provided."

THE SEWER PROJECT TAKES A FIVE YEARS' REST.

The outlook for the form of relief furnished by a system of sewers at this date was far from encouraging. The City Hall was in process of construction and absorbed all the attention and all the available money at the disposal of the municipal authorities. The Council did, however, go so far as to pass a resolution authorizing a popular vote on the question of sewers at the April election in 1864. The majority in opposition to sewers was 604.

Taken as an indication of the popular wish this result was meaningless, or at best misleading. The form of voting was simply, "Sewers, Yes," "Sewers, No." Not one hundred voters had informed themselves as to the plans proposed. When these plans, the cost and the advantages came to be understood there was a revulsion in feeling. As a stimulant to investigation the sewer election happily resulted in some benefit.

During the next three years there is little to report. The unrest increased. In 1884 the cholera invaded Europe and there was the general warning to clean up. The following memorial was presented to the Council:

To the City Council:

In view of the prevalence of contagious diseases, and of the possible spread of epidemics dangerous to life to this portion of the country, and of the well established fact that the danger from such epidemics is greatly increased by the retention of offensive waste matters in, or near the homes of the people, we would urge upon the City Council the necessity of immediate action for the construction of house sewers as a sanitary measure of the first importance. The health and general welfare of our city have already suffered much from want of sewers. In the presence of the danger that now threatens, any further delay will be inexcusable and suicidal.

WM. DANNEMILLER,
WM. A. LYNCH,
JOSIAH HARTZELL,
Sewer Commissioners.

CANTON, July 28th, 1884.

The city Board of Health instructed a committee to report as to the best means of promoting the public health. An extract from said report is as follows:

Third—These drainage wastes may be hauled away in vehicles, or may be removed beyond the city limits by means of properly constructed drains or sewers. Owing to the imperfect working of the first-named method, and to the enormous expense it entails, if thoroughly done, we would recommend the construction of a house sewer system for the accomplishment of the purpose named in your resolution.

R. P. JOHNSON,
J. H. DUMOULIN,
Committee of the Board of Health.

May 27, 1886.

Grevious complaints were made by householders and business men. Public improvements were hindered. The public business suffered. Complaints about the condition of things at the county buildings became a matter of record. A few extracts will reveal their nature:

Extract from the report made by the Grand Jury to the Court of Common Pleas, October 26, 1883:

"The Grand Jury report the basement of the jail in a very unhealthy and filthy condition, caused by the filtration of water, more or less impregnated with refuse matter from the cesspool on the west side of the jail into the basement. They recommend steps to obviate this nuisance."

From the Grand Jury report, January term, 1884:

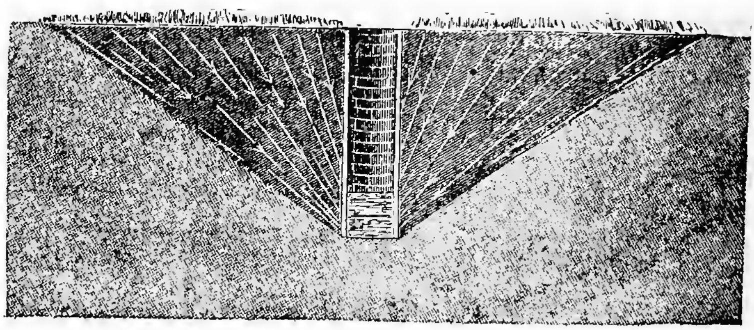
"We find the basement of the jail in a most filthy state. * * * The grand jury are of the opinion that nothing further can be done to abate the nuisance existing about the buildings, except what the commissioners are doing, until some good sewerage system is adopted and constructed."

During the same term of Court Judge Pease, after charging the Grand Jury, said:

"Last term the Grand Jury of this County in their report represented that the basement of the jail was in a horribly filthy state, arising from the overflow from the cesspools surrounding it; that this state of things was a matter over which the sheriff had no control and for which he was in no way responsible, and the commissioners in said report were asked to give it immediate attention and to purify it, as will be seen by their report which will be furnished you if you desire it. If you visit the jail early you will find a portion of the contents of the cesspools on the bottom of that jail cellar, which makes it in a terribly filthy condition. We get the horrible air arising from that filth, and not a term passes but what men are prostrated here before our very eyes from its effect; and the wonder is that every one of us are not sick. The officers complain, the inmates of the jail complain, and the Commissioner's attention has been called to it by the report I have mentioned, and by the Board of Health of the city. All public buildings are under the direct supervision of the Commissioners, and it is their duty to keep them all in a healthy condition. The visiting committee appointed one year ago has made a special report, which has been published and which, doubtless, many of you have read; this report will be presented to you and you will see by that that they call the attention of the Commissioners to this same thing. I have severnl times spoken to you in regard to it. It is insufferable and unbearable and delay in remedying this is dangerous and should be punished. As I said before, sickness of the persons whose duty it is to be around here is caused by it. The condition of our Sheriff to-day, I have no doubt, is more or less due to this. And now, I desire to recommend to you, as a Grand Jury, take this matter into your consideration, and I refer you to the section of the statute (Judge Pease read the section of the statutes appertaining to the maintaining of a nuisance) and to the section of the statute pertaining to a commissioner's neglect of duty being a cause for removal from office. (Here he read the section in full relating as above). Now, gentlemen, unless you are satisfied that measures are being taken to speedily remedy this matter, I recommend that the Commissioners be indicted."

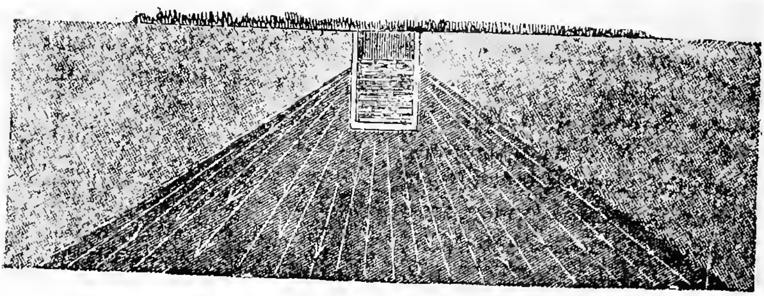
DANGERS TO WELL WATER.

WELL.



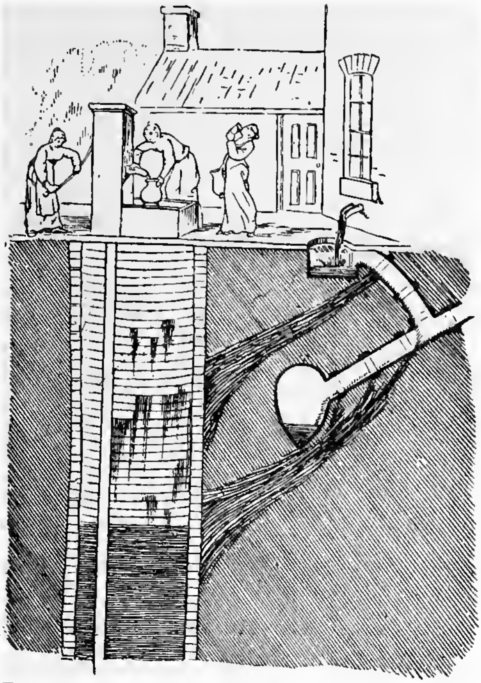
Drainage area.

CESSPOOL.



Cone of pollution.

THE CITY COUNCIL OF 1887-1888 INAUGURATES ACTIVE WORK.



To be assured that the drainage area of the well, and the filtration, or pollution scope of the cesspool, are as portrayed elsewhere one has only to recognize the facts. The situation shown in the picture was discovered, and the well suppressed, only after a considerable number of persons had been sickened, some of whom died. A leaky sewer pipe is about as bad as a cesspool. At best, well water in a thickly settled place must be regarded with suspicion. The well here referred to was noted for the sparkling purity of its water.

With the advent of the City Council, which came into control in the spring of 1888, the Sewerage project assumed a more hopeful aspect. The danger of further delay was great, and the increasing irksomeness of the "odorless excavators" had become intolerable. The conviction that the inauguration of a wisely planned drainage system would be approved, and should be no longer deferred, was shared by every member of that body. The Sewer Commission and the Engineer made known that which they would recommend, with their reasons therefor, and the estimates which the proposed improvements would require. As the money would have to be furnished and the practical work done, by the Council, measures looking to the achievement of these purposes commenced to be canvassed.

SEWAGE DISPOSAL PRELIMINARIES.

Two questions remained to be disposed of before any positive action on the part of the Council would be vouchsafed. One was a stumbling-block of threatening proportions, viz.: the problem of sewage disposal.

The effluent of the proposed system, and of any system, would eventually have to flow into the creek, south of the city. Whether used for irrigation, or treated in any manner known to science, the resultant water would inevitably have to pass off by that route.

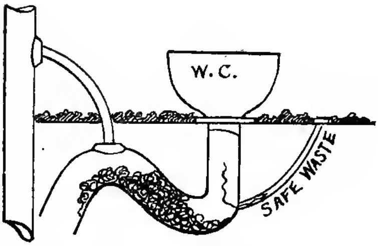
Persons having riparian interests that would be affected acknowledged this, but they made known their reasonable objections to the use of the creek by the city a as means of conveying away sewage in its crude form. Besides, the language of the State law leaves no doubt as to the attitude the courts would have to assume toward the party who would attempt such a wholesale pollution of a fresh water stream.

It is popularly known that the crude outflow of many city sewer systems is delivered directly into streams of considerable size, and is defended on the ground that the evil is cured by dilution. But the sanitary history of populations living contiguous to streams that are so employed does not confirm.

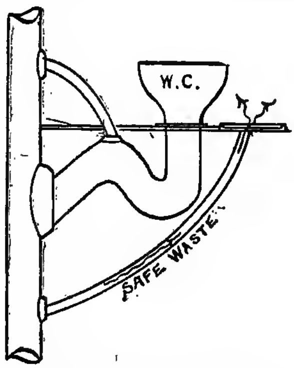
the correctness of any such theory. Exactly the contrary is true. The history of the Ohio River, in more recent years, is a case exactly in point. The scheme which has for its purpose the drainage of the sewage of Chicago through the Illinois River is also defended on the dilution theory. Such a proceeding is out of harmony with the scientific advancement of this age and, under the laws of Ohio, it would be impracticable of realization.

But granting that the evil of stream pollution may, to some extent at least, be modified by large dilution, the volume of water in the Nimishillen at the minimum stage is totally inadequate. The approximate average flow from the several tributaries which constitute its current are as follows:

	Gallons Per Minute.
Gallons per minute (at Tuscarawas street bridge)	1,400
From springs between bridge and junction of creek	2,000
From East Creek	3,000
From other springs	600
Total	7,000



The safe waste should not enter the trap in this manner, for any stoppage in the trap would force the sewage back, via the waste-pipe, into the house.



Neither should the safe-waste be connected to the soil pipe, for this would conduct sewer air into the house. To obtain a correct adjustment consult a good plumber.

Inasmuch as the effluent of crude sewage from the city sewers would probably reach one million gallons daily it becomes apparent that, certainly in our situation, all the dilution obtainable would be simply a farce.

This subject in many of its phases had already engaged the serious attention of the Sewer Commissioners and they were of the opinion that the city, in a matter of such a complex nature, and involved in so much difficulty and doubt, resort should be had to the safest and most successful engineer in this special field. Their choice fell upon Samuel M. Gray, of Providence, R. I. Mr. Gray was recommended and employed for the purpose stated. He reached Canton on January 22d, 1887.

Assisted by City Civil Engineer Holl, Mr. Gray spent the following three days in making an examination of our situation. His report, which was placed on file on March 8th, was as follows:

ENGINEER GRAY'S REPORT.

Messrs. William Dannemiller, President; Josiah Hartzell, Secretary; W. A. Lynch, Daniel Parr, Dr. E. O. Portmann, Sewer Commissioners:

GENTLEMEN:—Having carefully considered the question submitted to me, viz: The disposal of the sewage of Canton, I respectfully present the following report:

In order to make estimates and comparisons of cost it is necessary to assume some definite number of people to be provided for not only for the present, but also for the future. Errors may be made by over estimating as well as by under estimating for the future, and there is a limit beyond which it is not wise to provide. I have based my estimates on a present population of 12,000 inhabitants connected with sewers, and for a future population of 50,000.

METHODS OF DISPOSAL.

The principal methods for disposal of sewage are as follows: Crude disposal, disposal by broad irrigation, by intermittent filtration, and by chemical precipitation; the latter sometimes is supplemented by filtration through land.

We will consider these in the order named.

CRUDE DISPOSAL.

In crude disposal the sewage is collected at one or more convenient points, and there discharged in its crude state directly into the ocean, lake or running stream. This system is admissable when the currents are sufficiently strong, and the volume of water sufficiently large, in proportion to the quantity of sewage discharged, so that no nuisance is caused thereby. Exceptions may be taken to this disposing of the sewage where the water from the stream is taken for domestic supply below the point of sewage discharge.

BROAD IRRIGATION.

In this method of disposal the sewage is turned upon the land for the purpose of irrigation, as well as for the purification of the sewage, the earth acting as a purifier of the foul liquid by first arresting upon its surface the coarser substances; the particles sufficiently minute to pass into the earth are next caught; the water thus freed from insoluable matter descends into the earth and is absorbed by the soil, and oxydized by the air in the ground. It is quite essential for the successful working of irrigation, that the land be so underdrained that the purified water may be readily taken from the ground. Soils differ in their powers of purification, but it has been found by experience that on an average one acre of land is required for the disposal of the sewage of one hundred people.

INTERMITTENT FILTRATION.

This system of disposal is in some respects not unlike broad irrigation; the main difference being that the ground is more thoroughly underdrained, more care taken in preparing the surface, which is brought to a level. The solids are allowed to settle in tanks, after which the sewage is intermittently applied in much greater quantities than in broad irrigation. It is not unusual to apply the sewage of eight hundred or one thousand people to the acre.

In intermittent filtration it is necessary to remove the solids from the sewage before applying it to the land, which is done in single tanks by sedimentation only (no chemicals being used) while in broad irrigation only so much sewage is applied as the crops are able to receive without injury.

CHEMICAL PRECIPITATION.

Chemical precipitation consists in mixing with the sewage certain chemicals which precipitate all solids held in suspension. The mixture of chemicals and sewage being allowed to flow into tanks where it comes to an absolute or comparative rest, and the precipitated matter settles to the bottom of the tanks and is called sludge, the effluent or clarified liquid being allowed to flow off into the nearest stream. The sludge contains about ninety per cent. of water and is in a semi-fluid state, and is best treated by the use of hydraulic filter presses by which the amount of water is reduced to about fifty per cent. of the weight of the sludge. As it comes from the presses the sludge is nearly devoid of odor and is of such compactness that it can be readily handled. The general features of precipitation works may be briefly stated as follows: Mechanical arrangements for separating the grosser solids from the sewage, and for dissolving the chemicals and mixing them with the sewage; tanks of the proper size for the precipitation of the impurities; channels for the escape of the effluent; pumping machinery for removing and handling the sludge from the tanks; presses and conveniences for the removal of the pressed sludge; buildings for the protection of the machinery; store houses, etc.

From the information furnished me, I am of the opinion that you can safely practice crude disposal for a part of the year for some time to come, emptying the sewage into the Nimishillen creek, at a point west of Mr. Miller's house, below the dam. There would, however, probably be times during the season when crude disposal would not be satisfactory; and the time will doubtless come when, as the city grows, such disposal will cause a nuisance. Your authorities inform me that if crude disposal should be practiced during the entire year action would be taken to prevent the same during the low stage of the creek; and it is therefore necessary to provide some other mode of disposal. The most suitable tracts of land for irrigation or intermittent filtration within reasonable distance of the city are the Sarver fields and the Carnes land. If irrigation or intermittent filtration be adopted, it will be wise to secure, if possible, the amount of land required for future use, preparing only so much as is needed at the present. If precipitation be adopted, the works should be of proper size to treat the sewage for the present, and at the same time be capable of extension to meet further needs.

ESTIMATES FOR BROAD IRRIGATION.

SARVER FIELDS.

Extending sewer	$ 5,500 00
Engine and pump, house and land for same, force main, etc.	6,100 00
3co acres of land at $350 per acre	105,000 00
Preparing 120 acres	30,000 00
Total	$146,600 00
Contingencies	21,990 00
Sum total	$168,590 00
Interest on cost at 4 per cent	$ 6,743 60
Cost of pumping per annum	2, 042 00
Total expenses per annum	$ 8,789 00

CARNES LAND.

Extending sewer	$ 9,660 00
Engine and pump, house and land for same, force main, etc.	6,100 00
300 acres of land at $300 per acre	90,000 00
Preparing 120 acres	30,000 00
Total	$135,760 00
Contingencies	20,354 00
Sum total	$155,123 00
Interest on cost	$ 6,244 96
Cost of pumping per annum	1,942 40
Total expenses per annum	$ 8,187 46

ESTIMATE OF INTERMITTENT FILTRATION.

SARVER FIELDS.

Extending sewer	$ 5,500 00
Engine and pump, house and land for same, force main, etc.	6,1000 00
50 acres of land at $350 per acre	17,500 00
Preparing 13 acres of land, sludge tanks, etc	10,450 00
Total	$ 39,656 00
Contingencies	5,932 50
Sum total	$ 45,482 50
Interest on cost	$ 1,819 30
Cost of pumping per annum	2,420 00
Total expenses per annum	$ 3,861 30

CARNES LAND.

Extending sewer	$ 9,660 00
Engine and pump, house and land for same, force main, etc	6,100 00
50 acres of land at $300 per acre	15,c00 00
Preparing 12 acres of land, sludge tanks, etc	10,450 00
Total	$ 41,210 00
Contingencies	6,181 50
Sum total	$ 47,391 50
Interest on cost	$ 1,895 66
Cost of pumping per annum	1,942 50
Total expenses per annum	$ 3,838 16

ESTIMATE OF PRECIPITATION.

RAYNOLD'S BOTTOM LANDS.

Filter presses, chemical mixers, etc	$ 10,500 00
House, tanks, connections, etc	6,200 00
20 acres of land at $350 per acre	7,000 00
Total	$ 23,700 00
Contingencies	3,555 00
Sum total	$ 27,255 00
Interest on cost	$ 1,090 20
Cost of treating sewage 4 months in the year	2,000 00
Total expenses per year	$ 3,090 20

BRILLHART BOTTOM LANDS.

Extension of sewer	$ 6,440 00
Filter presses, chemical mixers, etc	10,500 00
House, tanks, connections, etc	6,200 00
20 acres of land at $160 per acre	3,200 00
Total	$ 26,340 00
Contingencies	3,752 00
Sum total	$ 30,201 00
Interest on cost	$ 1,211 64
Cost of treating sewage 4 months in the year	2,000 00
Total expense per year	$ 3,211 64

From the data furnished me neither the Sarver fields nor the Carnes land seems to contain more than 300 acres, an insufficient quantity of land for broad irrigation, having regard for future needs. Aside from the deficiency of land, a glance at the estimates will show the impractability of broad irrigation at either of these locations. A comparison of the estimates for intermittent filtration at the Sarver fields and the Carnes land shows the first cost of the former to be slightly less than that of the latter, while the annual expense of operating the farm is slightly in favor of the Carnes land. For this reason and from the fact that the Carnes land is more remote from the city and the Sarver fields lie in the track of the prevailing summer winds to the city, the Sarver fields may be excluded from further consideration. It will be noticed that for crude disposal, or for precipitation, pumping is not required, while for irrigation or filtration at either locations pumping would be necessary. Neither the estimates for irrigation nor for filtration includes the cost for taking care of the sewage after it had been delivered on the ground, it being assumed that

THE INCOME FROM THE CROPS

will meet this expense. The estimates for precipitation are based on a location at the Raynold's bottom land, and the Brillhart bottom land, either of which locations is suitable for such work, the Raynolds bottom land being the most desirable from the nature of the soil and the lay of the land. As sewage is more fully purified by irrigation or filtration than by precipitation I have included in the estimates for precipitation the purchase of twenty acres of land; this amount of land is not necessary at present and will not probably be so for some time to come, but if in the future, towns below should take water from the creek for domestic purposes it may be necessary to filter the effluent through the earth, and it would be well to have land for that purpose.

It is difficult to estimate the annual cost of chemical precipitation, for much will depend upon the required purity of the effluent and upon the portion of the year it will be necessary to treat the sewage. For the purpose of comparison of the cost of operating the different methods, I have assumed the expense of precipitation as

FIFTY CENTS PER HEAD PER ANNUM,

which I believe in your case is quite enough, and this is intended to cover the cost of treating the sewage twelve months in the year. After carefully considering all the existing conditions in your case I recommend chemical precipitation to supplement crude disposal, so far as it shall be found necessary, and this I believe wlil prove the most applicable to your needs. As before stated it will be well to secure land for the filtration of the effluent should it become necessary in the future. There will probably be much of the time to come when crude disposal may be made of the sewage or to say the least, the chemical treatment need not be carried to a high degree of perfection. I am informed that some parties are ready to contract with your city to take the sludge from the tanks free of expense to you, and while I cannot encourage the expectation that such arrangements will prove lasting or satisfactory, still it may not be unwise to consider such an offer from responsible parties, and should you be able to make such arrangements permanently the cost of the works would be much reduced, for you would thereby be able to do without the filter presses and other parts of the plant included in the estimate. I desire to acknowledge my indebtedness to Mr. John H. Holl, City Engineer, for much valuable information furnished me in a very concise and comprehensible form.

SAMUEL M. GRAY.

On July 28th, 1887, the following projects were recommended by action of the Board of Sewer Commissioners:

"*First*—The adoption of the plan of sewage disposal recommended for Canton by Samuel M. Gray in his report to the Commissioners, viz.: by precipitation, and

"*Second*—The purchase by the city of twenty-seven and fifty-eighths one hundredths (27 58-100) acres of land near the intersection of Allen and Kimball streets, now owned by Louisa Staufer, for the purpose of carrying the plan above recommended into effect."

The tract of land above named was bought by the city on January 30th, 1888, for the price of $4,000.

Concerning the reasons which actuated the Sewer Board in taking this step a very few words will have to suffice. The present report aims to present that which has been accomplished, and the latitude that is permissible for sustaining argument and testimony is necessarily very restricted. It will easily be believed that a detail of the considerations which had more or less bearing on our decision in this matter would, of itself, require more space than several entire documents as large as this report.

What will you do with the sewage? had been a grave conundrum with the sewers' friends; it was also a favorite flippancy of the sewers' enemies. For non-professionals the proper answer was:

We do not know. We do, however, know that sewage disposal problems far more vexatious than ours have been satisfactorily and permanently solved. We also know that the services of the engineers who have planned sewers and sewage disposal under similar and even more intricate conditions, can be had to answer this important question satisfactorily and with scientific and mathematical correctness. Until such answer is made by an engineer whose record of success justifies entire faith in his conclusions, it is nearly idle for persons without knowledge or experience to speculate as to the best method of disposing of the drainage wastes of our city.

Such were the opinions which had been formed by the members of the Board of Sewer Commissioners after a somewhat careful study of the available printed literature bearing on this vexed problem.

Mr. Gray was, himself, the largest contributor to published knowledge in this field. He had visited, and made a study of all the sewage disposal plants in Europe, and his report on that subject was recognized as that of the highest value. His character and qualifications were known to be such as would confer upon his recommendation for Canton the greatest authority.

As has already been stated, the Sewer Commissioners felt justified in adopting the plan recommended by Mr. Gray for Canton, namely, the precipitation method.

It may be added, paranthetically, that sufficient time has elapsed since the above action was taken to permit a personal inspection of several disposal plants, situated at various points in the eastern part of this country, with the result that we are fully confirmed in the wisdom of our action. This inspection was conducted by a committee appointed by the City Council for that purpose, consisting of L. E. Chapin, City Engineer; J. M. Campbell, on the part of the Council, and Josiah Hartzell, on the part of the Sewer Commissioners. This committee's report, prepared by Engineer Chapin, and presented to the Council on February 16th, 1892, was as follows:

REPORT OF SPECIAL COMMITTEE ON SEWAGE DISPOSAL.

Following is the report of the special committee appointed under the resolution of Council to investigate sewage disposal works in the east with especial reference to the best method to adopt for the city of Canton, Ohio. This committee having visited such eastern works made the following report and recommendations to the Council meeting of last night. The most successful method of sewage purification as practiced at home and abroad are: First, chemical precipitation; second, Filtration; third, irrigation. In irrigation the sewage is applied to the surface of a sandy or loose soil in continuous sheets or by means of carriers and trenches and when suitable soil is had in proper condition and in sufficient areas it can be cultivated and at the same time so purify sewage that the effluent will be quite satisfactory and sale of crops materially reduce working expenses. The area of land required varies largely with character of soil and sewage—probably one acre for each 10,000 gallons sewage applied per day, requiring, say 100 acres for treatment of the present sewage. Second: Filtration as practiced generally consists of preparing ground by grading and underdraining and distributing sewage by surface carriers passing sewage over a portion of land for a time, and then allowing this portion to rest, turning flow on next area, and so on. When land is cropped much larger areas are required than when no attempt is made to realize from cultivation. Sewage, say from thirty to sixty thousand gallons per day, can be purified by filtration without cropping, requiring for present needs of Canton say about thirty acres of land. In both filtration and irrigation the land must be especially prepared for the reception of sewage and such channels dug repeatedly to dietribute same, requiring an outlay for preliminary preparation of from one to four hundred dollers per acre. The effluent from such land when not overloaded with sewage is good, and generally satisfactory to owners of abutting land on outfall streams. Third: Chemical precipitation is the system recommended by Mr. S. M. Gray, consulting engineer, as being best adapted to the needs and means of Canton. This method consists in mixing certain chemical solutions with the sewage, which while acting as deodorizers and disinfectants, also enter into chemicai combinations with the organic and inorganic properties of sewage, thereby promoting precipitation of the solid and much of the dissolved matter. This mixture of chemicals and sewage passes into a series of larger masonry tanks from which the effluent flows off as practically clear water, leaving such impurities as have been removed in the bottom of the tanks in the form of a semi-fluid mass called sludge, composed of the solid and organic matters before contained in the crude sewage, and about ninefy-five per cent. of water. The sludge is disposed of by drawing off, and either by passing through filter presses, removing most of the water and compressing the sludge into cakes, which are hard and dry enough to be readily handled. Or instead of pressing, the sludge is sometimes spread on the surface of a sandy, open soil, the water being largely removed by evaporation and by filtration, and the resultant sludge, as in case of pressed sludge, disposed of by cremation or for fertilizers, if demand should be had for such.

The chemical precipitation plant seen at Worcester had little or no odor in connection with any part of the buildings or grounds. They treating the sludge by spreading on sandy or gravelly soil, while the East Orange, New Jersey works, being located in the midst of a thickly settled community, used the filter process to condense sludge, after which it was used as fertilizers or burned.

At Worcester the change from sewage to purified effluent was rather surprising. Crude sewage entering the tanks being black, foul looking and filled with every conceivable matter in suspension, was at the outlet of the tanks transformed into sparkling springlike water.

At East Orange the effluent from tanks was first passed over a small area prepared for filtration, from which the effluent entered into the waters of Second river of sufficient purity to satisfy the local health boards of the abutters on the line of the stream. The cost of a complete plant in working order will be approximately $38,000, and be of such capacity as to buildings, tanks and principal machinery that will suffice for possible increase on present flow by adding future tanks and minor machinery and without materially increasing the operating expenses.

The annual cost of operating the plant will not be far from $5,000 per million gallons of sewage treated per day, requiring in addition of lime, chemicals, fuel, oil, etc., probably the service of three men, two by day and one by night. The present flow of sewage in outfall sewer is not far from 800,000 gallons per day, coming entirely from sewer district No. 3. In this district, however, are many houses not yet connected with the sewer. About 30 per cent of improved property abutting on house sewers are still using vaults and cesspools. The completion of the disposal works will place the city in position to enforce section 357, codified ordinances relating to sewer connections.

On a careful consideration of the problem and with ideas and results gained and had from various disposal works visited, this committee is of the opinion that the method of chemical precipitation as recommended by Mr. Gray to be the best and most practicable for our needs. And we therefore recommend that immediate steps be taken to carry out his plans, making some modifications in constructing the works, believing in their ultimate success, and that effluent reaching the creek will be in no manner objectionable to owners and residents along and in the lower creek valley.

JOSIAH HARTZELL,
Clerk Sewer Commission.
J. M. CAMPBELL,
Chair. Council Com. on Sewage.
L. E. CHAPIN,
City Engineer.
Committee.

It need be only added here that inasmuch as the City Engineer has consented to prepare a supplementary statement fully explicative of our sewage disposal works, to be added to, and constitute a part of this report, that branch of the subject will now be dropped.

THE COUNTY COMMISSIONERS APPROPRIATE $10,000.

There still remained a feature of the question of taxation which members of the Council resolved should be settled before other action was taken, viz.: the status of the county in regard thereto. It was reasoned that while the county seat property would be by far the largest single beneficiary of the sewer system, the county property could not be taxed in the regular way to assist in paying for the same. Even if the per foot front tax, by the proceeds of which it was intended to pay for the lateral sewers, was allowed, there still remained the main sewers, right of way, the disposal works, the sewer farm, and more important than all else, the perpetual maintenance of both the sewers and disposal works; all these would have to be paid for by a general tax on city property from which the county would escape entirely.

Inasmuch as the taxpayers of the city of Canton already pay nearly one-third (about 12-38ths) of the entire county tax, and as only a very small proportion of the sum so contributed is expended within the boundaries of the municipality, it was deemed wholly inadmissable that these sewer immunities, for perpetuity, should be conceded, in the absence of a substantial consideration. In regard to the sum that should be contributed by the county $20,000 was deemed not unreasonable, inasmuch as the county was already paying $1,200 a year to have the Court House sewage hauled away; and with the result, as appears by the charge of Judge Pease to the Grand Jury, that a large share of it was not hauled away at all, but leaked under the foundations of both Court House and jail, to the great disgust and injury of the inmates and contiguous property interests. From these evils there was no escape except by means of sewers. The County Commissioners had repeatedly uttered this opinion. The following is an extract from the report of the jail physician to the judge of the court:

"It is my opinion that this evil cannot be remedied except by some general plan of sewerage, and it would seem to me to be advisable that the County Commissioners act in concert with the city authorities and agree on some plan which would relieve the jail and the court house of this offensive odor."

At a session of the County Commissioners, held on October 10, 1887, the Board of County Commissioners agreed to allow the city the sum of $10,000, to be paid in three installments, as follows: One-third when sewer is properly connected with the county premises; one-third in one year thereafter, and one-third in two years thereafter.

Late in the fall of 1889 the county premises were connected with the sewer. On the 3d of January, 1890, the first part of the county's installment, being $3,333.33, was paid over to the city as agreed.

(On February 6th of the following year, and before the second installment had been paid, Messrs. Zachary Shoemaker, John C. Dielhenn, C. Frank Schorm and Joseph Oppenheimer, representing the Board of Trade of the city of Massillon, applied for and obtained from the judge of the court of Common Pleas a temporary injunction restraining the County Treasurer from making further payments on the ground that the act of the County Commissioners was not legal.

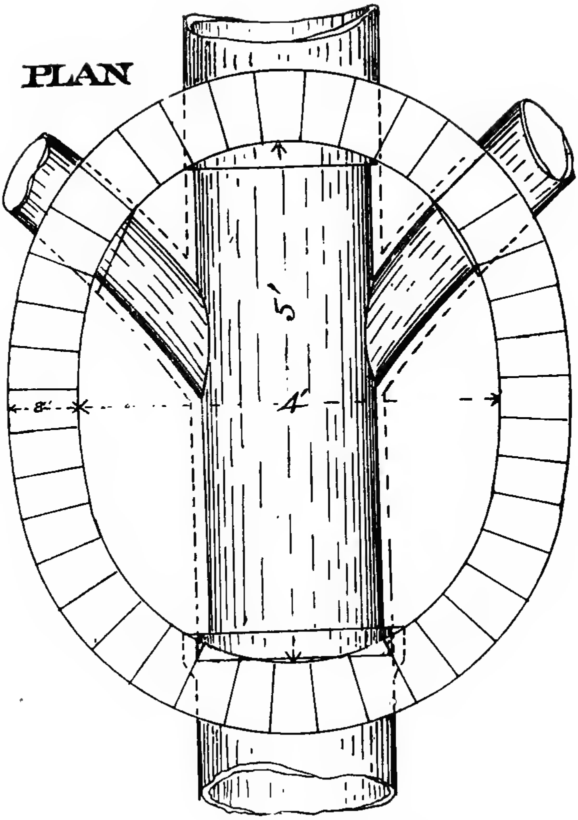
Subsequently the case came up for hearing before Judge McCarthy, by whose decision the injunction restraining the county from paying the remaining $6,666.66 was made perpetual.

The judge expressed the opinion that the action on the part of the County Commissioners could rightfully be considered in the light of a judicious investment by the county, but if no power was vested in them to make such a contract, then the latter could not be ratified. He said that taxing schemes must be uniform, that the city could not discriminate against the county, that the statutes do not authorize such a contract, and that therefore there was no power to order the payment of money on such a contract. This decision was rendered April 6, 1893. The City Solicitor gave notice of appeal.)

ACTS OF THE CITY COUNCIL AND STATE LEGISTATURE TO PROVIDE MONEY FOR BUILDING THE MAIN SEWER.

A remedy for the anticipated evils liable to result from stream pollution having now been provided, and a satisfactory contract made with the county authorities, all impediments in the way of concerted practical action had been removed. The need of sewers was too pressing to permit the delay exacted in waiting for money to be raised by a tax levy. Therefore, at a meeting of the City Council held on April 30, 1888, the following action was taken:

WHEREAS, The city of Canton, Ohio, has a population of 25,000 people, which is rapidly increasing, and has no means of drainage, either natural or artificial, for the disposal of house sewage, and its citizens are suffering for lack thereof, and a due regard for their health and convenience demands the construction of a general sewerage system without further delay, and,



HOUSE SEWER LATERAL JUNCTION MAN-HOLE.

In the man-hole bottoms the channel is in the shape of a split pipe, the top half being removed. By removing the man-hole lid the conduct of the sewer and branches is instantly obvious.

WHEREAS, There is no money in the sewer fund and there will not be for several years to come under the present restricted method of taxation, a sum sufficient to provide a proper and adequate system of sewerage to meet the growing wants of the people, and there is no other mode of raising the amount except by the issuing and sale of bonds of the said city in anticipation of a tax hereafter to be levied. Therefore be it

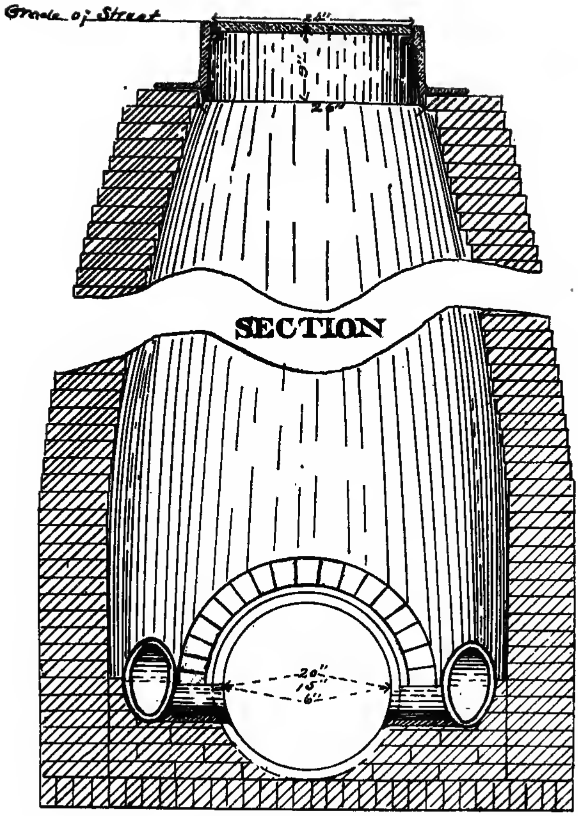
RESOLVED, That we, the City Council of the city of Canton, Ohio, heartily approve and endorse the bill entitled an "Act authorizing the City Council of the city of Canton, Ohio, to issue and sell bonds for sewer purposes," and rsepectfully petition and urge the General Assembly of the State of Ohio to enact the same without unnecessary delay.

The following is a copy of the sewer bill as passed:

A BILL

Authorizing the City Council of the City of Canton, Ohio, to issue and sell bonds for sewer purposes:

SECTION 1. Be it enacted by the General Assembly of the State of Ohio, that the City Council of the city of Canton, Ohio, be and is hereby authorized to issue and sell bonds of the city in the sum of fifty thousand dollars, bearing interest not exceeding six per centum per annum, payable annually, and of denominations not less than one thousand dollars each, made payable at such times as said Council may, by resolution, prescribe, but not less than three nor more than twelve years from date. Said bonds shall not be sold for less than par, and the proceeds therefrom shall be used for the



SEWER AND MAN-HOLE.

This sectional view of a man-hole on the house sewer system shows how the main and lateral sewers enter through the wall of man-hole.

purpose of constructing a main or trunk sewer, between such points and along such line as the Council may direct, and procuring the right of way therefor; and for the purpose of purchasing such land and providing such apparatus as in the opinion of the Council may be necessary for the disposal of sewage by chemical precipitation, or such other plan as the Council may adopt.

SEC. 2. If there be any balance from the proceeds of the sale of said bonds over and above what is necessary for the purposes set forth in section 1 of this act, the same shall be paid over into the sewer fund of said city and shall be used for such sewer purposes as the Council may from time to time direct.

SEC. 3. For the purpose of paying said bonds and the interest thereon as they may become due, the City Council of said city is hereby authorized to levy a tax not exceeding one mill per annum on all taxable property, both real and personal, of said city, in addition to the amount otherwise allowed by law, to be collected as other taxes, and the money so collected shall be used for the payment of said bonds and the interest thereon, and shall not be used for any other purpose.

SEC. 4. This act shall take effect and be in force from and after its passage.

A copy of the above was placed in charge of Senator T. C. Snyder, who procured its prompt passage without opposition.

Upon learning of the passage of the bill, the Board of Sewer Commissioners met, on March 9, 1888, and took the following action, basing the same on the belief that $25,000 would suffice to build the main sewer, thus leaving $25,000 to be employed in paying for the sewage disposal plant, when that work should be undertaken.

WHEREAS, This board is advised that the Legislature of Ohio has passed a law authorizing the City Council to issue bonds to the amount of $50,000 for the purpose of constructing a main sewer and proper disposal works for sewage; therefore be it

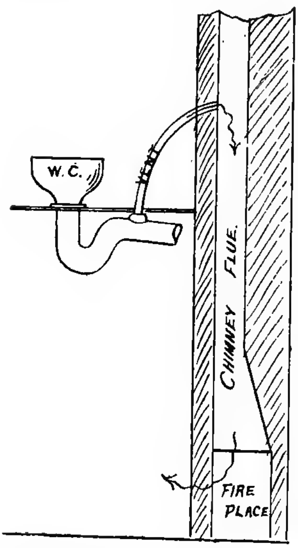
RESOLVED, That as soon as the Council has sold $25,000 of said bonds, so that there is money in the treasury for the purpose above stated, this board proceed to adopt plans as required by the statute for the said sewer, and that the secretary of the board advise the City Council of the action.

ROUTE AND RIGHTS OF WAY.

By reference to the sewer map it will be seen that the lower end of the main sewer is built on Allen street, from the sewer farm to the intersection of the C., C. & S. Railroad with that street. So far the city owned the right of way. From Allen street the course of the sewer, for a distance of about 1,000 feet, is along the south line of the railroad track, to Shriver's Run. This part was over the property of the Saxton heirs, and the right of way for the sewer and the needed drains was conceded for a consideration to which reference will be made further on.

The course of the sewer from the last named point to the foot of Walnut street is through private property. Portions of the way, south of the premises of C. Aultman & Co., had to be paid for, and were bought by the city. C. Aultman & Co. donated the right of way through their premises. The balance of the route to North street being on Walnut street the right of way belonged to the city.

The surface grade over the entire route was quite uniform and favorable, the entire fall being over 40 feet. A short fill was required south of Allen street bridge; also a longer fill south of the Valley Railway track; also a fill about 600 feet long north of the bridge. As portions of the street surface at these points were nearly two feet below the bottom of the proposed sewer a fill of about seven feet had to be made over the greatest depressions. The earth to make these fills was obtained from the higher ground on Allen street, south of the Valley Railroad track. Fortunately for the interests of that street the excavations and fill, taken together, brought the surface to an almost perfect grade.



The column of air in chimneys reaches the living rooms by pipe-holes or fire-place. If the closet is vented into the chimney sewer air may enter the house in the manner shown in the cut. Therefore our ordinance forbids venting into chimneys.

That part of the fill lying north of the bridge adjoined the Saxton heirs' tract. In conceding to the city rights of way over said tract the condition was made that the fill on Allen street should be extended 12 feet on the Saxton land side so as to comprise the area of a sidewalk.

As required by law, specifications of the main sewer had been prepared by the engineer. For convenience the sewer was divided into two parts, number one comprising the sewers north of the Allen street bridge, and number two the sewers south of the bridge. Following are the specifications:

SPECIFICATIONS

OF THE MATERIAL AND WORK REQUIRED FOR THE CONSTRUCTION OF MAIN SEWER NUMBER ONE, IN THE CITY OF CATNON, OHIO.

ENGINEER'S OFFICE,
1888.

Beginning at the intersection of the south line of North street with the middle of Walnut street; thence southwardly with the middle of Walnut street and the valley of Shriver's Run to the south side of the Cleveland & Canton Railroad; thence southwesterly seven and one-half feet from said railroad to the middle of Allen street; thence south wardly with said street to the east branch of the Nimishillen creek.

DIAMETERS OF SEWER.

The sewer from North street to Ninth street will be fifteen inches in diameter, from Ninth to Douglas street eighteen inches in diameter, and from Douglas street to the Allen street bridge, twenty inches in diameter.

TRENCHING.

The trenches shall not be less than four feet wide on the bottom, clear of shoring or bracing, all shoring or bracing will be furnished and placed by the contractor, and will be retained in position until so much of the back fill is made as will in the opinion of the engineer of the work, be sufficient to secure the sewer from disturbance when it is removed. The contractor will furnish all pipe and fittings or branches which may be required, and lay the same.

SEWER PIPE.

The pipe shall be of the best quality of vitrified socket sewer pipe, and for twenty-inch pipe shall have one and three-eighth inches thickness, eighteen-inch pipe one and one-fourth inches, and fifteen-inch pipe one and one-eighth inches; and no diameter of any pipe shall be more than three-eighth inch greater or less than that prescribed. They will be laid truly to the grade and line furnished by the engineer, so as to form when laid a continuous concentric tube.

LAYING TO GRADE.

The grade for each pipe will be ascertained by measuring down from a line stretched parallel to grade, by a straight edge used in connection with grade stakes set in the bottom of the trench, or other methods satisfactory to the engineer.

Great care will be taken to avoid excavating below the grade, and the trench will generally first be taken out to a line about four inches above grade, and the remainder removed immediately in advance of the pipe layers, by men skilled in following a grade.

When the pipes are laid on a curve, the ends will be cut to correspond to the radius of the curve.

CEMENTING PIPE JOINTS.

In all cases before the joints of the pipe are cemented, a gasket of oakum of sufficient size to prevent the entrance of the cement to the interior of the pipe, will be tamped into each joint. The cement joint of the pipes shall be made with the hand and not with the trowel. The cement shall be first pressed into the sockets with the fingers, so as to entirely fill the same, and the joint then completed by adding a small ring of cement on the outside of the sockets. The branches will be closed with a vitrified stopper and lime mortar, finished with a skim coat of cement.

DRAIN TILE.

The ditch will be freed from water while the pipe is being laid and until the back fill is made as high as the top of the pipe, and for that purpose a drain pipe shall be laid as near the side of the trench as possible and below the grade of the sewer. This should be a six-inch pipe at the lower end, and may be reduced to a four inch tile whenever the volume of water, in the opinion of the engineer, indicates that it will be of sufficient capacity to drain the trench.

PUMPING.

The contractor will be required to use pumps also, if they are found necesaary. Excavations shall be made in the bottom for the sockets, and the pipes laid with an even bearing along their entire length. The socket holes will be of such dimensions as will permit the under side of the pipe joint to be well made. If water accumulates rapidly in the socket holes, the engineer may require them to be filled with concrete, otherwise they may be filled immediately with suitable material from the trenches.

CEMENT.

The cement used will be of such quality as shall be satisfactory to the engineer, and shall be fresh, finely ground and quick setting, and shall be equal in every respect to the the best quality of Louisville cement. It shall be mixed with clear, sharp sand, in the proportion for pipe joints of not less than one of cement to one of sand; for brick work, one of cement to two of sand. It shall be mixed in suitable mortar boxes in small quantities as it may be required, and shall not be used after it begins to set.

MAN-HOLES.

The contractor will be required to construct man-holos at such intervals as may be determined by the engineer, they will be built in accordance with the plans accompanying these specifications, of smooth hard burned brick laid in cement with full mortar joints, which for each brick shall be made with one operation, by placing the mortar and pressing the brick into it and not by filling in the joint after the brick is laid. They will be finished at the surface with a cast iron cover made according to plan, to be furnished by the engineer, to weigh not less than two hundred and twenty-five pounds, and shall be provided with wrought iron steps of three-fourth inch round iron, thirty-two inches long with four angles.

The engineer may dispense with man-holes on such portions of the lines as he may deem proper, or may substitute for them vertical T branches of vitrified pipe.

PLATFORMS FOR FOUNDATIONS.

Should it be necessary for any part of the trench, in the opinion of the engineer, to construct a sewer on a platform, the contractor will excavate the trench to the required depth, provide and put in place the platform and fill to grade on the same with such of the material taken from the trench as may be directed by the engineer.

CONCRETE.

The concrete used in the work shall be of one part cement, two parts sand and three of clean broken stone or gravel.

The sewer when completed shall be turned over to the city, clean and free from all rubbish or any deposits of any kind.

DAMAGE TO GAS OR WATER PIPE.

The contractor will be required to provide against the injury of any gas or water pipe encountered in the work, and will be required to restore to their proper grade and line or repair any which may be moved or injured.

ENGINEER TO INSPECT MATERIAL.

All the work done under these specifications shall be satisfactory to the engineer, and the material furnished shall be subject to inspection by himself, assistant or inspector, and he shall determine all questions as to quality or quantity of materials and work.

All condemned material shall be removed from the work immediately after inspection, and if not taken away in twenty-four hours after notice to do so by the Engineer, may be removed by the city, and the cost of the removal deducted from any money due to the contractor.

The return of the engineer shall be the account by which the value of the work, stone and materials furnished shall be computed.

DANGER LIGHTS.

The contractor will be required to set up and maintain such lights and barricades on the work as will be sufficient to warn passers of dangerous places, and the streets will not be obstructed more than is necessary for the proper prosecution of the work. All losses or damages resulting from the nature of the work or from the action of the elements, or from unforseen obstructions or from encumberences on the line of the work shall be sustained by the contractor.

RAILROAD TRACKS.

All railroad tracks crossing the line of the sewer shall be supported by the contractor during the construction under and near them, so as not to interrupt the use of the tracks or endanger the traffic on them, and such tracks shall be fully restored to their original condition.

ENGINEER.

Whenever the word engineer occurs in these specifications, it is understood to refer to the City Civil Engineer of the city of Canton, who shall superintend the construction of the sewer, but he may be represented on the work by assistants or inspectors; he may give instructions to foremen or other persons in charge of the work.

DAMAGES TO PRIVATE PROPERTY.

The contractor shall be responsible for all unnecessary damages to private property through which the sewer mav pass, and will be required to fully restore all fences or other improvements which it may be necessary to remove or disturb during the progress of the work, and through the property of C. Aultman & Co. the contractor will be required without extra compensation to remove and replace all lumber and leave the premises when the work is completed in a satisfactory condition to the proprietors.

When required to do so by the engineer, the contractor shall discharge from the work any employe who shall fail or refuse to perform his work according to these specifications or directions of the engineer, or shall act in a disorderly or insubordinate manner on the work.

PROPOSALS, HOW DETAILED.

The proposals for the work shall contain prices for the following items which will be considered full compensation for furnishing all of the material and labor required to complete the work herein described, including all of the work and material necessary or incidental to the work priced.

For trenching per lineal foot, for cutting of eight feet or less depth, for cutting between eight and twelve feet, for cutting over twelve feet in depth.

For furnishing and laying pipe of each size named and for the branch pipes of the same diameters.

For each man-hole.

For each man-hole cover placed in position per pound.

For furnishing and laying down foundation platform, including nails, per 1,000 feet B. M.

The bottom width of the trenches shall not be less than two feet greater than the outside diameter of the pipe or sewer, clear of shoring.

THE BACK FILL.

The back fill must be done with such care as will not disturb the pipe and shall be free from stones of larger diameter than one and one-half inches, to such height as may be necessary to cover the top of the pipe to a depth of not less than eight inches. The filling shall be rammed if required by the engineer, in such manner as he may direct.

WHAT EXCAVATION OR TRENCHING INCLUDES.

The excavation is intended to mean all the work, both excavation and backfilling, trimming and shaping the bottom of the trench to grade and the shape of the sewer shoring and bracing wherever necessary, ramming and packing the earth along the sides of the sewer and settling the earth in the new filled trench by saturating with water and cleaning away all rubbish after the completion of the work, for the street shall be left in as good condition by the contractor as it existed before ground was broken.

FILLING AND GRADING ALLEN STREET.

Before constructing the sewer the contractor shall fill the depression in Allen street, between the Cleveland & Canton Railroad and the east branch of the Nimishillen creek, by excavating that part of said street lying between Center street and said railroad, and depositing the material into said depression so as to make a roadway thirty feet wide when the embankment is brought up to grade. The fill must be made to such a height that there will not be less than four feet covering on the sewer at any place.

The excavation north of said railroad will be made for a roadway thirty feet wide, and in depth of cutting must correspond to the grade as established by ordinance on Allen street, and the engineer will set stakes to indicate the lines and grade, the gutters shall be nine inches deep below the curb grade.

If the excavation north of the said railroad is not sufficient to make the necessary fill, the contractor must furnish ground from the high land on Allen street, south of the Valley Railroad, or else from some other place. In the middle of the roadway the fill will be made in layers of not more than one foot at one time, and must be well solidified to the satisfaction of the engineer, by saturating the same with water, ramming, or turning the travel of the street on the same, before depositing another layer. The fill must be made at least two feet higher than the top of the sewer before the sewer is constructed, and the balance of the filling may be done after the sewer work is completed and the cement has well set.

The contractor will state in his bid the price per cubic yard for filling, which will be measured in the fill or embankment.

MANNER OF MAKING PAYMENTS.

Payment will be made monthly as long as the work makes a reasonable progress to the amount of eighty per cent. of all work done, upon the estimates of the engineer, the remaining twenty per cent. will be paid when the work is completed and accepted by the City Council. The work shall be completed within three months of the time of entering into a contract for the same.

APPROXIMATE QUANTITIES.

The quantities by which bids will be compared, are approximately as follows:
Trenching less than eight feet, 700 lineal feet.
Trenching from eight to twelve feet, 7000 lineal feet.
Trenching over twelve feet, 700 lineal feet.
Fifteen inch sewer pipe, 2,050 lineal feet.
Eighteen inch sewer pipe, 1,850 lineal feet.
Twenty inch sewer pipe, 3,800 lineal feet.
Fifteen inch Y branches, 100.
Eighteen inch Y branches, 40.
Twenty inch Y branches, 20.
Man-holes, 25.
Cast-iron in man-hole covers, 5,700 pounds.
Lumber in foundations, 6,000 feet B. M.
Filling in Allen street, 5,000 cubic yards.
Twelve hundred lineal feet of 6 inch drain tile.
Twelve hundred lineal feet of 4 inch drain tile.
One thousand lineal feet of 3 inch drain tile.
Fifty cubic yards of concrete.

FOR MAIN SEWER NUMBER TWO.

The specifications were the same as for number one, with the exception of the following details:

PROPOSALS, HOW DETAILED.

The proposals for the work shall contain prices for the following items, which shall be considered full compensation for furnishing all the material and labor required to complete the work herein described, including all the work and material neceesary or incidental to the work priced.

For trenching per lineal foot, for cutting of eight feet or less depth, for cutting between eight and twelve feet in depth, for cutting over twelve feet in depth.

For furnishing and laying pipe of each size named and for the branch pipes of the same diameter.

For each man-hole complete.

For each man-hole cover placed in position.

For furnishing and laying down foundation platforms, including nails per 1,000 feet B. M.

For furnishing and laying brick in egg shaped sewer per thousand.

For furnishing and constructing frame of white oak plank, for foundation of brick sewer per 1,000 feet B. M.

WIDTH OF TRENCHES.

The bottom width of the trenches shall not be less than two feet greater than the outside diameter of the pipe or sewer, clear of shoring. The fill must be done with such care as will not disturb the pipe, and shall be free from stones of larger diameter than one and one-half inches, to such height as may be necessary to cover the top of the pipe to a depth of not less than eight inches. The filling shall be rammed if required by the engineer, in such manner as he may direct.

BRICK SEWER.

An egg shaped brick sewer, two feet, two inches by three feet, three inches, will be built with a four inch wall, from the south end of Allen street bridge to the northeast corner of the city's sewage disposal property.

After the trench for the brick sewer is excavated to the proper depth, the contractor will lay to grade a cradle or frame made of white oak plank, one and one-half inch by four inches, spiked to cross ribs three inches by two inches, placed not more than seven feet apart so as to conform accurately to the outside of the brick work of the sewer and as shown on the plans.

BRICK WORK.

None but the best hard burned, perfect shaped brick shall be used, which are also subject to the inspection and acceptance by the engineer. The contractor may be required to wet the brick before using them, if it is considered necessary by the engineer; every course of brick must be laid by a line perfectly straight in the direction of the sewer and parallel to it.

Every brick will be laid in a full, close joint of mortar, and surrounded by it at one operation, the bottom and top courses shall be thoroughly grouted after being laid, and the top of the outside of the sewer shall be well plastered to the spring lines with cement mortar.

The center or frame upon which the arch is built must be strong and according to size and shape required, and must not be removed until the work upon it has well set and the refilling of the trench has progressed above the crown. The center must be struck and drawn with care so as not to crack or injure the work. All work must be properly protected and injuries repaired by the contractor without extra charge.

WHAT EXCAVATION OR TRENCHING INCLUDES.

The excavation is intended to mean all the work, both excavation and backfilling, trimming and shaping the bottom of the trench to grade and shape of the sewer, shoring and bracing wherever necessary, ramming and packing the earth along the sides of the sewer, and settling the earth in the new filled trench by saturating with water, and cleaning away all rubbish after the completion of the work, for the streets shall be left in as good condition by the contractor as it existed before the ground was broken.

FILLING AND GRADING ALLEN STREET.

Before constructing the sewer, the contractor shall fill the depression in Allen street, south of the east branch of Nimishillen Creek, by removing the earth above grade on the high land in Allen street, south of said depression, and build an embankment so as to make a roadway thirty feet wide, when the embankment is brought up to grade. The fill must be made to such a height that there will not be less than four feet of covering on the sewer at any one place. The excavation in said high land south of the Valley Railroad, will be made first for a thirty foot roadway, and if that does not furnish enough material to make the necessary fills, the sidewalk on each side of the street shall also be included; and the depth of the cutting must correspond to the grade as established by ordinance on Allen street. The engineer will set stakes to indicate the lines and grade; the gutters shall be nine inches deep below the curb grade; if the excavations including sidewalks are not sufficient to make the necessary fills, the contractor must furnish the additional material from other places at the same price per yard as the rest of the filling.

In the middle of the roadway the fill will be made in layers of not more than one foot at one time, and must be well solidfied to the satisfaction of the engineer, by saturating with water, ramming or turning the travel of the street on the same before depositing another layer. The fill must be made at least two feet higher than the top of the sewer before commencing the construction, and the balance of the fillng may be done after the sewer work is completed and the cement has well set.

The contractor will state in his bid the price per cubic yard for filling, which will be measured in the fill or embankment.

MANNER OF MAKING PAYMENTS.

Payment will be made monthly as long as the work makes a reasonable progress to the amount of eighty per cent. of all the work done, upon the estimates of the engineer, the remaining twenty per cent. will be paid when the work is completed and accepted by the City Council. The work shall be completed within three months of the time of entering into a contract for the same.

APPROXIMATE QUANTITIES.

The approximate quantities by which the bids will be compared, are as follows.

Trenching less than eight feet deep, 2,000 lineal feet.

Trenching from eight to twelve feet deep, 1,800 lineal feet.
Trenching over twelve feet deep, 400 lineal feet.
Brick in brick sewer, 240,000.
Twenty inch sewer pipe, 710 lineal feet.
Six ten inch slants.
Seven man-holes.
Cast iron in man-hole covers, 1,600 pounds.
Oak lumber in foundations, 20,000 feet board measure.
Grading and filling 10,000 cubic yards.
Fifty cubic yards of concrete.

Sewer Number Two is 4,200 feet in length. For 3,490 feet of this length the sewer is of brick, egg-shaped, small end down. Its greatest diameters are 2 feet, 2 inches by 3 feet, 3 inches. This sewer is capable of carrying a volume equal to more than three times the effluent of the 20-inch main which drains Sewer District Number Three.

The reasons for this greater capacity are, first, that all sewage from the city will have to pass through the Disposal Works; and, second, this brick main is large enough to carry away the added volumes from the mains draining Districts One and Two which will converge, and connect with the brick sewer at Allen street bridge.

The 710 feet of 20-inch sewer pipe on the course of Sewer Number Two would convey the crude sewage temporarily from Allen street to the creek, over the sewer farm. It will be used permanently to carry the purified effluent from the Sewage Disposal Works to the creek.

The situation now warranted the publication of the following preliminary notice, as required by the statute:

SEWER NOTICE.

At a meeting of the Sewer Commissioners held at the office of the City Engineer, Monday evening, April 9th, 1888, the following notice was ordered to be published in the Repository, Democrat and Volks Zeitung:

Notice is hereby given that plans, maps, profiles and specifications for a main sewer to be built from the intersection of Walnut and North streets southward on Walnut street to the terminus, as shown by the plan, have been prepared, and are now on file in the office of the City Engineer for examination and inspection by parties interested. This main sewer (and laterals,) is designed to furnish sewer facilities for the central sewer district of the city of Canton, comprising within its boundaries so much of the city's area as is properly tributary to said main sewer.

An adjourned meeting of the Board of Sewer Commissioners will be held at the office of the City Engineer on Saturday, April 21st, at 7;30 p. m., when parties interested having suggestions to make, will be heard.

JOSIAH HARTZELL,
Clerk of Board of Sewer Commissioners.

April 10, 1888.

(This notice, the preliminary resolution, the bond notice and ordinance, the sewer ordinance, and notice to contractors, printed on the next few pages constitute the formalities of publicity required by law for all sewers. These preliminaries will be omitted from our mention of the other sewers referred to in this report.)

At a meeting of the Sewer Commissioners held April 21st, 1888, the following action was taken:

"WHEREAS, The notice ordered to be published at our last meeting has been published as ordered, and,

WHEREAS, No objection, suggestion, or remonstrance to sewer plans on file in the office of the City Engineer have been presented before us, therefore,

Resolved, That said plans, profile and specifications be adopted by this Board, and that the same be evidenced by the attachment of the signature of the President and Secretary of this Board thereto in approval of the same."

Following as promptly as possible after this action, and a Resolution declaring the necessity of the improvement, the steps indicated by these several published articles, and required by the State law on the subject of Sewer Construction, were taken by the City Council:

AN ORDINANCE

Issuing Bonds for Sewer Purposes.

SECTION 1. Be it ordained by the Council of the City of Canton, Ohio, that, by virtue of "An act authorizing the City Council of the City of Canton, to issue and sell bonds for sewer purposes," in anticipation of a tax hereafter to be levied upon all taxable property, real and personal, of the said city, bonds be issued for the purpose of constructing a main or trunk sewer between such points and along such line as the Council may direct, and procuring the right of way therefor, and for the purpose of purchasing such land, and providing such apparatus as in the opinion of the Council may be necessary for the disposal of the sewage.

SEC. 2. The said bonds shall be issued in denominations of not less than one thousand dollars each, shall bear interest not exceeding five per cent. per annum, payable semi-annually, and shall be redeemable as follows, to-wit:

Six thousand dollars shall be due and payable four years from the date of issue; six thousand dollars due and payable five years from date of issue; six thousand dollars due and payable seven years from date of issue, and seven thousand dollars due and payable eight years from date of issue.

SEC. 3. The said bonds shall be signed by the Mayor and the City Clerk, and be sealed with the corporate seal and have interest coupons attached.

SEC. 4. The committee on ways and means of the City Council is herewith authorized, empowered and instructed to negotiate the sale of the said bonds.

SEC. 5. That this ordinance shall take effect and be in force from and after its passage and legal publication.

Passed May 7, 1888.

L. A. LOICHOT,
Vice President of the Council.

Attest: HENRY G. SCHAUB, Clerk.

SALE OF SEWER BONDS.

$25,000 of Coupon Bonds.

OFFICE OF THE CITY CLERK,
CANTON, O., May 22, 1888.

Sealed bids are invited at the above named office until Friday, June 22, 1888, at 2 o'clock p. m., for the purchase of the bonds of the city of Canton.

The bonds to be in denominations of $1,000 each in the aggregate sum of $25,000, and to be on interest at the rate of 5 per cent. per annum, payable semi-annually; and both principal and interest payable at the Chase National Bank, New York City, or the Treasurer's office, Canton, Ohio.

The bonds to be dated July 1, 1888, and redeemable as follows: $6,000 July 1, 1892; $6,000 July 1, 1893; $6,000 July 1, 1895, and $7,000 July 1, 1896.

Bidders should specify the number of bonds bid for and the premium offered, and the aggregate amount, interest and premium, for all the bonds proposed to be purchased.

The Ways and Means Committee reserves the right to accept any or reject all bids. The same to be delivered in Canton, Ohio.

L. A. LOICHOT,
W. L. ALEXANDER,
J. H. DUMOULIN,
Committee Ways and Means.

AN ORDINANCE

To Improve Central Sewer District Number 3, in the City of Canton, by Sewering.

SECTION 1. Be it ordained by the Council of the City of Canton, Ohio, That the Central Sewer District number 3, in the said City of Canton, be improved, by constructing a main sewer, with the necessary appurtenances thereto, along the following described line:

Beginning at the intersection of the south line of North street, with the middle of Walnut street, and extending thence south, 16 degrees west, along the middle line of Walnut street, three thousand two hundred and two feet; thence on a curve to the left, with a radius of one hundred and fifty feet, crossing the Pittsburgh, Fort Wayne and Chicago Railroad, one hundred and thirteen and four-tenths feet; thence south, 27 degrees and 32 minutes east, through out-lot number twenty-nine, two hundred and thirty-two and seven-tenths feet; thence on a curve to the right, with a radius of one hundred and fifty feet, a distance of one hundred and fourteen and six-tenths feet; thence south, 16 degrees and 14 minutes west, along the west side of Shriver's Run, and continuing through said out-lot twenty-nine, one thousand and eighty-seven and three-tenths feet; thence south, 16 degrees and 37 minutes west, through out-lot number thirty-one and city lot number two thousand five hundred and sixty-three, six hundred and fifty-eight and eigth-tenths feet; thence on a curve to the left, with a radius of two hundred feet, a distance of one hundred and thirteen and two-tenths feet, passing through city lot number one thousand, seven hundred and forty-five; thence south, 15 degrees and 49 minutes east, through city lots numbers one thousand, seven hundred and forty-four, and one thousand, seven hundred and forty-nine and out-lot number thirty-eight, three hundred and twenty-eight feet to the middle of Center street; thence south, 14 degrees and 39 minutes east, through out-lots numbers thirty-nine and forty-one, two hundred and sixty-five and seven-tenths feet; thence on a curve to the right, with a radius of two hundred feet, crossing the Cleveland and Canton railroad, a distance of two hundred and thirty-two and two-tenths feet; thence south, 51 degrees and 51 minutes west, and seven and one-half feet from the south line of the said Cleveland and Canton railroad, passing through out-lot number forty-one, city lot number two thousand, eight hundred and thirty-five, and out-lot number forty-five, one thousand, two hundred and twenty-four feet; thence on a curve to the left, with a radius of two hundred feet, a distance of one hundred and sixty-seven and nine-tenths feet to the middle of Allen street; thence south, 3 degrees and 45 minutes west, six hundred and sixty feet to the east branch of the Nimishillen creek, in accordance with the plans, profiles and specifications on file in the City Civil Engineer's office.

SECTION 2. That fifty-eight (58) cents shall be assessed per front foot upon all lots or land bounding or abutting thereon, according to the laws and ordinances upon the subject of assessments; provided that no assessment shall be made upon lots or land which do not need local drainage or are provided therewith.

SECTION 3. That the expenses of the said improvement which are to be borne by the city, shall be paid out of the proceeds derived from the sale of bonds, made under and by virtue of the act of the Legislature, entitled "An act authorizing the City Council of the city of Canton, Ohio, to issue and sell bonds for sewer purposes."

SECTION 4. That this ordinance shall take effect and be in force from and after its passage and legal publication.

Passed June 18, 1888.

L. A. LOICHOT,
Vice President of the Council.

Attest: H. G. SCHAUB, City Clerk.

AN ORDINANCE

To improve the City of Canton, Ohio, by constructing a main trunk sewer.

SECTION 1. Be it ordained by the City Council of the City of Canton, Ohio, that the improvement of the City of Canton, Ohio, by constructing a main trunk sewer with the necessary appurtenances thereto, for the disposal of house sewage, beginning for the same at the point where the east branch of the Nimishillen Creek intersects with the middle line of Allen street and extending southwardly along the middle line of Allen street to the northeast corner of a tract of land containing twenty-seven and fifty-three hundredths acres owned by the City of Canton, and thence southwardly through the same land to Nimishillen creek, be proceeded with in accordance with the preliminary resolution adopted May 7, A. D. 1888.

SECTION 2. The expenses of the said improvement shall be paid out of the proceeds derived from the sale of bonds made under and by virtue of the act of the Legislature entitled "An act authorizing the City Council of the City of Canton, Ohio, to issue and sell bonds for sewer purposes."

SECTION 3. This ordinance shall take effect and be in force from and after its passage and legal publication.

Passed May 22, 1888.

L. A. LOICHOT, Vice Pres't.

Attest: H. G. SCHAUB, Clerk.

All the preliminary steps required by the statutes having been taken the following notices were now published:

SEWER NUMBER ONE.

Notice to Sewer Contractors.

Sealed proposals will be received at the office of the City Civil Engineer of the city of Canton, Ohio, until 12 o'clock noon of Friday, July 27, 1888, for the furnishing of the materials and the construction of a Main Sewer, beginning at the intersection of Walnut and North streets; thence southwardly along Walnut street and the valley of Shriver's Run to the Cleveland and Canton Railroad; thence southwestwardly along said railroad to Allen street; thence south on Allen street to the East Branch of the Nimishillen Creek. The work shall be done according to plans and specifications on file in said office.

The approximate quantities are as follows:

15 inch pipe, sewer 2,050 feet in length.
18 inch pipe, sewer 1,850 feet in length.
20 inch pipe, sewer 4,500 feet in length.

8,400

25 Man-holes.
Filling embankment in Allen street, 5,000 cubic yards.
160 15x18 inch Y branches.

Each proposal shall be signed by the bidder, or all bidders interested in the same, and must be accompanied by a bond of $500, conditioned for the execution of the contract in case the bid is accepted.

Proposals must be made on blank forms which will be furnished on application.

The right is reserved to reject any or all bids.

By order of the City Council.

JULES PY,
A. O. ESSIG,
C. H. HENDERSON,
Committee on Sidewalks and Sewers.

JOHN H. HOLL, City Civil Engineer.

SEWER NUMBER TWO.

Notice to Sewer Contractors.

Sealed proposals will be received at the office of City Civil Engineer of the City of Canton, Ohio, until 12 o'clock noon of Friday, July 27th, 1888, for the furnishing of the materials and the construction of a Main Sewer in Allen street, from the East Branch of the Nimishillen Creek to the city sewage disposal lands; thence southwestwardly through said lands to the Nimishillen Creek. The work shall be done according to plans and specifications on file in said office.

The approximate quantities are as follows:

3,450 lineal feet of brick sewer, 3 feet, 3 inches by 2 feet, 2 inches.
710 lineal feet of pipe sewer, 20 inches diameter.
Seven man-holes.
Filling an embankment, 10,000 cubic yards.

Each proposal shall be signed by the bidder or all bidders interested in the same, and must be accompanied by a bond of $500, conditioned for the execution of the contract in case the bid is accepted.

Proposals must be made on blank forms which will be furnished on application.

The right is reserved to reject any or all bids.

By order of the City Council,

JULES PY,
A. O. ESSIG,
C. H. HENDERSON,
Committee on Sidewalks and Sewers.

JOHN H. HOLL, City Civil Engineer.

On the day named in the above notices, July 27, 1888, the bids on the work that had been received were opened. A few of the bids were on Sewer Number One, only; most of the bids covering the work on both jobs. The bids, in detail, were as follows:

BIDS ON SECTIONS OF MAIN SEWER NOS. 1 AND 2.

	SEWER NO. 1.	SEWER NO. 2.	TOTAL.
H. C. Babbit, Cleveland, O.	$15,093.91	$10,602.90	$25,696.81
Coyle & Boren, Steubenville, O.	19,972.50	11,989.50	31,962.00
Hadley & McKinney, Canton, O.	16,568.50	10,450.50	27,019.00
Thomas Connell, Youngstown, O.	16,577.58	10,912.57	27,490.15
W. J. Irwin, Greenville, O.	17,561.50	....	....
Thomas J. Peter & Co., Cincinnati, O.	16,528.00	12,255.50	28,783.50
J. C. Muria & H. C. House, Newark and Norwalk, O	11,816.91	11,787.90	23,604.81
Thomas B. Keating, Mansfield, O.	12,641.40	....	....
C. H. Voute, Toledo, O	12,480.78	....	....
John Nauman, Canton, O	11,158.53	7,030.03	18,188.56
Thornton Kell, Canton, O	24,829.50	11,132.80	35,962.30
J. H. Doyle, Akron, O	16,592.23	11,606.43	28,198.66
A. N. Campbell, Cleveland, O	13,476.10	10,249.80	23,725.90
W. H. Crooks, Massillon, O.	13,664.90	....	....
J. J. Everson, Akron, O.	14,428.00	14,200.00	28,628.00
James Wilds, Akron, O.	13,746.75	10,468.50	24,215.25
Geo. Hibberd & Son, Wheeling, W. Va.	14,577.78	15,779.20	30,356.98
Stanton & Barber, Canton, O	11,178.35	10,714.95	21,893.30
Clements Bros., Cleveland, O	12,971.50	9,628.00	22,599.50
T. K. Turnbull, Canton, O.	20,340.23	10,272.00	30,612.23
R. H. Adams, Canton, O.	10,544.18	8,145.97	18,890.15
Daniel F. Minahan, Springfield, O.	14,391.00	12,651.00	27,042.00

As will be seen by the above table there were plenty of bidders, and the names in the list comprised those of experienced sewer builders of excellent reputation who came amply recommended. The lowest bid, that of John Nauman, was vitiated by non-compliance with the advertised conditions. The next lowest bidder was R. H. Adams, a citizen of Canton, whose measure of qualifications for this special work also left much to be desired.

Wishing to have the construction of the sewer as nearly perfect as possible, and distrusting Mr. Adams' adequacy, the Sewer Commissioners used such influence as they could bring to bear to prevent the acceptance of his proposal. The City Solicitor, however, expressed the opinion that, under the statutory requirement that such work should be given to the lowest responsible bidder, there was no legal way to escape from the claims of Adams. He was also of the opinion that, although Adams himself was wholly irresponsible, valid bondsmen would cure this infirmity in the eye of the law.

The majority of the Council gave to this opinion a very reluctant assent and ordered a contract to be made with Adams, who had been able to obtain as bondsmen, the names of three citizens of irreproachable financial standing, viz.: Jacob Miller, Andrew Schwertner and W. A. Strayer.

BUILDING THE MAIN SEWER.

Adams immediately sub-let his contract for Sewer Number Two to John Skeels, who commenced work in September and had the same completed by January. No water was encountered and the work met no other impedi-

SEWAGE DISPOSAL WORKS.

View taken from the northeast corner of tanks when the same were partially built. The men in the foreground are laying the floor of brick and concrete in the northeast tank. For particulars see description by L. E. Chapin, C. E., at end of this report.

ment than a section of rock. This incident not having been anticipated in the specifications, an extra allowance of $250 was made to the contractor. The fall of the sewer is one and one-quarter inches per 100 feet, being purposely made small in order that the sewage might be delivered at the higher level necessitated by the interposition of the disposal works between Allen street and the creek.

The brick part of Main Sewer Number Two was a work which gave a high degree of satisfaction. Descending into the man-hole at the north end the full outline of the mouth at the south end, 3,500 feet distant, was clearly perceptible, the walls of the conduit appearing to be entirely without deviation from a straight line.

The fill north of the bridge having been made, Mr. Adams started laying the 20 inch pipe main at the bridge about August 15. The first 600 feet, on Allen street, being in a dry ditch, the work proceeded without interruption. Immediately after starting east, on the higher ground bordering on the track of the C., C. and S. Railroad, water was encountered.

Before leaving the lower ground on Allen street the precaution had been taken to carry along in the bottom of the trench, as the work advanced, a six-inch pipe, for drainage purposes in case water was struck. Before fifty feet of wet ditch had been excavated this pipe was overtaxed. Inasmuch as a bottom free from water was imperatively required in order that the cement setting of the joints might have time to harden, another drain pipe for the water, nine inches in diameter, was put down. After advancing about 200 feet farther it was found that both pipes were entirely inadequate. In fact, with both pipes running full, the sewer itself was forced to carry off a large share of the water. An inferior steam outfit was placed in operation, but failed to furnish any perceptible relief.

The excavation at, and east of, the point that had been reached, was the deepest on the entire line, the depth being about twenty feet. This fact caused additional embarrassment. The City Engineer strove to have the contractor lay the sewer in accordance with the specifications, which the latter seemed helpless to do.

The subject came up in the City Council, where a special committee for purposes of investigation made the following report on October 2d:

"Your committee, to whom was referred the matter of investigating the work now in progress upon the main house sewer in the southern portion of the city, would respectfully report that the entire committee, together with the civil engineer, visited the work this morning and found everything, with the exception of the trench-digging, at a stanstill, as the pumping engine was undergoing some needed repairs.

Only about one-half dozen lengths of sewer pipe partly prepared for covering were still in view, there being about eight inches of water in the bottom of the trench. We were informed by Mr. Adams, the contractor, and Mr. Adolphus Neu, the expert employed by the city to see that the letter and spirit of the contract and specifications are not violated, that the few lengths still in view were a fair sample of the twelve or fifteen hundred feet already laid and buried out of sight. The manner of joining the pipe together was minutely described to us and the exposed samples used to illustrate; in this manner we were informed just how the work is done. To say that it is a very unsatisfactory way of doing is drawing it rather mild, as it is in nowise in accord with the plan laid down in the contract and specification and will never do unless, perhaps, the builders propose to preserve inviolate the virgin soil of the sewer farm from the contaminating touch of everything and anything foul, which in course of human events may find its way into the main sewer or laterals within the city.

We find that clay has been substituted for cement in making joints, that the pipe is not properly placed together and packed or "yarned" before cementing, that the opening calculated to receive the cement is filled with packing at the mouth, so that there is no room left for cement or clay either, if clay would answer. The consequence is that instead of the joint being properly connected there is only a thin rim of cement on top, one-half way around the pipe and the remaining half, or the under side is simply daubed with clay, and this too while the bottom of the pipe is four or five inches under water.

We are probably safe in saying that there are not one dozen perfect joints in the entire job. In our humble opinion the work so far is very unsatisfactory and we leave it with the Council.

But in the interest of a complete system of sewerage, the fair fame and name of our goodly city, the health and prosperty of our fellow citizens and the strangers within our gates, we insist that a practical sewer builder be employed to exact of and from the contractor a complete piece of work such as the plans and specifications now on file in the Civil Engineer's office call for.

This is a serious matter and one calling for prompt action. If we fail to do this we fail to do our simple duty as public officials.

Respectfully submitted,

PAUL FIELD,
CHARLES W. HENDERSON,
H. VOGELGESANG.

The report of the proceedings of the meeting concludes with the following paragraph:

"The report was then adopted, and on motion of Dumoulin, Field and Volkmann and the Engineer were appointed a committee to go to Cleveland or Toledo at once and secure a practical sewer builder to oversee the construction of the sewer."

The committee named employed Mr. A. Garfield as expert inspector and assistant to the Engineer.

After the useless experiment with the pump, above mentioned, Contractor Adams disappeared from the work. The Council delegated William Volkmann to verify the accounts of the men and pay them off. Work on the sewer stopped.

Thus were realized the apprehensions which had been expressed, prior to the contract, in regard to entrusting the work to one whose fitness and aptitude for such an undertaking were very questionable.

Several defects in the construction of the main sewer are directly attributable to this inauspicious beginning. As shown by markings taken recently there is a considerable infiltration of ground water above the intersection of the sewer with Allen street. When it is considered that the stretch of cemented joint is about two and one-half times longer than that of the sewer, being about 5 feet to every 2 feet of pipe, it can hardly be regarded as surprising that a perfect barrier against the ingress of water was not obtained. That the leakages are too abundant cannot be doubted.

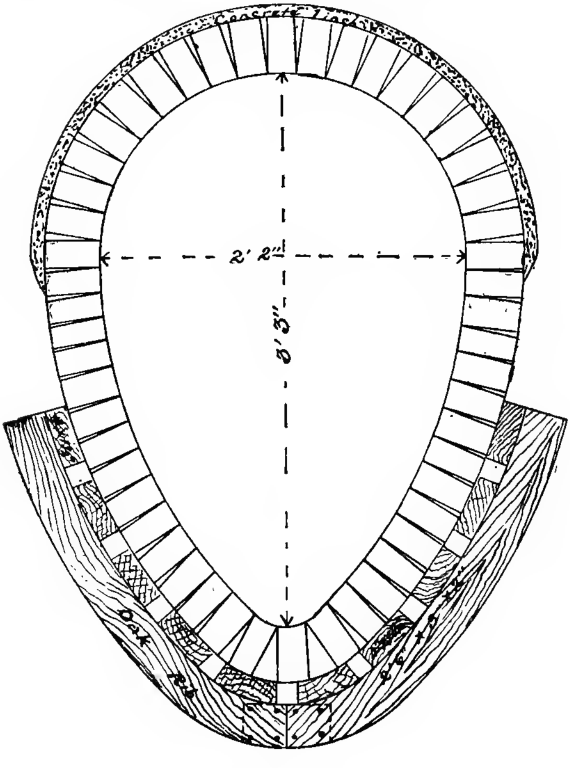
Another defect has made itself manifest by the settling of the sewer on the made ground north of the Allen street bridge; and there has also been a slight settling of the sewer south of the bridge, both arising from the same causes, viz: the made ground under the sewer was not effectievly compacted.

These defects in no wise interfere with the practical successful working of the sewer, and may never do so, but they nevertheless constitute deviations from that perfection of work which we ardently desired should characterize the entire work.

The bondsmen of Mr. Adams were now officially apprised of the situation. These gentlemen at once held a conference, "faced the music," and as the result of their deliberations they employed John Skeels to complete the contract with the city. On the part of the city A. Garfield had been employed as inspector on the ground to see that the sewer specifications as to grade, pipe-laying, joint-connecting, &c., were complied with. With the co-operation of Messrs. Skeels and Garfield, operating under the superintendence of City Engineer Holl, the main sewer was completed to its terminus on North Street about May 1st, 1889.

Upon taking charge of the work for the bondsmen Mr. Skeels encountered a continually increasing influx of water until he reached the point near Shriver's Run where the course of the sewer is deflected to the north. Relief from this water was obtained, first, by constructing a relief-drain from a point about 650 feet east of Allen street, south to the creek ; and, second, by draining the water from the point where the sewer crosses the C., C. & S. R. R. track south, into Shriver's Run. From the C., C. S. R. R. track north as far as Eighth street water was still found to some extent, but not in quantity to cause any serious embarrassment in the advancement of the work.

In crossing a strip of land, also the property of the Saxton heirs, about 200 feet south of the lands of C. Aultman & Co., a patch of quicksand, about 150 feet in width had to be passed. The excavation to the proper depth was attended with much difficulty. At length the Engineer suc-in flooring the bottom with heavy oak plank and in laying the sewer thereon with its proper alignment.



SECTION TRUNK HOUSE SEWER.

The cut shows the plan of the main house sewer from Allen street bridge to the sewer farm. The advantage gained by this shape is in the accelerated flow and the greater scouring effect of a small flow in the small end over that which would obtain over the larger diameter.

The back fill at the sides of the sewer over this place was made of the quicksand which had been thrown out, and the clayey top-soil was restored as before. A little more than a year later it was found that the part of the back-fill made by the quicksand had sunken or escaped. With the supporting pressure at the sides of the pipe removed, the top soil pressed down on the top of the pipe so heavily as to break it. By direction of the Council the pipe lying in the quicksand was removed, a solid flooring of brick and cement was laid down, and a brick sewer built over the distance which had caused the trouble. Danger of further annoyance seems to have thus been entirely obviated.

At the foot of Walnut street the tracks of the P., F. W. & C. Railroad cross the street. Beneath the tracks, and covered with about five feet of ground, passes the Walnut street storm water drain, crossing the tracks at an oblique angle. The course of the house sewer was about two feet below the bottom of the storm water sewer, and the point of crossing was directly below the intersection above mentioned.

The brick drain, five feet in diameter, was first entirely removed from under the railroad. A foundation of hard burned brick was then put down and the main sewer pipe placed in position thereon. A brick arch was then thrown over the latter, and a fill made to the bottom line of the storm water drain and the earth well packed and rammed. The broken section of the storm water drain was then rebuilt and the re-fill completed to surface grade. The job was attended with considerable difficulty and delay.

The fall indicated by the profile of the main sewer is two and one-half inches per 100 feet on that part of the line north of the Allen street bridge, and, as before mentioned, one and one-quarter inches per 100 feet on the sewer south of the bridge. While a more rapid fall might have been obtained, had it been deemed essential, it was decided, owing to the intervention of sewage disposal works, to deliver the output at as high a level as was safely practicable.

The bridge is spanned by a wooden trough suspended to the bridge itself. The outward aspect of this device would perhaps be improved by substituting an iron pipe. The latter would, however, have the disadvantage of entailing considerable expense. In addition to this it is believed that high floods at the breaking up of winter occasionally reach a stage when an ice blockade, and consequent destruction of the work, would be inevitable. The wooden conduit answers every purpose, and if carried away by the ice can be replaced with slight expense.

On the course of the sewer through the city streets there are man-holes at all intersections. Below the platted part the man-holes are 250 feet apart. These afford access at all times for inspection, and for repairs if any should ever be found necessary. With the single exception of the broken pipe at the quicksand patch, already mentioned, there has been no need of repairs or change of any kind.

On the occasion of the inspection of the sewer, and its acceptance by the Sewer Commissioners and the City Council, there was found to be only a trace, not more than half an inch, of water at the bottom of the sewer at the third man-hole, east of Allen street. In the man-hole nearest Allen street there was one and one-half inches of water by measurement. Above the first named man-hole, and south of the bridge, the sewer was dry.

With these observations we dismiss the subject of the main sewer of District Number Three. The works have now been in use for four years. Its operation has been watched with all that keen interest and careful attention which hostile criticism and predictions of failure would naturally induce in the minds of its sponsors. The result has been most satisfactory. With

800 house connections (including those of most importance) and 52 flush tanks already in operation, and these with a depth of not more than eight inches in the bottom of the 20-inch pipe at the hour of largest flow, there can no longer remain any doubt as to the capacity of the work for the drainage of all the sewage that may be derived from the Central Sewer District. The ventilation is perfect. There are no odors. There are no repairs. In short, there is every reason to believe that if the maintenance of the sewer shall always be in harmony with the principles upon which it was recommended and constructed, viz.: no connection larger than four inches, no rain-water, no street water, no improper use of the sewer, unobstructed four-inch ventilation to the tops of the houses; it will continue in the perpetual discharge of the functions for which it was designed, and that without money and without price so far as repairs are concerned.

THE LATERAL SEWERS.

The main sewer having been completed, the next step was to construct tributary, or lateral sewers, by means of which all parts of the sewer district might be reached, and the assemblage of the wastes of the city into the main sewer effected. With the main sewer, built by a general tax, in readiness, there was no obstacle in the way to the commencement of the work, inasmuch as the State law empowers cities to construct lateral sewers at the expense of abutting property.

The location and diameters of the lateral sewers will be seen by reference to the sewer map. Since the map was drawn two additions to the system have been made as follows: One starting at the intersection of Seventh and Court streets and extending 175 feet south on Court street, and another starting at the intersection of Lake and North Market streets and extending 600 feet east on Lake street. It should be the policy of the authorities to afford to all newly settled areas tributary to the central system the advantages of the system on the same terms as to those originally abutting on the sewers. Other additions to the system on newly opened streets are now under contemplation.

Although we were in possession of the sewer map and plans prepared by Major Humphreys, it was deemed best to offer to Engineer Holl the needed facilities for some comparative examination. He visited Pullman, Ill., and Kalamazoo, Mich., both of which cities were noted for the excellence of their sewer systems. Subsequently he also inspected the sewers of Norfolk, Va. The latter city had been sewered by Major Humphreys, and Mr. Holl's visit there was partially predicated on a desire to know more in regard to the value which should rightfully be attached to the recommendations made to us by that gentleman. His report on that head was very satisfactory. In regard to the Norfolk system of sewers his report was as follows:

To the City Council:

GENTLEMEN:—I visited the city of Norfolk, Va., on the 11th, 12th and 13th days of June, and found the Waring or separate system of sewerage in successful operation there, consisting of 15 miles of 18, 15, 12, 8 and 6 inch pipe sewers, and 8½ miles of 4 inch house connection pipes laid in the street between the curb lines, also 43 man-holes and 123 flush tanks and a number of stand pipes or hand holes.

The grades on the main and lateral sewers are generally one in three hundred, but in their construction it was found necessary to deviate from this rule, and there are some sewers with a fall of 1 in 4, 1 in 450 and 1 in 600.

On account of the very flat surface over the whole city, no point being over 12 feet above low tide water, the sewers discharge into a well 12 feet in diameter and 25 feet deep, the sewers discharge into this well about 10 feet below low tide water. The sewage is pumped from the well with two Davidson pumps, each 2,000,000 gallons capacity in 24 hours, into a cast iron pipe 18 in diameter and 1,600 feet long, which discharges the sewage into the Elizabeth River at a point where the current and tide carry the sewage away from the city.

The sizes of the sewers are calculated to carry five gallons per hour for each person, six persons for each house and twenty-five feet of street frontage for each house.

A Fields automatic flush tank of 140 or 150 gallons capacity is placed at the head of every lateral sewer, and is regulated so as to discharge two or three times in twenty-four hours. This is found to give sufficient flushing to keep the sewers clean; the flush tanks cost from $50 to $60 each, complete. When the system was adopted five years ago, the city paid a royalty for each tank shown on the plan, and the city has not yet exceeded that number. By experiments the details of the flush tanks have been perfected so that the time and frequency of their discharge can be relied upon, a 140 gallon discharge in one minute.

The lateral sewers are usually constructed with six inch pipe for the first ten or twelve hundred feet, and experience shows that the capacity of a six inch pipe is ample to carry all the sewage accumulating on that length of street, but stoppages are found to be more frequent in six inch than in any other sized pipe; and the City Engineer of Norfolk has almost concluded not to use any more six inch pipe on lateral sewers in the future. On the whole stoppages are not frequent, and are invariably caused by improper construction or abuse and neglect on the part of those using them.

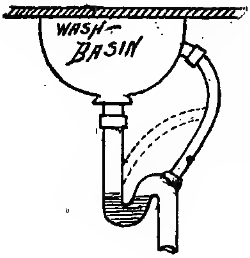
In observing the flow of the sewer at various times and places in the afternoon from 1 to 5 o'clock no pipes were running more than one-third full. The first two years after the introduction of sewers, people were very slow in making connections and the sewers were little used, but during the last three years the sewer system has been greatly appreciated and has come into general use over the city. The entire cost of constructing sewers was paid by the city by general taxation.

Respectfully submitted,

JOHN H. HOLL,
City Civil Engineer.

MAN-HOLES.

The only departure made from Humphrey's plans was in style of man-holes, and the number, which was considerably increased.



Sewer air can reach the house through an overflow from bath-tubs, wash-stands or other fixtures, if connected as above. By connecting as shown approximately by the dotted line the difficulty would be remedied.

From Mr. Holl's observations it was decided that man-holes should be made at every intersection or junction of the sewers. The section of the sewer passing through the man-hole is a trough, or split pipe, with upper half removed, of the same diameter as the sewer. The sewer junction, whether made with sewers entering in from one or both sides, is made in the bottom of the man-hole. This renders easy the satisfactory inspection of all the sewers in the city. By simply removing the man-hole lid one sees at a glance the conduct of the main or lateral sewer passing through it, also of the tributaries that pass into the same from the sides through their open sections at the junction. The advantage that would be afforded by these man-holes, only 200 to 250 feet apart in a straight line, in case of possible stoppage, is too obvious to need comment. Digging up streets for sewer repairs is a spectacle which will probably never be seen in Canton.

The form of the man-holes will be readily apprehended from the cut on page 53. An iron ladder gives easy access to the bottom of the sewer. The lid, which is flush with the surface of the street, is made strong enough to withstand heavy shocks. It is also perforated to admit air for the ventilation of the sewers. Through these perforations is fed that fresh air current which is constantly ascending the entire length of our entire system, finding its exit at the extreme upper ends, through the stand-pipes, or vent-pipes, which are required, at every connection with the sewer, to pass up through and out of the tops of the houses. Just beneath, and attached to every man-hole lid is a pan to catch dirt and prevent the same from falling into the sewer. There are, in all, 295 man-holes.

In many cities the practice has been to place a running trap on the course of the house connection with the sewer. The possible utility of this yard trap has been largely discussed by engineers. Its advocates claim that it protects houses from sewer-gas. This claim may possibly have some validity where combined sewers are in use. As Col. Waring's system does not admit of the formation of sewer gas no such obstruction was needed. Besides, this form of trap has been shown to be of doubtful value in any event. On the other hand it would be difficult to conceive of a more perfect assurance against gas pressure, sufficient to rupture the water seals in our house traps, than is afforded by the always present stand-pipe, open, full bore, to the top of the house.

FLUSH TANKS.

One of those devices which is most eminently in harmony with the growing intelligence of this age, and with the spirit of the maxim that "cleanliness is next to godliness," is the automatic flush tank. The wastes from our houses pass into the sewers and are lost sight of. But, thanks to the flush tank, we know that, twice a day, and before any hurtful decomposition can possibly take the place, these wastes are all swept away beyond the boundaries of our habitations. It is the silent, underground, unseen, self-acting, but thorough scavenger whose operation leaves no footing for the slightest criticism or reproach.

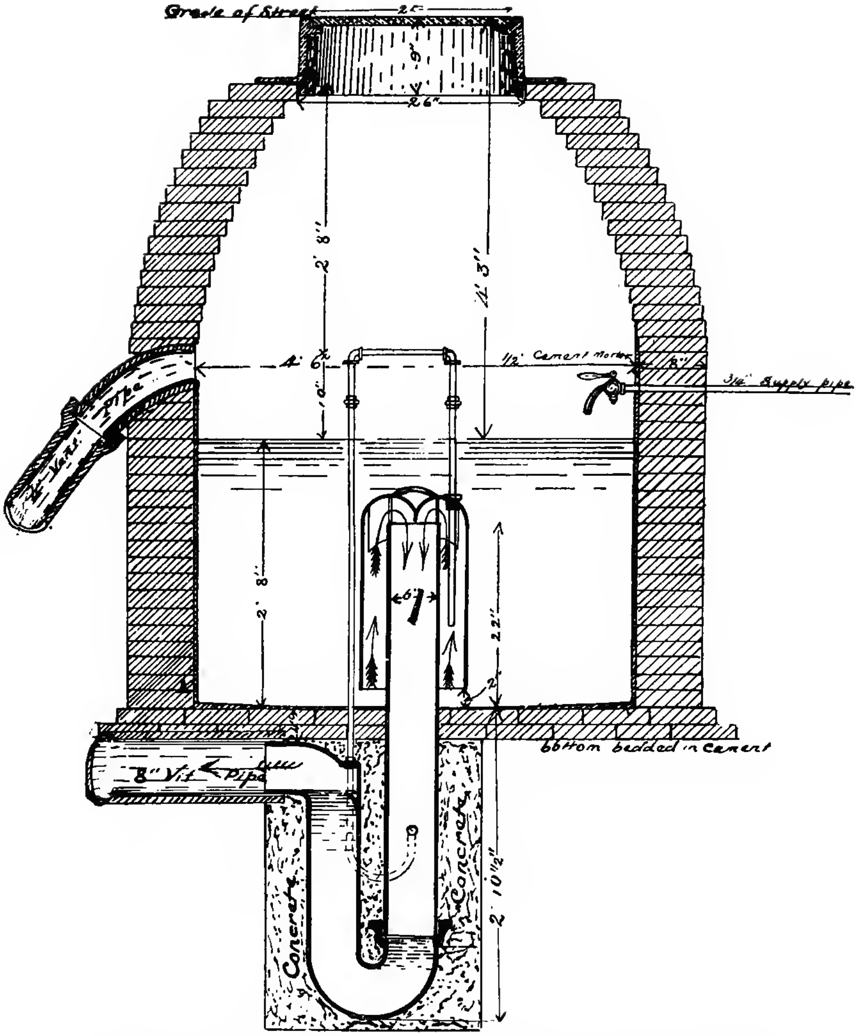
The tank part of the flushing apparatus is made of hard-burned brick and cement. The siphoning part is of cast iron. A flush tank is built, well underground, at the extreme end, or dead end, of every lateral sewer. Thus is secured the effective cleansing and scouring of every foot of sewer drain in the city as often as the siphon is brought into action, and this is timed to take place about twice a day.

The first seven tanks placed in position were of the Field-Waring pattern, and were obtained from the foundry, at Norfolk, Va., which had supplied the tanks for that city. An illustration is shown on page 75. Its work has been satisfactory.

In the meantime the merits of other tanks were pressed upon our attention, with the result that it was deemed best to adopt the Rhodes-Williams tank, made by the Flush Tank Company, of Chicago, for general use. A diagram of this tank is printed on page 74.

The operation of the Rhodes-Williams tank, or siphon, is described as follows: It consists of an angular intaking limb, and a discharging limb terminating in a deep trap below the level of the sewer. Below the permanent water line in the discharging limb, is connected one end of a small blow-off, or relief trap, having a less depth of seal than the main trap, the other end of which joins the main trap on the opposite side, at its entrance to the sewer and above the water line of the trap. At the same point is connected an upright vent pipe which rises through the tank to a point above the high water line and is turned down through the top of and into the intaking limb of the siphon, terminating at a given point above its bottom.

As the tank fills (the main and blow-off traps being full) the water rises in the intaking limb, even with the level of the water in the tank, until reaching the end of the vent pipe, a volume of air is confined in the two

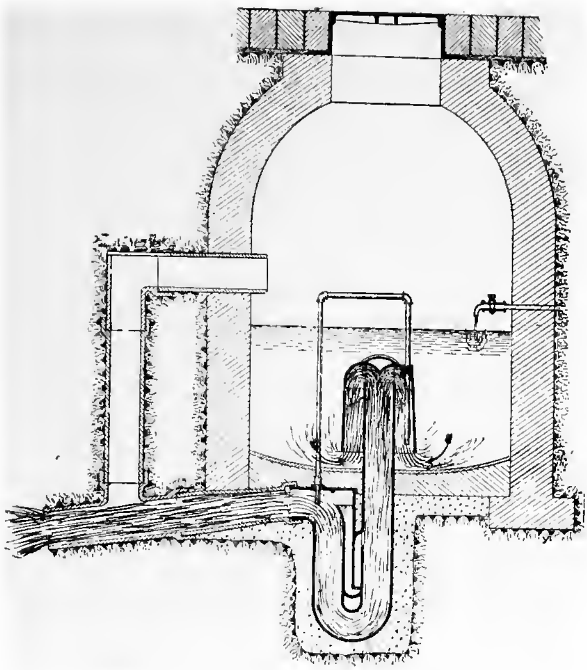


SECTION OF FLUSH TANK—RHODES-WILLIAMS SIPHON.

This cut shows the way in which most of the flush-tanks in Canton are built. Supply-pipe enters at top. Vent pipe communicating with sewer enters tank about the middle. The warmer sewer air guarantees the water in flush-tank against freezing in winter.

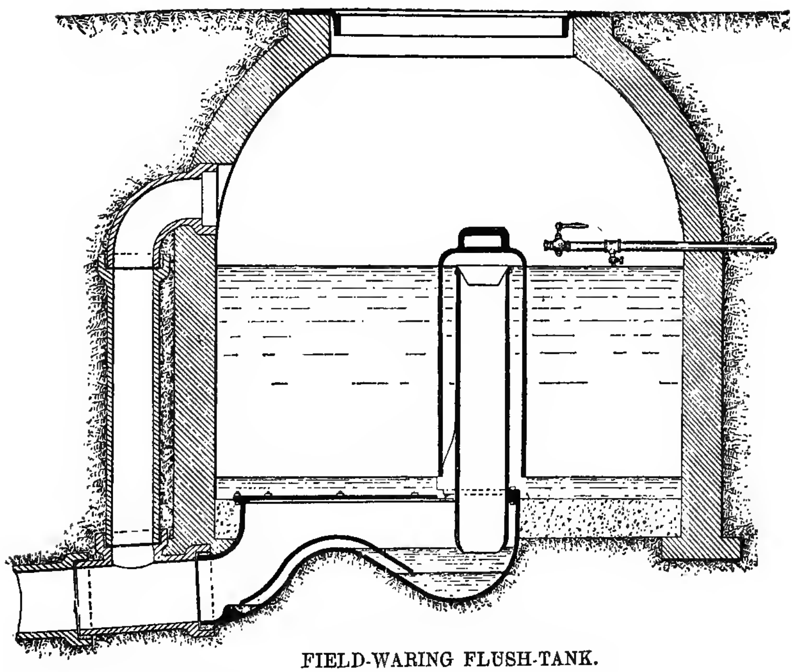
limbs of the siphon between the water in the intaking limb and the water in the main trap. As the water rises higher in the tank the confined volume of air is compressed, and the water is depressed in the main trap and in the blow-off trap. This process goes on until the water in the tank reaches its highest level above the top of the intaking limb, at which time the water is depressed in the blow-off trap to the lowest point and the confined air breaks through the seal, carrying the water with it out of the trap, thus releasing the confined air and allowing an inflow from the tank, putting the siphon into operation.

On the tank being discharged to the bottom of the intaking limb the flow is checked, and the siphon is vented by the admission of air to it through the vent pipe.



RHODES-WILLIAMS FLUSH TANK.

At moment of being set in operation for discharge.



FIELD-WARING FLUSH-TANK.

The first sewer flush-tanks used in Canton were of this pattern. They have operated successfully.

There are no moving parts about the mechanism of this device. Everything is fixed, stationary, and it will continue to perform its functions indefinitely. Its operation is regulated exactly by the amount of water admitted in a given time. The rise of the water to a given height causes a degree of air pressure in the upper end of an inverted iron dome sufficient to break through a trap, or seal, when the entire contents of the tank are sent rushing through the sewer, sweeping away whatsoever matters may have been too weighty for the normal, lazy, ordinary flow of the sewer. The number of flush-tanks on the entire system is 71.

It is worthy of remark, in passing, that the city was greatly favored, in the prosecution of the sewer work, by several incidents. Labor was obtainable on very low terms. Competitive influences also made the best quality of sewer pipe available at unheard of prices. The manner in which these facts enured to the advantage of the city will be obvious from a glance at the following table. In March, 1889, there were ten sewers to be let. The Engineer's estimate on these was based on the prices ordinarily ruling. The estimates and the bids which obtained the work were as follows:

ENGINEER'S ESTIMATE AND LOWEST BID ON TEN LATERAL SEWERS, MARCH 21, 1889.

	Gribben & Riley's Bid, (Cleveland, O.)	Engineer's Estimate.
Market	$ 4,033 37	$ 5,100 00
Poplar	3,620 30	4,800 00
North	1,541 81	1,500 00
Third	2,150 79	3,000 00
Fourth	2,042 25	2,700 00
Fifth	1,234 13	2,700 00
Seventh	1,290 53	2,700 00
Eighth	2,195 81	3,000 00
Ninth	2,088 46	3,000 00
Tenth	1,695 56	2,700 00
Totals	$21,586 75	$31,200 00
Deduct total of bids		21,586 75
Excess of estimate over bids		$9,613.25

It is not our purpose to enter into larger detail in regard to the work on the lateral sewers. The legal method of getting the main sewer under way was given at some length. The same method preceded the inauguration of the laterals. So far as route and diameters are concerned the map will give all needed information. The material, cost and names of contractors are given in the table on page 77, prepared by City Engineer Chapin.

THE OPPOSITION TO SEPARATE SEWERS.

The period immediately preceding the inauguration of our sewers was characterized by great activity in this field. Urban populations were interested as never before. The printed literature on the subject of sewers received a wide extension. The opinions and extracts presented in the preliminary pages of this report exhibit the practical tendencies, and the direction in which enlightened experiment was leading the way. These testimonies were not engrafted into this report for the sake of argument, as

SANITARY SEWERS.

SHOWING LOCATION, SIZE, MATERIAL AND COST OF ALL SEWERS BUILT TO DATE, MARCH 17, 1893.

No. Sewer.	Location. On	Location. Between		Length in Feet. Diameter in Inches. 4	6	8	9	10	12	15	18	20	Brick, 24x42 In.	No. of Manholes.	No. Flush Tanks	Contractor.	Cost.
1	Allen Street	Nimishillen Creek.	North Street							515	2105	5744		54		R. H. Adams	$18,779.63
2	Allen Street	Nimishillen Creek.	Sewer Farm									768	3320	15		R. H. Adams	11,654.22
3	North Street	Walnut Street	Plum Street		186	260			1014					5	1	Frank Riley & Co.	1,565 93
4	Third Street	Plum Street	Herbruck Street		743	1993			482					11	4	Frank Riley & Co.	2,764.67
5	Fourth Street	Plum Street	Herbruck Street		656	2490								10	3	Frank Riley & Co.	2,981.59
6	Fifth Street	Plum Street	Cherry Street	483	360	1515								6	2	Frank Riley & Co.	1,980.30
7	Seventh Street	Plum Street	Cherry Street		355	1537								5	2	Frank Riley & Co.	2,014.12
8	Eighth Street	Marion Street	Cherry Street		430	248		2044						9	2	Frank Riley & Co.	3,473.11
9	Ninth Street	Marion Street	Saxton Street		436	1717		284	494					9	2	Frank Riley & Co.	2,009.07
10	Tenth Street	Marion Street	Cherry Street		789	1784								8	4	Frank Riley & Co.	2,348.44
11	Market and Piedmont Streets	South Street	Lake Street		1984			646						10	10	Frank Riley & Co.	4,527.65
12	Cleveland Avenue	South Street	Lake Street		2097			2631						12	9	Frank Riley & Co.	4,990.01
13	Cherry Street	South Street	Cross Street		526	1062	466	1046	462					15	4	John Skeels	4,996.84
14	Walnut Street	North Street	500 ft. N. Wash. Ave.			924	832							4	1	John Skeels	2,415.03
15	Tuscarawas Street	Herbruck Street	400 ft. W. Shorb Street	418	926	3416	44							17	5	Turnbull & Hadley	5,200.26
16	Mulb-rry, Cherry and Douglas Sts	Main Sewer	Ninth Street			1693	760							9	1	John Skeels	2,066.03
17	Jackson Street	Main Sewer	Market Street						970					4		John Skeels	1,226.89
18	Cleveland Avenue	South Street	Cedar Street		232	959								6	1	Frank Riley & Co.	1,680.32
19	West Fifth Street	Plum Street	Newton Street		354	1162								6	2	Frank Riley & Co.	1,599.99
20	Plum Street	Cedar Street	Summit Street		226	4166	541	644						18	2	C. H. Connell	7,497.32
21	William Street	Walnut Street	Cleveland Avenue			1008								3		C. H. Connell	1,666.87
22	Cedar Street	Market Street	Plum Street					516	340					3		C. H. Connell	1,118.89
23	West Fourth Street	Plum Street	Shorb Street		338	508								3	2	C. H. Connell	1,165.93
24	Saxton Street and Hahn Alley	Ninth Street	Fifth Street			196	480	256						3		C. H. Connell	1,018.91
25	Wells Street	Fourth Street	Third Street			241								1		C. H. Connell	331.63
26	South Market Street	Jackson Street	Williams Street		237	673			762					6	1	Jacob McKinney	2,062.86
27	South Street	Cherry Street	High Street		345	2010								6	2	Jacob McKinney	3,102 60
28	West Third Street	Plum Street	Shorb Street		659	210								2	3	Jacob McKinney	763.50
29	High and Cassilly Streets	South Street	Third Street		635	260		784	247					2	3	Jacob McKinney	1,777.91
30	Second Street	Plum Street	Herbruck Street		565	2594								8	3	Jacob McKinney	2,811.95
31	Lake Street	Cleveland Avenue	Market Street	584	242		962							4	1	Jacob McKinney	1,739.32
32	Cleveland Avenue	Lake Street	N. Corporation Line	1546		2970								9	1	Hadley & McNichols	4,687.64
33	Market Street	Lake Street	N. Corporation Line			2821								9	1	Hadley & McNichols	3,685.20
34	Court Street	Seventh Street	Tuscarawas Street	114	200										1	Connell & Gribben	534.00
35	Fifth Street	Cherry Street	Herbruck Street	325	465	700								3	3	John Skeels	955.39
41	East Lake Street	Market Street	Walnut Street		692									3	1	John Skeels	505.48
..	South Court Street	Eighth Street	Seventh Street		200											City	
..	Franklin Street	Cleveland Avenue	West Street		225											John Skeels	76.50

Total miles, 16 8-10. Total Cost, $113,976.15.

argument. The time for that has passed by. As a matter of fact this presentation of authorities had no other object than that of placing the action of the Board of Sewer Commissioners in a proper light before the public.

Some of the reports above printed show that the introduction of the separate system was met with violent opposition. Such was not the case on the part of the Canton City Council. On the other hand, every recommendation of the Sewer Board received the approval of the Council. But very many citizens predicted inadequacy and speedy failure. The small pipe network that was put into the streets was ridiculed as an expensive toy arrangement that would in a few days or weeks at most be clogged with house refuse. The judgment of the Sewer Board was freely and gravely impugned.

Impelled by the desire to convince our citizens and taxpayers that the public money was not being injudiciously misapplied, the following statement was published:

"Inasmuch as many of our citizens have expressed doubts in regard to the sufficiency of the sewer system that is being introduced, a brief review of the subject is deemed advisable.

"The main sewer on Walnut street has the following diameters: fifteen inches from North to third streets; eighteen inches from Third to South streets, and twenty inches from South street to the creek. The main sewer from the creek to the city tract and disposal grounds, is about two by three feet in diameter, egg-shaped and built of brick. This brick main extension is made of the larger capacity indicated in order to provide for the removal of the sewage from a city double the size of Canton, even in case every house was connected with the system. Its capacity is sufficient to admit of its receiving the outflow of several other mains as large as that on Walnut street.

"The main on Walnut street is of stoneware sewer pipe. It has, on its course, the needed man-holes and lateral openings for the connection of the lateral or collecting sewers. It is, however, in regard to the diameters and the system adopted that explanation is most essential. As a rule skepticism on this point vanishes just in the proportion that investigation advances. Those who have seen only the larger combined sewers in the older cities, naturally imagine that our safety would be best assured by following these precedents.

It must, however, be borne in mind that modern achievement is due to changed methods in nearly all departments of human activity. And, as a matter of fact, changes and improvements have been a notable feature of recent sanitary works. The operation of new principles in sewer construction is seen, not only in our own country, but in all the more enlightened cities of the world. That principle which has modified sewer building more than any other may be expressed in these words: Make your sewers to remove sewage, and nothing else. A glance at this subject will show the radical change of diamters or capacity that would ensue from adhesion to this principle. If only sewage is admitted, the current flowing through the pipe will have a depth of from four inches to ten inches during the several hours of the day. If rain water is admitted this flow may have a depth varying from four inches to six feet during the several hours of the same day.

"The cost of the extra capacity required if rain water is to be admitted is enormous. It is often, in fact, sufficient to render sewerage an impossibility, and always entailed municipal burdens. Recent experience shows that this burden may be avoided. Not only so, but that the practice is radically wrong; that collecting sewers always and main sewers generally, should exclude storm water, even if the sewers of large character could be had for the same prices as the separate sewers of smaller, but sufficient capacity. Permit me to enumerate a few of the reasons in favor of sewers of the smaller diameter required for the removal of sewage only:

"A maxim of sanitation is: Keep storm water on the surface and allow it to flow away in open gutters as long as no harm arises from overflow. Everyone is familiar with the cleansing power of a dashing rain on streets and gutters. In our city the danger from quick collections of storm water has mainly been provided for by the conduits built on Pennsylvania avenue, West Tuscarawas and Walnut streets. There is need of sewers of increased size in order to dispose of storm water.

"Another very forcible argument in favor of separate sewers is their greatly diminished cost, which has already been referred to. The cost of the Walnut street sewer from North street to the creek was $10,544. The most favorable estimate for a sewer of equal length of sufficient capacity to carry storm water, was $97,000.

"In the combined sewer the ordinary flow of sewage would have a depth of only a few inches and the comparatively rough cement or brick bottom would be foul with the precipitation of the more solid parts, presenting, in this respect, a marked contrast with the self-cleansing properties of smooth, vitrified sewer pipe. When storm water is added the volume fills the sewer more or less full of sewage contaminated water. As this volume subsides and the surface falls, sewage in greater or less quantities clings to the sides, leaving the sewer in a very foul and objectionable condition. On the score of cleanliness the advantage of pipe sewers is most decided, for they are also the only kind of sewers that can be perfectly and frequently flushed with a comparatively small expenditure of water.

"As sewers are connected with houses in which people live their ventilation is very important. A sewer without proper ventilation favors fermentation, and the production of gases inimical to health. The safe ventilation of large sewers is almost an impossibility. The separate sewers, having house connections open to the tops of the houses, are the best ventilated sewers in existence. The air in them is in constant motion. There is no room or time in them for the growth and maturing of those unwholesome products which find their most favoring conditions in the stagnated air spaces of the large sewers.

"If the out-flow of the sewer is into a very large river, or into the sea, it makes no difference in that respect whether the sewer is a combined or separate one. But if the sewage must pass through some process of purification before the effluent is delivered into a smaller stream, then the advantages of the separate system, carrying sewage only, are very great. In fact, the handling and treatment of a storm wafer flow are so great that it might be set down as a practical impossibility. No settling tanks or filter beds could effect its detention, or prevent the sewage laden water from finding its way to the lowest level. In fact, it was owing to difficulties of this nature that certain English cities were forced into the adoption of the separate system of sewerage for the first time that the experiment was ever tried. Where sewage has to be in any manner purified, the employment of the separate system is now the rule.

"It must be conceded that so far as economy in first cost, cleanliness, ventilation and final disposal are concerned, the advantages of the separate system for Canton are overwhelming. The only remaining question about which there can be any doubt is: Has the sewer which has been adopted for Canton sufficient capacity to carry away the waste products of the city? Happily for the conclusion arrived at by the Sewer Commissioners this question can be answered affirmatively with the most positive assurance.

"The proof of this rests upon observation and experience. The system has been in use many years, and in cities where a greater carrying capacity is required than will be needed in Canton for many years to come—in Memphis, for example, which is a much larger city, and were attachment to sewers is compulsory as fast as they are laid, the cesspools being filled up under municipal direction as the sewer attachments are made. Both in Memphis, Omaha, Kalamazoo, Pullman, Norfolk and other cities employing the separate system, has the depth of flow in the main sewer been observed and recorded at all hours of the day. Engineer Holl recently returned from an inspection of the sewers of Norfolk, Va., where eight miles of sewers are drained through one eighteen-inch main, and he reports that the latter was never so much as half-full even in the early and middle forenoon, the period of highest water-mark.

"The carrying capacity of the sewer is a problem for the engineer. The amount of sewage per capita to be delivered to the sewer is not difficult to estimate approximately. Its maximum is about two barrels a day. Knowing this, and having the inner shape and surface, and the grade of the sewer, the engineer easily estimates its carrying capacity. The result of such a calculation confirms actual observation, and shows that a twelve-inch main sewer would probably carry away all the waste products that will be collected in the Canton sewers for some time to come.

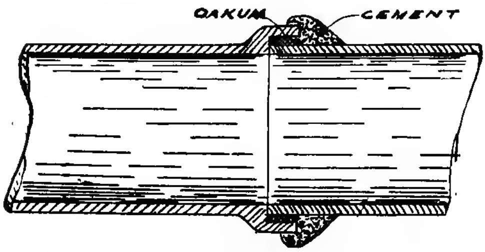
It is asked why the combined system is still in use in so many cities if the advantages of the separate system are so apparent. The answer to this is that these advantages were not always so apparent. Had this been the case the large sewers—excepting for intercepting purposes—would be a rarity.

Not only so, but ancient usage and engineering precedent carry great weight. A venerable error is hard to put down. For these reasons large combined sewers are still occasionally adopted. It may also be said that many cities with big-bore sewers, and a big debt in consequence, now deeply regret the course they adopted. We shall make no such costly and useless blunder. We have great respect for precedents, and we are fortunate in having as precedents the work constructed by many of the most enlightened communities that can be found. Our project has the approval of the most distinguished and successful sewer builders in the country, and I am sure it will secure the approval of every unprejudiced person who, divesting his mind of preconceived notions will give the subject a careful examination."

THE LATERAL SEWERS—COMPARATIVE COST.

The preceding remarks have general reference to the main sewer. It has been shown, from actual estimates made by competent engineers, that a main sewer of sufficient capacity to carry off storm water would have cost five times as much as the house-waste sewer which has been built, and which will be fully adequate to our needs when the present population of Canton shall have been doubled.

When we come to the laterals the saving will be much greater, owing both to their greater length and to their average depth. In order to receive outflow from cellars these laterals must have a minimum depth of nine feet, and in order to have sufficient fall this depth ranges from nine to sixteen feet. Certainly the carrying of rain water at such a depth below the surface, is unnecessary. The merest glance will satisfy anyone of the great economy of the pipes now being laid over the building of brick conduits large enough to admit the passage of storm water at such a depth under ground. On the score of economy then it may be taken for granted that argument is not needed. If the removal of sewage only, not accompanied by storm water, is the object aimed at, then the advantages of the plan now being carried out in Canton are as four or five to one over a system that would be adequate to the safe removal of the heaviest rainfalls.



SECTION SHOWING PIPE JOINT.

Very many persons freely express the opinion that the diameters being used in Canton are too small. The natural and quick explanation is that these sewers are for the removal of house wastes only. This exlpanation does not always remove doubt. Predictions are freely made that the pipes will become clogged, that they are inadequate. It is sufficiently well known, the facts having frequently been printed, that the main sewer is two by three feet in diameter at the outlet, and fifteen inches in diameter at its smallest end. Its diameter gradually increases as the laterals contribute to its proposed volume. The laterals range in diameter from one foot down to six inches, depending on the area to be drained. No sewer remains six inches in diameter for a greater distance than one block, or 200 feet, from the dead end, or highest point of that sewer.

The reasons for believing that these diameters will be amply sufficient may be generally summed up by the statement that such has been the experience of other cities. The opinions of practically all the cities using the separate system were obtained and the approval of the plan was without exception. Since the adoption of this plan by Canton, sewer-building has taken a very large extension. Nine-tenths of the new systems are upon the same plan. In the larger cities intercepting sewers have to be built, but even in such cases the collecting or lateral sewers are generally on the small pipe system.*

Naturally in such an engineering work, nothing is left to chance or caprice. Our separate sewers are designed on certain formula, the result of large experiment. These take into account the number of persons living on a given area, and assume that each person will furnish 100 gallons of liquid waste in 24 hours, also that one-half of this amount will be furnished in six hours.

It thus becomes apparent why those in control of the sewers feel compelled to refuse their use for the drainage of elevator water and other forms of overflow than the hurtful wastes of the city.

In the planning of storm water drains a different formula is used in fixing the capacity which is predicated on the acreage areas drained, on maximum rainfall, activity of flow, etc.

SEWER GAS.

Sewer gas stands as a general term expressive of the unwholesome volatile products of sewers. In regard to its composition a competent authority says:

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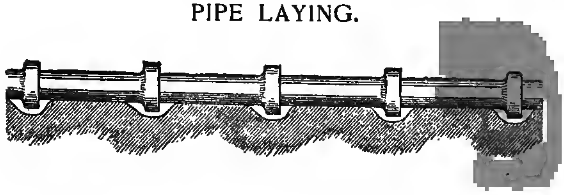
* Since the sewers of Canton were built a great many cities have introduced the separate system of sewers, comprising, among others, Chelsea, Lenox and Pittsfield, Mass.; Stanford, Conn.; Round Lake, Schenectady and Corning, N. Y.; Mt. Holly, East Orange, Long Branch and Englewood, N. J.; New Castle and Wilkesbarre, Pa., Pensacola, Fla.; Birmingham and Decatur, Ala.; East Liverpool, O.; Lincoln, Neb.; Wichita, Kan.; Pueblo, Col.; Ft. Worth and Little Rock, Ark.; San Bernardino and Riverside, Cal.; El Paso, Tex.; Leavenworth, Kan.; Laconia, N. H.; Athol and Westboro, Mass.; Hoosiac, N, J.; Charleston, S. C.; Savannah, Ga.; Nashville, Tenn.; Owensboro, Ky.; Wyoming, O.; Danville, Ill.; Springfield, Mo.; Kingston, Ia.; Emporia, Kan ; Sacramento and Stockton, Cal.; Seattle, Wash.; Kingston, Island of Jamaica, and in many other cities whose names we cannot recall.

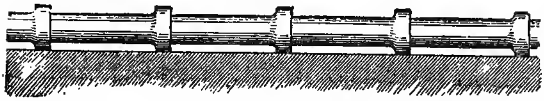
"Sewer gas, as is well known, is a composite substance which may be represented by no one chemical formula, various conditions of sewage producing different combinations of gases, which we indiscriminately call 'sewer gas.' Now the danger in sewer gas may be attributed to two separate and distinct causes: First, from components, such as sulphureted hydrogen, which are actually poisonous. To this cause we may ascribe such fatalities as one which occurred in Kansas City some three or four years ago. Some men in digging a sewer trench opened an old vault which had been closed for some years. The men were almost instantaneously overcome, and at least one of them died. Similar cases are not rare, but the promptness with which the poison acted was remarkable. Such gases are intolerably offensive. Secondly, air carrying germs of disease which, having become detached from the liquid body of sewage, generally by bubbles from, or air currents passing over the sewage, are borne along with the other gases to the outlet.

"These two sources of danger are quite distinct, but either may prove fatal. The first, acting more quickly on the system, usually warns us by an odor, the offensiveness of which is greatest when most dangerous. Inhalation produces headache, torpor, nausea, giddiness or unconsciousness, as the case may be, or it may act merely as a slight depressent. The second is odorless, but may eventually produce endemic disease and death. Ventilation is the simplest and often the most effective preventive in either case."

PIPE LAYING.



Pipes resting on their full length.—The proper way to lay the vitrified pipe.



Pipes resting on their shoulders.—The improper way to lay the vitrified pipe.

With separate sewers complete, regular and automatic flushing is an integral part of the system. Owing to the small volume of contained air, the house connections, carried full bore to the roofs, ventilate the sewer thoroughly. Sewer gas cannot be formed, and if formed cannot enter the house. In a concluding paragraph of a recent report of Dr. James T. Gardner, director of the New York State Survey, and a sanitary engineer of national repute, the following statement is made: "Those cities which have already spent large sums in completing sewers must either continue to suffer from the evils of sewer poison, or incur the further expense of a separate small system for carrying sewage only, retaining the large sewers for storm-water."

In the item of keeping the sewers in effeective working order the proportionate saving to the city effected by separate sewers is even greater than the saving in first cost. In this we do not include expenses incurred in the treatment of sewage at the outfall. That is a separate matter. The removal of street debris, washed into large sewers by storm, entails heavy expenses which are almost entirely avoided by separate sewers, while the sewage is removed with very much greater rapidity and facility. In a report on this very subject, made to his own city, C. H. Latrobe, the distinguished engineer of Baltimore says that " Separate sewers fully answer the purpose for which they are intended, and which I conceive to be, primarily the object of all sewerage, viz.: 'To carry off all human and industrial waste with rapidity and cleanliness to its ultimate destination."

We have purposely cited a few opinions from engineers who are recognized authorities on this subject, and could present many more to the same effect; and we would prefer to do that if they occurred so condensed, and in form adapted to our situation. But enough has been said—leaving our own observations out of the count—to convince the fair inquirer that the flippant dictum of the passer-by, whose only knowledge of sewers is limited to that which he has seen in some of the older cities, is not based on any proper examination of the subject.

With no more light before him than the testimony and opinions that have been presented, it is believed that the impartial reader will say that no other course was advisable for the Sewer Board than the one which they actually pursued. Happily there is now at hand more convincing proof of the soundness of the decisions arrived at by the Board. The sewers have been in operation nearly four years. They have performed their functions perfectly. There has been no complaint, and no cause of complaint. In the presence of these facts opposition has been silenced, and evil predictions and reproaches have given place to hearty approbation.

It is with great satisfaction that we are able to state that although much skepticism and dissent was avowed, and legal obstructing processes were threatened, the sewer system of District Number Three was carried forward without interruption and was practically completed in the spring of 1890.

SEWER CONNECTIONS ON PAVED STREETS.

At a meeting of the Sewer Board held on July 1, 1889, the following was passed:

WHEREAS, The work of paving certain streets is in contemplation, therefore,

"*Resolved*, That the Sewer Commissioners hereby recommend that the house connections be put in to the curb line on all streets that are to be paved a sufficient time before said paving is done."

The City Council took action in compliance with the above recommendation and with one exception (in which the provision was overlooked in preparing specifications) the paved streets are provided with sewer connections, under the paved areas, in the manner indicated.

THE USE OF THE SEWERS.

As soon as the sewer construction was sufficiently advanced the applications for permission to use the sewers became very pressing. The first permit was issued December 31, 1889. Up to the present date 825 permits have been issued, though a considerable number of those to whom permits have been conceded have not yet built their proposed connections. A register of the name, date and name of sewer-builder is kept in the office of the City Engineer, also a list of the licensed plumbers in the city. The form of application and the permit is as follows:

APPLICATION FOR A PERMIT.

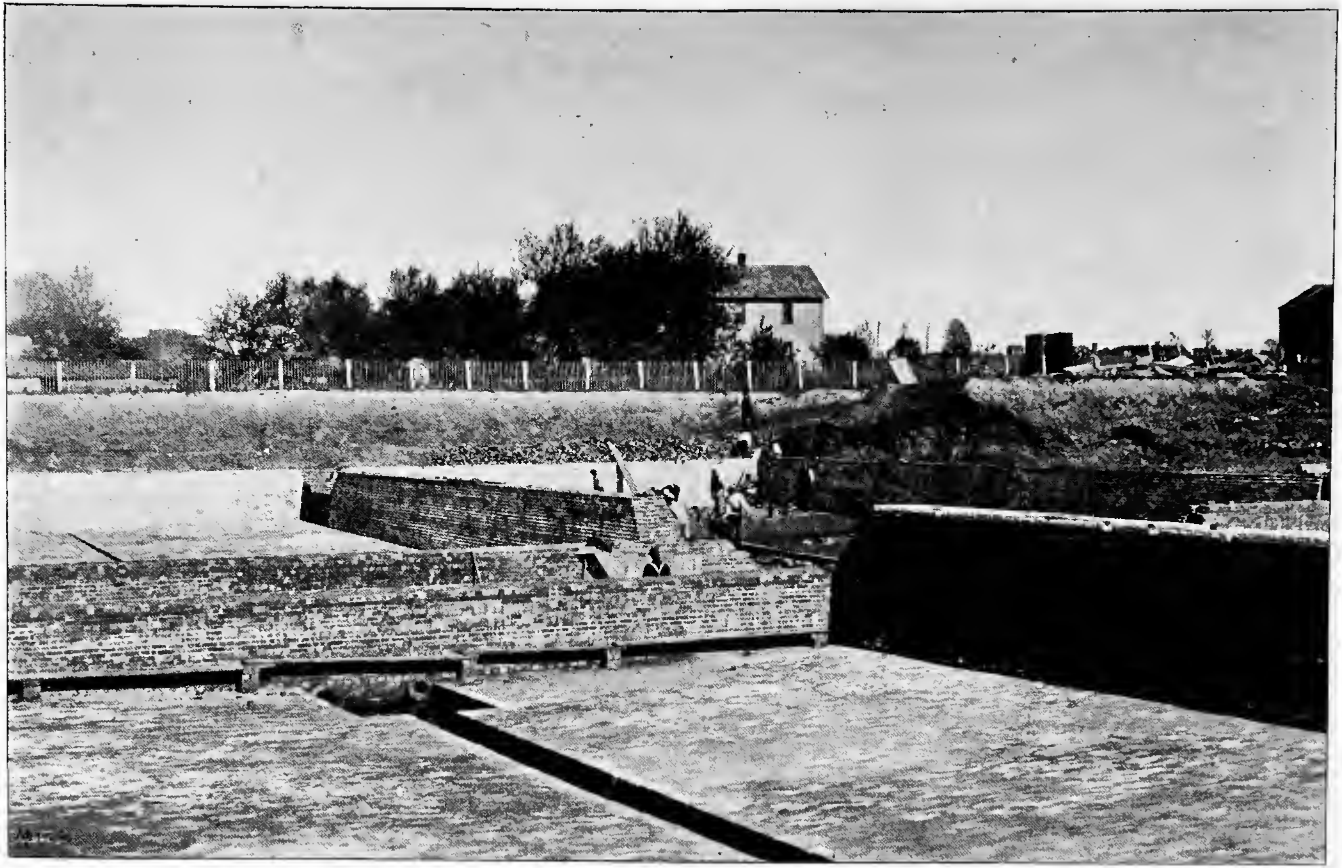
No.............. CITY CIVIL ENGINEER'S OFFICE.

CANTON, OHIO,......................189....

Application is hereby made for permission to connect premises, house No........... on...............No................on the ....side of.................. Street, between ....Street and............................ Street, with sewer in.. ....Street, and..... desire to have the work done by .... a licesened ....who is authorized to obtain for ....the necessary Permit, and..........agree to accept the Permit with the printed conditions thereon, and......hereby bind............................heirs, executors, administrators and assigns, to become responsible to the City of Canton for any damages whatsoever that may result to said City, or to any person or property in said City, by reason of the construction, existence or abuse of said connection.

Owner................................

Address........... ....



SEWAGE DISPOSAL WORKS.

View taken from southwest corner of tanks when the same were partially built. The floor of the tank in the foreground is completed, showing inward slope and sludge channel and drain which carries sludge to the sludge-well. See description in report of L. E. Chapin, C. E., at end of this report.

No.............. CITY CIVIL ENGINEER'S OFFICE.

CANTON, OHIO....................189.....

WHEREAS, Permission is to be given to the undersigned, a duly licensed.......... to connect premises, house No........on........lot No .... on the..... ....side of ....street, between...... ....street and...........................street, with sewer in.......................... ... street; subject at all times to the provisions of Ordinance No. 77, regulating the use and construction of sewers, etc., passed December 16th, 1889;

THEREFORE,......hereby bind..............................heirs, executors, administrators and assigns, to become responsible to the City of Canton for any damage whatsoever that may result to said city, or to any person or property in said city by reason of the construction of said connection, and within three days after the commencement of the work..... hereby agree to have said...................... .... restored to as good condition as it was before said connection was made. If not replaced by........................ in the required time, the City of Canton is hereby empowered to have said work done at .... expense.

PERMIT.

No.............. CITY CIVIL ENGINEER'S OFFICE.

CANTON, OHIO,......................189.....

Permission is hereby given to................... .... duly licensed ....to connect premises of............................ house No..........on......... lot No..... ... on the ....side of............ ....Street, between ....Street and..........................Street, with Sewer in.... .... Street, subject at all times to the provisions of Ordinance No. 77, regulating the use and construction of Sewers, etc., passed December 16, 1889, and............. application for this permit.

....

City Civil Engineer.

The method of using the sewers and the restrictions to be placed on those connecting with them, immediately required attention, and the whole subject was very properly referred to the Sewer Board. Having assumed the responsibility for the plan of sewers as built, it was eminently proper that the views of the Board in regard to the manner of utilizing the sewers should be heeded. The Board framed and submitted the following ordinance, which was passed, as reported, May 6th, 1889:

AN ORDINANCE

Regulating the Use and Construction of Sewers, and the Disposal of Sewage.

SECTION 1. Be it ordained by the Council of the City of Canton, Ohio, That no person shall be authorized or permitted to do the work of making connections with any of the public sewers or drains or their lateral connections, until he shall have first registered his name and place of business in the office of the City Civil Engineer, and received a license from the Mayor. In case any change in his place of business, or his business connection, notice of the same shall be immediately given to the City Civil Engineer. No person shall be licensed to do any of the aforesaid work until he has furnished the Mayor with a satisfactory certificate, signed by at least two reputable plumbers, if he be a plumber, to the effect that the applicant is a person regularly educated to the business and qualified for the duties he undertakes; and previous to being so authorized or licensed by the said Mayor, he shall file a bond with the Mayor in the sum of fifteen hundred dollars, with two or more sureties, to the approval of the Mayor, conditioned that he will indemnify and save harmless the City of Canton from all loss or damage that may be occasioned in any wise, by accident, or the want of care or skill on his part in the prosecution of such work, or that may be occasioned by reason of any opening by him or caused to be made in any street, lane, alley, avenue, market space or common, as the case may be, and to restore such opening, to as good a state and condition as he found it previous to opening the same, and that he will conform in all respects to the rules and regulations which may be, from time to time, established by the Board of Sewer Commissioners or City Council, in relation to the construction, repair or regulation of any of the public sewers or drains.

SEC. 2. All sewers shall be designated by consecutive numbers in the order of the date of passage of the ordinance providing for their construction.

SEC. 3. Whenever the word "street" is used singly, it shall be understood to embrace streets, lanes, alleys and other public grounds, the same as though named in each case. All sewers and drains of every kind within the lines of any street, lane, alley, or other public grounds or right of way, shall be under the control of the City Civil Engineer.

SEC. 4. Every plumber or sewer builder before doing any work connected with any sewer, shall file with the Engineer a notice and drawing of the work to be performed, and no such work shall be done without the approval of the Engineer, or one of his assistants. Application for permits shall be made, in each special case, to the Engineer by the owner, agent, or person in whose interest the work is to be done, and he shall issue the permit to the plumber or sewer builder in the name of the owner or person in whose interest the work is to be done before the work is commenced, and in no case shall such work be prosecuted unless such permit is on the grounds and in the possession of the person doing the work; each certificate shall designate the street and number of the house and lot, and shall include such definite description of the premises as to clearly define the location of the same on the map.

Applications so filed shall be approved or rejected without unreasonable delay. After a plan has been approved no alteration of the same will be allowed except on a written application of the owner.

SEC. 5. The Engineer shall keep a daily record of the permits applied for and allowed or rejected, as well as all violations of this ordinance.

A fee of twenty-five cents must be paid as a permit fee for each connection to the sewer, which money shall be paid into the sewer fund.

Each plumber or sewer builder will be held responsible for any injury he may cause to any main or lateral sewer in the prosecution of his work.

SEC. 6. Drawing and descriptions of the plumbing and drainage of buildings done prior to the passage of the ordinance may be placed on file with the Engineer. The latter may, at his discretion, require such plans to be so filed. The City Civil Engineer and Health Officer shall, at proper times, have access to all plumbing fixtures connected with the sewer. In all cases where private sewers have been constructed the owners or occupants of the premises shall, at their own expense, maintain and keep such sewers in good working order and repair.

SEC. 7. All house connections shall be of the uniform size of four inches in internal diameter. All sewer pipes, except those which enter buildings, shall be of the best quality of vitrified socket pipe, of the kind or kinds acceptable to the Engineer or his assistants.

Where soil pipes enter a building under the foundation thereof, the Engineer, or his assistant, may require the pipe to be of cast-iron. At such place the wall shall leave two inches clear space over the top of the pipe or it shall be arched so as to prevent injury to the pipe by settling. The ventilating pipe shall also be of cast-iron, and of same bore as soil pipe to the top of same. All iron pipes used in the construction of drains or house connections shall be coated inside and outside with coal or tar applied hot, or rustless material acceptable to the Engineer, and the joints thereof shall be made with gaskets of oakum, thoroughly caulked in with hot lead at one pouring so as to render them impermeable to gases; but wrought iron pipe may also be used with thread and screw joints.

The nearly horizontal portions of iron soil pipe, used under ground, shall in no case weigh less than—

For 4 inch pipe, 13 lbs. per lineal foot.
For 3 inch pipe, 9½ lbs. per lineal foot.
For 2 inch pipe, 5½ lbs. per lineal foot.

Waste pipes or lateral drains from bath tubs, basins, or other fixtures (with the exception of water closets), may be of two inch diameter pipe.

When it is practicable the soil pipe must run on a cellar or other wall and be securely fastened thereto. When it is impracticable the soil pipe may be laid in a trench beneath the cellar floor; and, in that case, may be of iron, or, except under walls or other heavy pressure, of sewer pipe. If of sewer pipe, the latter must be of perfect quality, the joints must be made of Portland cement, iron filings and sand thoroughly mixed with a weak sal-amoniac solution. Whether of iron or stone ware, said pipes must be shown to the Engineer or one of his assistants, in open trench filled with water, and subject to his approval or rejection.

Said soil pipes placed in the ground shall be supplied with an accessable clean-out either inside or outside the walls of the building

SEC. 8. All connections with the main branch sewers shall be made at the regular connections, or junctions built in the same, except by special permit from the City Civil Engineer, who shall give such information as the city may possess relative to the location of such junctions, depth of sewer, etc., on application, and all reasonable care will be taken to insure the correctness of such information; but the city shall not be liable for any errors arising therefrom.

SEC. 9. All openings made within the street lines for the purpose of laying any such sewer, except under the tracks of street or other railways shall be in open trench. All material for flaging, curb or ballasting, to be carefully removed and preserved, and after the connection is properly made, the trench shall be refilled and puddled, (in puddling the earth must be put in layers not more than one foot in depth, and each such layer shall be thoroughly puddled or rammed before another layer is put in), and the paving and other material that had been removed shall be properly replaced by the sewer builder, and if not replaced within three days after the same has been removed, then the same shall be replaced by the city at his expense.

The course of drain pipes shall be laid not nearer than eighteen inches to any water pipe; at crossings, the latter shall be protected from corrosion by a cement covering.

All sewers and drains beyond the street lines may be laid in open trench, or in trench and tunnel, as may be directed, but in the latter case no tunnel shall enclose more than two joints of pipe.

SEC. 10. When sides of the trench will not stand vertical, sheeting and braces shall be used to prevent unnecessary caving. The sewer builder must erect proper safe guards and maintain danger signals wherever and whenever necessary. He will be liable for all damages to persons and property caused by his acts of negligence.

All water pipe shall be protected from injury to the satisfaction of the water works superintendent, and gas pipe to the satisfaction of the City Civil Engineer.

SEC. 11. The sewer builder will also be held responsible for any subsequent settlement of the ground and pavement, and must on notification make the same as good as before he began the work.

SEC. 12. All house connections shall be made straight, or in as direct line as possible to the "Y" branches in the sewers into which the premises are drained and shall be at least four feet below the surface of the ground. All pipes shall be laid to a proper fall of not less than one-half inch to every two feet, where practicable, by the use of the spirit level.

The joints shall be made oakum gaskets well caulked in, and finished with the best hydraulic cement, and clean sand placed in and around each joint, so that the same shall be used at all angles in the house connections greater than three inches deviation from a straight line in the length of one joint of pipe.

SEC. 13. Whenever it is necessary to make a connection with any main or lateral sewer where no "Y" has been placed, the junction pipe will be furnished by the sewer builder, and the same will be inserted under the supervision of the City Civil Engineer or one of his assistants.

No sewer builder shall cut or break into the sewer unless the City Civil Engineer or one of his assistants be upon the ground and give his approval of the method employed.

SEC. 14. All "Y" branches or junctions not intended for immediate use shall have their ends closed water tight with brick or stone and cement. Care should be taken that the interior of the pipes are free from rough mortar and that the whole house connection and sewer be left clean and in good condition.

SEC. 15. Sewer builders shall in no case use water from street hydrants without a permit from the superintendent of the water works. All joints in waste pipes, except where screw joints are used, must be with oakum gaskets and lead or cement, well caulked so as to render them water and gas tight.

SEC. 16. All connections of lead with iron pipes must be made with brass sleeve or ferrule of the same size as the lead pipe, and thoroughly caulked with lead, and the lead pipe to be attached to the sleeve or ferule by a wiped lead joint.

All connections of lead pipe must be by wiped joints. Putty joints will not be permitted.

SEC. 17. The drain, soil and waste pipes, and the traps must, if practicable, be exposed to view for ready inspection at all times, and for convenience in repairing. When necessarily placed within partitions or recesses in the wall, soil and waste pipes must be covered with wood work so fastened with screws as to be readily removed. In no case shall they be absolutely inaccessible.

SEC. 18. Absolutely horizontal waste pipes shall be prohibited. Drips or overflow pipes from safes under water closets or other fixtures, or from tanks or cisterns, shall be run to some place in open sight, and in no case shall any such pipes be connected directly with a drain, waste or soil pipe. Waste pipes from refrigerators, or other receptacles in which such provisions are stored, shall not be connected with a drain soil pipe, or other waste pipe, unless such waste pipes are provided with traps, suitably ventilated, and in every case there shall be an open tray between the trap and the refrigerator.

SEC. 19. All pipes exposed to frost should be covered with mineral wool or other substance equally good, and they shall be cased to the satisfaction of the Engineer.

SEC. 20. When the soil pipe enters a building, a ventilating pipe shall enter said soil pipe, and shall pass in undiminished bore, by the wall, inside of same extending at least two feet above the roof or top of the highest window.

SEC. 21. Soil, waste or vent pipes in an extension must be extended above the roof of the main building, when otherwise they would open within twenty feet of the windows of the main house or the adjoining house. It must not open below a window nor an air shaft which ventilates living rooms, nor nearer to same in any direction than eight feet.

SEC. 22. No trap or any manner of obstruction to the complete or perfectly free flow of air throughout the entire course of the drain or house connection will be permitted. Every room having a water closet, urinal, bath tub or any drainage connected with the sewer must have a window or shaft of an area of at least two square feet communicating directly with the outer air.

SEC. 23. Every water closet trap must be separately ventilated and protected from syphonage by a special vent pipe of not less than two inches in diameter. If traps for above fixtures are vented the pipes used must have diameters of not less than one and one-fourth inches. If the pipes exceed fifteen feet in length they shall be one and one-half inches in diameter.

These vent or air pipes shall extend at least two feet above the roof. If they are branched into the soil pipe, it must be eight feet above the inlet pipe of the highest fixture.

They may be continuous by branching those which serve several traps, provided they are branched into a vent pipe of not less than two inches in interior diameter. These vent or air pipes must always have a continuous slope to avoid collecting water by condensation. No trap vent pipe shall be used as a waste or soil pipe.

SEC. 24. No butcher's offal or garbage, dead animals, wood, stone, straw, rags or other articles or obstructions of any kind whatever, of a tougher or harder texture than newspaper or closet paper, shall be placed, thrown or deposited in any catch basin, sewer, ditch or drain in the city, and any person so offending or causing any such obstruction to be placed so as to be carried into such sewer or basin, shall be subject to the penalty hereinafter prescribed for such an offense, also any person breaking, injuring or removing any portion of any catch basin, man-hole cover or any part of any sewer or appurtenances thereto, or obstructing in any manner the inlet or outlet of any sewer or drain.

SEC. 25. Elevator waste water, roof water, overflows from cisterns, etc., shall not be connected with the sewers. The waste water which shall enter the sewers shall comprise only:

1—Waste water from kitchen sinks.
2—Waste water from water closets.
3—Waste water from wash stands and bath tubs.
4—Waste water from urinals.
5—Waste water from slop hoppers.
6—Such waste waters from factories, laundries, restaurants or other buildings as the Engineer may consider admissible without detriment to the sewer.

SEC. 26. All exits from kitchen sinks, wash stands, slop hoppers, and other receptacles except water closets, shall be provided with strong and permanently attached metal strainers; except in case of urinals and wash bowls already provided with good earthenware strainers.

SEC. 27. No steam exhaust or blow off pipe from a steam boiler will be allowed to connect with any soil pipe, or directly with the house drain. They should discharge into a tank or condenser, the waste from which after being condensed and suitably trapped may enter the sewer.

Sub-soil drains from cellars may be connected with the sewer, but the connection must be made with the approval and under the personal supervision of the City Civil Engineer or one of his assistants. Every such connection must be provided with a trap; also with a good metal strainer, with perforations not more than one-fourth of an inch in diameter, and exposed to plain view.

SEC. 28. No trap nor any manner of obstruction to the complete and perfectly free flow of air throughout the entire course of the drain or soil pipe will be permitted. No brick sheet metal or earthenware flue shall be used for this purpose.

SEC. 29. Every wash basin, bath tub, sink, urinal, water-closet or other fixture connected with the sewer pipe of any building shall be separately trapped as close to the fixtures as possible, except in the case of syphon water closets. Water sealing traps of any pattern may be used when separate air pipe connections from the top of the same are provided; where separate air pipe connections are not provided traps which will not unseal must be used.

Overflow pipes from fixtures must in each case be connected on the inlet side of the trap. The sediment pipe from kitchen boiler, if there is any, must be connected on the inlet side of the sink trap.

SEC. 30. All closets, basins and urinals shall be provided with a sufficient supply of water to insure the cleaning of the same after each time of use; and in no case shall any such closet, basin, or urinal be used longer than one hour without such water supply, if from any cause the same be cut off, unless water is supplied from other sources. Ball cock valves of cisterns must be so fitted and adjusted as to prevent wasting of water.

SEC. 31. No sewer or kitchen drain from any building or premises shall discharge into any cesspool, vault or other like receptacle where such building or premises abut on streets provided with proper sewerage accommodations with which the same can be connected; and if at any future time such premises are provided with the said sewerage accommodations, within thirty days thereafter the further use of such cesspools, vaults or other receptacles for the disposal of sewage shall be discontinued and the proper connections made with the main or lateral sewer. And the said cesspools, vaults, or other receptacles shall be cleaned out and filled up under the direction of the health officer.

SEC. 32. When a privy vault or cesspool must necessarily be used, it shall be absolutely water tight; shall be at least ten feet from any well or cistern of which the water is used for household purposes, and must not be allowed to fill within four feet of the top. Whoever violates any provision of this section shall be fined not more than one hundred dollars; and for the second offense not less than one hundred nor more than two hundred dollars.

SEC. 33. Water closets may be of any approved pattern, except pan closets, which are prohibited.

SEC. 34. No waste pipe from any kitchen, sink, urinal, closets or other fixtures shall discharge into the soil beneath any floor or building. No privy vaults or cesspools shall be connected with private or public sewerage. No privies or cesspools shall be allowed in the basement of any cellar. All private sewers connecting with packing or butcher shops, laundries, hotels, eating houses, restaurants, or other public cooking establishments, shall be provided with grease traps of such design as the Engineer may approve.

SEC. 35. All sewers, drains, urinals, sewer gas and waste traps and pipes, and everything pertaining to house drainage beyond the lines of any street, lane, alley or other public grounds shall be accessible to the City Civil Engineer, his assistants and Health Officer, and shall, except where otherwise provided, be under the care and control of the Health Officer.

SEC. 36. Pipes and other fixtures shall not be covered or concealed from view until after the work has been examined by the Engineer or one of his assistants, who shall be notified when the work is sufficiently advanced for inspection.

SEC. 37. Any house drain or sewer put in and covered without due notice to the Engineer or one of his assistants must be uncovered for inspection, at the discretion of the Engineer.

SEC. 38. Whoever shall violate or fail to comply with any of the provisions of this ordinance, except where another penalty is especially provided, shall upon conviction thereof, be fined not less than $5 nor more than $50 and the costs of the prosecution.

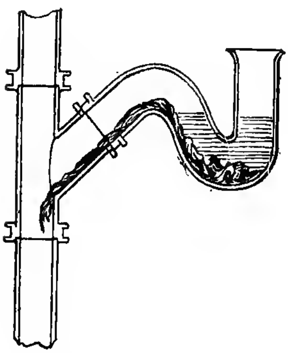
SEC. 39. This ordinance shall take effect and be in force from and after its passage and legal publication.

J. H. DUMOULIN,
Vice President of the Council.

ATTEST: H. G. SCHAUB,
City Clerk.

REMARKS ON THE ORDINANCE.

Compliance with the provisions of the ordinance, which has been in effect nearly four years, has resulted in a very decided improvement in the character of the appliances and methods used in removing house wastes. In some minor matters the ordinance is still susceptible of improvement.



Safety in the house demands that the traps be kept full. In the case shown above a rag lapping over the S kept the seal open by capillary attraction.

If people leave the house unused for a considerable period the water may be evaporated out of the traps. Before taking such a step a good plumber should be consulted as to the best method of insuring a constant water seal in all the traps.

Up to the present time no effort has been made to enforce the provisions of Section 31. Parties most in need of the sewers were quick to connect their premises. On the other hand there existed, on the part of the city, a desire to trespass as gently as the nature of the case permitted, on the forbearance of property owners whose interests would be affected by the sewage pollution of the creek.

Coincident with the completion of the sewage purification plant it will become the duty of the Health Board to see to it that the requirements of this section of the ordinance are enforced, to the end that Sewer District Number Three may reap the sanitary benefits which this improvement has made available.

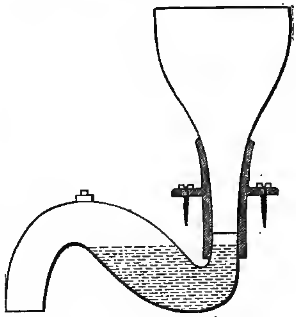
While the city builds the main and lateral sewers, when it comes to connecting with the same a good deal of discretion is necessarily left with the householder. Blunders in plumbing connections and fixtures would seem to be inevitable—such are the varied requirements and conditions that are certain to be encountered, a state of things which is made yet more unsatisfactory by the varying degree of intelligence, honesty and capacity possessed by the plumber himself. And mistakes, when they do occur, bring discomfort, and possibly disease, into the house, and discredit upon the sanitary system.

SIMPLE FORMS OF CLOSETS.

Iron Short Hopper.

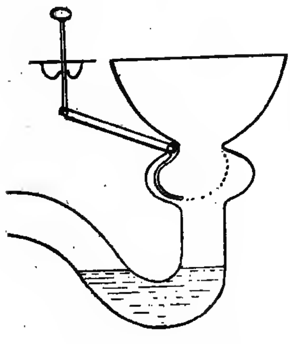
Short Hopper Section Showing Seal.

Short Hopper, Earthenware Bowl.



Long Hopper Section, Showing Seal.

All the forms of closets above shown are admissible and safe, providing the connections are properly made. The iron hopper is made somewhat undesirable by the greater difficulty there is in keeping it clean. White earthenware hoppers are best in this respect.



PAN CLOSET.

Because of the use to which these fixtures are put it is a mistake, and a very common one, to suppose that they require no cleaning. They should be cleaned daily. Deposits left to cling induce chemical action and discoloration, and by and by the surface that should look white and clean becomes permanently stained and unsightly.

We do not feel called upon to speak of the higher priced closets, specimens of which may be seen in any plumber's outfit. Many of these are brought to a high point of excellence, and even elegance, and render excellent service.

But inasmuch as it is desirable that all the residents of Sewer District No. 3 should connect with the sewers, and as the expense of fixtures may be urged as an excuse for neglecting to do so, it has been deemed advisable to state that the simple and cheap hopper closet, properly connected and cared for, will answer every purpose that can be required of a closet.

The use of the "pan closet" was formerly almost universal. An outline of this style is here shown.

It is a self-fouling affair, and cannot be cleaned. Its use is prohibited by section 33 of the Canton ordinance.

THE ILLUSTRATIONS IN THIS REPORT.

For obvious reasons the printer of this report has been instructed to present, in various pages, some illustrations, which will indicate how certain features of plain pipe-laying and plumbing should be done, or should not be done. No attempt is made in these to present any substitute for the plumber's art. Persons wishing plumbing work should employ and rely on the advice of a plumber of good reputation.

It is nevertheless true that there are certain plain principles upon which depend the safety or danger of these house connections which everybody should understand, and upon these only do the illustrations presented have any bearing. In addition to this there are certain requirements in the ordinance, the reasons for which can be made plainer by printed cuts than by any amount of printed description.

If some of our illustrations commend themselves as appertaining rather to the domain of the Health Board, we may be pardoned for suggesting that the subjects which engage the attention of both these boards have many common points of contact. As a matter of fact, during the earlier history of the Canton Sewer Board, the sanitary feature was diligently canvassed in the effort to impress upon householders the private and personal advantages which would accrue to them from a good sewer system. On the other hand the damages that menaced the victims of bad drainage, defective plumbing, and cesspool storage, furnished object lessons that were not entirely neglected.

THE COST OF THE LATERAL SEWERS.

It has already been stated that the laws of Ohio place the construction and taxing features of sewer enterprises in the authority of the municipal councils. It will, however, contribute to the completeness of this report if the ratio of cost, and the reasons for the method of assessment, are briefly stated.

The cost of the lateral sewers to householders has been one dollar per foot of frontage liable to assessment. If the lot had frontages on two streets, the tax was assessed only on the shortest of these frontages; only one tax was allowed to be imposed on any single piece of property. The clauses of the statute bearing upon this subject were cited to the City Council by the City Solicitor as follows:

ASSESSING COST.

SECTION 2379. [Assessment of Cost of Main Sewers.] The Council shall provide for assessing the cost and expenses of constructing main sewers upon the lots and lands bounding or abutting upon the streets, lawns, alleys, highways, market spaces, public buildings and commons, in or along which the same shall pass, by the front foot, or according to the valuation of the same on the tax list, or according to benefits as it shall determine.

LIMITING ASSESSMENTS.

SEC. 2380. [Limit of such Assessment.] The assessment shall not exceed the sum that would in the opinion of the Council be required to construct an ordinary street sewer or drain, of sufficient capacity to drain or sewer such lots or lands; nor shall any lots or lands be assessed that do not need local drainage, or which are then provided therewith, and the excess of the cost over the assessment herein authorized, shall be paid out of the street fund of the corporation.

VALUATION OR STREET FRONTAGS.

SEC. 2381. [Assessment of Cost of Local Sewerage.] The Council shall also provide for assessing the expenses of local sewerage, upon the feet front of lots and lands, by or through which any portion of the main sewer may pass, or according to the valuation of the same upon the tax list or in proportion to the benefits, as it may determine in each case.

IF THE COUNCIL MAKES IT FRONTAGE.

SEC. 2382. [Rules of Assessment Act.] If the assessment is upon the feet front, the basis shall be determined by taking the total cost of constructing the main and lateral sewers and drains and the necessary apparatus and inlets and then dividing the gross amount by the number of feet front, subject to assessment, as herein provided for, on each side of the street, lane, alley, highway, common, market place or public landing, through or in which such sewets and drainŝ may be laid, the quotient forming the amount to be assessed per foot front on each street, lane, alley, highway, common, market place or public landing, as a charge for the cost of expenses of constructing the sewers and drains, and their necessary appurtenances.

WHAT MAY BE EXEMPTED.

SEC. 2383. [Discrimination in Assessment in Certain Cases.] The Council may exempt from assessment such portion of the frontage of any lot having a greater frontage than its average depth and as much of any frontage or corner lots, as it may seem equitable, and charge the deficiency caused by such exemption on the whole frontage taxed pro rata; but in so doing it shall specially set forth, in the ordinance making such assessment, each lot so exempted, which ordinance, when passed, shall be binding upon the parties interested.

The method of assessment was generally satisfactory; though exceptions were taken to entire exemption of the long frontage, on one street, of lots having a comparatively short frontage on another street, the latter only being taxed.

City, church, and other properties generally exempt from taxes, were all assessed, there being no exemption made by law.

The bonds upon which the money for the lateral sewers was obtained was made payable in three annual installments, and they have all been paid.

RECENT RESUME BY THE CITY ENGINEER.

In a recent report to the City Council the length and cost of our city sewers to date are given as follows:

17.88 miles house sewers, cost	$114,082.15
7.55 miles storm water sewers, cost	127,293.88
25.43 miles in all, costing	241,376.03

The cost of the house sewers has been about $6,300 per mile, while that of the storm water sewers was about $17,000 per mile.

In a previous page of this report the comparative cost of separate and combined sewers was given as about one to five. When it is considered that combined sewers, carrying sewage, must be a much greater depth and width than sewers draining storm water only, the reasons for this increased discrepancy will be obvious.

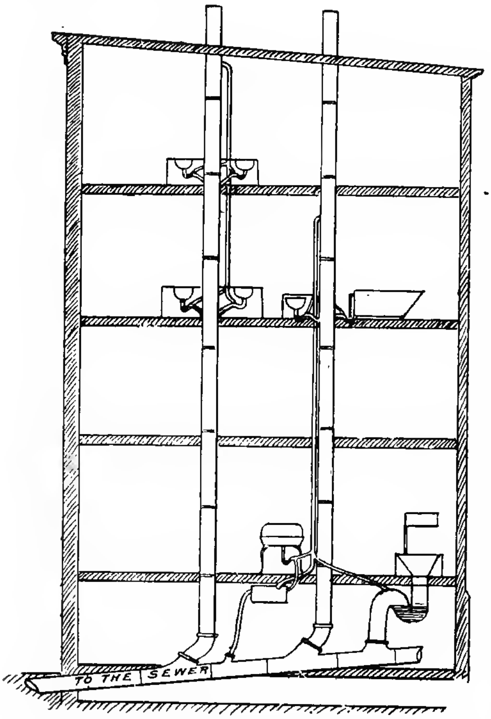
The concluding paragraph of Engineer Chapin's last annual report of the sewers, after four year's use, is an indication of the most satisfactory character. It is as follows:

"A total of 880 permits for house sewer connections has been issued to date, of which 178 were issued during the past year. The expense in maintaining the separate system is almost entirely the salary paid to inspector to examine the connections when laid, besides occasionally clearing the dirt pans in man holes."

The world might be challenged to produce a report on current expenses on so large a work which would be more pointed and significant than that.

SEWER DISTRICTS 1 AND 2.

Many residents in both the east and west sewer districts are already looking to the city for drainage relief. These districts will have to be reached by separate mains which will, in their courses, necessarily conform more or less, with the channel of the east and west creeks which furnish the surface drainage of their several areas. As has previously been stated, the problems presented by these sewer districts have already engaged some attention on the part of the City Engineer, and will be seriously considered in the near future.



For the sake of illustration two stand pipes are shown. In both cases the venting connections enter pipe eight feet above highest fixture, as the ordinance requires. Traps are as near as possible to fixtures. The branch vent from trap enters vent pipe at a point as high as the fixture. This is important, as otherwise the sewage or waste water might escape through the branch vent in case the trap became choked. Choking should be made instantly perceptible by the fixture itself, so that the cause of it can be removed.

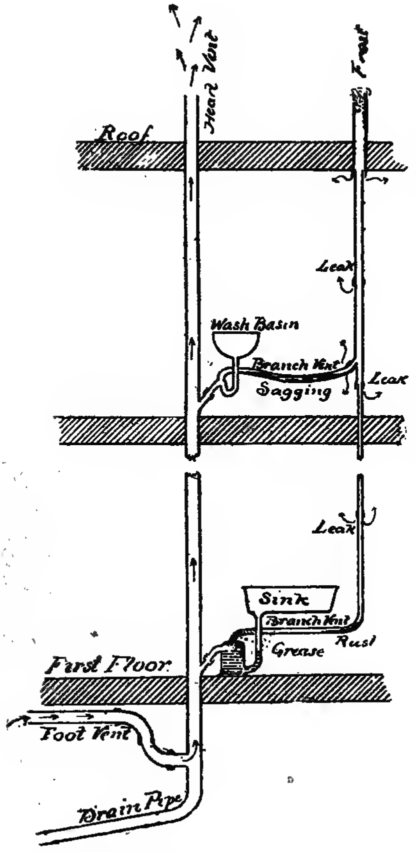
THIS REPORT.

It is possible that, in some features, this report may seem liable to the charge of redundancy. It ought, however, to be borne in mind, that this is the first and only statement that has been made covering the period of operations extending over ten years. A more or less general familiarity with the features of this enterprise does not absolve us from the necessity of stating material facts incident to its history and development. After all, the most has to be left unsaid. But we trust that it is sufficiently complete to give to our fellow citizens an intelligent comprehension of Canton's Sewer System, and of the principal events which attended and characterized its construction, so that, taken with the map, every query that could reasonably have been anticipated may have been fairly answered.

THIS BOARD AND THE CITY COUNCILS.

The fact has already been noted that, with a single exception, the personnel of the Board of Sewer Commissioners has been the same from its creation to the date of this report. It has also come to the attention of the reader that, prior to the spring of 1885, the methods and necessity of action were urged upon successive Councils without effect. There was a want of interest and a dearth of funds. But from the date when active operations were inaugurated to the present time every recommendation of this Board has been carried into effect.

While this fact justly implies that the responsibility, so far as principles involved are concerned, rests entirely with the Sewer Board, it is nevertheless the dictate of propriety that we should place on record our thanks to the several Councils having discretion in this matter for the courtesy and confidence which have uniformly been extended to us in the prosecution of this work.



There is nothing in our ordinance against the use of a fresh air inlet, or a "foot vent," as it is called in the picture. With our system of sewers it is believed to be a needless precaution. The use of an extra vent pipe passing out through the roof stands in the same category. Good plumbers do not always agree about such matters, but the best class of plumbers now-a-days are not liable to make mistakes that endanger health and comfort

If extra vent pipe is used it should be made of imperishable material, and not of tin or sheet iron to leak and rust out in a short time. And the branch vent should always have a sharp rise which will insure its freedom from obstructions.

CONCLUSION.

After more than four years of practical use of our sewers, the plans and methods employed, and the merits of the system itself, can be intelligently criticized. As may rightfully be supposed, we have, ourselves, carefully observed the conduct of the system with a feeling of liveliest interest from the beginning. The humiliations and the disappointments that would have overtaken us had the predictions of our hostile critics been verified have failed to arrive. On the contrary we feel the utmost satisfaction in being able to present this most important work to the City of Canton with the entire assurance that it is as free from faults and as perfect in detail as the most modern methods in sanitary engineering admits of.

It was most economically built. It is paid for. The cost has not been oppressive. There has been no breath of jobbery and no waste. It entails no repair bills. It is accompanied by no nuisances. It brings to our homes no dangers, no taxes, no bill collectors—nothing but blessings.

Side by side with those works which rise up before the view and fascinate the eye, this underground, unseen city-plat of narrow channels presents itself at a disadvantage. The grateful conveniences afforded by it become an everyday matter and fail of appreciation.

But by recalling the days when the hideously suggestive "excavators" frequented our principal thoroughfares; when the foulest of wastes, ever ready to rise up armed with the darts of contagion, had to be stored and kept even in the most thickly settled parts of the city; when permanent street improvements and enterprises of solid worth requiring drainage could no longer be undertaken; the contrast strikingly emphasizes the wise prudence which inaugurated and carried forward this important work to its present state of completeness.

Measured by the experience of other cities, in both the old and new worlds, employing similar methods, as well as by the observed working of our system thus far, there is every reason to believe that the benefits made available to our householders will be perpetual, and that citizens may continue indefinitely to point to the sewer system of Canton with a feeling of unabated confidence and pride.

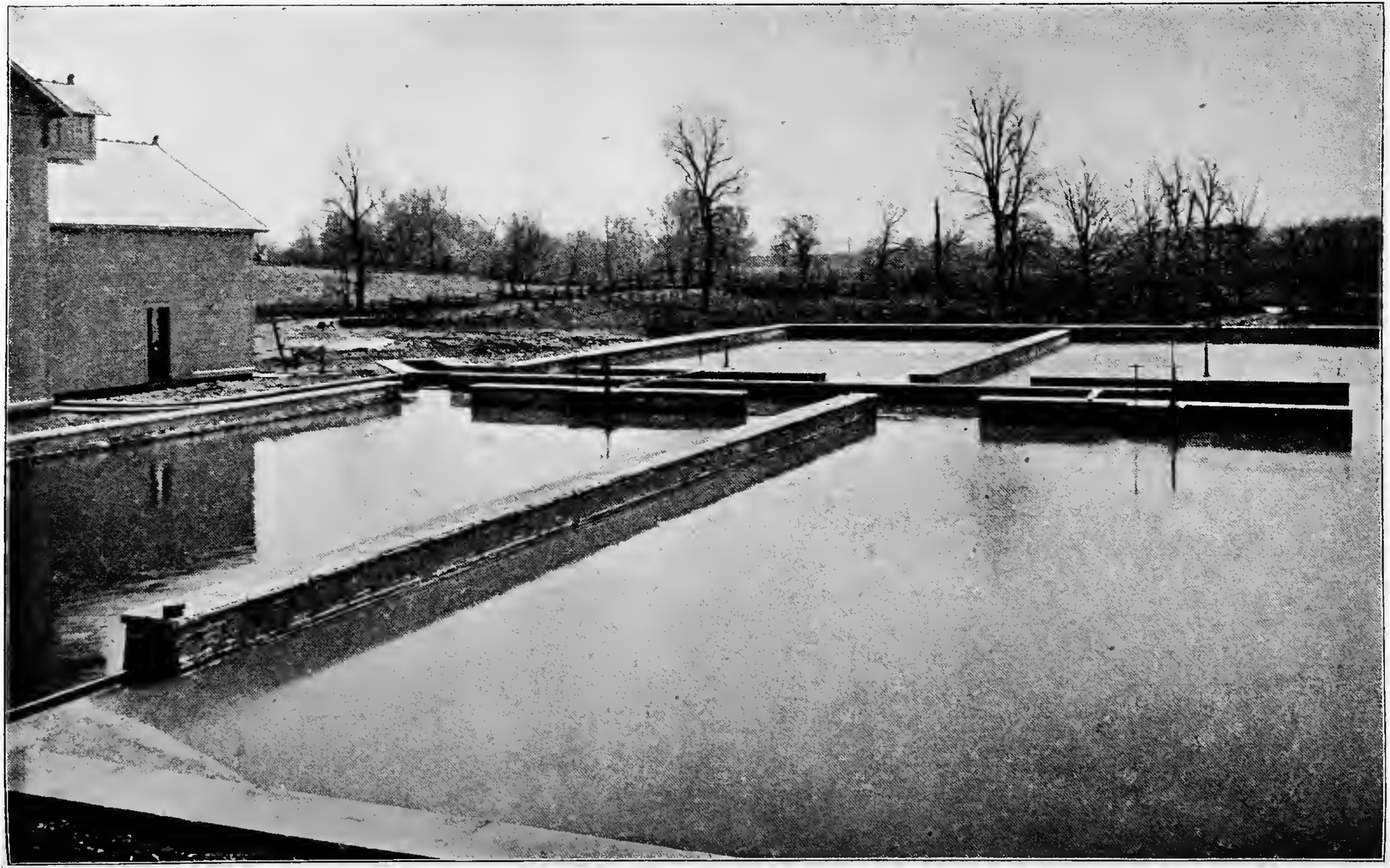
WILLIAM DANNEMILLER, President.
DANIEL PAAR,
E. O. PORTMAN,
W. R. DAY,
JOSIAH HARTZELL, Clerk.

SEWAGE DISPOSAL WORKS.

REPORT OF

L. E. CHAPIN, CITY CIVIL ENGINEER,

Associate M. Am. Soc. C. E.



SEWAGE DISPOSAL WORKS.

Photo-View of Tanks, April 4, 1893.

SEWAGE DISPOSAL WORKS.

To the Honorable Board of Sewer Commissioners, Canton, Ohio :

GENTLEMEN :—I herewith present for your consideration the following report and description of the Sewage Disposal Works now in operation :

METHODS OF TREATMENT.

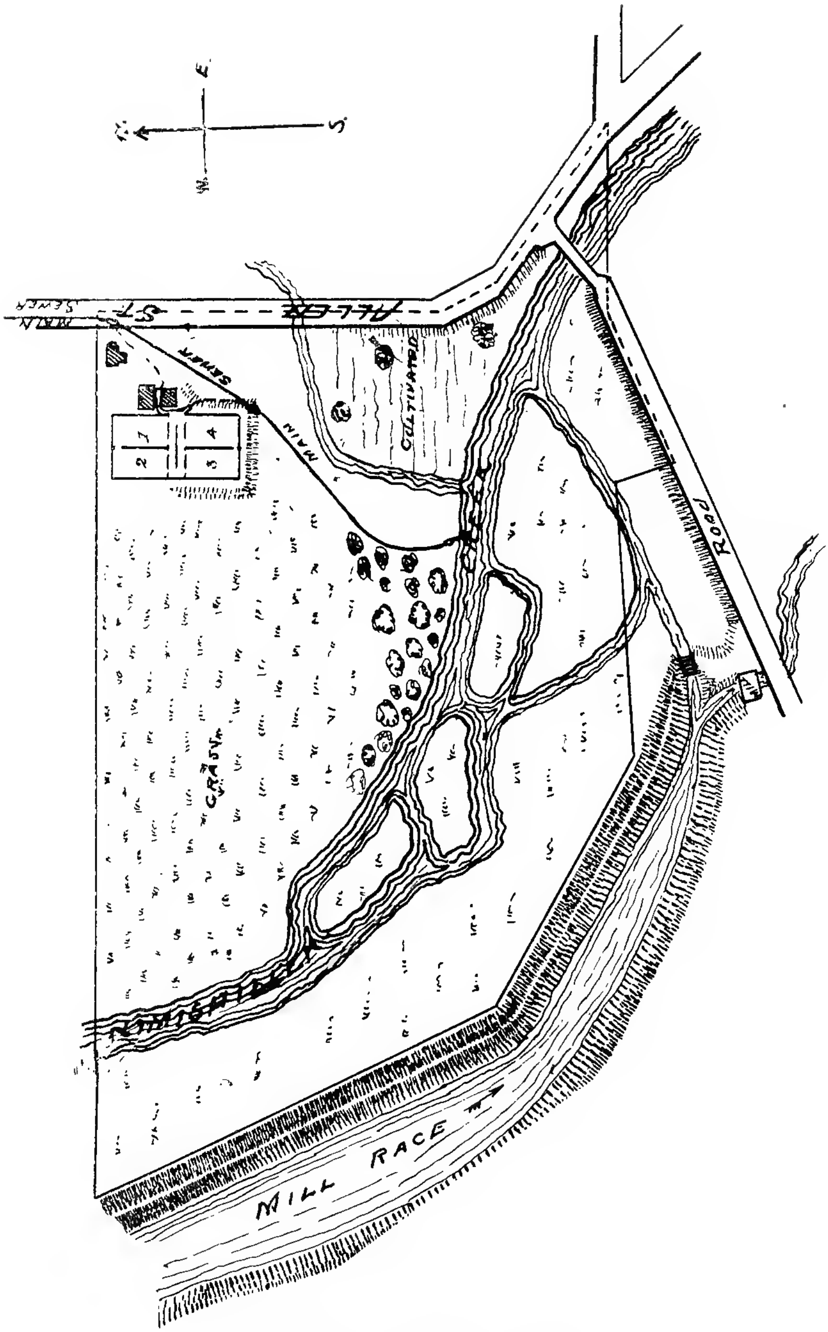
Tho works have been designed and built for purification of our house sewage by chemical precipitation, the precipitating agents, lime and sulphate of alumnia, being added to the crude sewage in certain specified quantities and the whole thoroughly commingled, after which the sewage so treated is allowed to pass slowly through the precipitating tanks, where the heavier matters fall to the bottom and the clarified effluent, passing off over a series of steps in the effluent chamber to the main effluent sewer and then to the creek.

LOCATION OF PLANT.

The works are located in the northeast part of the 28 acre tract of land purchased in 1888 for a sewage farm, the sewage being carried into the works by a by-pass known as the "inlet sewer," and from the works by an effluent sewer back to the main sewer and thence to the Nimishillen Creek.

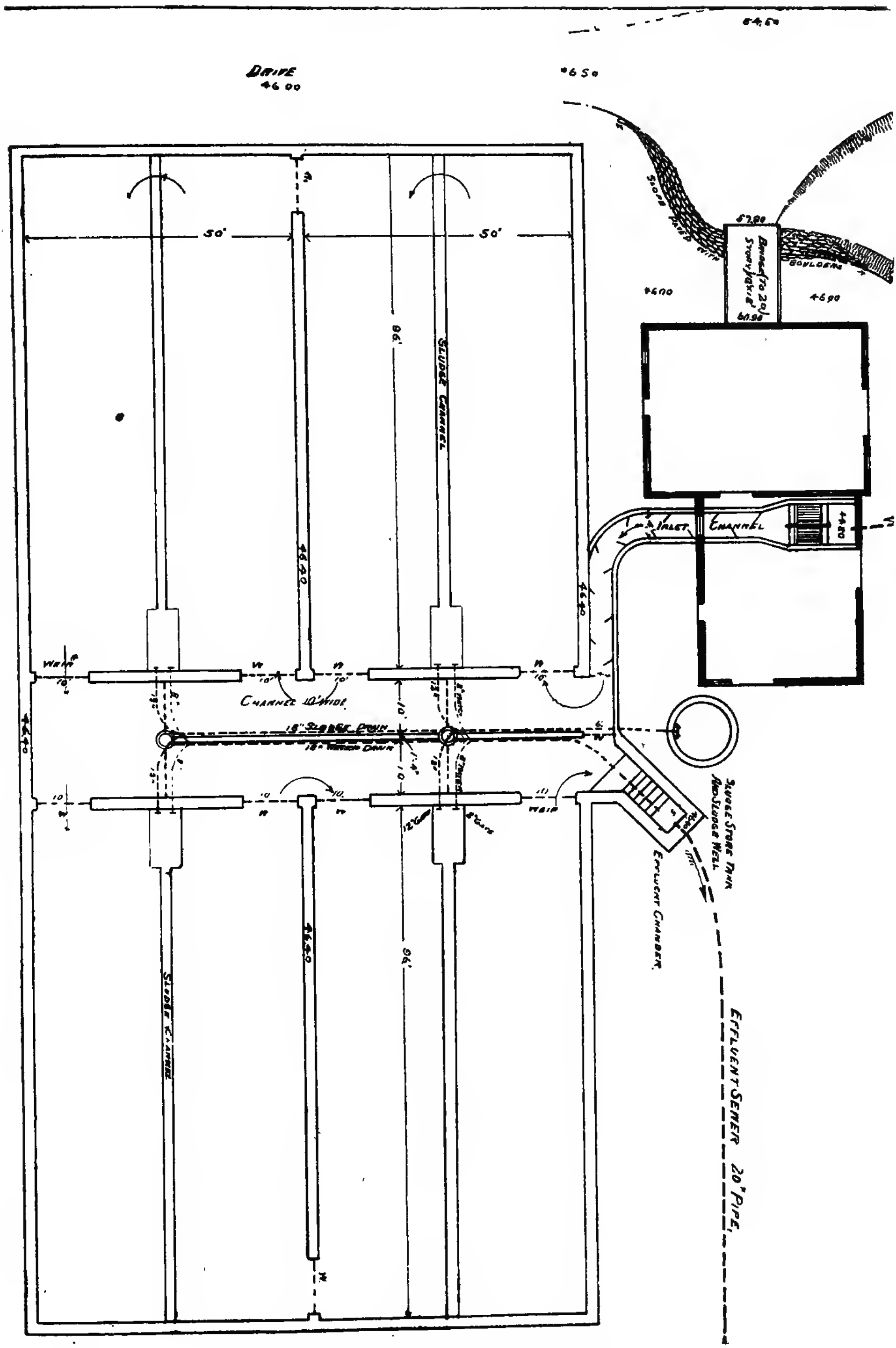
The plant consists of a building for machinery, an inlet screen chamber for removing papers and bulky matters, an inlet channel, leading from screen chambers, the four precipitation tanks, an effluent chamber and sewer and a sludge well.

The building is a two story frame structure with slate roof and divided into a mixing and press room, 30 by 40 feet and 12 feet high in the clear, with a chemical storeroom of the same size above, and into which the chemicals are delivered by a bridge from the bank drive, also a boiler room 28 by 35 feet which is lined with brick, and under the floor of the boiler room and next to mixing room is located the screen chamber. The building is constructed of 2 by 6 studding with 6 inch drop siding outside and ceiled inside, having double floors carried by 2 by 12 joists spaced 12 inches centers, and is provided with large double and single doors, all fitted with transoms; all doors are arranged to slide instead of swing. Large windows are provided in each room so as to allow an abundance of light and ventilation. The second floor ot mixing room and the main roof is supported by heavy trusses designed to support a weight equal to 50 tons of chemical, a span of horses and wagon, as well as a 2,000 gallon overhead water tank in which is stored the water for steam and mixing uses.



SEWAGE DISPOSAL FARM.

28 Acres.



PLAN OF DISPOSAL WORKS.

The gate and screen chamber is 3 feet deep, 8½ feet wide, and about 14 feet long, divided by a longitudinal partition into two compartments, each having an iron screen, through which the flow of sewage is regulated by sliding flume gates, the rear of the gate chamber narrowing down to 4 feet in width and forming the inlet channel. The sides of inlet channel and gate chamber are of 12 inch brick masonry resting on an 8 by 20 inch brick footing course, the bottom of the channel having a pavement of 5 inches concrete, then one inch sand, then paving brick on edge, the joints and spaces being grouted with Portland cement.

The tanks are four in number, with provision made for future requirements by opportunity to extend to the west. They are each 50 by 96 feet inside dimensions, and walls ranging from 5.75 to 7.58 feet high above the bottom pavement. These walls are all 26 inches thick under the coping (except the center walls separating each pair of tanks which are 28 inches thick), and by offsets on outside, and a batter of 1½ inches to the foot on the inside, increase to, from 44 to 48 inches thick at the base, all resting on footing courses 8 by 60 inches. These walls are built of hard burned shale sewer brick, laid up in Buckeye Portland cement mortar, mixed one part cement to three parts coarse sharp sand. All walls have a coping of 4 inch thick sawed Berea sand stone, projecting one inch over face of wall and showing quarry face edges.

The bottom of each tank has a slope of 1 in 40 from rear to front, and also from sides to central sludge channel which is 2 feet wide, being 2 inches deep at upper end, and 14 inches deep at lower end, below bottom of paving. This paving is hard burned shale paving brick on a 1 inch sand cushion with a 5 inch concrete foundation, the brick being well grouted with neat Portland cement grout and forms a practically smooth surface.

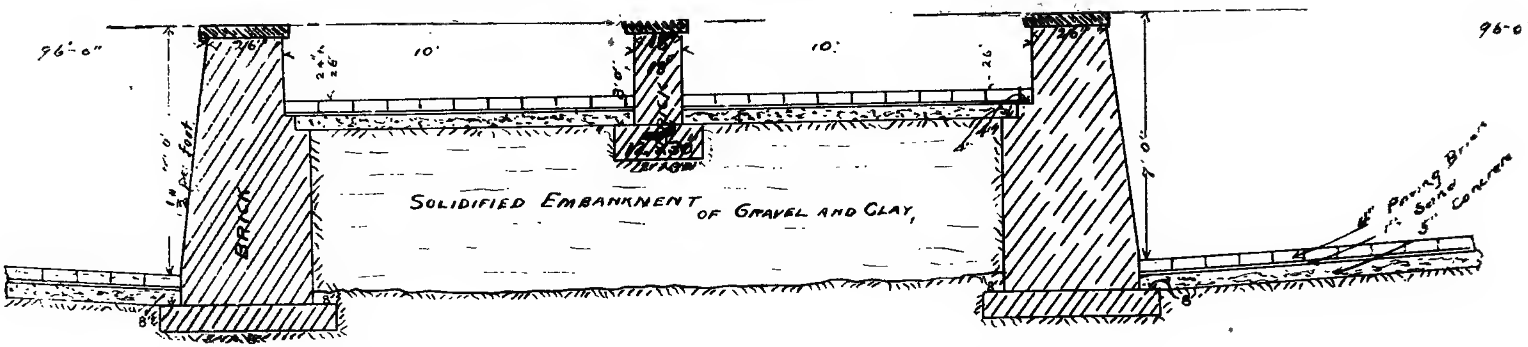
All brick masonry has been thoroughly cleaned of loose mortar and treated with three coats of Portland cement wash, which makes a clean hard surface impervious to moisture and has endured the frosts of the winter without scaling.

The effluent chamber is 5 feet wide and 12 feet long, of brick masonry laid in the same manner and with same final treatment. The steps in this chamber are Berea sand stone sawed to exact dimensions and imbeded in the side walls. The sludge pump well is 10 feet inside diameter and 18 feet deep, having 16 inch brick walls and bottom. This well has a capacity of 700 cubic feet sludge to its flow line, the admission of which is controlled by an 18 inch sluice gate with hand wheel and standard and operated from above.

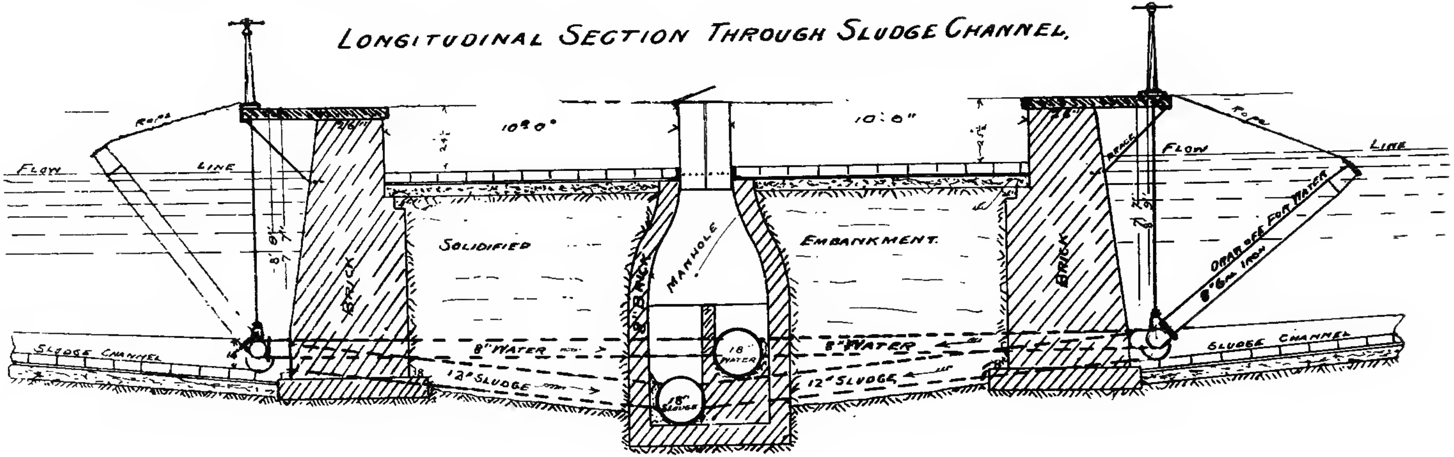
SLUDGE AND CLEAR WATER DRAINS.

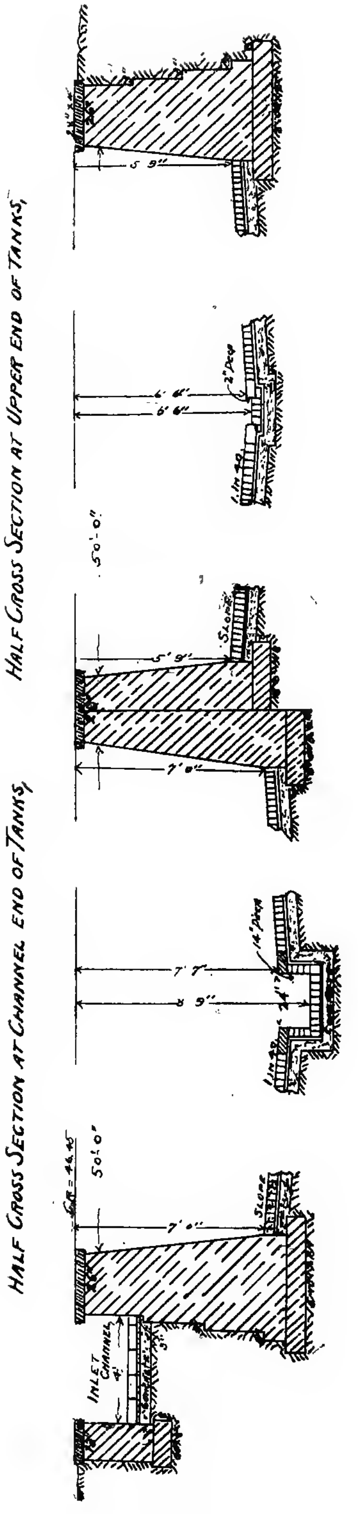
Midway between the two pairs of tanks, and under the central channel wall is located an 18 inch diameter sludge drain connecting with the sludge well and having a 12 inch branch to each tank, and controlled by a 12 inch gate valve. At one side of this drain, but at a level, 24 inches higher, is an 18 inch clear water drain connected to the tanks by 8 inch branches, this drain delivering the supernatant water of each tank, at such times as they may be cleaned, to the effluent chamber discharging under the stone steps by means

LONGITUDINAL SECTION AT SIDE OF TANKS.



LONGITUDINAL SECTION THROUGH SLUDGE CHANNEL.




Half Cross Section at Channel End of Tanks,
Half Cross Section at Upper End of Tanks,
50'-0"
7'0"
5'9"
6'6"
7'7"
8'9"
Slope
Inlet Channel
4'

SEWAGE DISPOSAL WORKS.

Photo-View of Tanks and Machinery House.

of 8 inch connections, and at the lower end of the sludge channel in the tanks and to these is attached an 8 inch valve, and an 8 inch swing joint together with two elbows and 8 feet of galvanized iron pipes with floats, forming a floating skimmer pipe, to draw of the supernatant water of each tank from the surface till the sludge is reached. The floating skimmer pipes, with their valves, and also the sludge valves are operated by hand wheels from a platform overhanging the tank walls.

Ready inspection can be had at all times for the drain sewers and their connections by means of two double man-holes over them, and forming part of the dividing wall of the central channel, and having wrought iron rims and covers opening from the top of coping of the wall.

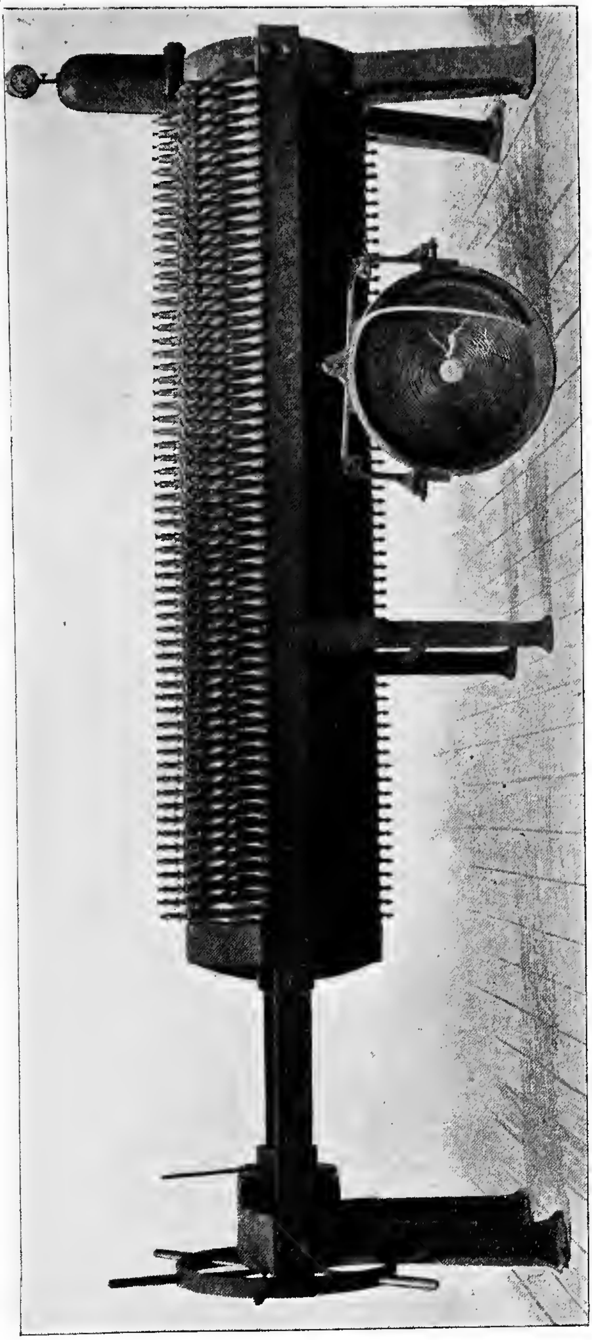
MACHINERY.

The necessary machinery to prepare the chemicals and press the sludge consists of a boiler, engine, pressure pump, filter press, and two agitating chemical mixers. The boiler is a return tubular, 54 inches in diameter and 12 feet long, having 40 four inch tubes and set up in a substantial brick setting, with smokestack 28 inches in diameter and 53 feet high above the grates. The boiler is provided with both feed pump and an injector The engine is an 18 h. p. vertical automatic slide valve engine, of simple construction and requiring but little room. It was built by C. Aultman & Co., of Canton. The main engine shaft is provided with fly wheel pully which can be used to drive an electric light dynamo for lighting purposes on grounds and in the building.

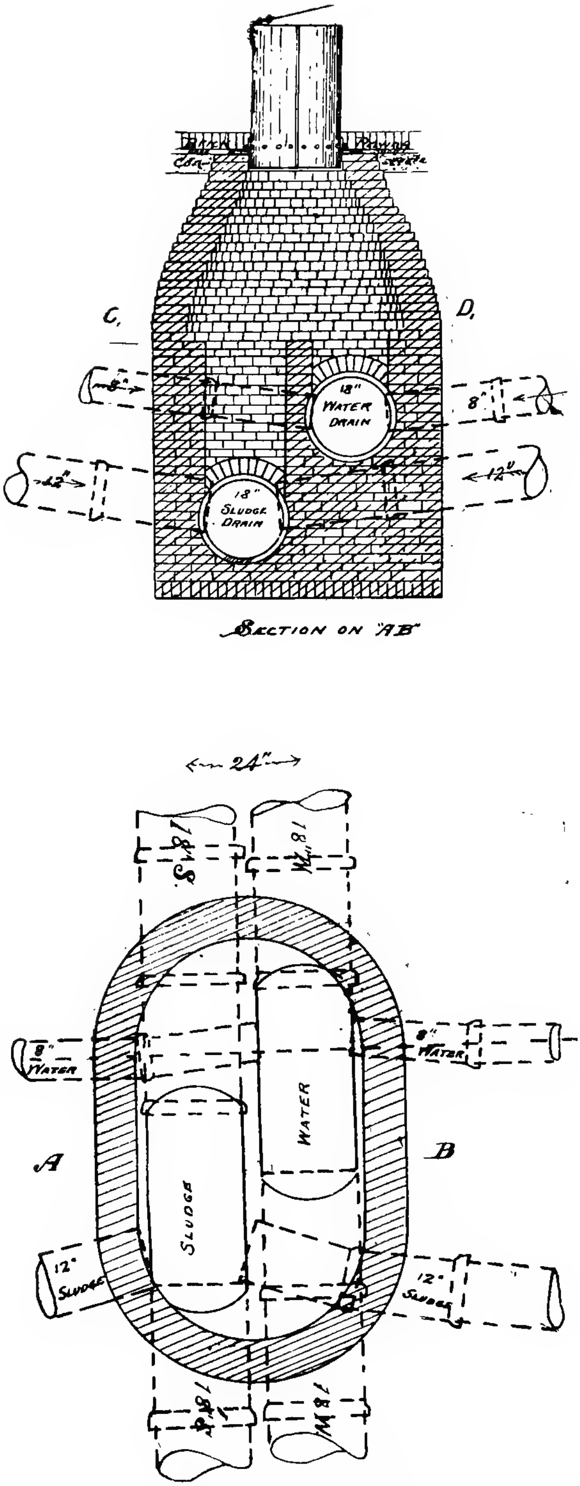
The pressure pump is a horizontal direct-acting duplex plunger pump, having 8-inch steam cylinder, 5-inch water plungers and both 10-inch stroke, It rests on a stone foundation, and is provided with double suction and discharge connections. One suction pipe takes sludge from sludge pump well, and the other water from a supply well, both being so connected that either can be used at a moment's notice, also one discharge goes to an overhead clear water tank, and by means of a gravity governor, is so controlled as to automatically start and stop, thus keeping a constant supply of water in this tank. The other discharge connection is the sludge pipe to the filter press, and has a relief valve with pipe connected back to the sludge well. The pump was built by the Voisard Steam Pump Co., of Canton.

THE FILTER PRESS.

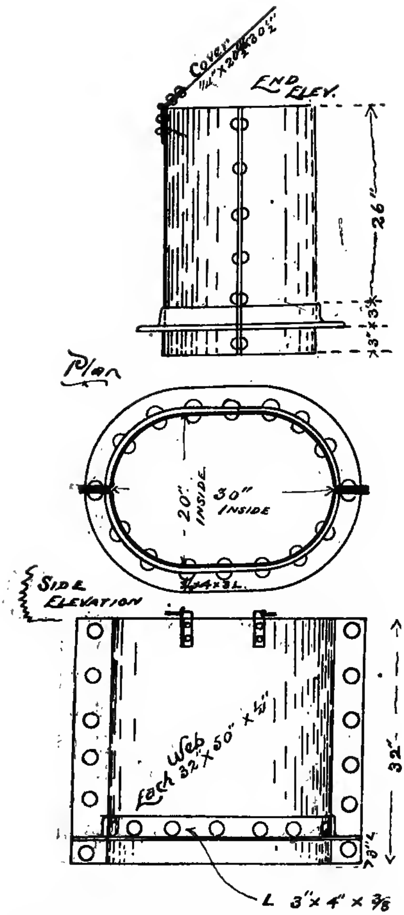
The filter press is a 60 chamber Bonnot press, provided with all necessary appurtenances and built to withstand a pressure of 150 pounds per square inch. The exuded water from the drip cocks falls into a trough built into the floor beneath the press, from which it runs into a hopper and then back into the inlet channel. The chemical mixers are two elliptical tanks of wood, 5 by 9 feet diameters, and 6 feet high, each provided with two sets of beater arms, each on a vertical shaft. The chemicals are mixed and slacked separately in desired amounts of water on the chemical storeroom floor and from there flow into the chemical mixers below and continually agitated while the mixture is added to the crude sewage in inlet channel.



FILTER PRESS.



DOUBLE MANHOLE.

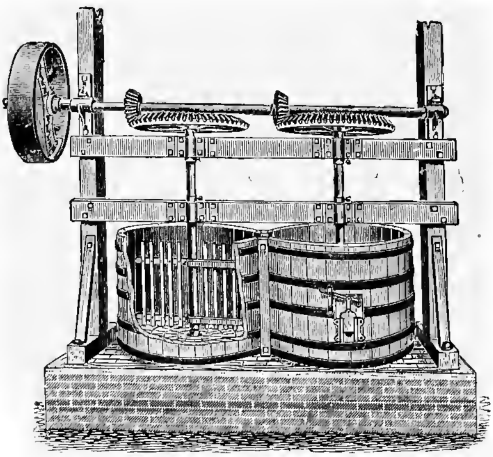


WROUGHT IRON MANHOLE TOP.

METHOD OF OPERATION.

The chemicals from the chemical mixers flow into two flat cast iron pans, suspended over the inlet channel, each pan has one edge serrated so as to allow the mixture to dribble in small streams into the flowing sewage below. Outside of building and in the inlet channel are placed deflecting dams of wood which serve to break up the current and thoroughly mix the chemicals with the crude sewage before it reaches the tanks. And after the sewage so treated reaches the tanks, by reason of their capacity, the velocity becomes so checked that precipitation immediately takes place, the effluent being quite clear after having passed through the first two tanks.

After using the first tank in the series for about two days, it becomes necessary to cut this tank out of the series, for the purpose of removing the accumulated sludge. This is done by closing the flash board gates separating this tank from the main channel and opening channel gate, allowing sewage to pass by the tank so cut out and into the next tank and thence through the remaining tanks to the effluent chamber. When the tank is so cut out the water remaining therein is allowed to stand for a time to allow floating matter to precipitate, after which the floating skimmer pipe is lowered, the valve opened and the surface water drawn off to near the sludge, when the skimmer is raised, valve closed, and sludge valve opened, which allows the sludge to pass into the sludge well. After the sludge is so drawn off the sludge gate is closed, weir gates opened and sewage allowed to re-enter the tank.



SEWAGE DISPOSAL.

Chemical mixers, from the works of the Bonnot Company, used in the preparation of the precipitation salts before passing the same into the sewage.

From the sludge well the sludge is pumped into the filter press, which retains the solid matters and allows the water to flow back into the inlet channel. To facilitate the separation of the solid matter a strong lime water is added to the sludge in the well before pumping into the press.

SEWER DISCHARGES.

For the purpose of obtaining the exact daily amount of sewage to be treated at present, measurements were taken of flow in main sewer at two points, one at Jackson street below the last sewer connection or lateral sewer, and the other on the Saxton farm, 2,400 feet from Jackson street. These measurements were by means of weirs, inserted in the main sewers, and at which hourly readings were taken for a period or 24 hours. These weirs were of correct form, and were fitted tightly to the bore of the 20-inch pipe sewer so that no loss of water resulted. The hourly flow of the sewer at each of these points is given in the following table:

SEWER GAUGINGS IN MAIN SEWER TWENTY INCHES DIAMETER, CANTON, OHIO, SEPARATE SYSTEM.

MAN-HOLE AT JACKSON STREET.				MAN-HOLE IN SAXTON LAND.			
TIME.	GALLONS IN ONE HOUR	GALLONS IN FOUR HOURS.		TIME.	GALLONS IN ONE HOUR.	GALLONS IN FOUR HOURS.	REMARKS.
7:15 A. M.	25,423	-----------		7:30 A. M.	27,123	-----------	
8:00	27,705	-----------		8:15	28,854	-----------	
9:00	30,054	-----------		9:15	30,643	-----------	
10:00	30,054	113,236	Maximum.	10:15	31,240	117,860	
11:00	25,423	-----------		11:15	27,123	-----------	
12:00	24,314	-----------		12:15	27,705	-----------	
1:00 P. M.	25,423	-----------		1:15 P. M.	26,553	-----------	
2:00	27.123	102.283		2:15	28,281	109,662	
3:00	26,553	-----------		3:15	27,705	-----------	
4:00	26,553	-----------		4:15	27,705	-----------	
5:00	25.423	-----------		5:15	27,705	-----------	
6:00	24,544	103.073		6:15	27.123	110.238	
7:00	23,670	-----------		7:15	24,314	-----------	
8:00	22,881	-----------		8:15	23 670	-----------	
9:00	22,130	-----------		9:15	23,670	-----------	Sewage becoming clearer.
10:00	21.074	89.755		10:15	22.130	93.784	
11:00	20,016	-----------		11:15	21,074	-----------	Clear water mostly from 12 m. to 6 a. m., and but little odor and occasional scrap of paper.
12:00	15,055	-----------		12:15 A. M.	15.270	-----------	
1:00 A. M.	15,055	-----------		1:15	16,135	-----------	
2:00	13,233	63,359		2:15	14,190	66,669	
3:00	8,985	-----------	Minimum.	3:15	11,469	-----------	Poor light at night rendered the reading difficult and not so accurate as n day-time.
4:00	8,985	-----------		4:15	9,792	-----------	
5:00	13,233	-----------		5:15	14,190	-----------	
6:00	13,233	44,436		6:15	14,190	49,641	
Total.	516,142	516,142		Total	547,854	547,854	

Or an excess for the 24 hours of 31,712 gallons in the lower man-hole over that of the upper one, being about six per cent of the total sewage flow.

Of this 516,142 gallons, probably 45,846 gallons are due from flush tank water. As measurements by meter of water used show about 772 gallons per flush tank per day, and the 63 flush tanks now connected at 772 gallons each, give the above total, or about nine per cent. of total sewage flow is flushing water.

From an inspection of the quantities discharged each four hours it is seen that during the period of from 12 m. to 6 a. m. the flow is only 14 6-10 per cent of the total daily quantity or 14 6-10 per cent. of sewage is then to be treated in 25 per cent of the day. Also during this time the flow is quite clear, showing it results from leaking fixtures, flush tanks and infiltration water.

The result of this series of discharge measurements is such that I think it possible to shut down the machinery during this time. And by having partly drawn off one of the tanks could have abundant storage capacity to hold this sewage till the machinery is started in the morning. By this method we may be able to reduce our operating expenses by quite a considerable sum.

SEWAGE PER CAPITA.

Taking the flow at upper man-hole at Jackson street as a total of 516,142 gallons per day, and deducting the tank water, 45,846 gallons per day, results in a net flow of sewage of 470,656 gallons per day from an average of 800 sewer connections or 583 gallons per connection per day. Inasmuch as most of the present connections are from the larger residences, large stores, hotels, etc., and it is probable that as the connections are added the average discharge per connection will be reduced to perhaps 500 gallons per day, or assuming five people per family would result in 100 gallons of sewage per capita per day.

The distance from the Saxton farm weir to the sewer farm is about 4,800 feet, and on a portion of which the sewer lies in very wet ground, from which a good deal of infiltration water no doubt makes its way into the sewer so that, probably, 800,000 gallons of sewage per day will be the amount to be treated at present.

The cost of completed works has been as follows:

For plans, drawings, photographs and printing	$ 268	70
For grading for tanks, buildings and about grounds	1,831	28
For masonry tanks, inlet chamber and sludge well	13,845	70
For cement wash on masonry walls approximate.	286	70
For foundations for machinery and supply well	236	83
For building complete except boiler room floor with tanks	3,236	64
For boiler room floor and deck of screen chamber	80	00
For iron gates, valves, weir guides, platform frames and iron pipe	885	24
For machinery and boiler set up complete	4,500	00
For sodding and fencing	244	00
For riprapping slopes at driveway and drainage	421	55
For plumbing, pipe fittings and miscellaneous	158	12
For inspection and superintendence.	489	00
Total cost of works in running order.	$26,483	76

Respectfully submitted,

L. E. CHAPIN, Chief Engineer.

Canton, O., May 5, 1893.

The following firms and individuals have been connected with the work :

ENGINEERING AND SUPERINTENDENCE.

L. E. CHAPIN, Associate M. Am. Soc. C. E. ....Chief Engineer.
W. L. BENDER.................................. .... Assistant Engineer.
O. W. PFOUTS... ....Assistant Engineer.
THOMAS BLAKE. ....Superintendent of construction.
GUY TILDEN ....Architect of Building.

CONTRACTORS.

L. C. DRESBACH.......................................Grading for tanks.
MCKINNEY & MCNICHOLS ....Grading about grounds.
MCKINNEY & MCNICHOLS ....Masonry work.
MR. CHAS. CASSELL.. Building.
THE WROUGHT IRON BRIDGE CO...........For guide frames and platforms.
THE BONNOT CO.................... ....For machinery and boiler.
THE LUDLOW VALVE CO ....For valves and standards.
THE LAKE SHORE FOUNDRY....................... .....For cast iron pipe.
THE BERGER MFG. CO............................For Galvanized iron pipe.
THE STANDARD COAL CO....................................For sewer pipe.

Report

on

Sewage Experimental Investigations

at

West New Brighton, Staten Island, N. Y.

WARREN R. BORST

Issued by

President of the Borough of Richmond,

City of New York,

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TABLES CONTAINING RESULTS OF CHEMICAL ANALYSIS

HON. CALVIN D. VAN NAME,
President of the Borough of Richmond,
Borough Hall, Staten Island, N. Y.

DEAR SIR:

Following a resolution of The Board of Estimate and Apportionment of The City of New York, on July 17, 1911, authorizing the construction and maintenance of an Experimental Sewage Disposal Plant at West New Brighton, in the Borough of Richmond, the President of the Borough directed the Bureau of Engineering, T. S. Oxholm, Engineer in Charge, to proceed with the construction and equipment of a suitable plant and to have the necessary investigations made.

The following is a report setting forth the methods employed and results obtained:

PURPOSE OF INVESTIGATION.

The purpose of the investigations was

First:—To secure data relative to methods of sewage treatment and develop them to apply to the existing conditions in the Borough of Richmond.

Second:—To obtain such other data as might be serviceable in the study of sewage disposal of Greater New York.

DESCRIPTION OF EXPERIMENTAL STATION.

In order to carry on the investigation an experimental plant was established at the foot of Taylor Street, West New Brighton, in the rear of the Destructor on the shore of the Kill Van Kull. The sewage was brought to the plant through a special gravity line of 8-inch cast-iron pipe.

The plant consisted of a frame building 50 x 84 feet in plan with a finished extension 15 x 50 feet. The experimental tanks and other appliances were housed in the main building. This building afforded protection from the weather as well as obviating any danger of nuisance in the neighborhood. The extension was divided into four rooms of equal size. One of the rooms was used for small scale laboratory investigations of treatment processes, another as an office, while the third and fourth were for chemical and bacteriological laboratories, respectively.

The following is a list of the experimental tanks installed:

- 2 wooden tanks 6 ft. wide, 20 ft. long and 10 ft. deep.
- 2 wooden tanks 6 ft. wide, 11 ft. long and 12 ft. deep.
- 2 steel tanks 6 ft. wide, 11 ft. long and 19 ft. deep.
- 4 wooden tanks 6 ft. wide, 25 ft. long and 6 ft. deep.
- 1 steel "syphon" tank, 4 ft. diameter, 12 ft. high, with cone shaped bottom.

The details of these tanks will be seen on the appended drawings, Nos. 1, 2 and 3. Two tanks of each kind were provided in order that investigation could be made in duplicate, so that any new arrangements, modification or changes in operation could be made with one tank without interference with the original investigation.

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Sewage.

The sewage brought to the station through the 8-inch pipe line was wholly domestic in character, as the district served was strictly residential with no factories contributing. The records of flow through the various tanks were obtained by Fox Boro recording gauges placed in rectangular weirs. These gauges were checked periodically by taking readings on a graduated glass attached to the sides of the weir boxes.

General Principles of Sewage Treatment.

Processes of sewage treatment may be grouped under three general headings, namely:

(1) Removal of suspended solids.
(2) Oxidation of dissolved solids.
(3) Removal of Bacteria.

Methods Employed:

1. Removal of suspended solids.
   (*a*) screening } with and without precipitation.
   (*b*) sedimentation }
2. Intermittent sand filtration treatment, contact beds, sprinkling filters and the activated sludge process.
3. Sterilization with chemicals.

Analytical Work.

In making the investigations, the foundation of the experiments was based upon the well recognized fact that the essential agents of sewage purification are employed by nature.

The slow action of bacteria aided by the oxygen from the air or water eventually converts into harmless mineral particles, all organic matter that comes within the sphere of its activity, the process being similar to that of combustion. In other words, the chemical composition of the sewage has been so altered that it is no longer capable of undergoing putrefactive decomposition. The amount of oxidation attained is the most useful measure of the work accomplished. The laboratory determinations of the samples of sewage and effluents were selected with the object of demonstrating the effectiveness of the methods employed.

The laboratory determinations selected were:

Suspended solids (Gooch crucible).
Oxygen consumed (10 minutes boiling acidified sample with permanganate).
Biological oxygen demand (absorption of dissolved oxygen upon incubation at 20° Centigrade).
Dissolved oxygen (Winkler method).

Suspended solids show the efficiency of the sedimentation processes and give information as to the amount of sludge to be cared for.

Oxygen consumed values indicate the amount of oxidizable organic matter present and by comparison show the removal of such organic matter by the process under observation.

Biological oxygen demand indicates the probable amount of oxygen required to oxidize the unstable organic matter in a sewage or sewage effluent when discharged into a natural body of water.

Dissolved oxygen determinations show the amount of atmospheric oxygen dissolved in a sewage effluent or in a receiving body of water.

Knowing, therefore, the oxygen demand of a sewage or effluent, the amount of oxygen dissolved in the effluent and also in the receiving body of water, means are available to compute with a fair degree of accuracy the permissible ratio of dilution. In other words, the maximum amount of sewage or effluent which may be discharged into a given volume of diluting water without causing putrefactive odors or too great depletion of oxygen in the receiving water can be obtained.

Character of Sewage.

Hourly chemical analyses of sewage was made for seven consecutive days during the summer months of June, July and August, 1913, to determine the amount of suspended solids and oxygen consumed.

The results of these tests are shown in appended tables, No. 2 and 3, Diagram 4 and 5. These results showed a sewage with a maximum strength on Mondays gradually decreasing during the week to Saturday, when it shows a slight increase, the minimum strength appearing on Sunday.

The hourly tests showed that the maximum strength during the 24 hours was reached between 10 A.M. and 12 M., while the minimum strength was found between midnight and 5 A. M.

Analyses were also made of composite samples, collected every 15 minutes from six other representative sewer outlets in the Borough and the results of these analyses showed that the sewage delivered to the station was about the average strength of the sewage throughout the Borough.

For results of analyses of Raw Sewage, see Appended Table No. 1.

Flow of Sewage.

The total amount of sewage reaching the station averaged about 150,000 gallons per 24 hours.

The maximum flow occurred on Monday and Tuesday and the minimum on Sunday.

The maximum hourly flow occurred about 11 A.M. and the minimum from 12 P.M. to 5 A.M.

Description of Experiments.

In deciding what investigations would be of the most value to this Borough, taking into consideration its geographical position, it was decided that inasmuch as the sewage would be fresh and would be discharged into a large body of salt water subject to tidal current, the principal studies should be made to determine the size and type of tank, which, with the smallest velocity of flow, would give the shortest retention period consistent with a satisfactory removal of settling solids. In view of the fact that certain localities would be adjacent to bathing beaches and oyster beds, studies were made with respect to disinfection.

Series of experiments were made also to determine the rate of reaeration of fresh and salt water polluted with sewage.

Methods of sludge treatment were given considerable study.

These experiments may be summarized as follows:

1. Sedimentation.
    - (*a*) Plain settling tanks.
    - (*b*) Imhoff tanks without colloidors.
    - (*c*) Imhoff tanks with colloidors.
    - (*d*) Syphon tank.

2. Disinfection of raw sewage.
   (*a*) With hypochlorite of lime.
   (*b*) With chlorine gas.
3. Sludge Treatment.
   (*a*) Drying in vacuum.
   (*b*) Digesting in separate tanks.
4. Rate of reaeration of sewage.
   (*a*) Diluted with fresh water.
   (*b*) Diluted with salt water.

(1) SEDIMENTATION.

(*a*) The operation of the plain sedimentation tanks was carried on principally with the object of securing data for comparison with that obtained in the operation of other types of sedimentation tanks. The plain sedimentation experiments were carried on for six months in the tanks 11 ft. long, 6 ft. wide and 12 ft. deep. The average results for these months were: flow through velocity .012 ft. per second, reduction Bacteria on Agar 37.5°, 19%, reduction Bacteria on Gelatin 20°, 29%, reduction suspended solids 47%, reduction oxygen consumed 26%. For detail, see appended Table No. 4.

(*b*) (*c*) The two steel tanks 11 ft. long, 6 ft. wide and 19 ft. deep were operated as two-story or Imhoff tanks. One was provided with furring strips, extending 4 ft. into the upper compartments, spaced 6 inches center to center and so staggered that the sewage passing through the compartment would have opportunity to come in contact with the surface of the strips. The other tank was operated without the use of strips.

These furring strips were used in an endeavor to combine the principles embodied in the Imhoff tank with those of the Hampton tank. The strips serving as colloidors furnishing surfaces upon which it was possible to obtain a growth of aerobic bacteria, which receiving the oxygen from the fresh sewage would give a more stable effluent than that obtained from the Imhoff tank without the colloidors.

The aeration of the sewage by forcing air through carborundum diffusers placed under each colloidor was considered, but no opportunity occurred to carry out this experiment. The time of retention in both of these tanks was 1½ hours. In a series of investigations running from November to March the results were practically the same, showing a reduction of 59% in suspended solids, 30% of oxygen consumed. Bacteria on Agar 37.5°, 28% and Bacteria on Gelatin 20°, 38%. For results see appended Tables, Nos. 8 and 9.

In order to determine the effect upon these effluents by standing at room temperature, samples of crude sewage and of each of the effluents were placed in one-galf-gallon wide-mouthed, unstoppered bottles and allowed to remain at room temperature for a period of 17 days. The crude sewage and the effluent from the Imhoff tanks became septic while only a slight sewage odor could be observed in the effluent taken from the tank provided with the colloidors; after 24 hours even this slight odor disappeared, leaving a musty odor, while the samples in other bottles remain septic. Analyses of these samples at the end of 17 days gave the following results:

	Nitrites, Parts per Million	Nitrates, Parts per Million	Dissolved Oxygen, Per Cent Saturation
Raw Sewage	2.8	0.0	0.0
Plain Imhoff Effluent	23.0	0.075	14.83
Imhoff with Colloidors	26.0	0.11	16.60

(*d*) *Syphon Tank.*—Many of the sewer outfalls in the Borough are located in populated sections where it would not be desirable to have odors from a sewage-treatment plant. In such instances, where the sewer outlets are sufficiently above high water to allow a free outfall, it was considered advisable to study the action of a closed settling tank operated on the principle of a syphon for treatment by sedimentation alone.

For this purpose a cylindrical steel tank, with a conical bottom (similar to the type described under the title of "The Kessel" on page 201 in the Proceedings of the Institution of Municipal and County Engineers, volume XXXVI, 1909) was constructed.

The tank at this Experimental Station was 12 ft. high and 4 ft. diameter, with 6-inch inlet and 2-inch outlet (for details see drawing No. 3). Before entering the tank the sewage passed through a small grit chamber constructed of a 30-inch tile pipe set vertically, from which the 6-inch inlet, submerged about 14 inches in the grit chamber for a water seal, extended into the tank. This chamber also prevented floating materials, such as matches, corks, grease, etc., from entering the tank.

The outlet of the tank, located near the top, consisted of an inverted conical funnel of sheet metal 2 ft. 6 ins. in diameter at the base, to which was connected the 2-inch outlet pipe; this outlet extending into the outlet chamber the same distance as the inlet pipe of the grit chamber. A valve provided on this 2-inch outlet line permitted control of the sewage flow through the tanks.

From the conical bottom of the settling tank a vertical 4-inch cast-iron pipe with a gate valve, extended into a sludge receiving tank which was 2 ft. 6 ins. deep and 2 ft. diameter.

The ends of the inlet, sludge and outlet pipes were all of the same elevation and therefore all had the same water seal. The difference in head was about 5 inches.

To start the operation of the syphon tank all valves were closed and the tank filled with water. After filling, the valves of the inlet, outlet and sludge pipes were opened, the syphon action caused the sewage to flow. The "flow through velocity" in the syphon tank being very low, the solids settled through the sludge pipe into the sludge chamber under the tank. This tank and its method of operation provided for immediate separation of the settled solids from the sewage and prevented septic action interfering with the sedimentation process. This tank was operated continuously for three months, treating approximately 12,000 gallons per day, with results as given in the following table:

RESULTS OF OPERATION OF SYPHON TANK FROM NOVEMBER TO FEBRUARY 1ST

	Storage	Corresponding Velocities, Feet per Second 6-in. Inlet	Tank	Per Cent. Settling Solids	Reduction, Suspended Solids
Maximum.....	2¾ hrs.	11.2	.175	81	42
Minimum.....	50 min.	2.44	.039	57	34
Average.......	1½ hrs.	6.22	.098	70	49

For details of these results see appended Table No. 10.

(2) DISINFECTION

Investigation of the disinfection of sewage was undertaken for the purpose of determining the most economical and satisfactory method of protecting bathing beaches and shell-fish beds on the seaward side of the Borough.

In these experiments studies were made of the relative efficiency of hypochlorite of lime compared with that of chlorine gas.

The chlorine gas was applied to the raw sewage by means of an apparatus furnished through the courtesy of the firm of Leavitt & Jackson, the diffusion of the gas in the sewage being accomplished through carborundum discs supplied by Wallace and Tiernan Company.

Chlorine Gas

Bacteria per c.c.

Chlorine, P.P.M.	Raw Sewage	Tank Effluent	Per Cent. Reduction
5	744,000	640,000	14
7	225,000	27,000	88
8	940,000	47,000	95
10	1,000,000	20,000	98
12	1,060,000	......	100
15	972,000	......	100

Description—Hypochlorite of Lime Treatment.

Two barrels, each having a capacity of 54 gallons, were used as solution tanks. These barrels were connected by galvanized iron pipes to an automatic electrical bleach orifice box, through which the desired amount of solution was fed into the raw sewage.

Method.

The bleach was weighed and mixed by hand to an approximate proper proportion of water, allowed to stand for about 12 hours to permit insoluble matter to settle. Chemical analysis was made of the solution and water added to dilute to proper strength.

Constant head was maintained in the orifice box and variation in the rate was made by increasing or diminishing the size of orifice in the bottom of the box.

Hypochlorite of Lime.

Bacteria per c.c.

Chlorine, P.P.M.	Raw Sewage	Tank Effluent	Per Cent. Reduction
14	840,000	781,000	7
20	950,000	446,000	53
30	800,000	280,000	65
34	870,000	125,000	85
49	1,072,000	95,000	91

As a result of these experiments it was found that the raw sewage could be satisfactorily disinfected by the application of about 10 P.P.M. of chlorine gas, while about 17 P.P.M. of available chlorine in the form of hypochlorite were required to produce equal results.

The results would indicate the desirability of adopting chlorine gas as a disinfecting agent.

From these experiments it was found that the application of 10 to 12 P.P.M. of chlorine gas to raw sewage caused a reduction in bacterial count varying from 88 to 100 per cent. at 20° C. and 37.5° C. See appended Tables Nos. 6 and 7.

(3) Sludge Treatment.

The treatment and disposal of sludge is one of the most difficult problems connected with sewage disposal and, on this account, considerable time was devoted to this phase of experimental work.

Sludge is particularly difficult to handle due to its high moisture content, and, on account of its extremely putrescible character soon becomes objectionable if allowed to remain exposed without suitable treatment.

Two methods of disposing of the sludge were studied, namely: separate digestion and drying in vacuum.

Separate Digestion.—Wet sludge was discharged into one of the tanks (20 ft. long, 6 ft. wide and 10 ft. deep) and allowed to digest. As septic action progressed, the gas formation brought all of the sludge to the surface, producing a thick leathery scum or mat 18 inches thick. Under this scum a highly septic liquid remained, however, the volume of the sludge had decreased about 40% while its moisture content was reduced from about 98% to 70%. The upper half of this scum was removed and burned at the destructor plant. Fresh sludge was placed in the tank below the scum that remained by means of a wooden hopper 12 inches square. As the gases due to septic action formed, the fresh sludge rose in turn in the form of scum, lifting the old scum, which, while it had absorbed considerable moisture from the fresh sludge, prevented the escape of noxious gases. In time it dried and, as before, was removed and burned.

This method of disposal of sludge was successful from about May to the latter part of September when the temperature was from 65° to 70°. During the winter months the top became frozen and could not be dried, although there was no odor perceptible from the sludge in the tank.

Drying in Vacuum.—By courtesy of the John Fuller Engineering Co. practical experiments were made in the drying of sludge in a vacuum drying machine, such as is used to remove moisture from linseed oil in the manufacture of linoleum. This drier consisted of a cylindrical steel chamber revolving within a steam jacket. This machine was 20 ft. long by 18 inches in diameter over all. The inlet and outlet consisted of 6-inch pipes, each provided with valves. This machine would easily reduce the volume of sludge, leaving a residue free from disagreeable odors with a moisture content of 73%.

Such a machine can only be operated economically if the heat required for drying can be obtained from exhaust steam otherwise wasted.

The following table illustrates the drying effect accomplished by this method:

Number of Times in Dryer	Weight of Sludge		Per Cent by Weight of Water Removed	Per Cent Moisture by Analysis		Inches of Vacuum Mercury	Pounds of Steam in Jacket	Temperature of Exhaust Vapors Degrees Fahr.	Time of Sludge Passing through Dryer
	Before Drying	After Drying		Wet Sludge	Dried Sludge				
First....	1276	243	81	88.5	83.6	20	52	120	2 hrs.
Second..	206	165	15	83.6	79.4	22	20	120	45 min.
Third...	138	30	78	79.4	73.0	20	20	120	45 min.

By laboratory studies a method was discovered by which the noxious liquid under the scum of the sludge tank could be made non-putrescible and, while the methods and results do not seem to accord with scientific principles, nevertheless, the results obtained were from three separate experiments made from samples taken two or three months apart, which gave results that seemed to verify each other.

Test.—60 c.c. of the liquid taken from under the scum of the sludge tank was added to 40 c.c. of the liquid taken from the open-mouthed bottle containing the sample from the Imhoff tank with colloidors which had been allowed to stand for 17 days as previously described on page 6. This mixture after standing 24 hours in a beaker at room temperature, about 70° F., was free from disagreeable odors and found to be non-putrescible by the methylene blue test at 37.5° C.

It would seem that this process could be continuous and rapid oxidation would take place, particularly if agitation is employed.

Absorption of Dissolved Oxygen by Sewage from Diluting Waters and Rate of Reaeration of Diluted Sewage.

Experiments for determining the amount of dissolved oxygen absorbed by sewage from fresh water and sea water as well as the rate of reaeration of a water with its dissolved oxygen content depleted by sewage, were made in the four tanks, each of which had dimensions 25 ft. long, 6 ft. wide and 6 ft. deep.

These experiments may be subdivided as follows:

1. Dissolved oxygen absorbed in dilutions of sewage with fresh water.
   (*a*) Without surface agitation.
   (*b*) With slight surface agitation by two electric fans.
2. Dissolved oxygen absorbed in dilution of sewage with sea water.
   (*a*) Without agitation.
   (*b*) With slight surface agitation by electric fans.
   (*c*) With the surface agitated, making a wave, without splashing, about 4 inches high.
3. Rate of reaeration produced by surface agitation in a mixture of sewage and sea water containing no dissolved oxygen.

The methods for carrying out these experiments were as follows: During the winter months when the weather was too cold to keep the temperature up to about 20° C., the water was heated by exhaust steam from the garbage destructor nearby, and allowed to stand from 16 to 18 hours; then the sewage was added to the proper proportion and thoroughly mixed.

At the beginning of each experiment samples were analyzed for dissolved oxygen and the dissolved oxygen demand (biological oxygen demand) by the Hoover method of incubation at 20° C. Simultaneous samples were collected at regular intervals and at different depths. Bottles of the dilution collected before the agitation of the tank contents were submerged, tightly stoppered. The decrease of dissolved oxygen in these submerged bottles at the end of any period indicated the amount of dissolved oxygen demand upon the diluting water.

The increase in dissolved oxygen in the dilution in the tank itself, plus the decrease in dissolved oxygen in the submerged bottles, minus the original dissolved oxygen gave the amount of oxygen taken from the air. For convenience this may be expressed in the following formula:

$$O = R - I + D;$$

where O=oxygen absorbed from air in P.P.M.;

I=initial dissolved oxygen in dilution;

R=residual dissolved oxygen in dilution;

D=decrease in dissolved oxygen in stoppered bottles or biological oxygen demand.

Samples were collected from the tanks at different depths through ¼-inch galvanized pipes projecting through the sides of the tanks at 1 ft. intervals.

Experiments with unagitated or quiescent tanks showed that very little absorption of atmospheric oxygen took place, except that due to change in temperature.

This is shown by appended Table No. 11.

On the other hand, the slight ripple of the surface of the liquid produced by two electric fans was sufficient to produce considerable absorption of atmospheric oxygen. The results of these experiments are shown in Tables Nos. 12, 13, 14 and 15.

A still greater absorption was produced by the disturbance of the tank surface with an agitator composed of a furring strip extending across the full 6 ft. width of the tank and moved up and down, by a small electric motor. The wave produced by the agitator was about 4 inches in height. The effect of this comparatively violent agitation of the surface is shown in the Table No. 16.

In the case of the dilution of 1 part of sewage to 20 parts of fresh water with ½ inch ripple, it was found that after the fourth hour the rate of absorption of atmospheric oxygen was about 0.18 parts per million per hour. With salt water the rate was .085 P.P.M. per hour.

Another experiment was made with a mixture of sewage and salt water which was devoid of oxygen. The surface was agitated with a 4-inch wave as described above, at the end of four hours it was found that the dissolved oxygen at all depths had increased from 0 to 6.56 P.P.M. or at the rate of 1.64 P.P.M. per hour. At the end of the fourth hour the agitation was stopped and the mixture allowed to remain quiet for 20 hours.

At the end of this period the dissolved oxygen had decreased to 4.50 P.P.M. or at a rate of 0.1 P.P.M. per hour. See appended Tables Nos. 19 and 20.

As a result of the above-described experiments and in view of the local condition in the Borough of Richmond the following conclusions may be drawn:

1. That the experimental results with respect to tank treatment may be summarized as follows:

(*a*) Tanks having a detention period of from 1 to 2 hours and velocities of flow of from .007 ft. per second to .015 ft. per second will remove from 50% to 60% of suspended solids and from 30% to 40% of oxidizable organic matter.

(*b*) Imhoff tanks provided with colloidors in the settling compartment with the sewage at this station gave a more stable effluent than the ordinary Imhoff tank.

(*c*) The syphon tank gave very satisfactory results and from our experience at this station it has shown considerable advantage over other sedimentation tanks, in that the settling solids are entirely separated from the flowing through chamber and can be treated or removed while in a fresh state and free from the disagreeable odors usually attending the disposal of sludge.

(2) That in the disinfection of sewage, chlorine gas is more efficacious than hypochlorite of lime, although either when applied in sufficient amount gives satisfactory bacterial purification.

(3) That the experiments in sludge drying although not carried through to conclusive results, indicate that the sludge may be treated without creating a nuisance by separate digestion, by vacuum drying or may be made non-putrescible by aeration.

(4) Much work in the laboratories had been done on the effect of dilution of sewage in bottles. The investigations made in the large tanks at this experiment station gives the resulting effects of what may be expected from a minimum disturbance upon the surface of a body of fresh water, salt water and sewage dilutions in various proportions, as well as what may be expected when the surface is more violently agitated. These results show that the reaeration is decidedly rapid and uniform throughout the body of water.

The rate at which the reaeration of the foul liquid sewage (devoid of all oxygen) took place was very rapid and the results show what may be expected from the agitation of the sludge compartments of two-story tanks in assisting the digestion of the sludge and prevention of the accumulation of noxious gases.

Recommendations.

(1) That tank treatment of the sewage of the Borough of Richmond be accepted as a means to produce effluents of such a character as to preclude the probability of local nuisances in the vicinity of the outfall sewers, but only on those outlets for which the flow of sewage is uniform throughout the year and which can be located at sufficient distance from any neighborhood so that any odor from the plant will not give cause for complaint.

(2) That, all effluents should be discharged into the waters surrounding the Borough at such points as to avoid stagnation and where agitation by wind and other agencies will provide for rapid absorption of atmospheric oxygen.

(3) That, in the vicinity of bathing beaches and shell-fish beds, the tank effluent should be treated with liquid chlorine at the rate of approximately 10 P.P.M.

(4) That, the syphon tank is thoroughly practicable and should be used in localities where covered tanks will be necessary. The sludge can be either removed from the lower sludge chambers before it has had an opportunity to become septic or they can be so arranged and equipped that the contents of the sludge chambers may alternately be thoroughly agitated for from four to six hours or such time that may be found sufficient to furnish oxygen to oxidize the organic matter. This tank is much more adaptable to locations where the population is not of a permanent character, such as summer resorts, where the variation of flow of sewage has a wide seasonable range.

(5) In the disposal of sludge in the Borough of Richmond, it would seem that by using the waste steam and heat from the destructors the sludge can be economically dried and burned with the garbage.

The Borough of Richmond is indebted to the following gentlemen for kindly advice and interest taken in the work of the experimental station: Prof. D. D. Jackson, C.E.; Kenneth Allen, C.E.; Chas. E. Gregory, C.E.; Robert Brown, C.E.; E. Sherman Chase, C.E.; John D. Fuller Engineer Co., the firm of Leavitt & Jackson, Wallace & Tiernan, Samuel R. Brick, Archt., to whom we are indebted for valuable aid in preparation of plans for the building, and to Louis L. Tribus, C.E., formerly Consulting Engineer and Commissioner of Public Works of the Borough of Richmond, whose interest in work of the above nature made the exeprimental station possible.

I wish to express my appreciation to L. W. Freeman, Assistant Engineer, under whose advice and supervision the plant was constructed and equipment installed, and to Theodore S. Oxholm, Engineer in Charge, Bureau of Engineering, for their personal interest in all matters pertaining to the work of the station.

Respectfully,

WARREN R. BORST,
Assistant Engineer.

Dated: Borough Hall, S. I.,
June 24, 1919.

APPROVED:

THEODOR S. OXHOLM,
Engineer in Charge.

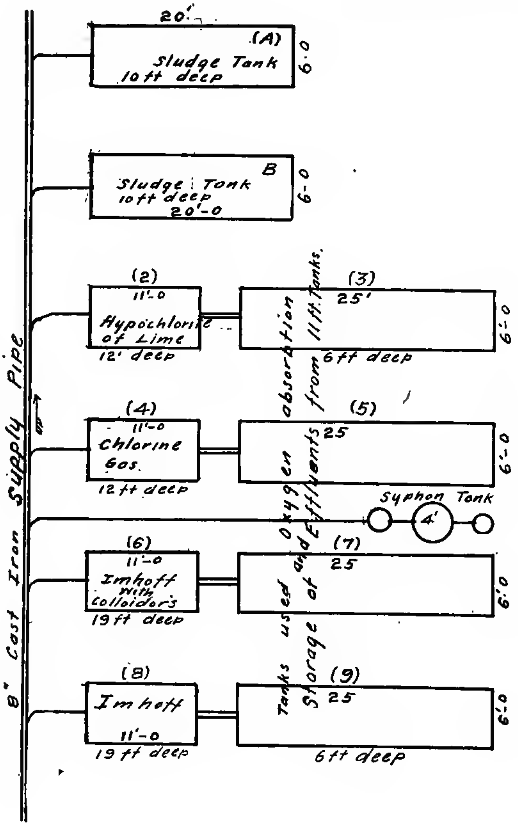
President Borough of Richmond ... Drawing No. 1 FILE

Bureau of Engineering; Sewage ... ACC

Experiment Station ... COMPUTER ... FROM ... TO

MADE IN CONNECTION WITH ... CHECKER ... DATE 1913-1915 191

Plan showing arrangement of Tanks of Sewage Experiment Station



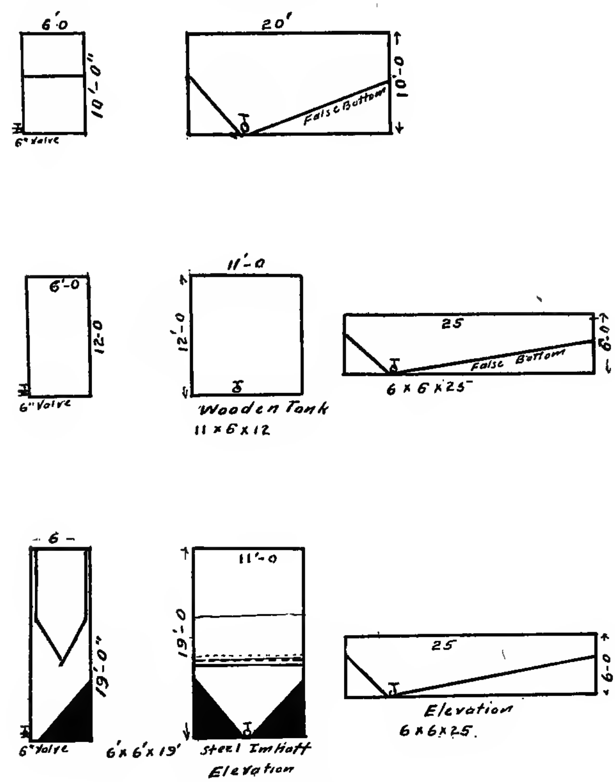
President Borough of Richmond — Drawing No. 2

Bureau of Engineering; Sewage Experiment Station

FILE ... ACC ... COMPUTER ... FROM ... TO ...

MADE IN CONNECTION WITH ... CHECKER ... DATE 1913-1915

Plan showing elevation of tanks



For syphon tank see sketch

President Borough of Richmond — Drawing No. 3 — FILE

Bureau of Engineering Sewage Experiment — ACC

Station — COMPUTER — FROM — TO

MADE IN CONNECTION WITH Sedimentation in Vacuum — CHECKER — DATE Feb 1915

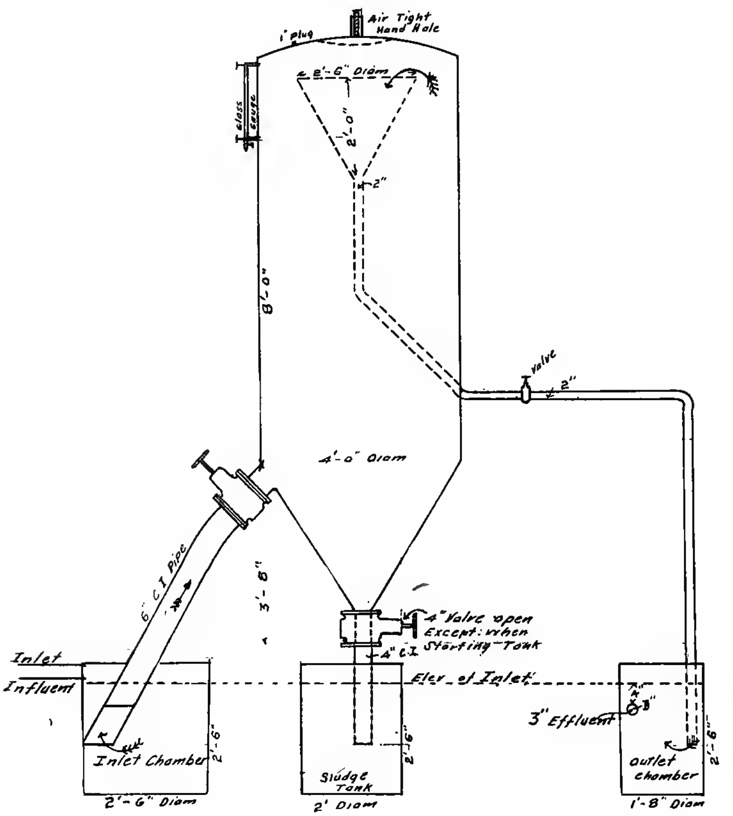


Table No. 1—Crude Sewage

April, 1914	Temperature Sewage	Bacteria 37.5° C.	Bacteria 20° C.	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Dissolved Oxygen, P.P.M.	Relative Stability (Phelps)
1........	9.5	243,000	584,000	186	65	0.27	29
2........	10	628,000	580,000	210	69	1.83	26
3........	10.5	131,000	472,000	196	73	1.19	13
4........	9.5	......	......	170	73	0.18	15
5........	9.5	24,000	19,000	232	86	2.10	21
6........	10	720,000	992,000	350	97	0.95	11
7........	10	189,000	47,000	250	77	0.96	17
8........	10.5	836,000	1,164,000	156	69	0.10	20
9........	10	600,000	472,000	288	89	1.74	21
10........	10	740,000	940,000	182	76	1.02	21
11........	10	660,000	840,000	244	83	0.10	11
12........	....	......	......	...	..	....	..
13........	11	181,000	452,000	170	109	1.56	11
14........	11	848,000	482,000	460	96	1.01	20
15........	10.5	512,000	1,200,000	188	71	0.17	76
16........	10.5	400,000	620,000	76	70	1.05	21
17........	11	500,000	908,000	232	79	0.16	13
18........	12	544,000	868,000	260	70	0.0	11
19........	13	1,260,000	1,575,000	152	77	0.0	13
20........	13	226,000	644,000	348	111	0.18	13
21........	11.5	412,000	860,000	252	96	1.07	11
22........	11.5	640,000	844,000	210	81	.76	17
23........	11.5	860,000	1,300,000	292	83	.85	13
24........	11.5	510,000	1,248,000	205	72	0.00	15
25........	11.5	278,000	832,000	240	62	0.00	24
26........	11.5	784,000	1,520,000	322	77	1.85	25
27........	12.5	786,000	772,000	278	89	0.77	19
28........	12.5	24,000	412,000	158	73	0.77	19
29........	12.5	183,000	782,000	220	72	0.0	15
30........	12	212,000	832,000	166	73	0.15	17
Average...	10	497,000	807,000	233	82	0.74	19
May							
1........	12	700,000	1,500,000	244	78	0.00	21
2........	12	420,000	1,000,000	282	88	0.15	13
3........	12.5	792,000	1,688,000	105	70	0.00	18
4........	13.5	1,120,000	1,146,000	134	102	0.00	13
5........	13.5	408,000	1,520,000	254	78	0.73	19
6........	13.5	347,000	680,000	196	83	0.00	11
7........	13	472,000	Liquifiers	186	67	0.00	18
8........	13	275,000	"	278	71	0.00	19
9........	13	300,000	"	70	71	0.19	17
10........	13	2,232,000	"	184	78	0.62	20
11........	14	760,000	"	312	107	0.46	11
12........	14	512,000	"	222	88	0.00	15
13........	13	868,000	"	208	80	0.00	13
14........	13	548,000	940,000	172	67	0.46	23
15........	13	460,000	Liquifiers	138	70	0.00	19
16........	13	684,000	"	204	78	0.00	11
17........	14	992,000	"	328	91	0.00	15
18........	14	412,000	"	282	110	0.23	11
19........	14	1,500,000	2,700,000	115	91	0.00	11
20........	14	332,000	760,000	148	71	0.00	23
21........	14	450,000	840,000	112	63	0.41	19
22........	14	460,000	420,000	150	72	0.08	19
23........	14	880,000	1,540,000	162	78	0.00	15
24........	14	1,008,000	2,340,000	146	62	0.00	23
25........	16	1,070,000	1,120,000	360	103	0.00	11
26........	16	510,000	660,000	184	63	0.00	11
27........	16	1,620,000	450,000	170	80	0.00	11
28........	16	1,320,000	1,450,000	124	61	0.40	21
29........	15½	1,200,000	1,920,000	156	74	0.00	16
30........	..	....	....	...	..	....	..
31........	..	....	....	...	..	....	..
Average...	14	747,300	1,259,000	194	79	.37	16

TABLE No. 1—CRUDE SEWAGE

June, 1914	Temperature Sewage	Bacteria 37.5° C.	Bacteria 20° C.	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Dissolved Oxygen, P.P.M.	Relative Stability (Phelps)
1........	16	948,000	1,624,000	164	97	....	15
2........	15.5	560,000	1,136,000	183	81	....	17
3........	16	350,000	632,000	112	72	....	11
4........	16	320,000	664,000	110	61	....	28
5........	16	875,000	1,200,000	144	69	....	20
6........	16	864,000	992,000	264	74	....	25
7........	16	1,880,000	2,156,000	132	68	....	30
8........	17	1,088,000	1,680,000	302	107	....	11
9........	16	916,000	1,800,000	196	90	....	14
10........	17	716,000	1,040,000	130	64	....	14
11........	17	1,028,000	1,076,000	138	72	....	14
12........	17	712,000	1,000,000	218	73	....	16
13........	17	1,080,000	1,448,000	120	69	....	15
14........	17	1,000,000	1,008,000	132	56	....	24
15........	17	856,000	1,440,000	236	87	....	16
16........	16½	1,008,000	1,432,000	180	78	....	22
17........	16	920,000	1,392,000	148	72	....	19
18........	16½	1,040,000	1,376,000	140	67	....	23
19........	16½	1,216,000	1,080,000	64	51	....	28
20........	16¼	1,660,000	1,800,000	190	81	....	13
21........	16½	1,224,000	1,808,000	104	56	....	..
22........	17	1,400,000	1,572,000	202	70	....	15
23........	17	1,168,000	1,232,000	268	87	....	15
24........	17½	920,000	1,384,000	162	73	....	11
25........	17½	920,000	1,688,000	188	72	....	11
26........	18	624,000	960,000	104	59	....	21
27........	17½	1,400,000	1,840,000	128	60	....	21
28........	17½	975,000	2,000,000	134	60	....	18
29........	17½	856,000	1,160,000	336	103	....	13
30........	17½	800,000	1,005,000	229	78	....	11
Average...	17	997,500	1,354,000	172	74	....	18
July							
1........	17½	1,462,000	1,784,000	160	78	....	11
2........	17½	1,056,000	1,280,000	126	68	....	18
3........	17½	1,702,000	1,520,000	208	71	....	21
4........	....	....	....	...	..	....	..
5........	17½	1,160,000	1,664,000	54	65	....	20
6........	17½	752,000	912,000	502	96	....	21
7........	17½	960,000	952,000	176	66	....	27
8........	18	1,224,000	1,504,000	86	79	....	15
9........	17¾	1,008,000	1,080,000	172	76	....	19
10........	17¾	1,080,000	1,248,000	100	73	....	21
11........	18	1,530,000	1,600,000	340	74	....	30
12........	18	800,000	1,120,000	186	68	....	21
13........	18¾	880,000	972,000	312	105	....	16
14........	18¾	606,000	720,000	224	87	....	15
15........	18	720,000	1,600,000	150	70	....	29
16........	18½	1,602,000	....	48	94	....	11
17........	18½	716,000	896,000	83	61	....	13
18........	18¾	1,250,000	1,620,000	64	61	....	15
19........	18½	....	....	140	62	....	..
20........	18½	....	....	276	98	....	..
21........	....	....	....	...	..	....	..
22........	....	Cleaning	Tanks	...	..	....	..
23........	....	"	"	...	.	....	..
24........	...	"	"	...	..	...	..
25........	....	"	"	...	..	...	.
26........	...	"	"	...	..	....	..
27........	...	"	"	...	..	.	..
28........	...	"	"	...	..	...	..
29........	....	"	"	...	..	....	..
30........	....	"	"	...	..	....	.
31........	....	"	"	...	..	...	..
Average...	18	1,089,000	1,240,000	204	85	....	19

Table No. 1—Crude Sewage

August, 1914	Temperature Sewage	Bacteria 37.5° C.	Bacteria 20° C.	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Dissolved Oxygen P.P.M.	Relative Stability (Phelps)
1........	....	....	....	...	77	....	..
2........	....	....	....	...	..	....	..
3........	19½	520,000	....	238	77	....	..
4........	18½	1,060,000	....	166	47	....	..
5........	19	956,000	....	129	57	....	..
6........	19	408,000	....	69	45	....	..
7........	19¼	348,000	....	114	49	....	..
8........	19½	1,020,000	....	95	58	....	..
9........	19½	652,000	....	108	39	....	..
10........	19¼	1,176,000	....	166	64	....	..
11........	20	....	....	88	55	....	..
12........	20	....	....	101	49	....	..
13........	20	....	....	150	57	....	..
14........	19½	....	....	135	55	....	..
15........	19¼	....	....	130	60	....	..
16........	....	....	....	....	..	....	..
17........	....	....	....	...	..	....	..
18........	....	....	....	190	77	....	..
19........	....	....	....	165	70	....	..
20........	....	....	....	202	58	....	..
21........	....	....	....	88	52	....	..
22........	....	....	....	96	..	....	..
23........	....	....	....	...	..	....	..
24........	20	....	....	333	101	....	..
25........	19	....	....	108	78	....	..
26........	19	....	....	119	59	....	..
27........	19	....	....	122	70	....	..
28........	19	....	....	97	61	....	..
29........	19	....	....	166	58	....	..
30........	19	....	....	...	..	....	..
31........	20	....	....	111	..	....	..
Average...	19	780,000	....	139	56	....	..
September							
1........	20	....	....	146	69	....	..
2........	20.5	1,664,000	2,120,000	105	72	....	..
3........	20	1,680,000	1,656,000	116	63	....	..
4........	20	542,000	856,000	105	63	....	..
5........	19¾	1,580,000	2,000,000	84	62	....	..
6........	19½	....	....	59	56	....	..
7........	20	....	....	99	77	....	..
8........	18½	1,524,000	1,632,000	125	79	....	..
9........	....	....	....	...	..	....	..
10........	....	....	....	...	..	....	..
11........	....	....	....	...	..	....	..
12........	....	....	....	...	..	....	..
13........	....	....	....	...	..	....	..
14........	....	....	....	...	..	....	..
15........	....	....	....	...	..	....	..
16........	....	....	....	...	..	....	..
17........	....	....	....	...	..	....	..
18........	....	....	....	...	..	....	..
19........	....	....	....	...	..	....	..
20........	....	....	....	...	..	....	..
21........	....	....	....	...	..	....	..
22........	....	....	....	...	..	....	..
23........	....	....	....	...	..	....	..
24........	....	....	....	...	..	....	..
25........	17	....	....	30	..	....	..
26........	17	....	....	34	..	....	..
27........	17	....	....	...	..	....	..
28........	17½	....	....	...	..	....	..
29........	17	....	....	...	..	....	..
30........	17	....	....	...	..	....	..
Average...	18.5	1,398,000	1,653,000	90	68	....	..

Table No. 1—Crude Sewage

October, 1914	Temperature Sewage	Bacteria 37.5° C.	Bacteria 20 °C.	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Dissolved Oxygen, P.P.M.	Relative Stability (Phelps)
1	17	400,000	520,000	...	76	....	..
2	17	1,000,000	808,000	...	..	....	..
3	17	1,360,000	936,000	...	..	....	..
4	17	....	....	...	..	....	..
5	17	688,000	800,000	...	..	....	..
6	17	1,216,000	1,720,000	...	..	....	..
7	17	1,152,000	1,336,000	...	..	....	..
8	17	1,048,000	952,000	...	..	....	..
9	18	936,000	1,360,000	...	..	....	..
10	18	1,488,000	1,520,000	...	..	....	..
11	18	....	....	98	77	....	..
12	18	....	....	133	119	....	..
13	17	1,200,000	1,360,000	172	97	....	..
14	17	....	1,500,000	107	22	....	..
15	17	832,000	1,280,000	123	69	....	..
16	17½	606,000	1,200,000	90	61	....	..
17	17½	1,148,000	1,648,000	180	93	....	..
18	17½	....	....	123	70	....	..
19	17	1,312,000	2,680,000	329	102	....	..
20	17	488,000	800,000	210	92	....	..
21	17	808,000	1,520,000	91	71	....	..
22	17	1,032,000	1,504,000	119	66	....	..
23	16	400,000	1,854,000	114	77	....	..
24	16	748,000	1,328,000	120	69	....	..
25	16	....	....	137	77	....	..
26	16	....	1,780,000	223	92	....	..
27	15	....	840,000	123	78	....	..
28	15	....	1,320,000	122	65	....	..
29	14½	....	1,400,000	128	63	....	..
30	14½	....	....	123	75	....	..
Average	17	940,000	1,332,000	127	73	....	..

November, 1914	Temperature, Cent.	Bacteria (1,000) 37.5° C.	Bacteria (1,000) 20° C.	Settled Solids, c.c. per liter	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Oxygen Demand, 5 da. Incubation at 20° C. P.P.M.
1	14½	1,320	....	....	97	61	...
2	14½	1,320	1,432	....	197	82	...
3	15	....	....	....	89	71	...
4	15	1,240	1,615	....	155	79	...
5	14½	870	1,584	....	134	75	...
6	14	1,010	1,408	....	144	69	...
7	13½	....	1,601	....	135	75	811
8	13½	....	....	....	114	88	...
9	13½	1,072	1,595	....	218	78	727
10	13¼	2,100	1,608	....	130	85	409
11	13¼	1,120	1,460	....	126	72	458
12	13½	1,230	1,720	....	113	77	808
13	14	....	....	....	108	67	453
14	14	1,010	1,800	....	146	71	514
15	15	....	....	....	131	77	...
16	14¾	664	728	....	157	93	494
17	12½	....	....	....	194	87	25
18	11½	1,168	1,560	....	125	80	432
19	12	1,160	1,320	....	108	67	365
20	11½	1,250	1,280	....	115	72	300
21	....	1,680	2,140	....	158	80	...
22	....	....	....	....	21	80	...
23	....	1,003	1,375	....	130	95	552
24	....	1,088	1,424	....	69	72	310
25	....	1,024	1,610	....	219	97	820
26	....	....	....	....	161	85	475
27	....	985	1,520	....	131	75	...
28	....	....	1,610	....	180	52	366
29	12¾	....	....	....	121	78	...
30	12¾	....	1,520	....	231	95	196
Average	13.5	1,166	1,519	....	139	82	476

Table No. 1—Crude Sewage

December, 1914	Temperature, Cent.	Bacteria (1,000) 37.5° C.	20° C.	Settled Solids, c.c. per liter	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Oxygen Demand, 5 da. Incubation at 20° C. P.P.M.
1.........	13	726	1,016	....	127	74	680
2.........	13	925	1,240	....	148	64	637
3.........	13	875	1,000	....	156	59	436
4.........	12	1,020	1,256	....	30	64	423
5.........	11½	....	....	....	186	80	241
6.........	10½	....	....	....	132	61	...
7.........	10½	768	1,048	....	187	57	260
8.........	10	656	800	....	129	50	290
9.........	9¾	848	968	....	189	66	142
10.........	9½	800	1,136	....	242	75	79
11.........	9	400	480	....	132	51	263
12.........	8½	1,104	1,320	....	158	56	510
13.........	8½	....	....	....	168	54	...
14.........	9	840	1,000	....	202	66	647
15.........	9½	768	800	....	109	64	879
16.........	9¼	....	....	....	137	49	814
17.........	9½	915	1,110	....	155	39	420
18.........	9¼	....	....	....	161	53	565
19.........	8¾	672	1,240	....	117	49	...
20.........	9	....	....	....	150	41	...
21.........	9¼	920	1,110	....	132	66	326
22.........	8½	821	985	....	213	67	335
23.........	8¾	1,208	1,552	....	122	51	320
24.........	8½	1,120	1,368	....	128	54	265
25.........	....	....	....	....	...	..	...
26.........	9¼	....	....	....	172	60	...
27.........	9	....	....	....	177	56	...
28.........	8¾	840	744	....	305	74	...
29.........	8½	792	....	....	415	56	...
30.........	8½	820	....	....	182	51	...
31.........	9¾	710	841	....	177	55	343
Average....	9.7	843	1,057	....	168	59	422
January, 1915							
1.........	....	....	....	....	...	..	...
2.........	8¾	....	....	....	182	55	...
3.........	9¼	....	....	....	145	60	...
4.........	9½	656	1,288	....	178	78	561
5.........	8	856	976	....	120	46	510
6.........	9½	864	1,648	....	173	47	266
7.........	9½	658	1,200	....	147	44	328
8.........	9	792	920	....	92	46	542
9.........	8½	904	1,310	....	176	50	501
10.........	9	....	....	....	135	46	...
11.........	8½	875	1,021	4	178	74	252
12.........	7½	472	480	2.4	132	35	519
13.........	7½	688	1,040	1.6	90	24	188
14.........	7½	800	912	4	195	41	547
15.........	8¾	850	1,110	2.6	106	35	253
16.........	8½	810	910	4.1	138	48	224
17.........	9	....	....	2.7	155	46	...
18.........	9	575	600	2.7	92	24	529
19.........	9½	1,192	760	5.2	119	42	360
20.........	9	920	920	5.2	128	43	457
21.........	8	440	1,200	4.4	149	55	378
22.........	7	542	910	3	108	55	360
23.........	8¾	875	875	2.7	128	49	517
24.........	8	....	....	1.8	86	58	...
25.........	7½	568	666	6.1	199	59	504
26.........	7¾	832	1,325	10.3	159	66	...
27.........	7½	....	336	1.6	89	44	907
28.........	7¾	624	376	1.4	94	41	538
29.........	7¾	....	520	1.6	104	46	657
30.........	7	616	1,212	2.6	123	55	538
31.........	7	....	....	2.4	79	49	...
Average...	8	747	938	2.02	133	49	454

Table No. 1—Crude Sewage

February, 1915	Temperature, Cent.	Bacteria (1,000) 37.5° C.	Bacteria (1,000) 20° C.	Settled Solids, c.c. per liter	Suspended Solids, P.P.M.	Oxygen Consumed, P.P.M.	Oxygen Demand, 5 da. Incubation at 20° C. P.P.M.
1	7	1,640	795	2.4	116	35	549
2	6½	600	674	1.2	43	39	853
3	6¼	640	1,720	2.2	69	35	880
4	8	920	984	1.8	110	47	897
5	7¾	472	1,656	1.6	95	38	...
6	8	652	1,420	.8	78	24	448
7	7½	....	....	.7	81	26	...
8	7	736	672	3.7	173	54	331
9	7½	810	712	2.7	93	39	222
10	7	720	960	1.7	100	40	191
11	7¾	776	936	2.4	99	41	573
12	8	....	....	2.6	108	43	...
13	8¼	712	1,064	1.6	98	56	199
14	8½	....	....	.7	73	41	...
15	9¾	1,048	1,096	9.6	163	44	813
16	9	1,651	1,680	5.4	113	41	...
17	8½	....	....	5.2	163	50	...
18	8½	512	744	3.5	97	41	...
19	9	920	704	2.6	80	35	...
20	9	....	....	4.4	105	45	...
21	9½	....	....	2.8	133	41	...
22	10	....	....	7.4	220	44	...
23	10	480	896	5.4	197	41	482
24	10	780	915	3.2	216	50	564
25	9	536	762	2.0	98	41	714
26	9	904	1,474	2.3	102	35	591
27	8½	....	....	2.6	115	45	483
28	8½	....	....	1.4	106	37	...
Average	8	816	1,045	3.1	116	41	587
March							
1	8½	680	840	12.9	125	52	514
2	9¾	872	880	5.6	113	48	616
3	9½	672	1,156	3.8	134	36	714
4	9½	1,952	1,472	3.5	117	45	531
5	9¾	....	....	4.8	162	49	905
6	9	920	1,280	3.6	205	43	498
7	9	....	....	2.9	135	41	...
8	9¾	960	960	7.4	209	67	...
9	9½	872	1,448	8.7	225	60	797
10	9½	1,120	1,528	2.8	132	38	...
11	9½	800	1,240	3.1	130	37	...
12	9½	1,032	1,240	2.7	65	33	598
13	10	528	1,312	....	149	45	797
14	10	....	....	2.0	152	39	...
15	10½	992	1,472	14.0	282	70	634
16	10	832	1,768	8.0	222	72	476
17	10	912	1,400	5.0	184	64	546
18	10	808	1,465	4.8	152	60	817
19	10	1,080	1,620	3.4	169	57	576
20	10¾	720	1,525	3.8	177	58	583
21	10½	....	....	3.3	169	53	...
22	11	1,376	1,600	1.3	261	47	658
23	11	....	1,424	7.5	134	52	559
24	11	1,160	1,456	2.8	115	51	528
25	11¼	800	1,088	3.6	172	52	887
26	10	585	728	10.3	156	53	650
27	10	628	1,440	4.4	131	64	726
28	10	....	....	3.1	172	69	...
29	10	....	....	12.7	194	79	...
30	9¾	....	....	6.2	144	58	...
31	10½	1,344	1,448	7.7	162	66	501
Average	10	941	1,324	5.52	164	53.5	641

Table No. 2—Record of Oxygen Consumed* in Hourly Samples of Raw Sewage.

Hour of Day	June 26 to July 3								July 17 to July 24								August 14 to August 21								
	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Average 21 days
12 A.M.	25	22	22	31	7	33	10	21	19	23	12	48	21	14	20	22	14	14	12	24	10	12	12	14	19
1 "	17	16	10	10	13	10	12	13	18	15	8	16	10	12	16	14	11	8	20	4	17	13	10	12	13
2 "	10	9	6	5	4	4	2	6	9	12	5	9	6	39	5	12	6	7	7	5	6	8	7	7	8
3 "	6	8	3	10	5	5	..	6	9	5	5	6	6	6	..	6	10	7	5	13	8	6	9	8	7
4 "	8	8	4	10	2	5	7	6	6	9	4	6	8	8	7	7	9	7	6	3	6	9	10	7	7
5 "	8	4	8	11	4	8	..	7	8	26	9	12	13	6	16	13	6	8	6	5	5	9	9	7	9
6 "	24	14	11	11	13	15	19	15	24	15	47	9	37	12	27	24	..	11	34	11	25	42	45	28	22
7 "	47	37	32	18	31	57	50	39	49	29	63	33	57	36	50	45	34	30	39	31	33	59	56	40	41
8 "	66	33	46	26	77	46	52	49	62	60	36	40	59	45	70	53	46	47	63	33	74	36	44	49	50
9 "	71	52	49	72	95	71	58	67	108	49	41	90	120	73	56	77	58	54	45	44	123	74	67	66	70
10 "	91	74	62	64	101	90	62	78	69	25	40	69	138	82	64	70	86	84	94	49	99	136	47	85	76
11 "	82	61	48	54	268	99	69	97	92	36	41	87	164	71	83	82	39	43	100	63	141	28	28	63	81
12 NOON	48	40	47	26	122	105	41	61	80	22	104	40	103	103	134	84	52	55	32	41	129	86	52	64	70
1 P.M.	65	42	36	44	137	56	132	73	36	28	43	52	65	81	45	50	52	119	79	43	111	86	43	76	66
2 "	105	45	65	34	144	76	89	80	52	47	80	72	91	53	33	61	69	60	84	88	65	94	101	80	74
3 "	45	39	68	61	71	54	26	52	28	47	36	28	43	55	43	40	29	35	52	39	84	100	51	56	49
4 "	36	39	39	42	65	78	28	47	24	34	71	45	39	162	37	59	41	85	24	19	100	65	27	52	53
5 "	30	34	31	34	40	26	34	33	20	43	51	25	34	56	21	36	29	19	30	20	34	35	22	27	32
6 "	53	27	16	19	48	26	35	32	66	29	53	29	27	46	31	40	33	27	15	14	69	37	20	31	34
7 "	57	33	46	34	51	29	31	40	34	47	42	32	52	49	38	42	43	28	73	32	49	28	41	42	42
8 "	57	42	39	38	47	49	47	46	41	30	71	18	56	50	53	46	34	46	33	19	30	36	56	36	43
9 "	32	34	33	31	50	27	30	34	25	26	32	59	38	38	23	34	39	15	41	16	32	24	34	29	32
10 "	41	38	14	67	33	25	39	37	24	19	19	22	25	28	21	23	19	18	13	24	18	24	36	22	27
11 "	27	31	28	17	44	45	27	31	28	23	29	38	39	22	34	30	21	21	23	17	23	18	35	23	28
Average	44	33	32	32	61	43	41	41	39	29	39	37	52	48	40	40	34	35	39	27	54	44	36	39	40

* Oxygen consumed determined by 10 minutes' boiling of acidified sample with permanganate. Results are expressed in parts per 1,000,000.

Table No. 3—Record of Suspended Solids in Hourly Samples of Raw Sewage.

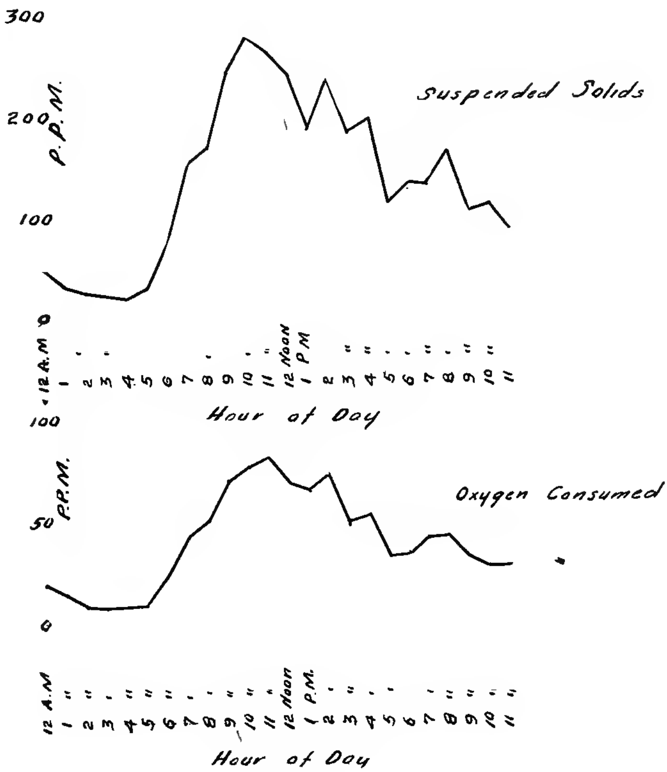
Hour of Day	June 26 to July 3								July 17 to July 24								August 14 to August 21								
	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Aver., 7 days	Average 21 days
12 A.M.	46	48	37	96	72	34	73	58	60	43	105	75	33	79	68	66	23	34	21	80	33	36	12	34	53
1 “	40	15	21	21	25	40	59	32	45	..	50	56	54	30	26	44	36	17	92	15	47	30	10	35	37
2 “	4	9	9	18	17	93	20	24	21	50	28	23	30	25	42	31	27	21	31	15	15	15	18	20	25
3 “	44	14	10	23	13	20	65	27	21	14	17	24	19	15	..	18	21	21	23	45	20	23	12	24	23
4 “	40	11	44	19	17	17	19	24	23	15	18	12	23	10	22	18	17	20	19	23	14	14	15	17	20
5 “	46	92	23	55	30	17	74	48	20	29	31	15	29	18	22	23	26	10	29	16	16	17	23	20	30
6 “	72	72	192	26	126	27	91	87	57	48	52	8	26	85	35	44	54	34	136	33	91	92	174	88	73
7 “	166	99	222	134	232	121	210	169	150	124	135	51	118	262	145	141	105	97	155	117	152	255	232	159	156
8 “	164	146	123	142	228	184	170	165	266	63	184	81	131	186	201	159	278	144	240	94	250	169	93	181	168
9 “	212	252	191	310	420	236	212	262	280	204	216	215	283	247	222	238	127	134	180	165	519	252	273	236	245
10 “	180	140	147	230	544	278	330	264	250	286	148	284	331	250	242	256	276	405	313	163	384	558	140	320	280
11 “	219	131	152	200	530	219	226	239	258	243	223	169	770	487	172	332	95	118	395	120	678	84	91	226	266
12 NOON	323	80	438	195	416	322	217	284	143	171	213	140	449	165	159	206	145	147	140	104	436	514	175	237	242
1 P.M.	122	152	96	138	99	225	126	137	252	126	183	181	318	189	413	237	143	213	235	134	282	264	115	198	191
2 “	243	157	240	170	294	151	105	194	448	290	223	221	398	198	200	283	168	218	250	175	214	306	362	242	240
3 “	108	165	186	126	148	138	146	145	150	222	235	193	250	177	133	194	82	141	238	193	270	386	170	211	183
4 “	64	105	201	231	138	504	277	217	113	143	235	252	166	287	89	184	109	281	91	72	434	300	111	200	200
5 “	44	134	323	86	92	148	120	135	48	140	156	70	120	113	114	109	95	88	143	119	116	153	72	112	119
6 “	224	72	194	87	67	232	224	157	169	107	72	85	141	84	196	122	101	88	66	48	234	135	78	107	129
7 “	127	167	100	116	164	142	143	137	120	186	127	112	121	150	120	134	105	122	287	90	108	94	161	138	136
8 “	148	126	123	125	220	195	267	172	284	270	166	143	175	121	238	200	88	136	101	88	137	145	163	123	165
9 “	70	112	100	84	100	114	77	94	280	141	141	72	112	112	103	137	123	78	96	64	94	80	123	94	108
10 “	82	47	64	86	192	109	68	93	103	278	100	404	90	86	79	163	55	87	64	97	78	72	156	87	114
11 “	71	93	76	135	128	72	182	108	95	137	91	84	169	131	78	111	71	76	36	61	68	50	50	59	93
Average.	119	102	138	119	180	152	146	136	152	141	131	124	182	146	136	144	99	115	141	89	195	169	118	132	137

Results are in parts per 1,000,000.

President Borough of Richmond. ~~Diagram~~ No. 5 FILE
Bureau of Engineering, Sewage ACC
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Diagram of Tabulation of 3 Weeks analyses Table No. 3 CHECKER DATE June, July and August 1913

Hourly Diagram of Flow of Raw Sewage

Average of Three Weeks analyses



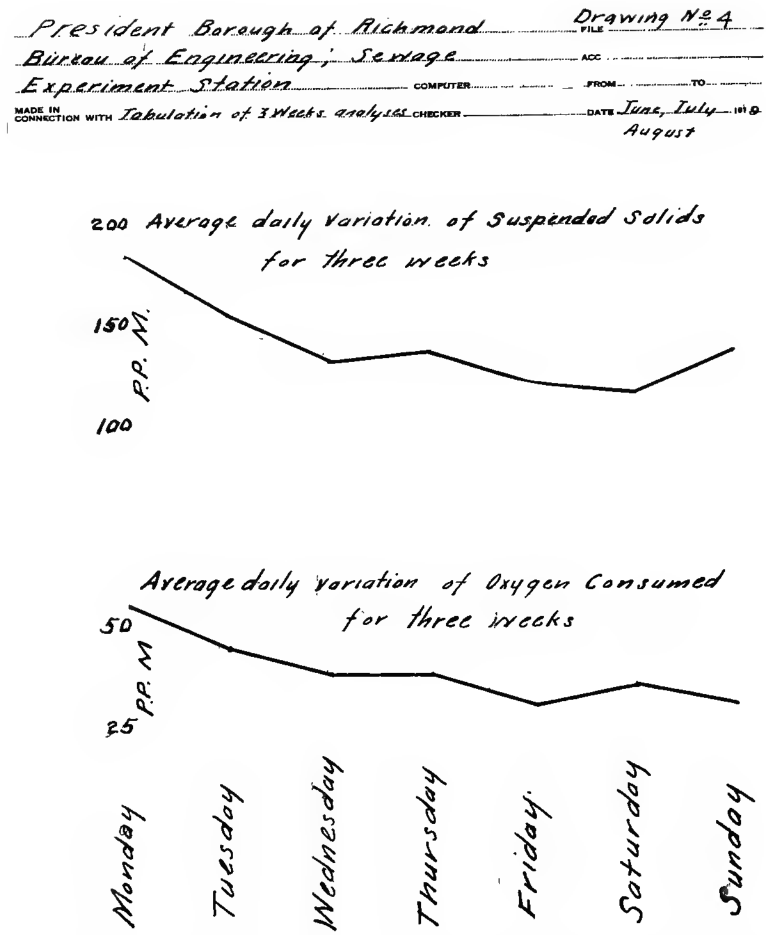


TABLE No. 4—SHOWING THE AVERAGE OF SEVEN-DAY ANALYSES OF SEWAGE, TAKEN FROM SEVEN DIFFERENT OUTLETS IN BOROUGH OF RICHMOND.

Sewer Outlet Number	Solids	Solids: Suspended			Oxygen Consumed Permanganate in ½ hour at 100° C.			Oxygen Demand			Chlorine	Alkalinity, $CaCo^3$	Fats
	Settled 60 Min. Vol.=c.c./liter	Raw Sewage	Settled 60 Min.	Per Cent Reduction	Raw Sewage	Settled 60 Min.	Per Cent Reduction	Raw Sewage	Settled 60 Min.	Per Cent Reduction			
6	4.9	217	79	64	55	40	27	339	179	47	321	251	115
8	4.0	279	..	..	69	47	32	436	...	..	345	229	...
10	2.8	221	117	47	54	39	28	345	272	20	482	270	...
23	2.6	120	54	55	31	23	26	188	115	39	181	190	54
25	7.9	253	72	72	74	50	32	228	149	35	169	225	87
28	4.2	389	95	76	70	44	37	298	210	30	159	198	81
35	2.8	201	63	69	53	35	34	228	165	28	138	202	33

Table No. 5—Plain Sedimentation.

March, 1914	Velocity in Feet per Second	Effluent from Tank No. 2. Bacteria (1,000) 37.5° C. Number	37.5° C. % Reduction	20° C. Number	20° C. % Reduction	Suspended Solids P.P.M.	Suspended Solids % Reduction	Oxygen Consumed P.P.M.	Oxygen Consumed % Reduction	Dissolved Oxygen, P.P.M.	Putrescibility
1......	.0012	...	...	...	...	201	22	59	53	....	..
2......	.0021	...	...	...	...	120	48	68	47	....	..
3......	.0016	...	...	...	...	101	63	60	45	....	..
4......	.0012	...	...	...	...	119	34	69	45	....	..
5......	.0006	...	...	...	...	102	43	61	27	....	..
6......	.0021	...	...	...	...	78	60	55	56	....	..
7......	.0021	...	...	...	...	107	43	63	51	....	41
8......	.0021	...	...	...	...	231	..	70	45	....	..
9......	.0012	...	...	...	...	211	63	92	3	....	39
10......	.0016	...	...	...	...	117	34	58	56	....	47
11......	.0021	...	...	...	...	121	43	70	41	....	43
12......	.0012	...	...	...	...	136	30	61	56	....	32
13......	.0033	...	...	...	...	127	44	53	58	....	45
14......	.0033	...	...	...	...	125	53	59	55	....	58
15......	.0033	...	...	...	...	134	20	49	72	....	..
16......	.0033	...	...	...	...	226	5	71	43	....	..
17......	.0021	...	...	...	...	124	7	54	69	....	49
18......	.0012	...	...	...	...	90	35	44	23	....	61
19......	.0012	...	...	...	...	93	27	42	77	....	51
20......	.0033	...	...	...	...	75	37	44	76	....	58
21......	.0012	...	...	...	...	116	27	57	64	....	56
22......	.0012	...	...	...	...	87	29	54	68	....	..
23......	.0012	...	...	...	...	189	41	81	17	....	32
24......	.0012	...	...	...	...	168	13	65	48	....	28
25......	.0012	353	...	576	18	155	12	48	63	....	42
26......	.0012	290	22	688	37	128	75	54	68	....	38
27......	.0012	176	+35	440	23	138	76	55	72	....	32
28......	.0012	530	5	500	5	124	78	54	65	....	53
29......	.0012	850	60	1,120	+3	100	99	51	67	....	..
30......	.0012	150	70	226	50	133	37	65	46	....	31
31......	.0012	528	14	292	2	100	39	70	5	....	16
Aver....	.0017	411	...	549	...	131	34	60	9	....	43
April											
1......	.0027	240	1	628	+8	116	33	49	25	1.00	..
2......	.0012	612	3	544	45	158	25	62	10	2.36	..
3......	.0003	268	+18	300	37	84	57	50	31	1.74	..
4......	.0009	...	...	...	...	84	50	53	28	1.05	..
5......	.0012	612	...	828	...	200	14	59	31	2.08	31
6......	.0012	1,216	+68	1,144	+15	166	47	77	20	1.65	21
7......	.0012	105	47	25	47	138	45	67	13	1.55	17
8......	.0012	332	60	93	92	118	24	51	26	0.65	33
9......	.0012	360	40	396	16	122	57	64	23	2.63	19
10......	.0012	1,248	+68	1,408	+50	128	30	63	17	1.50	19
11......	.0003	420	37	557	34	140	42	51	39	0.56	32
12......	...	...	...	...	...	...	..	..	..	....	..
13......	.0012	552	+20	604	33	178	+5	89	18	2.42	20
14......	.0012	720	+85	996	+104	174	62	71	26	1.79	20
15......	.0006	592	+15	480	60	90	52	58	18	1.38	78
16......	.0006	258	35	320	48	98	29	51	27	2.03	36
17......	.0012	456	10	848	14	154	34	61	23	0.49	21
18......	.0012	460	16	972	+12	116	54	54	23	0.34	26
19......	.0006	972	23	1,384	12	112	26	50	35	0.19	17
20......	.0009	380	53	580	10	130	63	80	28	0.54	20
21......	.0006	173	57	928	+8	128	49	66	31	1.23	25
22......	.0009	884	+38	1,092	+29	108	49	56	32	0.54	19
23......	.0012	105	88	1,520	+17	130	55	72	17	1.25	19
24......	.0006	412	19	840	+33	112	45	51	29	0.21	33
25......	.0012	...	100	...	100	150	58	44	29	0.00	21
26......	.0021	700	21	1,020	68	88	73	41	47	2.71	39
27......	.0012	553	29	680	12	96	65	67	25	0.99	21
28......	.0006	19	20	520	+46	92	42	61	16	0.34	21
29......	.0012	366	+50	636	19	92	58	52	28	0.00	25
30......	.0006	241	+14	612	17	76	52	54	26	0.46	19
Aver....	.0010	491	2	713	12	123	47	59	28	1.10	26

Table No. 5—Plain Sedimentation.

Effluent from Tank No. 2.

May, 1914	Velocity in Feet per Second	Bacteria (1,000) 37.5° C. Number	Bacteria (1,000) 37.5° C. % Reduction	Bacteria (1,000) 20° C. Number	Bacteria (1,000) 20° C. % Reduction	Suspended Solids P.P.M.	Suspended Solids % Reduction	Oxygen Consumed P.P.M.	Oxygen Consumed % Reduction	Dissolved Oxygen, P.P.M.	Putrescibility
1......	.0002	...	...	...	...	90	63	47	40	....	26
2......	.0011	...	...	...	...	164	44	63	28	1.06	17
3......	.0012	775	3	1,520	10	152	+5	58	17	1.23	21
4......	.0012	269	98	588	49	82	39	86	16	0.38	13
5......	.0012	200	51	776	49	90	65	55	29	0.3	30
6......	.0016	399	+15	740	+9	200	+2	61	27	0.23	19
7......	.0009	664	+40	...	...	158	15	68	+1	0.08	19
8......	.0003	...	...	...	...	122	56	54	24	1.53	27
9......	.0009	360	+12	...	...	80	+1	55	23	0.26	20
10......	.0009	1,520	33	...	...	108	41	57	27	0.19	30
11......	.0007	608	20	...	...	144	54	88	18	0.23	11
12......	.0012	460	10	...	...	136	39	72	18	1.30	13
13......	.0012	1,052	+22	...	...	150	31	71	11	1.42	15
14......	.0009	620	+13	760	19	104	40	66	1	0.23	19
15......	.0006	840	+85	...	...	118	15	56	20	0.15	21
16......	.0012	824	+20	...	...	132	35	59	24	0.00	11
17......	.0005	1,336	+33	...	...	96	71	65	29	0.08	19
18......	.0009	312	25	...	...	122	51	86	22	....	18
19......	.0009	1,240	16	2,000	25	60	48	74	19	1.66	11
20......	.0012	628	+84	796	+5	36	76	58	18	0.41	19
21......	.0016	520	+16	750	10	36	68	51	19	0.16	19
22......	.0009	310	+33	760	+81	50	67	41	43	0.00	25
23......	.0003	724	19	1,200	+102	92	43	53	32	0.00	19
24......	.0009	960	4	2,000	14	90	38	46	26	0.00	23
25......	.0009	500	53	750	33	104	29	83	19	0.24	11
26......	.0012	800	+57	700	+6	60	67	57	9	0.32	11
27......	.0006	450	26	370	82	164	4	66	17	....	11
28......	.0006	930	29	1,360	16	44	61	55	9	....	16
29......	.0006	1,040	13	1,600	17	80	49	56	25	....	13
30......	...	...	...	...	...	...	..	..	..	....	..
31......	...	...	...	...	...	...	..	..	..	....	..
Aver....	.00087	708	5	1,042	17	106	45	62	22	.4	18
June											
1......	.0012	588	38	960	41	122	26	79	19	....	18
2......	.0012	480	15	1,000	12	102	46	57	30	0.08	24
3......	.0016	420	+20	890	+40	80	29	60	17	....	11
4......	.0021	440	+40	884	+33	78	29	50	18	0.24	13
5......	.0012	792	5	990	16	80	44	55	20	0.24	22
6......	.0012	725	17	832	16	138	47	60	19	....	18
7......	.0012	1,536	28	1,160	+46	136	+3	48	29	0.09	31
8......	.0009	912	10	1,040	39	126	60	73	32	....	15
9......	.0012	612	24	1,304	18	86	56	66	27	....	21
10......	.0012	744	+13	812	22	102	22	63	2	....	11
11......	.0012	912	12	975	10	102	26	58	19	....	20
12......	.0012	848	+11	1,000	0	78	65	51	30	....	19
13......	.0012	976	10	832	42	124	+3	51	26	....	21
14......	.0012	730	27	888	12	108	18	53	5	....	11
15......	.0012	750	13	880	39	78	67	67	23	....	18
16......	.0012	1,072	+6	800	44	102	41	73	8	....	11
17......	.0009	896	3	1,136	19	36	76	47	35	....	31
18......	.0009	...	...	2,750	...	100	30	49	27	....	23
19......	.0006	1,200	1	1,200	+11	82	+28	45	10	....	29
20......	.0006	1,328	20	1,720	5	74	61	57	30	....	11
21......	.0006	928	14	1,048	42	36	56	45	20	....	..
22......	.0006	800	43	968	38	140	30	60	15	....	13
23......	.0003	1,002	14	1,136	8	80	70	57	35	....	11
24......	.0003	950	+32	1,256	9	78	52	53	28	....	15
25......	.0006	880	4	1,040	39	82	40	53	27	....	15
26......	.0003	480	23	600	39	124	19	53	10	....	15
27......	.0012	...	...	2,560	...	70	46	53	12	....	17
28......	.0012	960	2	1,527	27	66	51	44	27	....	11
29......	.0012	1,072	+25	1,104	5	166	51	63	39	....	15
30......	.0012	832	+4	880	13	80	65	60	23	....	19
Aver....	.0010	852	13	1,139	16	95	45	57	23	....	18

Table No. 5—Plain Sedimentation.

July, 1914	Velocity in Feet per Second	Effluent from Tank No. 2. Bacteria (1,000) 37.5° C. Number	% Reduction	20° C. Number	% Reduction	Suspended Solids P.P.M.	% Reduction	Oxygen Consumed P.P.M.	% Reduction	Dissolved Oxygen, P.P.M.	Putrescibility
1......	.0007	1,040	29	1,300	27	98	39	48	39	....	10
2......	.0006	752	29	1,000	22	47	63	51	20	....	11
3......	.001	792	54	648	58	89	58	45	37	....	26
4......	.....	...	...	...	...	...	..	..	..	....	..
5......	.0012	896	22	1,160	30	48	11	46	30	....	22
6......	.0012	576	23	812	11	109	80	72	25	....	22
7......	.0012	800	17	760	20	50	72	39	40	....	33
8......	.001	856	30	800	47	78	10	54	32	....	13
9......	.001	864	15	720	34	63	63	50	60	....	15
10......	.0009	832	23	800	40	68	32	37	44	....	27
11......	.0005	1,120	27	1,120	30	121	65	47	36	....	30
12......	.001	480	40	1,024	9	56	69	44	36	....	15
13......	.0009	920	+40	720	26	190	39	60	43	....	28
14......	.0012	528	13	672	7	183	19	48	45	....	13
15......	.0016	1,064	+46	1,120	30	79	47	45	36	....	26
16......	.001	1,400	13	...	...	77	..	49	48	....	18
17......	.0012	720	...	...	...	31	63	35	43	....	29
18......	.0009	900	18	1,200	...	43	33	40	35	....	30
19......	.0012	...	...	...	...	33	76	41	34	....	..
20......	.0009	...	...	...	...	94	33	54	45	....	..
21......	.....	...	Cleaning	Tank	...	...	..	..	..	..	..
22......	.....	..	"	"	...	...	..	..	..	....	..
23......	.....	...	"	"	...	...	..	..	..	....	..
24......	.....	...	"	"	...	...	..	..	..	....	..
25......	.....	...	"	"	...	...	..	..	..	....	..
26......	.....	...	"	"	...	...	..	..	..	....	..
27......	.....	...	"	"	...	...	..	..	..	....	..
28......	.....	...	"	"	...	...	..	..	..	....	..
29......	.....	...	"	"	...	...	..	..	..	....	..
30......	.....	...	"	"	...	...	..	..	..	....	..
Aver....	.001	855	22	924	23	82	58	48	37	....	22
August											
1......	.....	...	...	...	...	...	..	..	..	....	..
2......	.....	...	...	...	...	...	..	..	..	....	..
3......	.0012	...	...	...	...	210	20	49	36	....	..
4......	.0012	...	...	...	...	75	55	33	39	....	..
5......	.001	...	...	...	...	55	47	37	35	....	..
6......	.0012	...	...	...	...	17	75	33	27	....	..
7......	.0012	...	...	...	...	53	53	35	29	....	..
8......	.0014	...	...	...	...	39	58	33	40	....	..
9......	.001	...	...	...	...	53	50	29	26	....	..
10......	.0012	...	...	...	...	81	51	49	27	....	..
11......	.0009	...	...	...	...	55	38	40	27	....	..
12......	.0012	...	...	...	...	43	52	34	30	....	..
13......	.001	...	...	...	...	69	54	40	30	....	..
14......	.001	...	...	...	...	64	53	44	20	....	..
15......	.0009	...	...	...	...	98	25	43	29	....	..
16......	.....	...	...	...	...	...	..	..	..	....	..
17......	.0007	...	...	...	...	...	..	..	..	....	..
18......	.0012	...	...	...	...	106	46	59	23	....	..
19......	.0012	...	...	...	...	74	55	52	26	....	..
20......	.001	...	...	...	...	150	26	43	26	....	..
21......	.0012	...	...	...	...	49	44	33	37	....	..
22......	.0012	...	...	...	...	66	31	..	..	....	..
23......	.....	...	...	...	...	...	..	..	..	....	..
24......	.001	...	...	...	...	42	88	66	35	....	..
25......	.001	...	...	...	...	66	39	56	28	....	..
26......	.0012	...	...	...	...	62	48	47	20	....	..
27......	.001	...	...	...	...	72	41	53	24	....	..
28......	.001	...	...	...	...	68	30	50	18	....	..
29......	.0009	...	...	...	...	118	39	45	23	....	..
30......	.....	...	...	...	...	...	..	..	..	....	..
31......	.0007	...	...	...	...	76	30	..	..	....	..
Aver....	.0011	...	...	...	...	74	47	44	41	....	..

TABLE No. 6—DISINFECTION BY CHLORINE GAS.

MARCH, 1914. EFFLUENT No. 4

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Geletin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	9	....	....	....	....	....	....	76	—41	43	—41	....	..
2.....	9	....	....	....	....	....	....	71	—64	55	—30	....	..
3.....	9	....	....	....	....	....	....	57	—84	51	—44	....	..
4.....	9	....	....	....	....	....	....	58	—67	51	—35	....	..
5.....	9	....	....	....	....	....	....	73	—59	61	—17	....	..
6.....	9	....	....	....	....	....	....	65	—66	50	—38	....	..
7.....	9	....	....	....	....	....	....	81	—57	51	—37	8.0	..
8.....	9	....	....	....	....	....	....	100	—57	50	—37	....	..
9.....	9	....	....	....	....	....	....	120	—65	77	—14	8.8	..
10.....	9	....	....	....	....	....	....	75	—57	53	—31	8.5	68
11.....	9	....	....	....	....	....	....	96	—58	58	—31	8.8	84
12.....	9	....	....	....	....	....	....	85	—56	55	—20	9.2	96
13.....	9	....	....	....	....	....	....	94	—59	55	—30	9.2	94
14.....	9	....	....	....	....	....	....	110	—58	56	—16	9.0	..
15.....	8	....	....	....	....	....	....	103	—38	47	—13	....	..
16.....	9	....	....	....	....	....	....	154	—35	65	—19	....	..
17.....	9	....	....	....	....	....	....	89	—33	52	— 9	9.2	94
18.....	9	....	....	....	....	....	....	64	—54	44	—23	9.1	90
19.....	8½	....	....	....	....	....	....	55	—57	41	—50	....	90
20.....	9	....	....	....	....	....	....	59	—50	44	—19	....	90
21.....	9	....	....	....	....	....	....	81	—47	55	—13	....	50
22.....	9	....	....	....	....	....	....	92	—25	55	— 7	....	50
23.....	8½	....	....	....	....	....	....	96	—67	68	—36	....	11
24.....	9	....	....	....	....	....	....	84	—56	67	—15	....	30
25.....	9	102.5	12.3	Sterile	100	Sterile	100	113	—35	62	—18	....	84
26.....	9½	95	11.4	164,000	—56	120,000	76	108	—31	56	— 5	3.23	50
27.....	9½	303	36.3	Sterile	100	Sterile	100	124	—37	51	—18	4.72	80*
28.....	9½	....	....	840,000	+34	428,000	—18	104	—35	51	—22	....	90
29.....	9	....	....	820,000	+36	1,520,000	+28	60	—59	52	—21	....	..
30.....	10	60	7.2	Sterile	100	Sterile	100	98	—53	63	—24	....	60
31.....	9½	30	3.6	520,000	90	492,000	68	95	—54	69	—10	....	37
Aver...	8.7	118	14.0	33,000	92	366,000	74	88	—56	55	—17	7.9	69

* Free Chlorine, 12.63 P.P.M.

Table No. 6—Disinfection by Chlorine Gas.

April, 1914. Chlorine Tank No. 4

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Geletin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	9½	31.5	3.8	Sterile	100	Sterile	100	114	—38	63	— 3	....	37
2.....	10	36.9	4.4	107,000	83	173,000	70	100	—52	62	—10	....	30
3.....	9	68.1	8.2	155,000	+18	173,000	63	90	—55	59	—19	....	50
4.....	9	81.4	9.8	....	....	....	....	66	—60	63	—14	....	87
5.....	9½	40.7	4.9	Sterile	100	Sterile	100	82	—55	61	—28	....	30
6.....	10	40.7	4.9	912,000	—21	1,110,000	+17	130	—63	81	—27	....	30
7.....	10	60	7.2	15,000	92	Sterile	100	80	—68	62	—19	....	30
8.....	10½	60	7.2	69,000	92	67,000	95	60	—58	54	—22	....	44
9.....	10	77	9.2	39,000	99	184,000	61	112	—61	64	—18	....	30
10.....	10	40.7	4.9	640,000	14	842,000	21	92	—50	54	—28	....	30
11.....	10	68.1	8.2	65,000	90	9,000	99	112	—54	52	—37	....	44
12.....	....	....	....	....	....	....	....	....	....	..	....	....	..
13.....	11	68	8.2	564,000	26	768,000	+43	168	—42	76	—30	....	30
14.....	10¾	40.7	4.9	199,000	77	484,000	— 4	110	—76	71	—16	....	21
15.....	10½	40.7	4.9	1,000	100	....	....	116	—30	58	—18	....	75
16.....	10½	44.1	5.3	Sterile	100	Sterile	100	100	—33	59	—16	....	37
17.....	11	126.4	15.2	"	100	"	100	106	—54	61	—23	....	21
18.....	12	60	7.2	4,000	100	5,000	99.5	113	—54	57	—18	....	30
19.....	13	60	7.2	175,000	86	596,000	62	94	—38	46	—40	....	50
20.....	12	60	7.2	27,000	88	50,000	92	140	—60	80	—28	....	30
21.....	11½	60	7.2	52,000	87	50,000	94	98	—61	73	—24	3.2	21
22.....	11½	60	7.2	Sterile	100	Sterile	100	76	—64	55	—32	2.4	30
23.....	11½	60	7.2	42,000	95	115,000	91	126	—70	69	—29	3.3	37
24.....	11½	101	12.1	Sterile	100	Sterile	100	100	—50	62	—14	2.0	30
25.....	11½	84.6	10.2	45,000	84	145,000	84	110	—54	56	—10	0.3	30
26.....	11½	34.4	4.1	9,000	99	Sterile	100	116	—64	47	—39	4.2	44
27.....	12¼	60	7.2	Sterile	100	17,000	85	122	—53	79	—11	2.8	21
28.....	12½	77.8	9.2	9,000	56	....	....	94	—46	70	—10	2.8	30
29.....	12½	111.4	13.4	Sterile	100	Sterile	100	95	—50	63	—12	1.0	30
30.....	12	50.5	6.1	"	100	"	100	60	—64	62	—15	2.8	30
Aver...	10	62.0	7.0	112,000	77	184,000	77	102	—56	63	23	2.5	36

Table No. 6—Disinfection by Clhorine Gas.

May, 1914, Chlorine Tank No. 4.

Date	Tem-pera-ture	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduc-tion	Bacteria on Gelatin at 20°	Per Cent Reduc-tion	Suspended Solids, P.P.M.	Per Cent Reduc-tion	Oxygen Consumed, P.P.M.	Per Cent Reduc-tion	Dissolved Oygen 1 Per Cent Solution	Relative Stability
1	12	170	20.4	Sterile	100	Sterile	100	92	—62	63	—18	2.4	44
2	12	70	8.4	450,000	+ 6	730,000	—27	122	—57	73	—17	0.50	30
3	12	90	10.8	7,000	—99	Sterile	—40	122	—42	62	—11	2.32	21
4	13	36	4.3	200,000	—82	584,000	—49	104	—61	78	—23	1.9	11
5	13	....	....	264,000	—35	708,000	—38	70	—72	58	—26	0.0	30
6	13	....	....	270,000	—22	101,000	....	88	—55	64	—23	1.1	11
7	13	....	....	124,000	—74	90,000	....	100	—46	48	—19	0.8	21
8	13	....	..	295,000	+ 8	....	....	98	—65	56	—21	2.4	30
9	13	60	7.2	342,000	+14	....	....	80	—53	58	—18	0.4	30
10	13	60	7.2	992,000	—56	....	....	58	—68	56	—12	1.3	53
11	14	71	8.5	Sterile	100	....	....	94	—70	83	—22	1.6	44
12	14	66	8.0	"	100	....	....	68	—69	74	—16	2.6	37
13	13	23	2.8	560,000	—36	....	....	110	—47	66	—18	1.5	21
14	14	—	...	750,000	+11	1,040,000	—11	128	—25	65	— 3	0.2	21
15	13	—	....	548,000	+19	....	....	88	—36	50	—14	0.6	21
16	13	46	5.5	728,000	+ 6	....	....	62	—70	58	—25	0.2	21
17	14	90	10.8	484,000	—51	....	....	104	—68	65	—18	0.4	21
18	14	34	4.1	536,000	—30	840,000	—52	92	—67	88	—20	0.0	11
19	14	98	17.5	548,000	—28	920,000	—66	78	—29	73	—20	2.8	11
20	14	45	5.4	Sterile	100	10,000	—99	62	—58	65	— 9	1.8	21
21	14	45	5.4	750,000	100	Sterile	100	54	—52	58	— 8	3.3	44
22	14	45	5.4	768,000	+63	1,620 000	+14	98	—45	61	—15	1.6	30
23	14	45	5.4	975,000	—13	1,000,000	—35	84	—48	57	—17	0.8	11
24	14	71	8.5	568,000	—32	940,000	—60	90	—39	51	—18	0.0	30
25	16	46	5.5	520,000	—47	688,000	—39	60	—84	85	—17	1.6	11
26	16	46	5.5	310,000	—20	770,000	+17	102	—44	59	— 6	0.8	21
27	16	60	7.2	40,000	—50	370,000	—18	122	—28	65	—19	0.4	11
28	16	60	7.2	180,000	—97	60,000	—96	60	—52	60	— 2	1.5	37
29	16	60	7.2	....	—85	328,000	—83	76	—51	58	—22	0.6	44
30	..	..	....	....	....	....	....	....	....	..	....	....	..
31	..		...	....	....	....	....	....	....	..	....	....	..
Aver.	14	62	7.7	487,000	35	470,000	64	88	55	64	19	1.2	26

TABLE No. 6—DISINFECTION BY CHLORINE GAS.

JUNE, 1914, CHLORINE TANK No. 4.

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Gelatin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	16	55	6.6	Sterile	100	Sterile	100	88	53	86	11	2.00	30
2.....	15	60	7.2	"	100	"	100	96	49	64	21	2.00	30
3.....	16	46	5.5	"	100	"	100	85	24	57	21	2.00	50
4.....	16	60	7.2	"	100	"	100	74	33	60	2	2.2	30
5.....	16	85	10.2	"	100	"	100	30	79	61	12	2.2	21
6.....	16	71	8.5	"	100	68,000	93	132	50	59	21	1.3	37
7.....	16	60	7.2	100,000	88	Sterile	100	76	42	54	21	1.7	21
8.....	17	71	8.5	20,000	99	576,000	66	92	69	80	16	0.3	15
9.....	16	85	10.2	400,000	63	104,000	94	90	54	75	13	2.73	28
10.....	16	71	8.5	93,000	90	Sterile	100	64	51	53	17	2.00	38
11.....	16	60	7.2	Sterile	100	"	100	105	31	57	21	1.90	28
12.....	17	60	7.2	"	100	"	100	78	64	37	22	1.1	24
13.....	17	60	7.2	"	100	"	100	68	43	53	23	1.5	40
14.....	17	60	7.2	13,000	99	832,000	+17	84	36	51	9	0.0	11
15.....	17	60	7.2	720,000	38	Sterile	100	62	74	72	17	1.6	27
16.....	16	55	6.6	Sterile	100	14,000	99	100	44	78	0	1.6	17
17.....	16	60	7.2	8,000	....	Sterile	100	50	66	46	31	2.1	35
18.....	16	126	15.2	Sterile	100	"	100	50	64	56	16	1.7	28
19.....	16	126	15.2	"	....	"	100	64	24	44	14	1.8	34
20.....	16	71	8.5	800,000	52	664,000	63	64	66	54	33	0.0	23
21.....	16	154	18.5	600,000	51	740,000	59	44	58	42	25	2.2	..
22.....	17	100	12.0	332,000	83	508,000	66	62	63	71	+1½	1.2	15
23.....	17	23	27.7	640,000	45	268,000	79	76	71	68	22	1.2	15
24.....	17	..	....	1,000,000	+9	1,080,000	22	60	63	53	27	Trace	15
25.....	18	..	....	1,120,000	+2	1,175,000	31	68	64	60	17	0.0	15
26.....	18	152	18.2	416,000	?	640,000	94	80	23	51	14	1.2	24
27.....	18	152	18.2	7,000	97	18,000	99	100	22	54	10	1.2	30
28.....	18	294	35.3	Sterile	100	Sterile	100	68	49	46	23	2.2	37
29.....	18	340	40.8	"	100	"	100	92	72	73	23	1.4	17
30.....	18	191	22.9	"	100	"	100	82	64	69	11	1.3	23
Aver...	17	100	13	209,000	79	223,000	83	76	56	59	20	1.5	26

Table No. 6—Disinfection by Chlorine Gas.

July, 1914. Chlorine Tank No. 4.

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Gelatin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	18	152	18.2	760,000	—47	776,000	57	65	55	55	30	0.55	30
2.....	18	152	18.2	Sterile	100	Sterile	100	42	84	51	25	2.1	44
3.....	18	190.8	22.9	"	100	"	100	80	58	45	37	2.0	30
4.....	..	....	....	....	....	....	....	....	..	..	..	....	..
5.....	18	190.8	22.9	Sterile	100	Sterile	100	60	42	50	23	2.5	30
6.....	18	320	38.4	800,000	—64	432,000	—53	96	82	80	17	1.3	30
7.....	18	68.6	8.2	47,000	—95	76,000	92	67	32	51	23	1.7	30
8.....	18	167	20	Sterile	100	Sterile	100	73	51	65	19	1.5	30
9.....	18	106	12.7	"	100	"	100	86	41	68	11	1.7	30
10.....	18	84	10.1	20,000	98	25,000	98	65	59	55	25	1.3	30
11.....	18	151.7	18.2	200,000	81	250,600	84	162	56	57	23	1.2	30
12.....	18	127	15.2	....	....	Sterile	100	62	75	49	31	2.5	37
13.....	19	151.7	18.2	400,000	55	536,000	45	156	69	79	25	.8	8
14.....	19	90	10.8	29,000	95	5,000	99	79	59	61	18	.9	21
15.....	18	90	10.8	Sterile	100	Sterile	100	94	12	56	20	2.3	30
16.....	19	68.8	8.3	....	....	586,000	55	145	42	66	30	.2	30
17.....	19	90	10.8	....	....	Sterile	100	43	48	51	16	2.1	..
18.....	19	90	10.8	....	....	"	100	36	72	57	6	1.6	30
19.....	19	127	15.2	150,000	86	250,000	79	39	71	39	50	1.1	44
20.....	19	82.1	9.8	3,000	99	Sterile	100	86	63	72	16	1.7	9
21.....	..	..	....	....	....	....	....	....	..	..	..	...	..
22.....	..	....	....	....	....	....	....	....	..	..	..	...	..
23.....	..	....	....	....	....	....	....	....	..	..	..	..	..
24.....	..	....	....	....	....	....	....	....	..	..	..	...	..
25.....	..	Removing Sludge from Tanks			....	....	....	....	..	..	..		..
26.....	..	....	....	....	....	....	....	....	..	..	..	...	..
27.....	..	....	....	....	....	....	....	....	..	..	..	...	..
28.....	..	....	....	....	....	....	....	....	..	..	..	...	..
29.....	..	....	....	....	....	....	....	....	..	..	..	...	..
30.....	..	....	....	....	....	....	....	....	..	..	..	...	..
31.....	..	....	....	....	....	....	....	....	..	..	..	...	..
Aver...	18	132	15	162,000	84	155,000	88	81	60	58	32	1.5	29

TABLE No. 6—DISINFECTION BY CHLORINE GAS.

AUGUST, 1914. CHLORINE TANK No. 4.

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Gelatin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	..	....	....	....	....	....	....	....	....	..	....	....	..
2.....	..	....	....	....	....	....	....	....	....	..	....	....	..
3.....	19	126	15	296,000	43	....	....	115	—16	65	16	0.0	..
4.....	19	154	18.5	Sterile	100	....	....	97	+ 9	51	+	1.0	..
5.....	19	100	12	"	100	....	....	75	+ 2	58	+	1.7	..
6.....	19	100	12	"	100	....	....	22	+15	52	+	1.5	..
7.....	19	126	15	"	100	....	....	66	0	49	0.0	1.9	..
8.....	19	127	15.2	"	100	....	....	65	—12	51	12.0	1.4	..
9.....	19	106	12.7	160,000	75	....	....	115	+ 5	41	+	Trace	..
10.....	20	85	10.2	Sterile	100	....	....	89	+10	70	+	0.5	..
11.....	20	100	12	....	....	....	....	79	— 6	52	+	0.0	..
12.....	20	....	....	....	....	....	....	80	—12	43	+	0.0	..
13.....	20	....	....	....	....	....	....	81	—22	43	16	0.0	..
14.....	..	....	....	....	....	....	....	78	—20	44	20	0.0	..
15.....	..	....	....	....	....	....	....	79	—28	43	29	....	..
16.....	..	....	....	....	....	....	....	....	....	....	....	....	..
17.....	..	....	....	....	....	....	....	....	....	..	..	....	..
18.....	..	154	18.5	....	....	....	....	99	— 5	81	+	....	..
19.....	..	120	15.2	....	....	....	....	78	—21	55	22	....	..
20.....	..	154	18.5	....	....	....	....	127	—14	50	14	....	..
21.....	..	100	12	....	....	....	....	81	—13	45	14	....	..
22.....	..	126	15.2	....	....	....	....	73	—13	..	..	....	..
23.....	..	....	....	....	....	....	....	....	....	..	..	....	..
24.....	20	71	8.5	....	....	....	....	87	—22	79	22	....	..
25.....	..	126	15.2	....	....	....	....	76	—16	65	17	....	..
26.....	19	71	8.5	....	....	....	....	69	—10	53	10	....	..
27.....	19	126	15.2	....	....	....	....	79	—18	57	19	....	..
28.....	19	154	18.5	....	....	....	....	86	—16	62	+	....	..
29.....	19	100	12	....	....	....	....	107	— 3	60	+	....	..
30.....	..	....	....	....	....	....	....	....	....	....	—	....	..
31.....	19	154	18.5	....	....	....	....	....	....	..	—	....	..
Aver...	19	118	14.3	57,000	93	....	....	83	40	55	9	0.65	..

Table No. 6—Disinfection by Chlorine Gas.

September, 1914. Chlorine Tank No. 4.

Date	Tem-pera-ture	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduc-tion	Bacteria on Gelatin at 20°	Per Cent Reduc-tion	Suspended Solids, P.P.M.	Per Cent Reduc-tion	Oxygen Consumed, P.P.M.	Per Cent Reduc-tion	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1	20	154	18.5	660,000	..	396,000	..	74	....	..	....	....	..
2	20	154	18.5	552,000	68	356,000	82	45	....	..	....	....	..
3	20	154	18.5	440,000	68	640,000	79	51	....	..	....	....	..
4	20	126	15.2	620,000	19	375,000	25	67	....	..	....	....	..
5	20	154	18.5	....	....	....	81	50	....	....	....	....	..
6	20	126	15.2	....	....	....	....	144	....	....	....	....	..
7	20	100	12.0	872,000	43	840,000	49	65	....	....	....	....	..
8	19	100	12.0	....	....	....	....	95	....	....	....	....	..
9	..	....	....	....	....	....	....	....	....	....	....	....	..
10	..	....	....	....	....	....	....	....	....	....	....	....	..
11	..	....	....	....	....	....	....	....	....	....	....	....	..
12	..	....	....	....	....	....	....	....	....	....	....	....	..
13	..	Cleaning	Tanks	....	....	....	....	....	....	....	....	....	..
14	..	....	....	....	....	....	....	....	....	....	....	....	..
15	..	....	....	....	....	....	....	....	....	....	....	....	..
16	..	....	....	....	....	....	....	....	....	....	....	....	..
17	..	....	....	....	....	....	....	....	....	....	....	....	..
18	..	....	....	....	....	....	....	....	....	....	....	....	..
19	..	....	....	....	....	....	....	....	....	....	....	....	..
20	..	....	....	....	....	....	....	....	....	....	....	....	..
21	..	....	....	....	....	....	....	....	....	....	....	....	..
22	..	....	....	....	....	....	....	....	....	....	....	....	..
23	..	....	....	....	....	....	....	....	....	....	....	....	..
24	..	....	....	....	....	....	....	....	....	66	....	....	..
25	17	....	....	....	....	....	....	....	....	62	—70	....	..
26	17	....	....	....	....	....	....	....	....	54	—18	....	..
27	17	....	....	....	....	....	....	....	....	86	—35	....	..
28	17	....	....	....	....	....	....	....	....	72	—23	....	..
29	17	....	....	....	....	....	....	....	....	70	—23	....	..
30	17	....	....	....	....	....	....	....	....	....	—17	....	..
Aver.	19½	134	16	628,000	55	521,000	68	74	18	66	....	....	..

Table No. 6—Disinfection by Chlorine Gas.

October, 1914. Chlorine Tank No. 4.

Date	Temperature	Lbs. of Chlorine Gas per Million Gallons	Parts per Million	Bacteria on Agar at 37.5°	Per Cent Reduction	Bacteria on Gelatin at 20°	Per Cent Reduction	Suspended Solids, P.P.M.	Per Cent Reduction	Oxygen Consumed, P.P.M.	Per Cent Reduction	Dissolved Oxygen 1 Per Cent Solution	Relative Stability
1.....	17	....	....	688,000	+72	1,296,000	+14	....	....	50	—25	....	..
2.....	17	....	....	624,000	38	535,000	34	....	....	61	—13	....	..
3.....	17	....	....	528,000	61	736,000	21	....	....	54	—26	....	..
4.....	17	....	....	....	....	....	....	....	....	35	—34	....	..
5.....	17	....	....	1,008,000	+47	1,064,000	+33	....	....	74	—23	....	..
6.....	17	....	....	720,000	41	1,352,000	21	....	....	61	—16	Trace	..
7.....	17	....	....	968,000	16	1,016,000	24	....	....	57	—38	0.3	..
8.....	17	....	....	328,000	64	....	....	....	....	52	—40	0.4	..
9.....	18	83	10	774,000	17	1,200,000	12	47	—53	50	—49	....	..
10.....	18	155	18.6	1,128,000	24	1,040,000	32	47	—65	52	—36	0.3	..
11.....	18	83	10	....	....	....	....	37	—63	45	—41	....	..
12.....	18	83	10	....	....	....	....	29	—84	57	—37	....	..
13.....	17	68	8.2	1,192,000	....	1,072,000	21	59	—65	55	—43	....	..
14.....	17	68	8.2	1,128,000	....	1,414,000	57	64	—41	65	— 3	....	..
15.....	17	68	8.2	754,000	9	720,000	44	59	—55	67	— 1	....	..
16.....	17	68	8.2	480,000	21	950,000	21	58	—37	47	—23	....	..
17.....	17	51	6.1	1,312,000	14	900,000	45	57	—77	47	—48	....	..
18.....	17	42	5.1	....	....	....	....	69	—44	52	—26	....	..
19.....	17	66	8.0	640,000	51	1,212,000	55	82	—75	66	—35	....	..
20.....	17	63	7.6	584,000	+20	1,424,000	+78	44	—79	55	—42	....	..
21.....	17	51	6.1	456,000	44	1,256,000	—17	32	—65	57	—20	....	..
22.....	17	63	7.6	520,000	50	1,040,000	—31	34	—73	43	—25	....	..
23.....	16	63	7.6	456,000	+14	1,264,000	—32	55	—54	47	—39	....	..
24.....	16	63	7.6	624,000	16	1,464,000	+10	55	—54	44	—36	....	..
25.....	16	42	5.1	....	....	....	....	64	—53	50	—31	....	..
26.....	16	39	4.6	....	....	1,210,000	—32	68	—69	66	—28	....	..
27.....	15	51	6.1	....	....	785,000	—65	45	—63	55	—29	....	..
28.....	15	55	6.6	....	....	1,020,000	—23	49	—60	48	—26	....	..
29.....	15	63	7.6	....	....	1,250,000	—11	60	—53	53	—20	....	..
30.....	15	55	6.6	....	....	....	....	63	—48	54	—18	....	..
31.....	15	55	6.6	....	....	....	....	54	—52	43	—12	....	..
Aver...	16	65	7.8	745,000	21	1,097,000	18	54	57	55	25	....	..

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TABLE No. 7—UNSETTLED SEWAGE TREATED WITH HYPOCHLORITE OF LIME

	Hypochlorite of Lime		Bacteria (1,000) On Agar		Bacteria (1,000) On Gelatin		Suspended Solids		Oxygen Consumed	
October, 1914	Pounds per Million Gallons	P.P.M.	37.5°	% Reduction	20°	% Reduction	P.P.M.	% Reduction	P.P.M.	% Reduction
1......	48	57.5	280	30	584	+12	..	..	45	..
2......	35	42	984	1.6	1,160	+43	..	..	64	..
3......	37	44	676	47	800	14	..	..	45	..
4......	..	...	...	...	...	...	..	..	49	..
5......	36	43	840	+22	960	+20	..	..	62	..
6......	44	53	1,096	99	1,708	—18	..	..	67	..
7......	36	43	1,056	7	1,296	—30	..	..	66	..
8......	56	67	760	28	920	—33	..	..	52	..
9......	56	67	792	15	1,240	— 9	44	75	45	..
10......	65	78	1,008	32	992	—34	53	80	55	..
11......	...	...	...	...	...	...	57	43	48	47
12......	...	...	...	...	...	...	78	57	74	38
13......	42	50	1,288	6	1,480	+ 9	87	49	64	65
14......	54	65	1,140	5	1,576	+ 5	63	34	67	..
15......	56	67	784	6	984	23	67	46	50	—27
16......	62	74	512	16	895	25	56	38	52	15
17......	62	74	1,240	+8	1,472	11	66	70	48	48
18......	...	...	...	...	...	...	60	52	56	20
19......	50	60	608	54	1,208	54	125	58	83	19
20......	50	60	712	+46	1,032	+18	60	71	58	37
21......	52	62	480	37	1,464	37	25	75	57	20
22......	60	72	616	40	1,184	21	41	65	49	26
23......	49	59	340	15	1,320	30	56	20	55	19
24......	...	...	720	4	1,248	6	65	46	51	16
25......	...	...	...	...	...	...	70	49	55	29
26......	51	61	...	...	1,320	26	69	69	66	28
27......	...	...	...	...	795	5	54	56	60	23
28......	...	...	...	...	1,010	23	57	53	51	22
29......	...	...	...	...	1,210	13	59	54	49	22
30......	...	...	...	...	...	...	67	46	57	24
31......	...	...	...	...	...	...	65	42	54	7
Aver....	50	60	796	79	1,161	13	63	50	56	23
November										
1......	...	...	...	..	...	..	61	37	46	24½
2......	143	170	650	51	140	83	65	15	64	65
3......	118	142	1,040	..	...	..	58	35	69	3
4......	87	102	254	76	90	94	71	54	56	16
5......	87	102	125	85	125	23	53	60	54	15
6......	90	108	...	..	784	50	79	48	60	15
7......	90	108	...	..	351	78	72	47	47	37
8......	124	148	...	..	...	..	48	58	57	24
9......	124	148	95	96	1,064	32	89	59	75	4
10......	138	166	1,280	74	752	53	69	47	76	13
11......	138	166	800	28	720	51	76	40	65	10
12......	122	148	750	39	325	88	54	52	57	26
13......	113	184	...	..	...	..	66	39	60	10
14......	116	138	720	29	...	..	65	55	56	21
15......	92	110	...	..	...	..	65	50	54	30
16......	116	138	368	44	504	31	55	65	66	29
17......	131	156	...	..	...	..	52	73	67	23
18......	128	151	81	93	...	..	62	50	67	16
19......	100	120	...	..	...	..	54	50	52	22
20......	73	86	26	98	...	..	39	67	50	30
21......	91	109	680	60	...	..	56	65	62	22
22......	91	109	...	..	...	..	15	29	51	36
23......	91	109	40	96	265	82	60	54	68	28
24......	51	61	35	96	384	73	53	23	67	7
25......	110	132	65	96	...	..	67	70	67	31
26......	91	109	...	..	...	..	65	58	71	28
27......	110	132	25	98	400	74	67	49	66	12
28......	110	132	...	..	...	..	84	48	64	+23
29......	91	109	...	..	...	..	57	53	55	30
30......	79	95	...	..	30	98	78	66	65	31
Aver....	105	127	359	91	308	80	62	55	61	29

Table No. 8—Effluent from Imhoff Tank No. 6 with Colloidors

November, 1914	Bacteria (1,000) On Agar 37.5°	% Reduction	Bacteria (1,000) On Gelatin 20°	% Reduction	Suspended Solids P.P.M.	% Reduction	Oxygen Consumed P.P.M.	% Reduction	Oxygen Absorbed After 5 days Incubation at 20° P.P.M.	% Reduction
1......	...	..	...	..	47	50	34	50	...	..
2......	675	49	1,120	22	64	67	69	16	...	..
3......	...	..	...	..	64	28	64	10	...	..
4......	952	33	1,500	7	54	66	55	30	...	..
5......	368	58	556	65	62	54	52	30	...	..
6......	1,600	..	384	62	77	47	56	19	...	..
7......	...	..	795	50	70	48	44	41	...	..
8......	...	..	...	..	46	60	58	34	...	..
9......	1,240	..	1,280	20	55	75	77	2	341	53
10......	1,752	17	1,352	14	113	13	63	26	290	29
11......	1,380	..	1,220	17	64	49	61	16	199	57
12......	950	23	1,320	23	81	28	60	22	445	45
13......	...	..	...	..	63	42	54	19	355	20
14......	760	25	1,000	45	75	49	60	15	460	11
15......	...	..	...	..	70	46	52	32	...	..
16......	960	..	1,080	..	46	69	66	29	297	49
17......	...	..	...	..	65	66	65	25	910	..
18......	568	59	704	55	69	45	61	24	240	45
19......	560	49	680	49	56	49	54	19	240	34
20......	880	27	480	63	65	44	57	20	272	9
21......	1,600	5	1,440	32	71	55	52	35	...	..
22......	...	..	...	..	11	49	39	51	...	..
23......	1,040	..	910	34	50	60	62	35	573	..
24......	1,084	..	880	39	67	3	58	29	361	..
25......	1,021	..	824	49	76	65	66	70	348	58
26......	...	..	...	..	78	53	67	59	352	26
27......	950	..	1,120	26	49	63	53	60	...	..
28......	...	..	875	46	60	67	57	69	429	..
29......	...	..	...	..	62	49	49	59	...	..
30......	...	..	712	53	70	70	55	76	626	..
Aver....	1,019	13	965	36	63	55	57	49	396	17
December										
1......	728	0	912	11	55	57	46	38	348	50
2......	820	12	1,200	3	64	57	47	27	356	44
3......	750	12	1,096	0	59	61	44	25	455	..
4......	872	14	1,088	13	15	50	49	23	313	26
5......	528	..	624	..	61	67	50	37	589	..
6......	...	..	...	..	61	54	46	25	...	..
7......	536	30	712	32	65	65	43	24	73	72
8......	864	..	563	30	59	54	46	8	161	45
9......	280	68	880	9	62	67	36	45	198	..
10......	624	22	680	41	50	79	43	43	701	..
11......	648	..	610	..	65	50	36	29	189	21
12......	776	30	480	63	58	69	35	37	379	26
13......	...	..	...	..	95	43	34	37	...	..
14......	620	26	620	38	79	61	48	27	366	43
15......	648	16	520	35	54	50	50	22	659	25
16......	...	..	...	..	55	67	33	30	332	59
17......	715	22	675	40	55	64	33	15	277	34
18......	...	..	...	..	54	67	32	40	422	26
19......	424	37	576	54	44	62	34	30	...	..
20......	...	..	...	..	57	62	30	27	...	..
21......	630	32	725	35	80	40	33	50	220	32
22......	585	29	640	35	61	70	42	37	248	26
23......	496	59	832	47	49	60	30	41	257	20
24......	585	48	368	73	42	67	24	56	105	60
25......	...	..	...	..	..	..	..	..	...	..
26......	...	..	...	..	56	67	48	20	...	..
27......	...	..	...	..	53	70	35	38	...	..
28......	520	38	560	25	60	80	42	44	...	..
29......	492	38	...	..	115	72	35	37	...	..
30......	510	38	...	..	59	67	36	30	...	..
31......	430	39	621	26	59	67	38	30	260	25
Aver....	612	27	713	23	60	64	39	34	329	22

TABLE NO. 8—EFFLUENT FROM IMHOFF TANK NO. 6 WITH COLLOIDORS

January, 1915	Bacteria (1,000) On Agar 37.5°	On Agar % Reduction	Bacteria (1,000) On Gelatin 20°	On Gelatin % Reduction	Suspended Solids P.P.M.	Suspended Solids % Reduction	Oxygen Consumed P.P.M.	Oxygen Consumed % Reduction	Oxygen Absorbed After 5 Days Incubation at 20° P.P.M.	Oxygen Absorbed % Reduction
1......	...	..	...	..	..	..	..	..	...	..
2......	...	..	...	..	66	64	36	34	...	..
3......	...	..	...	..	53	63	33	45	...	..
4......	616	7	632	51	39	78	37	52	485	14
5......	520	39	544	44	58	52	35	24	487	5
6......	728	16	752	34	79	54	31	34	350	..
7......	560	15	720	40	49	67	32	27	408	..
8......	472	40	600	35	16	83	34	26	492	9
9......	448	50	576	36	56	68	35	30	367	29
10......	...	..	...	..	55	59	28	39	...	..
11......	701	20	640	37	74	59	40	46	188	25
12......	496	..	392	29	75	43	30	14	252	51
13......	496	29	504	52	45	50	23	5	529	..
14......	568	29	560	39	89	54	30	27	350	36
15......	504	41	648	42	62	41	31	12	818	..
16......	560	31	575	37	68	50	44	8	494	..
17......	...	..	...	..	41	73	26	43	...	..
18......	600	..	360	40	40	57	19	21	378	29
19......	168	86	141	81	56	53	29	55	378	..
20......	544	41	496	46	45	65	27	37	340	26
21......	256	49	615	49	47	68	38	31	441	..
22......	320	40	413	55	49	55	44	20	683	..
23......	441	49	475	46	58	55	28	43	459	11
24......	...	..	...	..	42	50	35	40	...	..
25......	320	44	512	10	104	48	44	25	365	28
26......	520	38	417	69	46	71	42	37	935+	..
27......	630	..	264	22	42	53	32	27	628	31
28......	624	0	10	73	48	49	34	17	388	28
29......	640	..	480	8	52	50	36	22	369	44
30......	408	34	464	62	40	67	34	39	467	13
31......	...	..	...	..	48	39	36	25	...	..
Aver....	506	32	745	21	55	59	33	..	461+	1½
February										
1......	...	..	320	58	42	64	26	26	...	..
2......	328	80	488	28	24	44	24	38	...	..
3......	480	20	510	71	38	44	30	14	...	..
4......	704	89	620	37	48	56	29	38	...	..
5......	432	53	431	74	42	56	24	37	...	..
6......	480	..	652	54	38	64	18	25	...	..
7......	...	..	...	..	30	63	18	31	...	..
8......	488	34	344	49	42	76	29	46	...	..
9......	505	38	410	42	46	50	28	28	...	..
10......	664	8	528	45	34	65	26	35	...	..
11......	560	38	328	65	62	37	29	29	...	..
12......	...	..	...	..	50	53	31	28	...	..
13......	240	67	304	71	44	54	32	43	...	..
14......	...	..	...	..	40	45	44	20	...	..
15......	512	51	499	54	59	63	36	13	...	..
16......	600	64	504	70	53	53	32	27	...	..
17......	...	..	...	..	60	63	32	22	...	..
18......	200	61	444	43	42	57	25	50	...	..
19......	680	29	608	14	14	92	30	27	...	..
20......	...	..	...	..	56	56	36	00	...	..
21......	...	..	...	..	46	65	28	38	...	..
22......	...	..	...	..	63	71	29	34	...	..
23......	688	..	640	29	100	49	31	24	...	..
24......	624	20	528	42	118	46	28	44	...	..
25......	408	24	368	52	48	50	22	46	...	..
26......	648	29	824	44	52	49	26	26	...	..
27......	...	..	...	..	60	48	26	42	...	..
28......	...	..	...	..	54	49	27	27	...	..
Aver....	513	37	491	53	49	58	28	32	...	..

TABLE NO. 8—EFFLUENT FROM IMHOFF TANK NO. 6 WITH COLLOIDORS

March, 1915	Bacteria (1,000) On Agar 37.5°	% Reduction	On Gelatin 20°	% Reduction	Suspended Solids P.P.M.	% Reduction	Oxygen Consumed P.P.M.	% Reduction	Oxygen Absorbed After 5 days Incubation at 20° P.P.M.	% Reduction
1......	384	43	560	33	59	53	39	25	409	21
2......	464	47	360	59	36	68	35	27	490	20
3......	604	10	560	52	52	61	29	19	508	29
4......	424	78	624	58	58	50	31	30	691	..
5......	544	..	480	..	77	59	34	30	889	2
6......	636	31	640	50	87	58	31	28	209	58
7......	...	..	...	..	54	60	29	30	...	..
8......	288	70	568	41	70	66	40	40	873+	..
9......	672	23	584	60	57	75	37	39	857	..
10......	542	52	640	58	58	56	31	29	915+	..
11......	480	40	768	38	57	56	26	30	881+	..
12......	815	21	912	27	69	..	34	00	604	..
13......	416	21	816	38	67	55	35	22	672	11
14......	...	..	...	..	61	60	29	26	...	..
15......	780	21	824	44	85	70	49	30	450	30
16......	696	16	1,078	39	91	59	59	18	400	16
17......	776	15	632	55	58	68	54	16	459	16
18......	648	20	820	46	64	58	45	75	574	30
19......	784	28	915	43	90	47	38	33	559	3
20......	360	50	1,080	29	84	52	46	20	808	..
21......	...	..	...	..	88	48	42	20	...	..
22......	896	35	798	50	76	71	60	..	550	17
23......	800	31	1,016	29	56	58	46	12	476	15
24......	856	26	1,004	30	59	49	44	14	476	10
25......	520	35	504	54	65	62	44	15	836	6
26......	370	37	604	17	76	51	43	19	511	20
27......	480	24	416	71	76	42	56	12	380	48
28......	...	..	...	..	69	60	46	33	...	..
29......	...	..	...	..	82	58	67	15	...	..
30......	...	..	...	..	70	52	45	24	...	..
31......	760	44	960	33	72	56	49	17	...	..
Aver....	600	36	725	45	68	58	42	12	603	6

Table No. 9—Effluent from Imhoff Tank No. 8 without Colloidors.

November, 1914	Bacteria (1,000) On Agar 37.5°	% Reduction	Bacteria (1,000) On Gelatin 20°	% Reduction	Suspended Solids P.P.M.	% Reduction	Oxygen Consumed P.P.M.	% Reduction	Oxygen Absorbed After 5 Days Incubation at 20° P.P.M.	% Reduction
1......	...	..	...	..	54	44	34	44	...	..
2......	1,200	9	1,520	..	63	68	56	32	...	..
3......	...	..	...	..	66	26	56	21	...	..
4......	1,130	9	1,415	12	46	70	48	39	...	..
5......	880	..	1,865	..	59	56	56	25	...	..
6......	975	4	1,128	20	75	48	46	33	...	..
7......	...	..	985	38	80	48	39	48	...	..
8......	...	..	...	..	41	64	39	56	...	..
9......	1,440	..	1,264	22	49	77	71	9	329	55
10......	...	..	1,350	16	73	44	61	28	343	16
11......	1,125	0	1,475	8	63	50	53	26	233	49
12......	940	24	1,529	11	42	62	54	30	161	20
13......	...	..	...	65	40	55	55	18	605	..
14......	904	10	1,056	42	64	56	53	25	520	..
15......	...	..	...	..	76	36	51	34	...	..
16......	824	..	1,008	..	66	58	74	20	182	63
17......	...	..	...	..	52	73	62	29	925	..
18......	560	51	606	61	58	54	58	28	255	40
19......	1,144	2	720	45	67	38	53	20	627	..
20......	1,320	..	1,128	12	58	50	55	24	174	42
21......	1,625	2	1,406	34	41	74	47	41	...	42
22......	...	..	...	..	10	50	59	26	...	..
23......	1,110	..	1,340	3	60	54	70	26	...	..
24......	1,080	0	1,124	21	73	..	56	22	...	..
25......	920	10	960	40	69	69	61	37	...	..
26......	...	..	...	..	77	52	57	33	...	..
27......	1,001	..	990	35	65	50	56	26	...	..
28......	...	..	1,200	26	65	64	52	0	...	..
29......	...	..	...	..	55	55	55	30	...	..
30......	...	..	912	40	64	72	50	47	401	..
Aver....	1,069	9	1,189	22	60	57	55	33	396	16
December										
1......	75	89	1,200	12	59	55	46	38	...	..
2......	920	00	1,100	11	51	65	33	49	...	..
3......	850	10	856	14	62	60	40	32	...	..
4......	712	30	1,032	12	15	50	45	30	...	..
5......	810	..	1,010	..	..	..	..	..	...	..
6......	...	..	...	..	70	47	55	10	...	..
7......	656	15	576	46	73	66	43	26	...	..
8......	616	28	760	5	57	56	40	20	...	..
9......	456	43	880	10	57	70	42	36	...	..
10......	504	..	616	46	62	75	43	43	...	..
11......	...	..	...	..	69	48	34	34	...	..
12......	17	84	...	..	65	59	36	36	...	..
13......	...	..	...	..	75	55	34	37	...	..
14......	495	47	815	19	90	56	42	36	...	..
15......	552	30	768	4	53	50	48	25	...	..
16......	...	..	...	..	58	58	41	16	...	..
17......	412	55	790	29	56	64	35	10	...	..
18......	...	..	...	..	43	74	31	40	...	..
19......	368	46	480	61	32	73	28	40	...	..
20......	...	..	...	..	48	68	26	34	...	..
21......	850	7	942	16	92	30	39	40	...	..
22......	710	14	920	0.7	77	64	41	39	...	..
23......	696	47	800	48	43	65	29	43	...	..
24......	721	36	424	73	34	74	25	44	...	..
25......	...	..	...	..	..	..	..	..	...	..
26......	...	..	...	..	62	64	41	30	...	..
27......	...	..	...	..	47	73	29	49	...	..
28......	824	2	832	..	64	79	40	34	...	..
29......	816	..	...	..	116	72	35	37	...	..
30......	740	10	...	..	57	69	31	39	...	..
31......	705	00	791	6	40	78	30	45	...	..
Aver....	614	27	820	22	58	65	37	36	...	..

TABLE NO. 9—EFFLUENT FROM IMHOFF TANK NO. 8 WITHOUT COLLOIDORS.

January, 1915	Bacteria (1,000) On Agar 37.5°	On Agar % Reduction	On Gelatin 20°	On Gelatin % Reduction	Suspended Solids P.P.M.	Suspended Solids % Reduction	Oxygen Consumed P.P.M.	Oxygen Consumed % Reduction	Oxygen Absorbed After 5 days Incubation at 20° P.P.M.	Oxygen Absorbed % Reduction
1......	...	..	...	..	..	..	..	..	...	..
2......	...	..	...	..	47	74	30	46	...	..
3......	...	..	...	..	41	72	33	45	...	..
4......	504	23	536	56	74	58	44	44	367	35
5......	568	39	640	34	52	57	36	20	369	28
6......	696	28	704	58	66	62	31	34	571	..
7......	296	55	344	31	46	69	27	39	295	10
8......	744	6	632	31	29	68	33	28	322	40
9......	376	58	432	67	74	58	36	28	362	28
10......	...	..	...	..	40	70	26	43	...	..
11......	604	39	560	45	64	64	35	53	368	..
12......	640	..	544	..	63	52	27	22	667	..
13......	20	97	...	100	37	60	21	10	250	..
14......	520	35	800	23	45	77	29	29	636	..
15......	30	65	60	33	58	45	30	14	854	..
16......	512	37	384	65	74	46	37	23	546	..
17......	...	..	...	..	22	86	26	43	...	..
18......	560	3	768	..	51	45	23	1	447	15
19......	528	56	610	20	54	55	32	24	565	..
20......	416	55	536	42	37	71	34	20	270	40
21......	400	10	510	57	25	83	32	42	557	..
22......	350	36	490	46	49	55	37	33	539	..
23......	410	53	512	31	65	49	34	30	352	32
24......	...	..	...	..	52	40	52	1	...	..
25......	392	31	520	22	100	50	100	..	449	11
26......	600	28	415	69	49	68	49	26	...	..
27......	592	..	328	3	30	66	30	30	...	..
28......	Sterile	100	595	..	45	52	45	..	440	51
29......	674	..	520	00	48	54	48	..	529	10
30......	192	69	480	60	36	74	36	35	502	34
31......	...	..	...	..	32	60	32	67	...	..
Aver....	443	41	497	47	50	38	36	26	466	..
February										
1......	464	71	392	50	50	57	24	31	...	..
2......	408	32	640	5	48	..	24	38	...	..
3......	480	25	360	78	53	23	22	37	...	..
4......	568	39	592	39	48	56	33	30	...	..
5......	416	12	425	73	39	59	28	26	...	..
6......	352	47	480	66	38	50	18	25	...	..
7......	...	..	...	..	22	73	17	27	...	..
8......	312	58	400	40	40	77	28	50	...	..
9......	395	51	391	45	31	67	29	26	...	..
10......	720	00	536	44	37	67	28	30	...	..
11......	336	57	464	50	41	63	18	56	...	..
12......	...	..	...	..	52	52	36	16	...	..
13......	332	53	260	76	44	54	40	29	...	..
14......	...	..	...	..	41	44	36	12	...	..
15......	688	34	560	50	69	58	37	16	...	..
16......	712	57	440	74	83	27	36	12	...	..
17......	...	..	...	..	52	69	35	30	...	..
18......	414	19	370	50	46	52	29	29	...	..
19......	520	43	472	33	20	75	28	20	...	..
20......	...	..	...	..	35	67	32	29	...	..
21......	...	..	...	..	52	60	26	27	...	..
22......	...	..	...	..	57	74	32	27	...	..
23......	536	..	480	46	102	48	33	19	...	..
24......	495	37	510	45	91	58	26	48	...	..
25......	672	..	520	32	47	50	21	49	...	..
26......	716	21	696	54	54	48	30	14	...	..
27......	...	..	...	..	52	55	24	47	...	..
28......	...	..	...	..	65	38	25	30	...	..
Aver....	502	38	473	55	50	57	28	30	...	..

TABLE No. 9—EFFLUENT FROM IMHOFF TANK No. 8 WITHOUT COLLOIDORS.

March, 1915	Bacteria (1,000) On Agar 37.5°	On Agar % Reduction	On Gelatin 20°	On Gelatin % Reduction	Suspended Solids P.P.M.	Suspended Solids % Reduction	Oxygen Consumed P.P.M.	Oxygen Consumed % Reduction	Oxygen Absorbed After 5 Days Incubation at 20° P.P.M.	Oxygen Absorbed % Reduction
1......	520	24	688	18	67	48	40	23	483	6
2......	392	55	440	50	42	63	35	22	557	6
3......	368	45	640	44	75	44	41	..	524	27
4......	232	98	360	75	61	48	28	38	225	58
5......	632	..	352	..	82	49	30	39	889	2
6......	621	32	652	49	97	53	35	19	451	9
7......	...	..	...	..	67	51	29	30	...	..
8......	512	47	672	30	82	60	38	43	881+	..
9......	496	43	720	50	59	34	37	39	648	19
10......	528	53	672	56	62	53	28	26	905+	..
11......	680	15	552	55	54	59	28	25	572	..
12......	872	15	848	40	52	20	32	00	539	10
13......	544	..	680	48	62	58	37	11	907	..
14......	...	..	...	..	65	57	29	21	...	..
15......	704	29	885	40	98	65	45	36	566	11
16......	704	16	1,168	34	84	62	55	24	442	8
17......	665	27	915	35	78	58	56	13	632	..
18......	536	34	840	42	74	51	42	30	558	32
19......	592	45	1,040	31	118	30	41	28	526	10
20......	480	34	1,120	27	78	56	46	20	759	..
21......	...	..	...	..	79	53	35	34	...	..
22......	1,144	17	1,168	27	102	60	60	..	600	9
23......	784	..	1,156	29	65	52	43	18	557	0
24......	968	16	1,004	8	82	29	44	14	484	9
25......	544	32	640	41	76	56	42	19	900	..
26......	375	36	574	23	62	60	44	17	624	1
27......	332	47	420	31	81	38	47	27	707	3
28......	...	..	...	..	71	59	40	42	...	..
29......	...	..	...	..	76	61	62	21	...	..
30......	...	..	...	..	69	52	46	20	...	..
31......	880	35	1,040	28	89	..	51	23	650	..
Aver....	604	36	770	42	75	54	41	24	623	3

TABLE NO. 10—RESULTS OF SYPHON TANK.

November, 1915	Temperature, Centigrade	Suspended Solids P.P.M. Influent,	Suspended Solids P.P.M. Effluent,	Oxygen Consumed P.P.M. Influent,	Oxygen Consumed P.P.M. Effluent,	Settling Solids Influent,	Settling Solids Effluent,	Hours Sewage Running	Gallons per 24 Hours	Gallons in Eight Hours, 8 A.M. to 4 P.M.
5......	15	157	132	50	48	...	...	24	19,123	5,844
6......	15	160	110	59	53	...	...	24	10,910	6,188
7......	15	148	74	62	44	...	...	24	3,111	2,406
8......	15	370	198	61	68	7.0	1.0	24	16,527	7,056
9......	15	358	238	65	62	6.0	2.0	24	9,306	4,554
10......	15	214	136	58	54	2.2	1.0	12	8,355	4,874
11......	15	196	124	53	52	2.5	1.0	21	4,829	4,097
12......	15	148	136	48	41	2.5	1.0	24	15,910	5,690
13......	15	194	134	58	51	3.0	0.7	8	5,112	5,112
14......	15	222	184	57	54	3.0	2.0	11	5,653	4,513
15......	15	245	176	71	62	2.0	1.0	24	5,385	4,205
16......	15	240	174	58	52	2.3	1.0	24	13,183	4,692
17......	15	230	132	59	53	1.2	0.4	8	3,585	3,585
18......	..	...	...	..	..	...	...	4	1,926	1,926
19......	14	...	...	..	..	...	...	24	15,162	4,149
20......	14	238	174	74	57	2.5	1.0	24	9,489	3,242
21......	14	208	148	49	37	2.0	1.0	22	6,888	2,161
22......	14	324	192	82	58	5.0	1.5	24	5,579	2,296
23......	13	210	112	63	45	3.0	0.7	24	5,408	2,326
24......	13	174	114	46	33	3.0	0.3	24	7,344	4,227
25......	13	306	130	49	33	3.5	0.5	24	11,594	4,933
26......	13	212	116	45	40	3.0	1.2	24	19,340	7,056
27......	13	250	161	43	37	3.0	1.0	24	16,622	6,004
28......	13	172	114	45	38	3.0	1.0	24	13,281	4,568
29......	14	376	218	76	67	8.5	1.5	24	3,926	2,173
30......	14	286	176	59	52	4.8	1.8	17	5,360	4,381
Aver....	..	235	150	59	49	3.5	1.1	20½	11,840	5,475
Reduction............	..		36%	..	17%	...	69%	..	......	......

TABLE NO. 10—RESULTS OF SYPHON TANK.

December, 1915	Temperature, Centigrade	Suspended Solids P.P.M. Influent,	Suspended Solids P.P.M. Effluent,	Oxygen Consumed P.P.M. Influent,	Oxygen Consumed P.P.M. Effluent,	Settling Solids Influent,	Settling Solids Effluent,	Hours Sewage Running	Gallons Total Time Running	Gallons in Eight Hours, 8 A.M. to 4 P.M.
1......	13	192	166	46	30	2.2	0.8	24	13,684	4,756
2......	13	160	142	54	51	1.5	.7	23	9,223	3,724
3......	13	190	138	62	57	2.0	.7	22	14,321	6,084
4......	12	214	158	57	47	2.0	.8	18	9,936	4,579
5......	12	162	150	60	50	1.7	.7	24	6,276	3,556
6......	12	672	188	147	68	19.0	1.5	24	6,630	3,852
7......	12	184	144	50	43	2.0	.8	24	10,722	5,259
8......	12	176	144	54	40	1.5	.5	24	14,338	5,259
9......	12	186	124	61	55	2.0	.5	24	10,082	5,297
10......	..	...	...	..	..	...	...	..	......	......
11......	..	...	...	..	..	...	...	19	6,614	1,438
12......	11	184	156	76	65	1.5	.3	24	13,293	5,829
13......	11	316	160	82	64	4.0	.3	24	16,918	6,308
14......	11	282	142	86	70	3.8	1.0	24	19,735	5,310
15......	11	178	142	75	63	3.0	1.0	24	9,863	5,262
16......	11	378	174	88	65	4.0	.8	24	14,378	4,026
17......	11	226	190	63	58	2.0	1.0	24	14,013	5,395
18......	11	286	148	67	48	5.0	2.0	24	19,094	7,104
19......	11	200	148	67	54	2.3	1.0	24	12,109	3,811
20......	11	404	212	120	107	10.0	1.8	24	8,300	2,672
21......	11	260	176	87	79	4.0	1.0	24	9,267	3,400
22......	11	220	180	84	71	3.0	1.0	15	6,896	1,896
23......	11	238	138	60	60	2.5	1.0	24	3,286	4,377
24......	11	292	192	93	65	6.5	3.3	24	9,573	3,718
25......	11	246	170	79	59	3.5	1.0	24	10,605	5,383
26......	11	220	200	91	80	2.8	1.5	19	12,197	4,972
27......	11	1492	320	278	105	36.0	3.8	24	6,851	4,680
28......	11	284	204	96	81	5.2	2.0	24	16,865	4,452
29......	9	204	170	76	74	3.0	2.0	16	13,296	4,292
30......	11	254	206	95	89	3.0	1.6	24	8,185	4,240
31......	11	322	204	71	67	3.0	2.0	17	8,924	4,609
Average........		298	172	83	64	4.9	1.25	22.5	11,860	4,808
Reduction......		...	42%	...	23%	...	73%			

Table No. 10—Results of Syphon Tank.

January, 1916	Temperature, Centigrade	Suspended Solids, P.P.M.		Volatile Solids, P.P.M.		Settling Solids, P.P.M.		Oxygen Consumed, P.P.M.		Hours Sewage Running	Gallons, Total Time Running	Gallons in 8 Hours 8 A.M. to 4 P.M.
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent			
1.....	10	256	170	...	...	3.7	1.2	81	68	23	6,417	3,725
2.....	10	264	150	...	...	2.3	0.5	79	70	24	5,755	1,969
3.....	10	386	218	...	...	7.5	0.6	112	95	24	4,492	2,305
4.....	10	278	156	...	...	4.8	1.5	89	74	24	11,475	3,623
5.....	10	172	152	...	...	1.0	0.2	55	50	19	10,487	3,066
6.....	10	242	172	...	...	3.0	1.8	77	65	24	11,384	4,744
7.....	10	252	204	...	...	2.8	0.8	68	67	24	7,268	3,287
8.....	9	220	162	...	...	3.0	1.0	70	64	24	11,770	4,686
9.....	9	282	156	...	...	6.0	0.8	99	73	24	17,454	6,362
10.....	10	280	244	...	...	5.0	1.0	90	86	24	12,514	5,330
11.....	10	272	174	...	...	9.0	1.5	79	71	24	13,695	6,314
12.....	10	180	138	...	...	2.0	1.0	64	62	24	14,132	4,696
13.....	10	178	136	...	...	2.7	1.2	59	59	24	11,527	4,969
14.....	10	174	120	...	...	3.0	1.0	84	70	24	6,316	2,674
15.....	9	172	138	144	114	3.0	1.5	79	65	24	15,439	4,579
16.....	9	196	146	174	136	3.5	1.5	73	70	24	15,280	5,056
17.....	8	334	210	286	192	7.0	1.5	117	84	24	8,364	3,657
18.....	8	254	194	206	154	4.0	1.8	85	84	22	13,741	1,841
19.....	9	638	202	508	176	10.0	1.2	167	105	24	16,261	6,273
20.....	..	...	...	...	...	...	...	...	...	24	6,455	5,112
21.....	10	292	172	242	140	6.0	2.0	77	54	24	17,298	5,154
22.....	10	192	154	160	132	4.7	3.0	65	55	24	11,064	6,196
23.....	11	178	130	144	96	2.6	1.0	67	48	24	10,904	2,271
24.....	10	346	196	284	164	8.0	1.5	119	88	24	6,865	3,528
25.....	10	224	140	188	126	4.8	1.8	72	54	24	12,602	4,004
26.....	10	276	236	228	192	4.5	3.0	67	64	23	13,890	9,576
27.....	11	232	188	176	138	3.5	2.5	64	53	7	3,704	3,704
28.....	..	...	...	...	...	...	...	...	...	..	.....	....
29.....	..	...	...	...	...	...	...	...	...	18	7,920	....
30.....	11	406	220	336	190	7.0	2.8	96	78	24	14,015	3,791
31.....	11	296	206	260	180	4.0	1.8	91	75	24	14,697	3,613
Average......		267	174	238	152	4.6	1.5	84	70	23	14,550	5,594
Reduction....		...	34%	...	36%	...	67%	...	17%			

Table No. 11—Absorption of O

Dilution 1 in 30 | Tap Water | Calm Surface

Date	Time	Temperature	Nitrites	Tank No. 7: Dissolved Oxygen, P.P.M.	Tank No. 7: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
February		° C.						
2........	10.30 A.M.	21	0.06	5.79	....	5.79	....	....
2........	11.30	21	....	5.79	0	5.79	0	0
2........	1.30	21	....	5.47	.32	5.39	.40	.08
2........	3.30	20.75	0.07	5.22	.57	5.14	.65	.08
2........	5.30	20	....	4.98	.81	4.90	.89	.08
2........	7.30	19.5	....	4.69	1.10	4.49	1.30	.20
2........	9.30	19	....	4.57	1.22	4.37	1.42	.20
2........	11.30	19	....	4.49	1.30	4.08	1.71	.41
3........	8.30	17	0.12	4.08	1.71	3.51	2.28	.57
3........	10.30	16.5	....	4.08	1.71	3.39	2.40	.69

Solids: Settled	Solids: Total Suspended	Solids: Organic
0	98 P.P.M.	84 P.P.M.

Oxygen consumed, 54 P.P.M.

Oxygen Demand, P.P.M.
Dilution 1 in 100 at 37½°

Day	Dissolved Oxygen	Oxygen Demand
Int.......	7.18	....
1........	6.00	1.18
2........	....	....
3........	....	....
4........	....	....
5........	....	....

Sewage Experiment Station at West Brighton .... Exp. Nº 50
Oxygen absorbed by sewage diluted with Fresh Water .... Table 11 ACC 88
.... Surface undisturbed .... COMPUTER [signature] .... FROM Table Nº 11 TO
MADE IN CONNECTION WITH Oxygen absorption tests .... CHECKER .... DATE Feb. 2d 1916

Tank Nº 7 — No Fan
Dilution 1:30 Fresh Water. Depth 4º ft.
Suspended Solids 98 P.P.M.
Oxygen consumed 54 P.P.M.
Temperature 21.0° to 16.5°C.

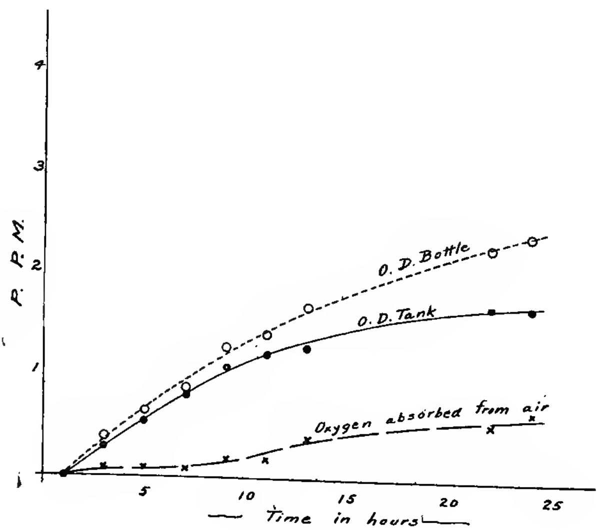

Table No. 11.—Absorption of Oxygen.—Experiment No. 52.

Dilution 1 in 30 Fresh Water Undisturbed Surface Depth 3 ft.

Date	Time	Temperature	Nitrites	Tank No. 7 Dissolved Oxygen, P.P.M.	Tank No. 7 Oxygen Demand, P.P.M.	Bottles Dissolved Oxygen, P.P.M.	Bottles Oxygen Demand, P.P.M.	Oxygen Absorbed
February		° C.						
14.......	11 A.M.	19	0.09	5.71	....	5.71	....	....
14.......	11.50	19	....	5.63	.08	5.63	0.08	0
14.......	1.30	18.5	....	5.39	.32	5.39	0.32	0
14.......	3.30	17.5	....	4.90	.81	4.90	0.81	0
14.......	5.30	....	....	4.16	1.55	4.16	1.55	0
14.......	7.30	15.5	0.10	3.35	2.36	3.18	2.53	.17
14.......	9.30	15	....	2.94	2.77	2.53	3.18	.41
14.......	11.30	13.5	....	2.61	3.10	2.12	3.59	.49
15.......	8.30	12	0.15	1.63	4.08	0.29	5.42	1.34
15.......	10.30	12	....	1.47	4.24	0.08	5.63	1.39

Oxygen Demand at 37.5°
Dilution 1 in 100

Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int.....	7.14	....
1.......	5.10	2.04
2.......	4.86	2.28
3.......	4.24	2.90
4.......	4.16	2.98
5.......	4.16	2.98

Solids

Suspended	Volatile	Ash	Settling
154 P.P.M.	136 P.P.M.	18 P.P.M.	0.8 c.c.

Oxygen consumed, 81 P.P.M.

Sewage Experiment Station at West Brighton — Experiment No. 52
Oxygen absorbed by sewage diluted with Fresh Water — ACC 93
Undisturbed surface — COMPUTER [signature] — FROM Table No. 11 TO
MADE IN CONNECTION WITH Oxygen absortion Tests — CHECKER — DATE Feb. 14th 1916.

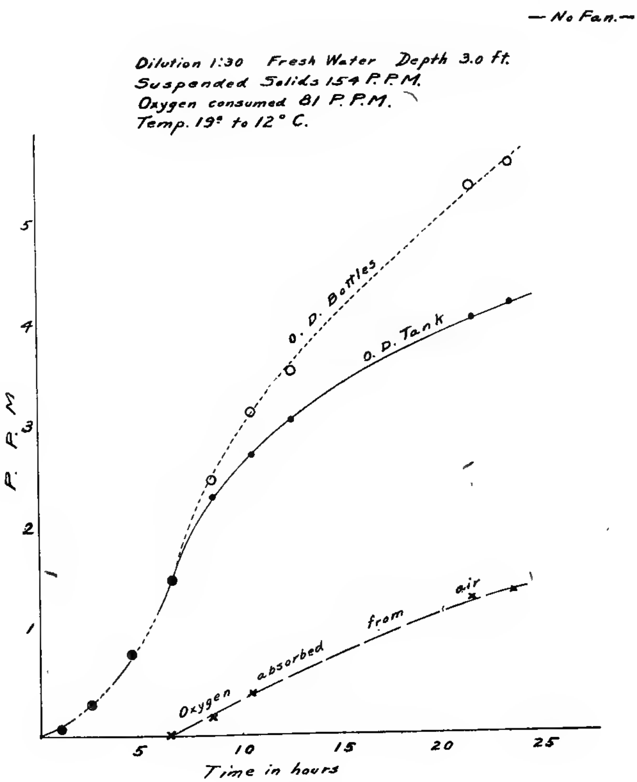

Table No. 11—Absorption of Oxygen.—Experiment No. 56.

Dilution 1 in 30 Fresh Water Calm Surface Depth 4 ft.

Date	Time	Temperature	Nitrites	Tank No. 7 Dissolved Oxygen, P.P.M.	Tank No. 7 Oxygen Demand, P.P.M.	Bottles Dissolved Oxygen, P.P.M.	Bottles Oxygen Demand, P.P.M.	Oxygen Absorbed
February		° C.						
29*......	11 A.M.	25.0	0.08	5.68	....	5.68	....	....
29.......	1 P.M.	24.5	....	5.52	.16	5.52	.16	0
29.......	3	24.0	....	5.28	.40	5.28	.40	0
29.......	5.30	23.0	....	4.87	.81	4.87	.81	0
29.......	7	22.5	....	4.59	1.09	4.63	1.05	—.04
29.......	9	22.0	....	4.22	1.46	4.22	1.46	0
29.......	11	21.5	....	3.90	1.78	3.94	1.74	—.04
March								
1........	9	18.5	....	3.57	2.11	2.60	3.08	+.97
1........	11	18.0	0.12	3.49	2.19	2.52	3.16	+.97

* Agitator broke down.

Oxygen demand at 37.5° C.

Day	Total Solids Dissolved Oxygen, P.P.M.	Total Solids Oxygen Demand, P.P.M.	Dissolved Solids Dissolved Oxygen, P.P.M.	Dissolved Solids Oxygen Demand, P.P.M.
Int......	7.15	....	7.11	....
1........	5.97	1.18	6.50	.61
2........	5.77	1.38	6.09	1.02
3........	5.68	1.47	5.97	1.14
4........	5.28	1.87	5.89	1.22
5........	5.20	1.95	5.89	1.22

Solids

Total	Dissolved	Suspended	Settling
714	652	62	0.1 c.c.

Organic Matter

Total	Dissolved	Suspended
444	396	48

Oxygen Consumed

Total	Dissolved	Suspended
48	32	16

President Borough of Richmond FILE Exp No 56
Bureau of Engineering ; Sewage ACC Table No 11
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of Oxygen CHECKER DATE Feb 29 1916

Depth 4 ft

Dilution 1:30 fresh Water
Suspended Solids 62 P.P.M.
Oxygen Consumed 48 P.P.M
Temp. 25°C to 18°C

Calm surface

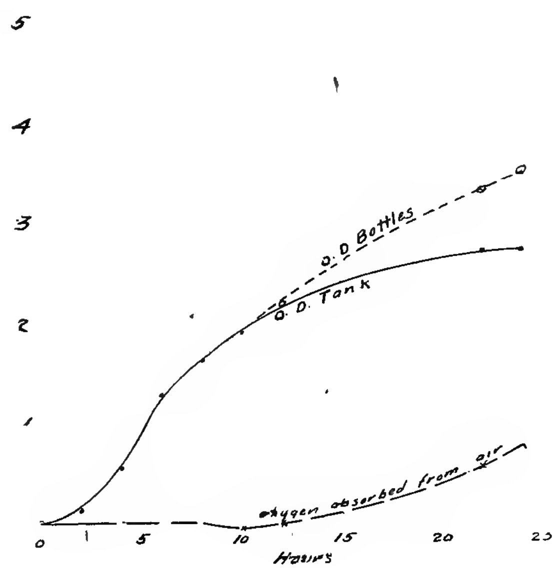

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TABLE NO. 11—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 58.

Dilution 1 in 40 Fresh Water Calm Surface Depth 3 ft.

Date	Time	Temperature	Nitrites	Tank No. 7: Dissolved Oxygen, P.P.M.	Tank No. 7: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
March								
3........	10.30 A.M.	19.0	0.10	7.63	....	7.63	....	....
3........	12.30	19.0	....	7.51	.12	7.51	.12	0
3........	2.30	18.5	....	7.39	.24	7.27	.36	.12
3........	4.30	18.0	....	7.15	.48	7.15	.48	0
3........	6.30	17.0	....	7.06	.57	6.86	.77	.20
3........	8.30	16.5	....	6.82	.81	6.78	.85	.04
3........	10.30	16.0	....	6.70	.93	6.54	1.09	.16
4........	8.30	13.0	....	7.39	.24	5.93	1.70	1.48
4........	10.30	13.0	0.12	6.25	1.38	5.77	1.86	.48

Oxygen Demand at 37.5° C.

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.
Int.	6.82	....	6.90	....
1........	5.89	.93	6.21	.69
2........	5.52	1.30	6.09	.81
3........	5.36	1.46	5.93	.97
4........	5.30	1.52	5.77	1.13
5........	5.30	1.52	5.77	1.13

Solids

	Total	Dissolved	Suspended	Settling
Solids	732	640	92	0.5 c.c.
Organic Matter	410	340	70	
Oxygen Consumed	50	37	13	

President Borough of Richmond FILE Exp. No 58
Bureau of Engineering Sewage ACC Table 1.
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE March 3. 1916

Dilution 1:40 fresh Water Depth 3ft.
Suspended Solids 92 P.P.M
Oxygen Consumed 50 P.P.M
Temp 19°C to 13°C

Calm Surface

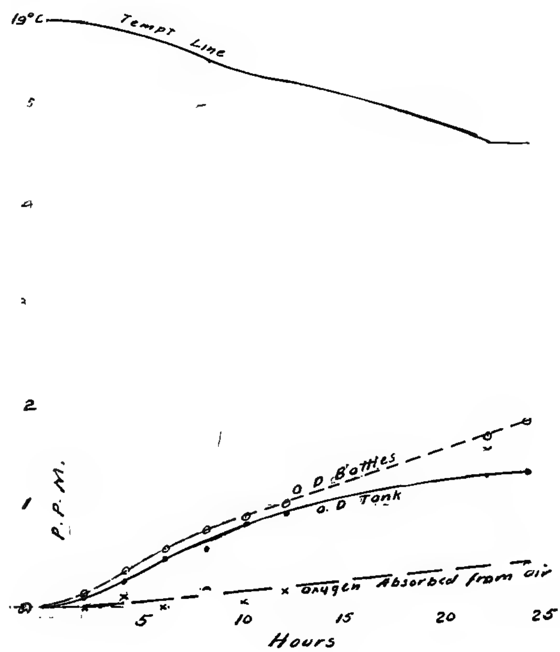

TABLE No. 11—ABSORPTION OF OXYGEN.—EXPERIMENT No. 60.

Dilution 1 in 20 Tap Water Calm Surface Depth 4 ft.

Date	Time	Temperature	Nitrites	Tank No. 7: Dissolved Oxygen, P.P.M.	Tank No. 7: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
March								
8........	12.30 P.M.	23.5	0.07	5.97	....	5.97	....	....
8........	1.30	23.5	....	5.77	.20	5.77	.20	0
8........	3.30	23	....	5.28	.69	5.28	.69	0
8........	5.30	22.5	....	4.59	1.38	4.79	1.18	—.20
8........	7.30	21.5	....	4.10	1.87	4.10	1.87	0
8........	9.30	20	....	3.82	2.15	3.98	1.99	—.16
8........	11.30	20	....	3.45	2.52	3.41	2.56	.04
9........	8.30	18	....	3.00	2.97	2.19	3.78	.81
9........	11.30	17.5	....	2.64	3.33	1.83	4.14	.81

Oxygen Demand, Dilution 1:100, 37.5°

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.
Int......	6.74	....	6.82	....
1........	5.79	.95	6.11	.71
2........	5.63	1.11	5.95	0.87
3........	5.47	1.27	5.63	1.19
4........	5.39	1.35	5.47	1.35
5........	5.26	1.48	5.43	1.39

Solids

	Total	Dissolved	Suspended	Settling
Solids	852	798	54	0
Organic Matter	490	444	46	
Oxygen Consumed	29	29	0.0	

President Borough of Richmond FILE Exp. No. 60

Bureau of Engineering, Sewage ACC Table No. 11

Experiment Station COMPUTER FROM TO

MADE IN CONNECTION WITH absorbtion of oxygen CHECKER DATE March 8 1916

Depth 4 ft.

Dilution 1:20 fresh water
Suspended Solids 54 P.P.M.
Oxygen Consumed 29 P.P.M.
Tempt. 23.5°C to 17.5°C

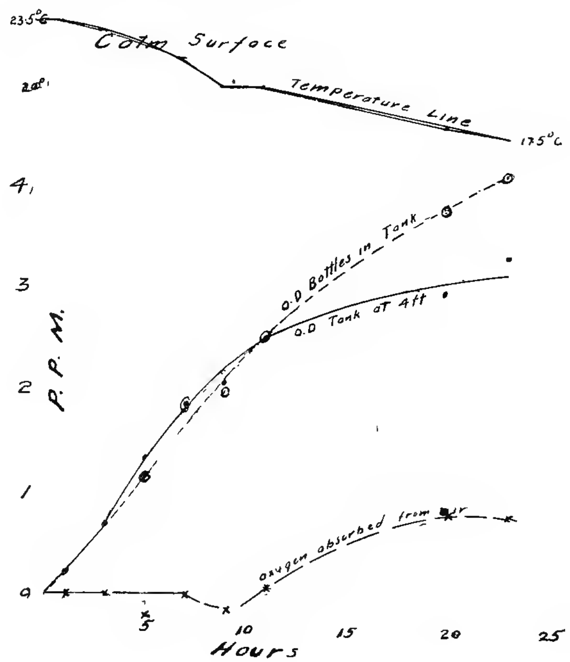

TABLE NO. 12—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 62.

Undiluted Tap Water — Two Electric Fans Blowing on Surface. — Samples Syphoned through Rubber Tubing Attached to End of Rod.

Date March	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
		Top	Bottom		D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen	Oxygen Increase	Oxygen Absorbed
13....	11 A.M.	17.5	17	0.07	6.79	....	....	....	6.79	....	....	6.79	....	....	6.83	....	....	6.87	....	....	6.87	....	....	6.87	....	....
13....	1	17	16	....	6.79	0.0	....	....	6.95	+.16	—.16	6.95	—.16	—.16	6.95	—.12	—.12	6.95	—.08	—.08	6.95	—.08	—.08	6.95	—.08	—.08
13....	3	17	16¾	....	6.75	.04	....	....	6.95	—.16	—20	6.95	—.16	—.20	6.95	—.12	—.16	6.95	—.08	—.12	6.95	.08	—.12	6.95	—.08	—.12
13....	5	16¼	16¼	....	6.71	.08	....	....	7.03	+.24	—.32	7.03	—.24	—.32	7.03	—.20	—.28	7.03	—.16	—.24	6.99	—.12	—.20	6.99	—.12	—.16
13....	7	16	16	....	6.71	.08	....	....	7.11	+.32	—.40	7.11	—.32	—.40	7.11	—.28	—.36	7.11	—.24	—.32	7.11	—.24	—.32	7.11	—.24	—.32
13....	9	16	16	....	6.71	.08	....	....	7.15	+.36	—.44	7.15	—.36	—.44	7.15	—.32	—.40	7.15	—.28	—.36	7.15	—.28	—.36	7.15	—.28	—.36
13....	11	15½	15½	....	6.71	.08	....	....	7.23	—.44	—.52	7.23	—.44	—.52	7.23	—.40	—.48	7.23	—.36	—.44	7.23	—.36	—.44	7.07	—.20	—.28
14....	9	13½	13½	....	6.71	.08	....	....	7.68	—.89	—.97	7.68	—.89	—.97	7.68	—.85	—.93	7.68	—.81	—.89	7.68	—.81	—.93	7.52	—.65	—.73
14....	11	13	13	....	6.67	.12	....	....	7.76	—.97	—1.09	7.76	—.97	—1.09	7.76	—.93	—1.05	7.76	—.89	—1.01	7.76	—.89	—1.01	7.76	—.89	—1.01
14....	1	12½	12½	0.04	6.59	.20	....	....	7.76	—.97	—1.17	7.76	—.97	—1.17	7.76	—.93	—1.13	7.76	—.89	—1.19	7.76	—.89	—1.09	7.76	—.89	—1.09
14....	3	12	12	....	6.59	.20	....	....	7.84	—1.05	—1.25	7.84	—1.05	—1.25	7.84	—1.01	—1.21	7.84	—.97	—1.17	7.84	—.97	—1.17	7.84	—.97	—1.17
14....	5	12	12	...	6.63	.13	....	....	7.88	—1.09	—1.22	7.84	—1.05	—1.18	7.84	—1.01	—1.14	7.84	—.97	—1.10	7.84	—.97	—1.10	7.84	—.97	—1.10

President Borough of Richmond FILE Exp. No 62
Bureau of Engineering; Sewage ACC Table. No 12
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE March 13 1919

Fresh Water to be used for dilution in Exp 63

Temperature 17°–12° C

Two Electric fans Ripple abt 1/2"

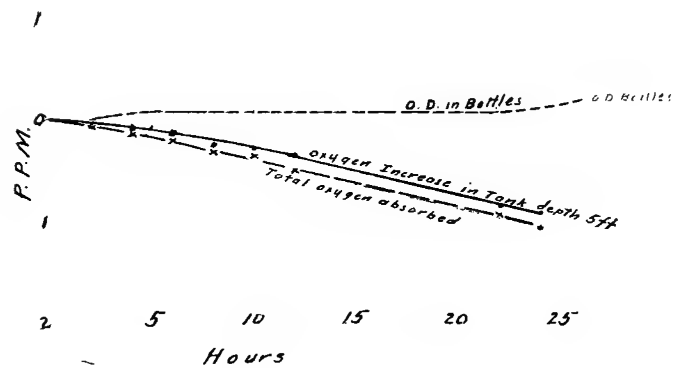

TABLE NO. 12—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 69.

Fresh Water for Diluting Sewage on April 6. Two Electric Fans.

Date April	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
3...	10.30 A.M.	21.5	22	....	5.85	....	5.85	....	5.87	....	....	5.87	....	....	5.87	....	....	5.87	....	....	5.83	....	....	5.81	....	....
3...	12.30	20.75	21.25	....	5.85	0	5.85	0	6.29	.42	.42	6.21	.34	.34	6.21	.34	.34	6.21	.34	.34	6.17	.34	.34	6.13	.32	.32
3...	2.30	20	20	....	5.81	.04	5.85	0	6.69	.82	.86	6.57	.70	.74	6.57	.70	.74	6.57	.70	.74	6.57	.74	.78	6.57	.76	.80
3...	4.30	19	19	....	5.81	.04	5.85	0	6.96	1.09	1.13	6.92	1.05	1.09	6.84	.97	1.01	6.92	1.05	1.09	6.84	1.01	1.05	7.00	1.19	1.23
3...	6.30	18.5	18.5	....	5.85	0	5.85	0	8.36	1.49	1.49	7.24	1.37	1.37	7.20	1.33	1.33	7.24	1.37	1.37	7.20	1.37	1.37	7.24	1.43	1.43
3...	8.30	18	18	....	5.81	.04	5.81	.04	7.56	1.69	1.73	7.56	1.69	1.73	7.48	1.61	1.65	7.56	1.69	1.73	7.52	1.69	1.73	7.64	1.83	1.87
3...	10.30	17	17	....	5.81	.04	5.81	.04	7.72	1.85	1.89	7.64	1.77	1.81	7.64	1.77	1.81	7.68	1.81	1.85	7.64	1.81	1.85	7.72	1.91	1.95
4...	8.30	14	14.5	....	5.79	.06	5.79	.06	8.60	2.73	2.79	8.52	2.65	2.71	8.52	2.65	2.71	8.52	2.65	2.71	8.60	2.77	2.83	8.64	2.83	2.89
4...	10.30	14	14	....	5.79	.06	5.71	.14	8.68	2.81	2.87	8.68	2.81	2.87	8.68	2.81	2.87	8.68	2.81	2.87	8.68	2.85	2.91	8.68	2.87	2.93

Oxygen Demand, 37.5°

Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int..........	5.85	....
1...........	4.99	.86
2...........	4.99	.86
3...........	4.93	.92

Total Solids.............. 648 P.P.M.
Organic Solids............ 280 P.P.M.

President Borough of Richmond FILE Exp No 69
Bureau of Engineering Sewage Experiment ACC Table No 12
Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE April 3 1916

Depth 5 ft.

Fresh water from tap for diluting sewage on April 6, 1916.

Two Electric fans blowing on surface making ripple abt ½"

Suspended Solids 0.0
Temperature 22°C - 14°C

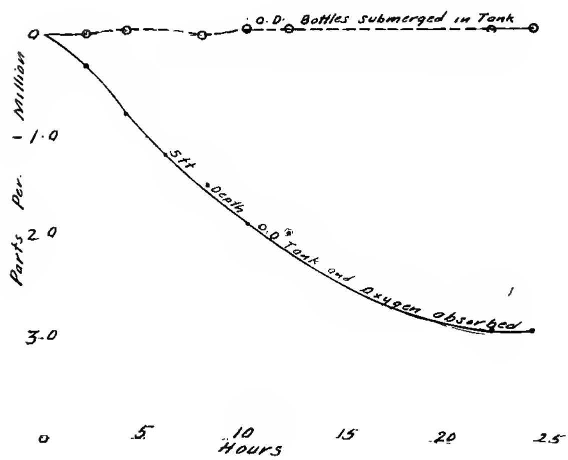

Table No. 12—Absorption of Oxygen.—Experiment No. 71.

Undiluted Fresh Water to be Used in Dilution of Sewage on April 12

Two Fans Blowing.

Date April	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D.O., P.P.M.	Bottles Tank O.D., P.P.M.	Bottles 20° Incubator D.O., P.P.M.	Bottles 20° Incubator O.D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
10..	9.15 A.M.	20	20	....	5.73	....	5.73	....	5.73	....	....	5.63	....	....	5.69	....	....	5.69	....	....	5.69	....	....	5.69	....	....
10..	11.15	19	19	....	5.69	.04	5.69	.04	6.18	.45	.49	6.06	.43	.47	6.10	.41	.45	6.10	.41	.45	6.10	.41	.45	6.18	.49	.53
10..	1.15	18	18.5	....	5.69	.04	5.69	.04	6.58	.85	.89	6.50	.87	.91	6.54	.85	.89	6.54	.85	.89	6.54	.85	.89	6.58	.89	.93
10..	3.15	17.5	18	....	5.69	.04	5.69	.04	6.94	1.21	1.25	6.90	1.27	1.31	6.90	1.21	1.25	6.90	1.21	1.25	6.94	1.25	1.29	6.94	1.25	1.29
10..	5.15	17.5	17.5	....	5.65	.08	5.65	.08	7.18	1.45	1.53	7.14	1.51	1.59	7.22	1.53	1.61	7.14	1.45	1.53	7.18	1.49	1.57	7.22	1.53	1.61
10..	7.15	16	16.5	....	5.69	.04	5.61	.12	7.50	1.77	1.81	7.54	1.91	1.95	7.46	1.77	1.81	7.50	1.81	1.85	7.50	1.81	1.85	7.50	1.81	1.85
10..	9.15	15	15.5	....	5.69	.04	5.61	.12	7.78	2.05	2.09	7.78	2.15	2.19	7.78	2.09	2.13	7.78	2.08	2.12	7.82	2.13	2.17	7.86	2.17	2.21
10..	11.15	15	15	....	5.61	.12	5.53	.20	7.94	2.21	2.33	7.90	2.27	2.39	7.94	2.25	2.37	7.94	2.25	2.37	7.94	2.25	2.47	7.94	2.25	2.37
11..	9.15	13	13	0.06	5.45	.28	5.37	.36	8.90	3.17	3.45	8.86	3.23	3.51	8.82	3.13	3.41	8.86	3.17	3.45	8.82	3.13	3.41	8.90	3.21	3.49

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Dissolved Solids
Int....	5.73	....	
1.....	4.81	.92	
2.....	4.30	1.43	
3.....	3.70	2.03	
4.....	4.66	1.07	
5.....	4.10	1.63	

	Total	Dissolved	Suspended	Settled
Solids.............	632			
Organic Solids......	2.78			
Oxygen Consumed..	.72			

President Borough of Richmond	FILE Exp. No 71
Bureau of Engineering; Sewage	ACC Table No 12
Experimental Station	COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen	CHECKER DATE April 10, 1916

Fresh Water to be used for diluting sewage in Exp. 72

Suspended solids 0.0
Oxygen Consumed 0.72 P.P.M.
Temperature 20°C to 13°C

Two electric fans making ripple abt. ½"

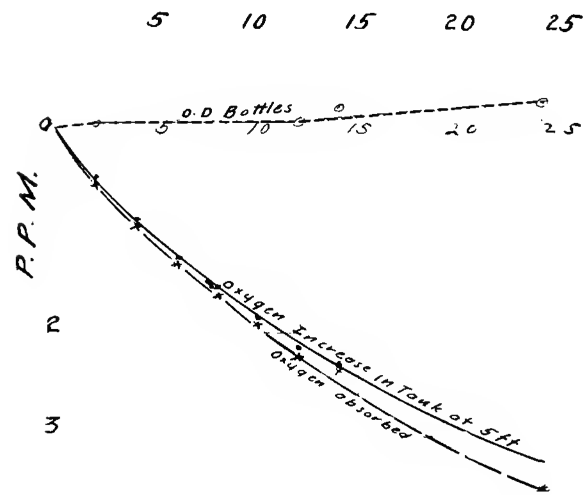

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Table No. 13—Absorption of Oxygen.—Experiment No. 64.

Dilution 1 in 20 | Fresh Water | Two Electric Fans

Date March	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
		Top	Bottom		D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Absorbed	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
17..	10.30 A.M.	23	23	0.10	4.85	....	4.85	....	4.85	....	....	4.85	....	....	4.77	....	....	4.85	....	....	4.77	....	....	4.81	....	....
17..	12.30	21	22	....	4.69	.16	4.77	.08	4.69	.16	0	4.69	.16	0	4.61	.16	0	4.69	.16	0	4.69	.08	.08	4.81	0	.16
17..	2.30	19½	21	....	4.69	.16	4.49	.36	4.65	.20	—.04	4.45	.40	—.24	4.45	.32	—.16	4.53	.32	—.16	4.45	.32	—.16	4.53	.38	—.12
17..	4.30	19½	19½	....	4.08	.77	4.28	.57	4.73	.12	.65	4.36	.49	.28	4.40	.37	.40	4.40	.45	.32	4.36	.41	.36	4.24	.57	.20
17..	6.30	19	19	....	3.48	1.37	3.71	1.14	4.08	.77	.60	4.20	.65	.72	3.84	.93	.44	4.20	.65	.72	4.20	.57	.80	4.20	.61	.76
17..	8.30	17	17	....	2.79	2.06	3.48	1.37	4.36	.49	1.57	4.28	.57	1.49	4.24	.53	1.53	4.28	.57	1.49	....	....	....	4.36	.45	1.61
18..	9.30	14	....	....	1.94	2.91	1.86	2.99	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18..	1.00	14	....	....	1.86	2.99	1.78	3.07	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Oxygen Demand Dilution 1 in 100 at 37.5°

Day	Total Solids		Day	Dissolved Solids	
	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.		Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int....	6.95	....	Int....	7.03	....
1.....	5.73	1.22	1.....	5.98	1.05
2.....	5.29	1.66	2.....	5.94	1.09
3.....	5.21	1.74	3.....	5.74	1.29
4.....	4.76	2.19	4.....	5.32	1.71
5.....	4.76	2.19	5.....	5.32	1.71

	Total	Dissolved	Suspended	Settled
Solids............	994	882	62	0
Organic Solids.....	376	322	54	..
Oxygen Consumed..	48	41	7	..

President Borough of Richmond FILE Experiment No. 64
Bureau of Engineering, Sewage ACC Table No. 13
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of Oxygen CHECKER DATE March 17 1916

Dilution 1:20 fresh water
Suspended Solids 62 PPM.
Oxygen Consumed 48 P.P.M.

Temperature 23°C – 14°C

Two electric fans

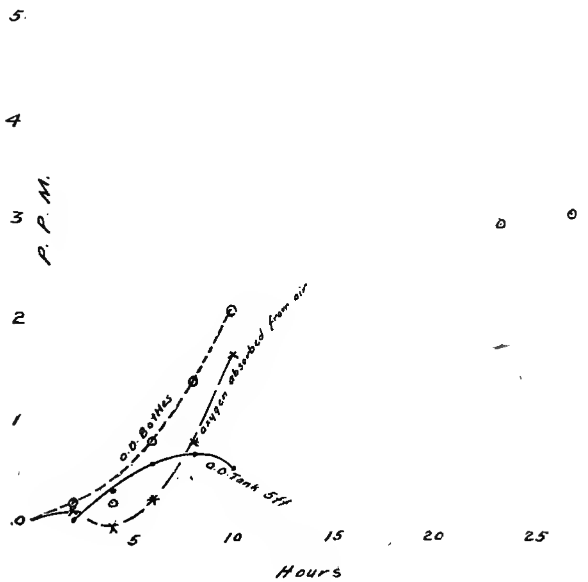


Table No. 13—Absorption of Oxygen.—Experiment No. 65.

Dilution 1 in 20 | Fresh Water | Two Electric Fans

Date March	Time	Temperature: Top	Temperature: Bottom	Nitrites	Bottles, Tank: D.O., P.P.M.	Bottles, Tank: O.D., P.P.M.	Bottles, 20° Incubator: D.O., P.P.M.	Bottles, 20° Incubator: O.D., P.P.M.	Surface: Dissolved Oxygen, P.P.M.	Surface: Oxygen Demand, P.P.M.	Surface: Oxygen Absorbed	1 Foot: Dissolved Oxygen, P.P.M.	1 Foot: Oxygen Demand, P.P.M.	1 Foot: Oxygen Absorbed	2 Feet: Dissolved Oxygen, P.P.M.	2 Feet: Oxygen Demand, P.P.M.	2 Feet: Oxygen Absorbed	3 Feet: Dissolved Oxygen, P.P.M.	3 Feet: Oxygen Demand, P.P.M.	3 Feet: Oxygen Absorbed	4 Feet: Dissolved Oxygen, P.P.M.	4 Feet: Oxygen Demand, P.P.M.	4 Feet: Oxygen Absorbed	5 Feet: Dissolved Oxygen, P.P.M.	5 Feet: Oxygen Demand, P.P.M.	5 Feet: Oxygen Absorbed
21...	11 A.M.	23½	24	0.09	5.91	....	5.91	....	5.97	....	....	5.91	....	....	5.91	....	....	5.91	....	....	5.91	....	....	5.91	....	....
21...	1	22	22	....	5.71	.20	5.79	.12	5.79	.18	.02	5.71	.20	0	5.79	.12	.08	5.75	.16	.04	5.55	.36	—.16	5.75	.16	.04
21...	3	21	21	....	5.40	.51	5.47	.44	5.55	.42	.09	5.41	.51	0	5.43	.49	.02	5.43	.49	.02	5.32	.59	—.08	5.47	.44	.07
21...	5	21	21	....	4.92	.99	5.28	.53	5.31	.66	.33	5.20	.71	.28	5.20	.71	.28	5.28	.63	.36	5.16	.75	.24	5.28	.63	.36
21...	7	20	20	....	4.44	1.47	4.64	1.27	5.08	.89	.58	4.92	.99	.48	4.88	1.03	.44	4.92	.99	.48	4.80	1.11	.36	5.00	.91	.56
21...	9	19	18	....	4.13	1.78	4.24	1.67	4.96	1.01	.77	4.84	1.07	.71	4.88	1.03	.75	4.88	1.03	.75	4.76	1.15	.63	4.92	.99	.79
21...	11	18	17½	....	3.89	2.02	4.13	1.78	4.96	1.01	1.01	4.84	1.07	.95	4.84	1.07	.95	4.88	1.03	.99	4.76	1.15	.87	4.92	.99	1.03
22...	9	15	15	....	2.82	3.09	2.78	3.13	6.03	—.06	3.15	5.79	.12	2.97	5.79	.12	2.97	5.87	.04	3.05	5.71	.20	2.89	5.99	—.08	3.17
22...	11	14	14	0.14	2.62	3.29	2.62	3.29	6.27	—.30	3.59	6.11	—.20	3.49	6.07	—.16	3.45	6.15	—.24	3.53	5.90	—.08	3.37	6.20	—.29	3.58
22...	1	14	....	....	2.54	3.37	2.54	3.37	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Day	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.
Int....	7.06	....	Int....	7.14	....
1.....	5.87	1.19	1.....	6.43	.71
2.....	5.40	1.66	2.....	5.95	1.19
3.....	5.36	1.70	3.....	5.75	1.29
4.....	5.16	1.90	4.....	5.71	1.43
5.....	4.92	2.14	5.....	5.67	1.47

	Total	Dissolved	Suspended	Settled
Solids.............	1046	994	152	0.2 c.c.
Organic Solids......	430	300	130	....
Oxygen Consumed..	57	42	15	....

President Borough of Richmond FILE Exp No 65
Bureau of Engineering, Sewage ACC Table No 13
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Oxygen obserbtion CHECKER DATE March 21, 191.
5 ft Depth

Dilution 1:20 fresh Water
Suspended Solids 152 P.P.M.
Oxygen Consumed. 57 P.P.M.
Tempt $23\frac{1}{2}°C - 14°C$

Two Elect. fans.

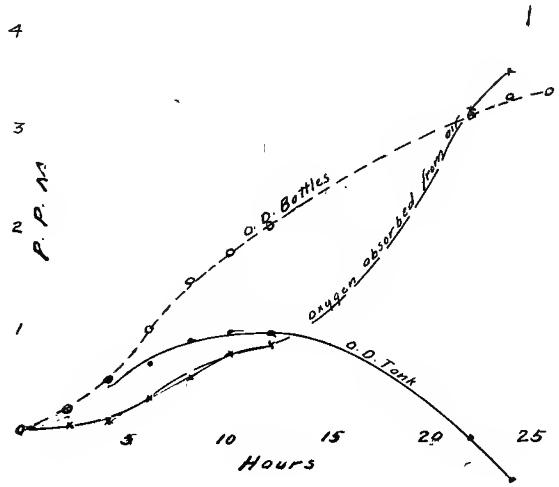


Table No. 13—Absorption of Oxygen.—Experiment No. 66

Dilution 1 in 20 — Fresh Water — Two Electric Fans Blowing

Date March	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
		Top	Bottom		Tank D.O., P.P.M.	Tank O.D., P.P.M.	20° Incubator D.O., P.P.M.	20° Incubator O.D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxugen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
23....	11 A.M.	22	23	0.09	5.04	....	5.04	....	5.08	....	....	5.08	....	....	4.92	....	....	4.92	....	....	4.86	....	....	5.04	....	....
23....	1	21	22	....	4.68	.36	4.80	.24	4.96	.12	.24	4.84	.24	.12	4.80	.12	.24	4.80	.12	.24	4.68	.18	.18	4.80	.24	.12
23...	3	20	21	....	4.36	.68	4.52	.52	4.76	.32	.36	4.52	.56	.12	4.52	.40	.28	4.52	.40	.28	4.44	.42	.26	4.60	.44	.24
23....	5	17	20	....	3.85	1.19	4.08	1.06	4.88	.20	.99	4.76	.32	.87	4.72	.20	.99	4.80	.12	1.07	4.78	.08	1.11	4.92	.12	1.07
23....	7	17	18½	....	3.52	1.52	3.73	1.31	5.43	—.35	1.87	4.82	.24	1.28	4.80	.12	1.40	4.92	0	1.52	4.60	.26	1.26	4.96	.08	1.48
23....	9	16	17	....	3.29	1.75	3.61	1.43	5.40	—.32	2.07	5.00	.08	1.67	5.08	—.16	1.91	5.16	—.24	1.99	4.92	—.06	1.81	5.20	—.16	1.91
23....	11	15	17	....	3.17	1.87	3.41	1.63	5.55	—.47	2.34	5.36	—.28	2.15	5.00	—.08	1.95	5.43	—.51	2.38	5.12	—.26	2.13	5.28	—.24	2.11
24....	9.30	13	12.5	0.11	2.46	2.58	2.30	2.74	7.34	—2.26	4.84	7.22	—2.14	4.82	7.30	—2.38	4.96	7.30	—2.38	4.96	7.26	—2.40	4.98	7.22	—2.18	4.76
24....	11.15	12.5	12	....	2.46	2.58	2.22	2.82	7.62	—2.54	5.12	7.54	—2.46	5.04	7.50	—2.58	5.16	7.50	—2.58	5.16	7.42	—2.56	5.14	7.50	—2.46	5.04
24....	1	11.5	....	....	2.30	2.74	2.22	2.82	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
24....	3	11	....	....	2.14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
25....	11	10.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Day	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.
Int....	6.74	....	Int....	6.86	....
1.....	5.63	1.11	1.....	5.87	.99
2.....	5.63	1.11	2.....	5.79	1.07
3.....	5.12	1.62	3.....	5.47	1.39
4.....	4.96	1.78	4.....	5.47	1.39
5.....	4.96	1.78	5.....	5.33	1.53

	Total	Dissolved	Suspended	Settled
Solids............	882	822	60	0
Organic Matter....	314	258	56	..
Oxygen Consumed.	37	28	9	..

President Borough of Richmond FILE Exp No 66
Bureau of Engineering, Sewage ACC Table No 13
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of oxygen CHECKER DATE March 23 1916

Dilution 1:20 fresh Water
Suspended Solids 60 P.P.M.
Oxygen Consumed 37 P.P.M
Tempt 22°C. to 12.5°C

Two electric fans

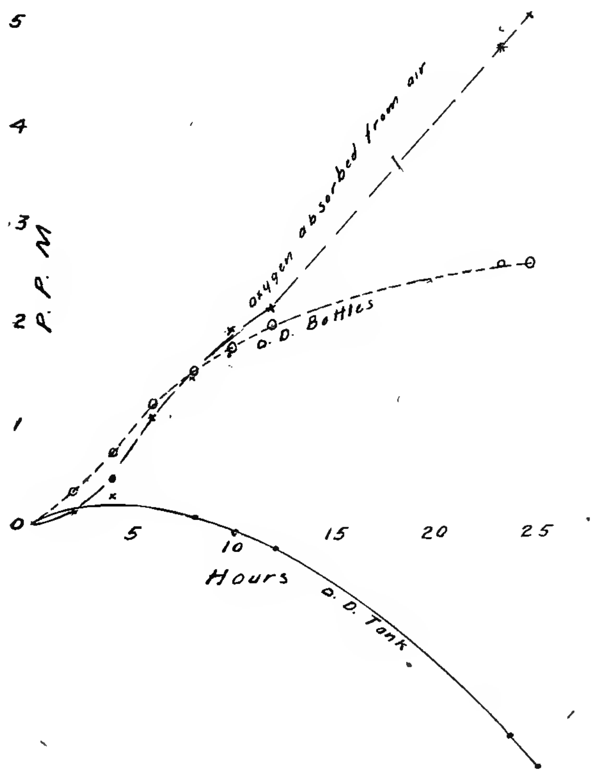


Table No. 13—Absorption of Oxygen.—Experiment No. 67.

Dilution 1 in 20 — Two Electric Fans

		Temperature			Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
Date March	Time	Top	Bottom	Nitrites	D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
27...	11.30 A.M.	26	26.5	....	4.46	....	4.46	....	4.46	....	....	4.46	....	....	4.46	....	....	4.46	....	....	4.46	....	....	4.46	....	....
27...	1.30	24	25	0.11	4.14	.32	4.22	.24	4.18	.16	.16	4.18	.28	.04	4.18	.28	.04	4.22	.24	.08	4.22	.24	.08	4.22	.24	.08
27...	3.30	24	24	....	3.62	.84	3.94	.52	3.86	.44	.40	3.86	.60	.24	3.86	.60	.24	3,90	.56	.28	3.90	.56	.28	3.86	.60	.24
27...	5.30	23	23	....	2.79	1.67	3.38	1.08	3.62	.80	.87	3.62	.84	.83	3.54	.92	.75	3.58	.88	.79	3.54	.92	.75	3.66	.80	.87
27...	7.30	22	22	....	1.99	2.47	2.87	1.59	3.46	.84	1.63	3.46	1.00	1.47	3.42	1.04	1.43	3.58	.88	1.59	3.50	.96	1.51	3.54	.92	1.55
27...	9.30	20	21	....	1.59	2.87	2.79	1.67	3.50	.80	2.07	3.50	.96	1.91	3.50	.96	1.91	3.58	.88	1.99	3.54	.92	1.95	3.58	.88	1.99
27...	11.30	16.5	20	....	1.15	3.31	2.03	2.43	3.58	.72	2.59	3.58	.88	2.43	3.58	.88	2.43	3.66	.80	2.51	3.62	.84	2.47	3.66	.80	2.51
28...	9.30	16.5	16.5	....	0	4.46*	0.48	3.98	4.93	—.63	5.09	4.93	—.47	4.93	4.93	—.47	4.93	5.01	—.55	5.01	4.93	—.47	4.93	5.01	—.55	5.01
28...	11.30	16	16	0.13	0	4.46*	0.24	4.22	5.33	—1.03	5.49	5.33	—.87	5.33	5.33	—.87	5.33	5.41	—.95	5.41	5.33	—.87	5.33	5.41	—.95	5.41
28...	1.30	....	....	....	....	....	0.16	4.30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Nitrites, 0.25. * 0.20.

Oxygen Demand Dilution 1 in 100 at 37.5° C.

	Dissolved Solids			Total Solids	
Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int....	6.84	....	Int....	6.77	....
1.....	6.09	.75	1.....	5.57	1.20
2.....	5.45	1.39	2.....	4.77	2.00
3.....	5.37	1.47	3.....	4.62	2.15
4.....	5.13	1.71	4.....	4.46	2.31
5.....	5.09	1.75	5.....	4.46	2.31

	Total	Dissolved	Suspended	Settled
Solids.............	948	812	136	1 c.c.
Organic...........	358	242	116	....
Oxygen Consumed.	57	35	22	....

President Borough of Richmond — Experiment No. 67 — FILE

Bureau of Engineering; Sewage — ACC Table No. 13

Experiment Station — COMPUTER — FROM — TO

MADE IN CONNECTION WITH absorbtion of oxygen — CHECKER — DATE March 27 1916

Dilution 1:20 fresh water
Suspended matter 136 P.P.M.
Oxygen consumed 57 P.P.M.

Temperature 26°C to 16°C.

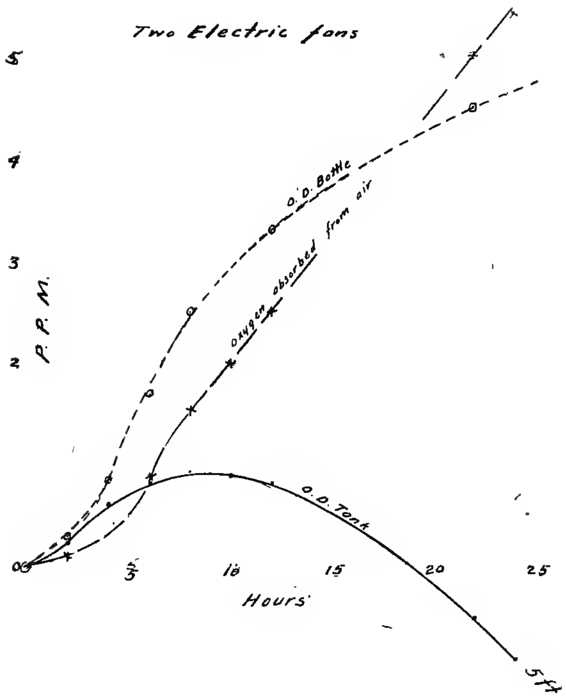


Table No. 13—Absorption of Oxygen.—Experiment No. 68.

Dilution 1 in 20 | Fresh Water | Two Electric Fans

		Temperature			Bottles Tank		Bottles 20° Incubator		Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
Date March	Time	Top	Bottom	Nitrites	D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
29..	10.30 A.M.	22	22.5	0.07	6.25	....	6.25	....	6.29	....	....	6.25	....	....	6.25	....	....	6.21	....	....	6.21	....	....	6.13	....	....
29..	12.30	19.75	20	....	5.93	.32	6.01	.24	6.17	.12	.20	5.97	.28	.04	5.97	.28	.04	5.97	.24	.08	5.97	.24	.08	5.81	.32	0
29..	2.30	19.75	20	....	5.37	.88	5.49	.76	5.49	.80	.08	5.45	.80	.08	5.45	.80	.08	5.41	.80	.08	5.41	.80	.08	5.45	.68	.20
29..	4.30	19.0	19.5	....	4.70	1.85	4.77	1.48	5.17	1.12	.73	5.05	1.20	.65	5.05	1.20	.65	5.10	1.11	.74	5.01	1.02	.83	5.01	1.02	.83
29..	6.30	19	18	....	4.14	2.11	4.38	1.87	5.05	1.24	.87	4.97	1.28	.83	5.01	1.24	.87	5.01	1.20	.91	4.93	1.28	.83	4.93	1.20	.91
29..	8.30	18	17.5	....	3.82	2.43	4.10	2.15	5.01	1.28	1.15	5.01	1.24	1.19	4.93	1.32	1.11	4.97	1.24	1.19	4.97	1.14	1.27	4.97	1.16	1.27
29..	10.30	18	17	....	3.54	2.71	3.87	2.28	5.01	1.28	1.43	5.01	1.24	1.47	4.93	1.32	1.39	4.97	1.24	1.47	4.97	1.14	1.57	4.97	1.16	1.55
30..	8.30	15	15.5	....	2.11	4.14	2.31	3.94	5.85	.44	3.70	5.73	0.52	3.62	5.73	.52	3.62	5.77	.44	3.70	5.73	.48	3.66	5.77	.36	3.78
30..	10.30	14.75	15	0.11	1.87	4.38	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Oxygen Demand 1 in 100 at 37.5° C.

	Total Solids			Dissolved Solids	
Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int....	6.77	....	Int....	6.84	....
1.....	5.33	1.44	1.....	6.05	0.79
2.....	5.17	1.60	2.....	5.73	1.11
3.....	5.09	1.68	3.....	5.41	1.43
4.....	5.01	1.76	4.....	5.33	1.51
5.....	4.66	2.11	5.....	5.05	1.79

	Total	Dissolved	Suspended	Settled
Solids.............	870	766	104	.07
Organic............	334	244	90	....
Oxygen Consumed..	43	35	8	....

President Borough of Richmond — Experiment No. 68 — FILE

Bureau of Engineering, Sewage — ACC Table No 13

Experiment Station — COMPUTER — FROM — TO

MADE IN CONNECTION WITH absorbtion of oxygen — CHECKER — DATE March 29 1916

Dilution 1:20 fresh water
Suspended Solids 104 P.P.M.
Oxygen Consumed 43 P.P.M.

Temperature 22°C to 15°C

Two Electric fans

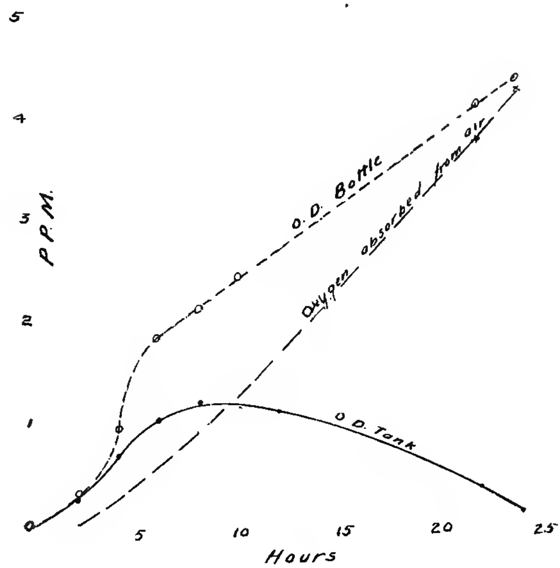


Table No. 13—Absorption of Oxygen.—Experiment No. 70.

Dilution 1 in 20 | Fresh Water (see Record of April 3rd) | Two Electric Fans

Date April	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles: Tank D. O., P.P.M.	Bottles: Tank O. D., P.P.M.	Bottles: 20° Incubator D. O., P.P.M.	Bottles: 20° Incubator O. D., P.P.M.	Surface: Dissolved Oxygen, P.P.M.	Surface: Oxygen Demand, P.P.M.	Surface: Oxygen Absorbed	1 Foot: Dissolved Oxygen, P.P.M.	1 Foot: Oxygen Demand, P.P.M.	1 Foot: Oxygen Absorbed	2 Feet: Dissolved Oxygen, P.P.M.	2 Feet: Oxygen Demand, P.P.M.	2 Feet: Oxygen Absorbed	3 Feet: Dissolved Oxygen, P.P.M.	3 Feet: Oxygen Demand, P.P.M.	3 Feet: Oxygen Absorbed	4 Feet: Dissolved Oxygen, P.P.M.	4 Feet: Oxygen Demand, P.P.M.	4 Feet: Oxygen Absorbed	5 Feet: Dissolved Oxygen, P.P.M.	5 Feet: Oxygen Demand, P.P.M.	5 Feet: Oxygen Absorbed
6..	10.45 A.M.	22.0	22.0	0.06	5.95	....	5.95	....	5.91	....	....	5.87	....	....	5.83	....	....	5.95	....	....	5.83	....	....	5.83	....	....
6..	12.45	20.75	21.0	....	5.65	.30	5.65	.30	5.85	.06	.24	5.81	.06	.24	5.81	.02	.28	5.81	.14	.16	5.81	.02	.28	5.81	.02	.28
6..	2.45	20.0	20.0	....	5.45	.50	5.49	.46	5.81	.10	.40	5.77	.10	.40	5.77	.06	.44	5.77	.18	.32	5.77	.06	.44	5.77	.06	.44
6..	4.45	19.5	19.5	....	5.09	.86	5.17	.78	5.65	.26	.60	5.61	.26	.60	5.49	.34	.52	5.57	.38	.48	5.49	.34	.52	5.33	.50	.36
6..	6.45	18.75	18.75	....	4.02	1.93	4.22	1.73	4.85	1.06	.87	4.77	1.10	.83	4.77	1.06	.87	4.77	1.18	.75	4.77	1.06	.87	4.86	.97	.96
6..	8.45	18.0	18.0	....	3.10	2.85	3.38	2.57	4.66	1.25	1.60	4.63	1.14	1.71	4.63	1.20	1.65	4.63	1.32	1.53	4.63	1.20	1.65	4.63	1.20	1.65
6..	10.45	17.5	17.5	....	2.79	3.16	2.86	3.09	4.66	1.25	1.91	4.66	1.21	1.95	4.66	1.17	1.99	4.66	1.29	1.87	4.66	1.17	1.99	4.66	1.17	1.99
7..	8.45	14.0	14.5	....	1.11	4.84	1.15	4.80	6.29	—.38	5.22	6.21	—.34	5.18	6.21	—.38	5.22	6.17	—.22	5.06	6.29	.46	5.30	6.29	—.46	5.30
7..	10.45	14.0	14.0	0.11	1.15	4.80	0.80	5.15	6.49	—.58	5.38	6.45	—.58	5.38	6.45	—.62	5.42	6.41	—.46	5.26	6.49	.66	5.46	6.57	—.74	5.54

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.	Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.
Int....	7.00	....	Int....	6.84	....
1.....	6.61	.39	1.....	5.97	.87
2.....	5.85	1.15	2.....	4.97	1.87
3.....	5.85	1.15	3.....	4.97	1.87
4.....	5.55	1.45	4.....	4.67	2.17
5.....	5.07	1.93	5.....	4.67	2.17

	Total	Dissolved	Suspended	Settled
Solids.............	908	812	96	0
Organic...........	362	276	86	..
Oxygen Consumed..	42	27	15	..

President Borough of Richmond Exp No 70 FILE
Bureau of Engineering, Sewage ACC Table No 13
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of Oxygen CHECKER DATE April 6 1910

Dilution 1:20 fresh Water April 3 Exp No 69
Suspended Solids 96 P.P.M
Oxygen Consumed 42 P.P.M.
Tempt. 22°C to 14°C

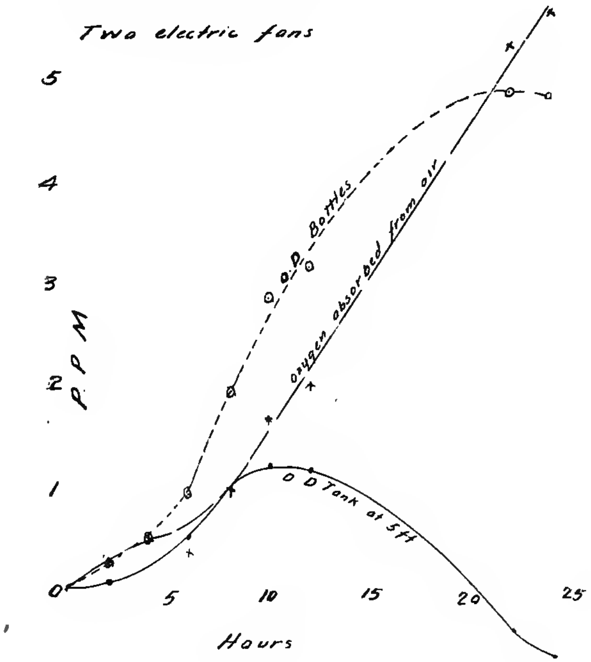


Table No. 13—Absorption of Oxygen.—Experiment No. 72.

Dilution 1 in 20. Fresh Water of April 10. Two Electric Fans.

Date April	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
12...	10 A.M.	19	19.5	0.06	7.32	....	7.32	....	7.32	....	....	7.32	....	....	7.32	....	....	7.32	....	....	7.28	....	....	7.30	....	....
12...	12	19	19	....	7.16	.16	7.16	.16	7.16	.16	0	7.16	.16	0	7.16	.16	0	7.16	.16	0	7.08	.20	—.04	7.12	.18	—.02
12...	2	18	18.75	....	6.83	.49	6.83	.49	6.83	.49	0	6.83	.49	0	6.83	.49	0	6.83	.49	0	6.83	.45	.04	6.79	.51	—.02
12...	4	18	18	....	6.51	.81	6.43	.89	6.43	.89	—.08	6.35	.97	—.16	6.35	.97	—.11	6.35	.97	—.11	6.35	.95	—.14	6.35	.95	—.14
12...	6	17	17.5	....	5.87	1.45	5.79	1.53	6.03	1.29	.16	6.03	1.29	.16	6.03	1.29	.16	6.03	1.29	.16	6.03	1.25	.20	6.03	1.27	.18
12...	8	17	17.0	....	5.31	2.01	5.31	2.01	5.87	1.45	.56	5.91	1.41	.60	5.79	1.53	.48	5.79	1.53	.48	5.79	1.49	.52	5.79	1.51	.50
12...	10	16.75	16.75	....	5.15	2.17	5.03	2.29	5.79	1.53	.64	5.75	1.57	.60	5.79	1.53	.54	5.79	1.53	.54	5.79	1.49	.68	5.79	1.51	.66
12...	12	16	16.5	....	4.78	2.54	4.78	2.54	5.67	1.65	.89	5.63	1.69	.85	5.63	1.69	.85	5.67	1.65	.89	5.49	1.79	.75	5.63	1.67	.87
13...	2	15.5	16	....	4.54	2.78	4.54	2.78	5.67	1.65	1.13	5.67	1.65	1.13	5.63	1.69	1.09	5.71	1.61	1.17	5.71	1.57	1.21	5.71	1.59	1.19
13...	4	15	15.5	....	4.22	3.10	4.02	3.30	5.87	1.45	1.65	5.83	1.49	1.61	5.71	1.61	1.49	5.79	1.53	1.57	5.71	1.57	1.53	5.79	1.51	1.59
13...	6	15	15	....	3.86	3.46	3.70	3.62	5.79	1.53	1.93	5.79	1.53	1.93	5.79	1.53	1.93	5.71	1.61	1.85	5.79	1.49	1.97	5.75	1.55	1.91
13...	8	14.5	14.5	....	3.86	3.46	3.54	3.78	5.83	1.49	1.97	5.79	1.53	1.93	5.79	1.53	1.93	5.87	1.45	2.01	5.79	1.49	1.97	5.87	1.43	2.03
13...	10	14.5	14.5	0.12	3.66	3.66	3.38	3.94	5.95	1.37	2.29	5.95	1.37	2.29	5.95	1.37	2.29	5.95	1.37	2.29	5.95	1.33	2.33	5.95	1.35	2.31

Oxygen Demand Dilution 1 in 100 at 37.5° C.

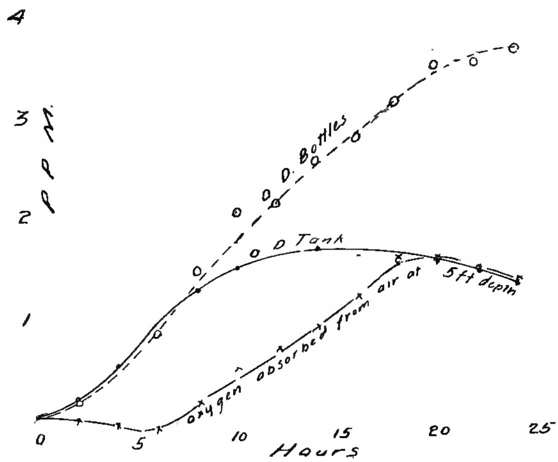
Day	Total Solids Dissolved Oxygen	Total Solids Oxygen Demand	Dissolved Solids Dissolved Oxygen	Dissolved Solids Oxygen Demand
Int.	6.92	....	7.08	....
1	5.31	1.61	6.11	.97
2	4.57	2.35	5.62	1.46
3	4.49	2.43	5.54	1.54
4	4.29	2.63	5.46	1.62
5	2.91	4.01	5.58	1.50

	Total	Dissolved	Suspended	Settled
Solids	1042	916	126	.5 cc
Organic Solids	422	316	106	....
Oxygen Consumed	62	40	22	....

President Borough of Richmond FILE Exp 72
Bureau of Engineering Sewage ACC Table 13
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of oxygen CHECKER DATE April 12 1916.

Dilution 1:20 fresh water April 10 Exp 71
Suspended Solids 126 P.P.M
Oxygen Consumed 62 P.P.M.
Tempt. 19 C to 14.5 C

Two Electric fans



President of Borough of Richmond; Bureau .... FILE Average of Nos 65, 66, 67, 68, 70, + 72

of Engineering; Sewage Experiment Station .... ACC Table No. 13

.... COMPUTER .... FROM .... TO ....

MADE IN CONNECTION WITH Absorbtion of Oxygen .... CHECKER .... DATE April 12, 1916

Dilution 1:20 fresh water

Two Electric fans blowing on surface making ripple abt. ½"

Average Temperature 18.8°C of Six observations

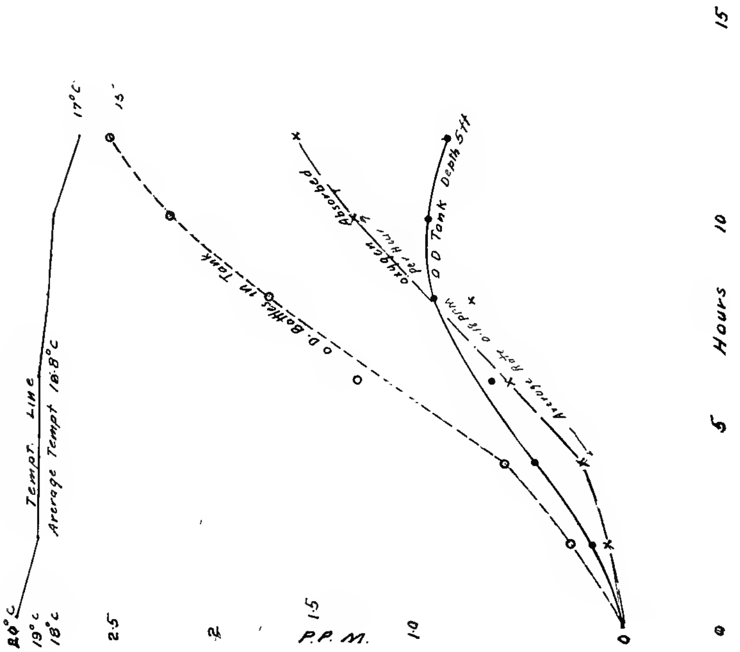


Table No. 14—Absorption of Oxygen.—Experiment No. 51.

Dilution 1 in 30 | Tap Water | Electric Fan Blowing | Depth 4 ft.

Date, February	Time	Temperature ° C.	Nitrites	Tank No. 9 Dissolved Oxygen, P.P.M.	Tank No. 9 Oxygen Demand, P.P.M.	Bottles Dissolved Oxygen, P.P.M.	Bottles Oxygen Demand, P.P.M.	Oxygen Absorbed
2........	10.30	22¼	0.06	6.04	....	6.08	....	....
2........	11.30	22	....	6.04	0	6.08	0	0
2........	1.30	19½	....	5.92	.12	5.75	.33	.21
2........	3.30	19	.07	5.79	.25	5.59	.49	.24
2........	6	18	....	5.75	.29	5.14	.94	.65
2........	7.30	17	....	5.84	.20	5.06	1.02	.82
2........	9.30	17	....	5.84	.20	4.90	1.18	.98
2........	11.30	16	....	5.84	.20	4.73	1.35	1.15
2........	8.30	13	0.17	6.61	—.57	4.16	1.92	2.49
2........	10.30	13	....	6.81	—.77	4.08	2.00	2.77

Solids

Settled	Total Suspended	Volatile
0	98 P.P.M.	84 P.P.M.

Oxygen Consumed, 54 P.P.M.

Oxygen Demand, Dilution 1 in 100 at 37½° C.

Day	Dissolved Oxygen	Oxygen Demand
Int..........	7.18	0.08
1..........	6.00	1.18

Sewage Experiment Station at West Brighton — Exp No 51
Oxygen absorbed by sewage diluted with Fresh Water — ACC .90
Fan blowing on surface — COMPUTER [initials] — FROM Table No 14 TO
MADE IN CONNECTION WITH Oxygen absorption tests — CHECKER — DATE Feb. 2 1916.

Tank No 9 — Fan blowing
Dilution 1:30 Fresh Water Depth 4 ft.
Suspended Solids 98 P.P.M.
Oxygen consumed 54 P.P.M.
Temp. 22¼° to 13.0° C.

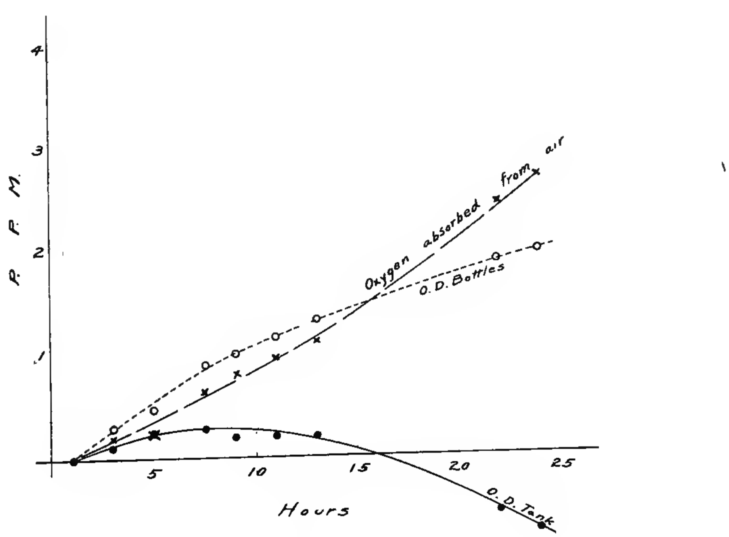


TABLE No. 14—ABSORPTION OF OXYGEN.—EXPERIMENT No. 53.

Dilution 1 in 30 | Fresh Water | Electric Fan Blowing | Depth 3 ft.

Date, February	Time	Temperature °C.	Nitrites	Tank: Dissolved Oxygen, P.P.M.	Tank: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
14.......	10.30	19	0.07	5.92	....	5.92	....	....
14.......	11.30	18.5	....	5.92	0	5.92	0	0
14.......	1.30	18	....	5.75	.17	5.71	.21	0.04
14.......	3.30	16.5	....	5.55	.37	5.39	.53	.16
14.......	5.30	15.5	....	5.22	.70	4.93	.99	.29
14.......	7.30	14.5	0.12	4.81	1.11	4.20	1.72	.61
14.......	9.30	14	....	4.69	1.23	3.79	2.13	.90
14.......	11.30	13	....	4.69	1.23	3.59	2.33	1.10
15.......	8.30	9.5	0.17	5.22	.70	2.53	3.39	2.69
15.......	10.30	8.5	....	5.22	.70	2.37	3.55	2.85

Oxygen Demand at 37.5° C.
Dilution 1 in 100

Day	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.
Int......	7.14	....
1........	5.10	2.04
2........	4.86	2.28
3........	4.24	2.90
4........	4.16	2.98
5........	4.16	2.98

Solids

Suspended	Volatile	Ash	Settling
154 P.P.M.	136 P.P.M.	18 P.P.M.	0.8 c.c.

Oxygen Consumed, 81 P.P.M.

Sewage Experiment Station at West Brighton — Experiment No 53
Oxygen absorbed by sewage diluted with Fresh Water — ACC 95
Fan blowing on surface — COMPUTER [initials] — FROM Table No 14
MADE IN CONNECTION WITH Oxygen absorption tests — CHECKER — DATE Feb 14 1916

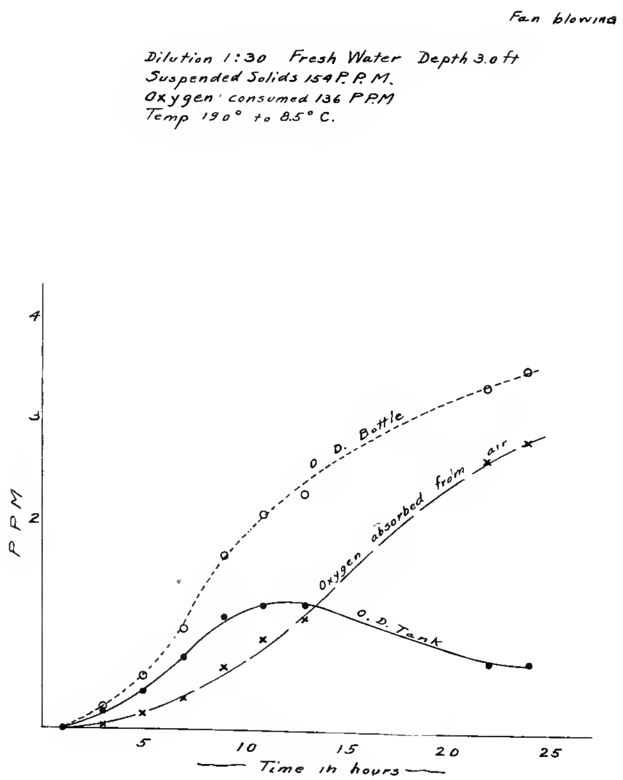


Table No. 14—Absorption of Oxygen.—Experiment No. 54.

Dilution 1 in 30 Fresh Water Wind Blowing Directly on Surface Depth 5 ft.

Date, February	Time	Temperature ° C.	Nitrites	Tank No. 7: Dissolved Oxygen, P.P.M.	Tank No. 7: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
24.......	11 A.M.	22	0.09	6.49	....	6.49	....	....
24.......	1 P.M.	22	....	6.28	.21	6.28	.21	0
24.......	3	21.5	....	5.84	.65	5.84	.65	0
24.......	5	20	....	5.46	1.03	5.22	1.27	.24
24.......	7	19.5	....	5.30	1.19	4.98	1.51	.32
24.......	9	19	....	5.30	1.19	4.65	1.84	.65
24.......	11	19	....	5.22	1.27	4.33	2.16	.89
25.......	9 A.M.	15.5	....	5.71	.78	3.22	3.27	2.49
25.......	11	15.5	....	5.79	.70	3.10	3.39	2.69

Oxygen Demand

Day	Total Solids at 37½°: Dissolved Oxygen, P.P.M.	Total Solids at 37½°: Oxygen Demand, P.P.M.	Dissolved Solids at 37½°: Dissolved Oxygen, P.P.M.	Dissolved Solids at 37½°: Oxygen Demand, P.P.M.
Int......	6.73	....	6.90	....
1........	5.67	1.06	6.20	.70
2........	5.39	1.34	6.08	.82
3........	4.98	1.75	5.87	1.03
4........	4.89	1.84	5.81	1.09
5........	4.51	2.22	5.77	1.13

Solids

Total	Dissolved	Suspended	Settled
822	710	112	0.3 c.c.

Organic Matter

Total	Dissolved	Suspended
362	276	86

Oxygen Consumed

Total	Dissolved	Suspended
52	40	12

President Borough of Richmond FILE Experiment No. 54
Bureau of Engineering, Sewage ACC Table No. 14
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE Feb. 24, 1916.
Depth 5 ft.

Dilution 1:30 fresh water
Suspended Solids 112 PPM
Oxygen Consumed 52 P.P.M
Temp 22°C to 15.5 C

Wind blowing on surface waves ½"

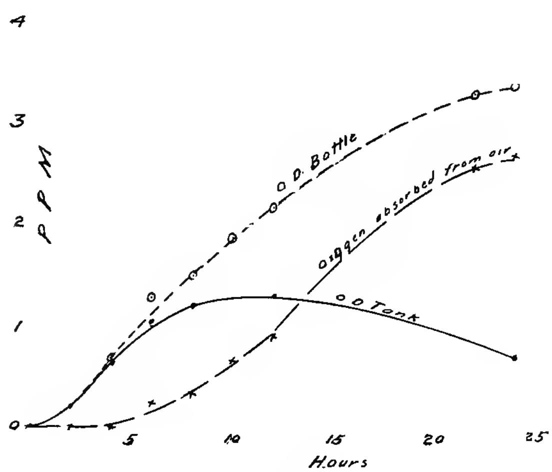


TABLE NO. 15—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 55.

Dilution 1 in 30 | Fresh Water | Wave Movement | Depth 5 ft.

Date, February	Time	Temperature ° C.	Nitrites	Tank No. 9: Dissolved Oxygen, P.P.M.	Tank No. 9: Oxygen Demand, P.P.M.	Bottles: Dissolved Oxygen, P.P.M.	Bottles: Oxygen Demand, P.P.M.	Oxygen Absorbed
24.......	11 A.M.	21.5	0.085	7.06	....	6.94	....	....
24.......	1 P.M.	21.5	....	7.10	—.04	6.77	.17	.21
24.......	3	21.0	....	7.18	—.12	6.28	.66	.78
24.......	5	20.5	....	7.02	+.04	5.72	1.22	1.18
24.......	7	20.0	....	7.02	+.04	5.46	1.48	1.44
24.......	9	19.5	....	7.92	—.86	4.98	1.96	2.82
24.......	11	19.0	....	8.41	—1.35	4.77	2.17	3.52
25.......	9 A.M.	16.5	0.14	7.51	—.45	3.75	3.19	3.64
25.......	11	16.5	....	8.08	—1.02	3.67	3.27	4.39

Oxygen Demand at 37.5°. Dilution 1 in 100

Day	Total Solids: Dissolved Oxygen, P.P.M.	Total Solids: Oxygen Demand, P.P.M.	Dissolved Solids: Dissolved Oxygen, P.P.M.	Dissolved Solids: Oxygen Demand, P.P.M.
Int......	6.73	....	6.90	....
1........	5.67	1.06	6.20	.70
2........	5.39	1.34	6.08	.82
3........	4.98	1.75	5.87	1.03
4........	4.89	1.84	5.81	1.09
5........	4.51	2.22	5.77	1.13

Solids

Total	Dissolved	Suspended	Settled
822	710	112	0.3 c.c.

Organic Matter

Total	Dissolved	Suspended
362	276	86

Oxygen Consumed

Total	Dissolved	Suspended
52	40	12

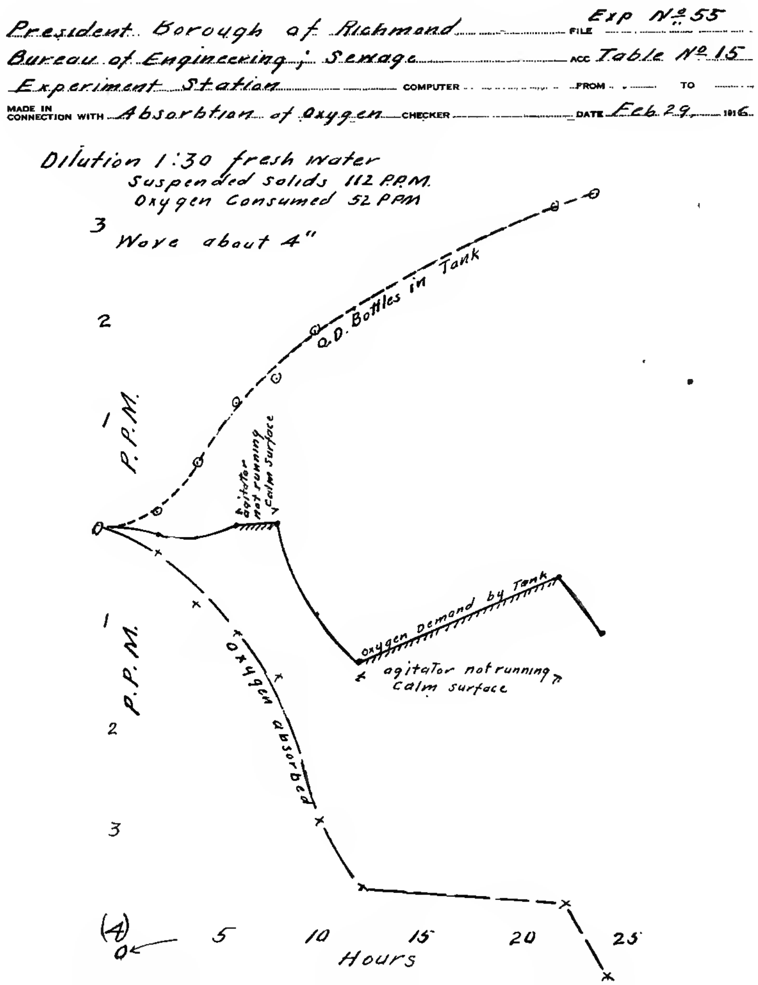


Table No. 16—Absorption of Oxygen.—Experiment No. 59.

Dilution 1 in 40 — Fresh Water — Fan Blowing on Surface — Depth 3 ft.

Date, March	Time	Temperature °C.	Nitrites	Tank No. 9 Dissolved Oxygen, P.P.M.	Tank No. 9 Oxygen Demand, P.P.M.	Bottles Dissolved Oxygen, P.P.M.	Bottles Oxygen Demand, P.P.M.	Oxygen Absorbed P.P.M.
3........	10.30	20	0.10	7.39	....	7.35	....	....
3........	12.30	19.5	....	7.39	0	7.15	.20	.20
3........	2.30	18.5	....	7.39	0	7.06	.29	.29
3........	4.30	17.0	....	7.35	.04	6.94	.41	.37
3........	6.30	15.5	....	7.47	—.08	6.86	.49	.57
3........	8.30	15.5	....	7.55	—.16	6.82	.53	.69
3........	10.30	15.5	....	7.43	—.04	6.54	.81	.85
4........	8.30	10.0	0.18	8.65	—1.26	6.09	1.26	2.52
4........	10.30	9.5	....	8.93	—1.54	5.68	1.67	3.21

Fan stopped from 8.30 to 10.30 P.M.

Oxygen Demand at 37.5°

Day	Total Solids Dissolved Oxygen, P.P.M.	Total Solids Oxygen Demand, P.P.M.	Dissolved Solids Dissolved Oxygen, P.P.M.	Dissolved Solids Oxygen Demand, P.P.M.
Int.	6.82	....	6.90	....
1........	5.89	.93	6.21	.69
2........	5.52	1.30	6.09	.81
3........	5.36	1.46	5.93	.97
4........	5.30	1.52	5.77	1.13
5........	5.30	1.52	5.77	1.13

Solids

Total	Dissolved	Suspended	Settled
732	640	92	0.5 c.c.

Organic Matter

Total	Dissolved	Suspended
410	340	70

Oxygen Consumed

Total	Dissolved	Suspended
50	37	13

President Borough of Richmond — FILE Exp No 59
Bureau of Engineering, Sewage — ACC Table No 16
Experiment Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH Absorbtion of Oxygen — CHECKER — DATE March 3 1916

Depth 3 ft

Dilution 1:40 fresh Water
Suspended Solids 92 P.P.M
Oxygen Consumed 50 P.P.M
Tempt 19.5°C to 9.5°C

One Electric fan

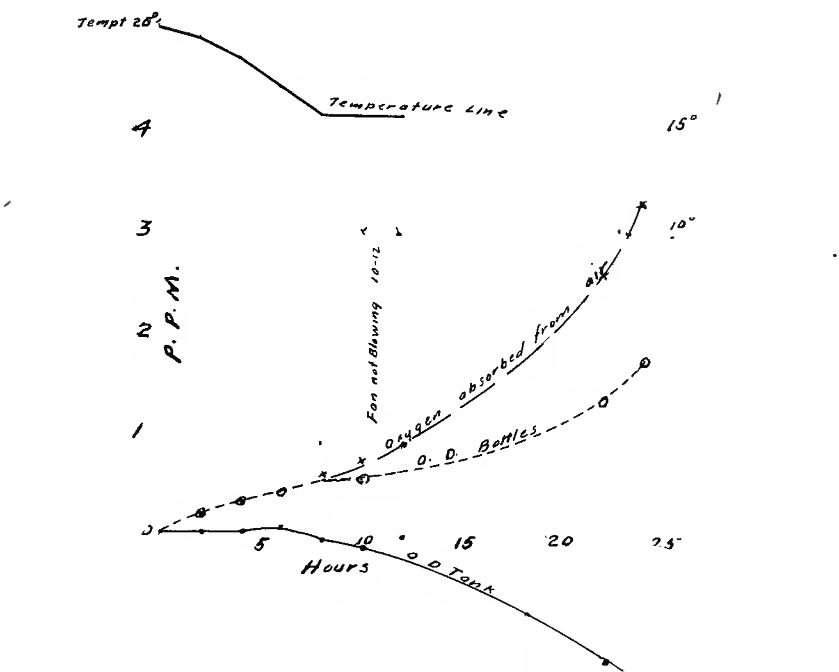


TABLE NO. 17—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 73.

Salt Water from Kill Von Kull to be used for Diluting Sewage April 19. Two Fans Blowing

		Temperature °C.			Bottles: Tank		Bottles: 20° Incubator		Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
Date April	Time	Top	Bottom	Nitrites	D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxugen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed
17..	10.30 A.M.	23	23	0.09	5.82	....	5.82	....	5.82	....	....	5.78	....	....	5.72	....	....	5.82	....	....	5.68	....	....	5.66	....	....
17..	12.30	21.5	21.5	....	5.66	.16	5.74	.08	5.86	.04	.20	5.66	—.12	.04	5.62	—.10	.06	5.74	—.08	.08	5.58	—.10	.06	5.66	.0	.16
17..	2.30	21	21.5	....	5.66	.16	5.66	.16	5.98	.16	.32	5.82	.04	.20	5.74	.02	.18	5.86	.04	.20	5.74	.06	.22	5.86	.20	.36
17..	4.30	20.5	21	....	5.62	.20	5.62	.20	6.02	.20	.40	5.90	.12	.32	5.86	.14	.34	5.94	.12	.32	5.82	.14	.34	5.94	.28	.48
17..	6.30	20	20.5	....	5.62	.20	5.54	.28	6.14	.32	.52	5.98	.20	.40	5.94	.22	.42	6.02	.20	.40	5.98	.30	.50	6.02	.36	.56
17..	8.30	19.5	20	....	5.50	.32	5.54	.28	6.14	.32	.64	6.14	.36	.68	6.02	.30	.62	6.10	.28	.60	6.14	.46	.78	6.22	.56	.88
17..	10.30	19	19.5	....	5.50	.32	5.41	.41	6.30	.48	.80	6.30	.62	.94	6.02	.30	.62	6.30	.48	.80	6.18	.50	.82	6.34	.68	1.00
18..	8.30	16	16.5	....	5.25	.57	5.33	.49	6.79	.97	1.54	6.63	.85	1.42	6.55	.83	1.40	6.63	.81	1.38	6.47	.79	1.36	6.63	.97	1.54
18..	10.30	16	16.5	0.12	5.05	.77	5.17	.65	6.79	.97	1.74	6.67	.89	1.66	6.63	.91	1.68	6.71	.89	1.66	6.63	.95	1.72	6.71	1.05	1.82

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int....	5.82	....
1..........	4.28	1.54
2..........	4.04	1.78
3..........	3.64	2.18
4..........	3.23	2.59
5..........	2.75	3.07

	Total	Suspended	Dissolved	Settled
Solids.............	17,330	29	17,301	......
Organic...........	6,300	12	6,288	......
Oxygen Consumed..	12	..	......	......

Chlorine, 6,200 P.P.M.

A-15

President Borough of Richmond	FILE Exp 73
Bureau of Engineering ; Sewage	ACC Table No 17
Experiment Station COMPUTER	FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER	DATE April 17 1916.

Salt Water from Kill Van Kull for dilution Exp No 74
Suspended Solids 48 PPM
Oxygen Consumed 32 PPM
Chlorine 6500 PPM
Temperature 23° – 16°C

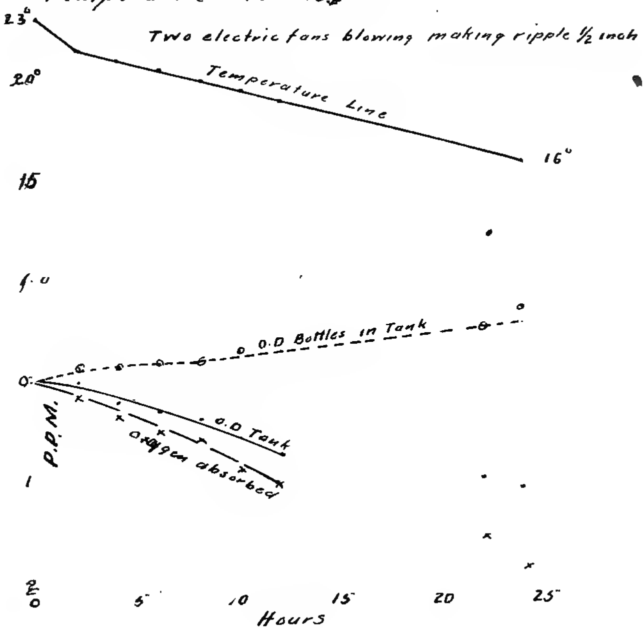


TABLE NO. 17—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 75.

Salt Water — For Dilution April 26 — Two Electric Fans

Date April	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
24..	9.45 A.M.	21	21.0	0.06	6.29	....	6.29	....	6.29	....	....	6.29	....	....	6.29	....	....	6.29	....	....	6.25	....	....	6.13	....	....
24..	11.45	20	20.0	....	6.09	.20	6.21	.08	6.45	.16	.36	6.37	.08	.28	6.29	.0	.20	6.37	.08	.28	6.25	.0	.20	6.37	.24	.48
24..	1.45	19.25	19.5	....	6.09	.20	6.09	.20	6.45	.16	.36	6.37	.08	.28	6.29	.0	.20	6.45	.16	.36	6.33	.08	.28	6.37	.24	.48
24..	3.45	19.0	19.0	....	5.97	.32	6.09	.20	6.53	.24	.56	6.45	.16	.48	6.37	.08	.40	6.49	.20	.52	6.37	.12	.44	6.49	.36	.68
24..	5.45	18.0	18.5	....	5.97	.32	6.05	.24	6.61	.32	.64	6.49	.20	.52	6.49	.20	.52	6.57	.28	.60	6.57	.32	.64	6.57	.44	.76
24..	7.45	18.0	18.0	....	5.97	.32	6.05	.24	6.65	.36	.68	6.61	.32	.64	6.53	.24	.56	6.61	.32	.64	6.57	.32	.64	6.57	.44	.76
24..	9.45	17.0	17.5	....	5.89	.40	6.01	.28	6.69	.40	.80	6.69	.40	.80	6.61	.32	.72	6.69	.40	.80	6.65	.40	.80	6.65	.52	.92
25..	8.00	15.5	16.0	....	5.57	.72	5.65	.64	7.00	.71	1.43	6.88	.59	1.31	6.84	.55	1.27	6.92	.63	1.35	6.84	.59	1.31	6.88	.75	1.47
25..	10.00	15.5	16.0	0.10	5.49	.80	5.45	.84	7.04	.75	1.55	6.92	.63	1.43	6.84	.55	1.35	6.92	.63	1.43	6.92	.67	1.47	6.92	.78	1.58

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int.	6.29	....
1	5.25	1.04
2	4.54	1.75
3	4.45	1.84
4	3.79	2.50
5	2.64	3.65

	Total	Dissolved	Suspended
Solids	13,950	13,916	34
Organic Solids	2,324	2,316	8
Oxygen Consumed	11	......	......
Chlorine	6,850	......	......

President Borough of Richmond — FILE Exp № 75
Bureau of Engineering, Sewage — ACC Table № 17
Experiment Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER — DATE April 24 191[illegible]

Salt Water from Kill Van Kull for Exp № 76

Suspended solids 34 P.P.M.
Oxygen Consumed 11 P.P.M
Chlorine 6850 P.P.M.
Temperature 21°C to 16°C

Two Electric fans making ripple abt. 1/2"

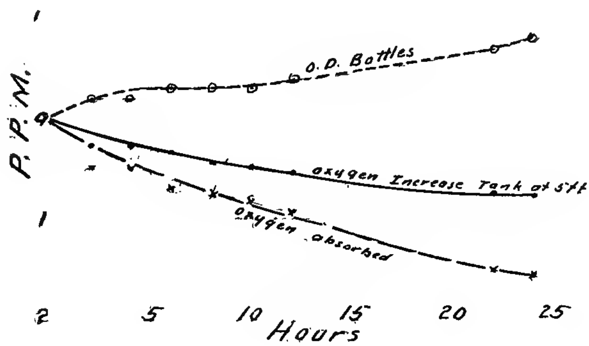


Table No. 17—Absorption of Oxygen.—Experiment No. 77.

Salt Water from Kill for Experiment No. 78. — Two Electric Fans.

Date May	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Ocygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
1...	10 A.M.	20.0	20.0	0.06	6.18	....	6.18	....	6.18	....	....	6.18	....	....	6.10	....	....	6.18	....	....	6.18	....	....	6.18	....	....
1...	12	20.0	20.0	....	6.18	0	6.18	0	6.31	.13	.13	6.26	.08	.08	6.18	.08	.08	6.26	.08	.08	6.26	.08	.08	6.26	.08	.08
1...	2	19.5	19.5	....	6.10	.08	6.10	.08	6.43	.25	.33	6.26	.08	.16	6.26	.16	.24	6.31	.13	.21	6.31	.13	.21	6.31	.13	.21
1...	4	19.0	19.25	....	6.10	.08	6.10	.08	6.51	.33	.41	6.43	.25	.33	6.43	.33	.41	6.43	.25	.33	6.43	.25	.33	6.43	.25	.33
1...	6	19.0	19.0	....	6.02	.16	6.10	.08	6.56	.38	.54	6.51	.33	.49	6.51	.41	.57	6.56	.38	.54	6.56	.38	.54	6.51	.33	.49
1...	8	18.5	18.5	....	6.02	.16	6.06	.12	6.68	.50	.66	6.60	.42	.58	6.51	.41	.57	6.64	.46	.62	6.51	.33	.49	6.56	.38	.54
1...	10	18.0	18.0	....	6.02	.16	5.98	.20	6.76	.58	.74	6.68	.50	.66	6.60	.50	.66	6.76	.58	.74	6.64	.46	.62	6.68	.50	.66
2...	8	17.0	17.0	....	5.94	.24	5.85	.33	6.97	.79	1.03	6.84	.66	.90	6.84	.74	.98	6.84	.66	.90	6.84	.66	.90	6.84	.66	.90
2...	10	17.0	17.0	0.12	5.85	.33	5.85	.33	7.01	.83	1.16	6.89	.71	1.04	6.84	.74	1.07	6.89	.71	1.04	6.89	.71	1.04	6.89	.71	1.04

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	6.18	....
1...........	5.57	.61
2...........	4.41	1.77
3...........	4.04	2.14
4...........	3.79	2.39
5...........	3.13	3.05

	Total	Dissolved	Suspended
Solids.............	13,714	13,691	23
Organic...........	2,434	2,425	9
Oxygen Consumed..	11	......	......
Chlorine...........	6,850		

President Borough of Richmond	FILE Exp. No. 77
Bureau of Engineering; Sewage	ACC Table No 17
Experiment Station COMPUTER	FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER	DATE May 1 1916

Salt Water from Kill Van Kull for Exp No. 78

Suspended solids	23 PPM.
Oxygen Consumed	11 PPM.
Chlorine	6850 PPM.
Tempt	20°C to 17°C

Two electric fans making ripple abt. ½"

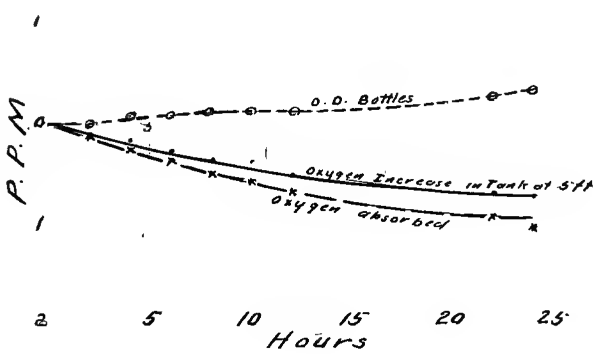


Table No. 17—Absorption of Oxygen.—Experiment No. 79.

Salt Water from Kill Von Kull for Experiment No. 80 — Two Electric Fans, Waves ½ inch.

Date May	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
8...	10 A.M.	22	22	0.08	5.85	....	5.85	....	5.85	....	....	5.85	....	....	5.85	....	....	5.85	....	....	5.85	....	....	5.69	....	....
8...	12	22	22	....	5.85	0	5.69	.16	5.85	0	0	5.85	0	0	5.85	0	0	5.85	0	0	5.85	0	0	5.77	.08	.08
8...	2	21.75	21.75	....	5.85	0	5.69	.16	5.93	.08	.08	5.85	0	0	5.85	0	0	5.85	0	0	5.85	0	0	5.85	.16	.16
8...	4	21.75	21.75	....	5.73	.12	5.60	.25	5.93	.08	.20	5.93	.08	.20	5.89	.04	.16	5.89	.04	.16	5.89	.04	.16	5.85	.16	.28
8...	6	21.5	21.5	....	5.69	.16	5.60	.25	6.01	.16	.32	5.93	.08	.24	5.93	.08	.24	5.93	.08	.24	5.93	.08	.24	5.93	.24	.40
8...	8	21.25	21.25	....	5.69	.16	5.60	.25	6.05	.20	.36	5.97	.12	.28	5.97	.12	.28	5.97	.12	.28	5.97	.12	.28	5.97	.28	.44
8...	10	21.0	21.0	....	5.56	.29	5.44	.41	6.09	.24	.53	5.97	.12	.41	5.97	.12	.41	5.97	.12	.41	5.97	.12	.41	5.97	.28	.57
9...	8	19.0	19.5	....	5.20	.65	5.28	.57	6.21	.36	1.01	6.17	.32	.97	6.17	.32	.97	6.17	.32	.97	6.17	.32	.97	6.17	.48	1.13
9...	10	19.0	19.5	0.10	5.20	.65	5.12	.73	6.25	.40	1.05	6.25	.40	1.05	6.21	.36	1.01	6.21	.36	1.01	6.21	.36	1.01	6.21	.52	1.17

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int...........	5.85	....
1...........	5.28	.57
2...........	4.39	1.46
3...........	3.90	1.95
4...........	3.29	2.56
5...........	3.14	2.71

	Total	Dissolved	Suspended
Solids.............	24,834	24,767	67
Organic Solids.....	10,906	10,877	29
Oxygen Consumed..	11	......	..
Chlorine..........	8,500	......	..

President Borough of Richmond — FILE Exp. No. 79
Bureau of Engineering; Sewage — ACC. Table No 17
Experimental Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH Absorbtion of Oxygen — CHECKER — DATE May 8, 1916

Salt Water from Kill VanKull to be used in Exp 80

Suspended Solids 67 PPM.
Oxygen Consumed 11 PPM.
Chlorine 5500 PPM.

Temperature 22°C to 19.5°C

One Electric fan making a ripple over 3/4 area of Tank

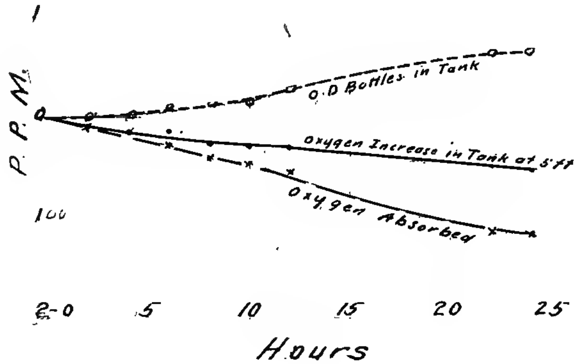


TABLE No. 17—ABSORPTION OF OXYGEN.—EXPERIMENT No. 81.

Salt Water from Kill Von Kull for Experiment No. 82 allowed to Settle Three days.

Two Electric Fans, Ripple ½ inch.

Date May	Time	Temperature °C. Top	Bottom	Nitrites	Bottles Tank D. O., P.P.M.	O. D., P.P.M.	20° Incubator D. O., P.P.M.	O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	Oxygen Demand	Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	Oxygen Demand	Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	Oxygen Demand	Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	Oxygen Increase	Oxygen Absorbed
16..	10 A.M.	18	17.7	0.02	7.67	....	7.67	....	7.67	....	....	7.67	....	....	7.67	....	....	7.67	....	....	7.67	....	....	6.12	....	....
16..	12	17.5	17.7	....	7.59	.08	7.63	.04	7.55	.12	—.04	7.55	.12	—.04	7.51	.16	—.08	7.51	.16	—.08	7.47	.20	—.12	7.35	—1.23	—1.31
16..	2	17.25	17.7	....	7.51	0.16	7.51	.16	7.47	.20	—.04	7.47	.20	—.04	7.43	.24	—.08	7.43	.24	—.08	7.43	.24	—.08	7.43	—1.31	—1.47
16..	4	17	17.5	....	7.43	0.24	7.43	.24	7.43	.24	—.0	7.39	.28	—.04	7.35	.32	—.08	7.35	.32	—.08	7.35	.32	—.08	7.35	—1.23	—1.47
16..	6	17	17	....	7.39	.28	7.39	.28	7.39	.28	—.0	7.35	.32	—.04	7.31	.36	—.08	7.31	.36	—.08	7.31	.36	—.08	7.31	—1.19	—1.47
16..	8	16.5	17	....	7.35	.32	7.35	.32	7.31	.36	—.04	7.27	.40	—.08	7.27	.40	—.08	7.27	.40	—.08	7.27	.40	—.08	7.27	—1.15	—1.47
16..	10	16.5	16.5	....	7.27	.40	7.27	.40	7.23	.44	—.04	7.18	.49	.09	7.18	.49	—.09	7.18	.49	—.09	7.18	.49	—.09	7.18	—1.06	—1.46
17..	8	16	16.0	....	7.02	.65	6.94	.73	7.02	.65	+.00	7.02	.65	0	7.02	.65	.00	7.02	.65	—.00	7.02	.65	.00	7.02	—0.90	—1.46
17..	10	16	16	0.02	7.02	.65	6.86	.81	7.02	.65	+.00	7.02	.65	0	7.02	.65	0	7.02	.65	.00	7.02	.65	.00	7.02	—0.90	—1.55

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	7.67	....
1...........	5.88	1.79
2...........	5.14	2.55
3...........	5.06	2.61
4...........	4.49	3.18
5...........	3 43	4.24

	Total	Dissolved	Suspended
Solids.............	27,762	27,730	32
Organic Solids......	9,262	9,245	17
Oxygen Consumed..	15	......	..
Chlorine...........	11,200	......	..

President Borough of Richmond FILE Exp No 81

Bureau of Engineering, Sewage ACC Table No 17

Experiment Station COMPUTER FROM TO

MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE May 16 1916

Salt Water from Kill Van Kull for Exp No 82

Suspended solids 32 P.P.M.
Oxygen Consumed 15 PPM
Chlorine 11200 P.P.M.
Temperature 18°C to 16°C

Two electric fans making ripple about ½"

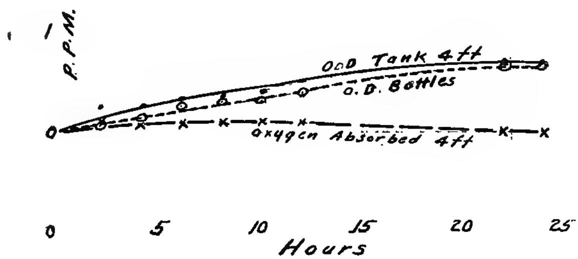


TABLE NO. 17—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 83.

Salt Water from Kill Von Kull for Experiment No. 84. Two Electric Fans, Waves ½ inch.

Date May	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxugen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
22..	9.30 A.M.	19.2	19.2	0.02	6.18	....	6.18	....	6.18	....	....	6.18	....	....	6.18	....	....	6.18	....	....	6.06	....	....	6.06	....	....
22..	11.30	19	19	....	6.02	.06	6.18	—.00	6.18	.0	.06	6.18	.0	.06	6.18	.0	.06	6.18	.0	.06	6.14	—.08	.14	6.14	.08	.14
22..	1.30	19	19	....	5.94	.06	6.10	.08	6.22	.04	—.10	6.22	—.04	.10	6.22	.04	.10	6.22	—.04	.10	6.22	—.16	.22	6.22	.16	.22
22..	3.30	18.7	18.7	....	5.94	.06	6.10	.08	6.30	.12	—.18	6.26	—.08	.14	6.26	.08	.14	6.26	—.08	.14	6.26	—.20	.26	6.26	.20	.26
22..	5.30	18.5	18.5	....	5.94	.06	6.10	.08	6.43	.25	—.31	6.38	—.20	.26	6.38	.20	.26	6.38	—.20	.26	6.38	—.32	.38	6.38	.32	.38
22..	7.30	18	18	....	5.94	.06	6.02	.16	6.47	.29	—.35	6.43	—.25	.31	6.43	.25	.31	6.43	—.25	.31	6.38	—.32	.38	6.38	.32	.38
22..	9.30	17.7	17.7	....	5.94	....	5.94	.24	6.55	.37	—.43	6.47	—.29	.35	6.47	.29	.35	6.47	—.29	.35	6.47	—.41	.47	6.47	.41	.47
23..	9.30	16.5	16.5	0.05	5.74	.44	5.74	.44	6.79	.61	—1.05	6.79	—.61	1.05	6.79	.61	1.05	6.79	—.61	1.05	6.79	—.73	1.17	6.79	.73	1.17

Oxygen Demand at 37.5° C.

Day	Salt Water Dissolved Oxygen P.P.M.	Salt Water Oxygen Demand P.P.M.
Int..........	618	...
1 day.......	501	117
2 days......	461	157
3 "	404	214
4	364	254
5	364	254

	Total	Dissolved	Suspended
Solids.............	27,624	27,550	74
Organic...........	12,056	12,017	39
Oxygen Consumed..	14	......	..
Chlorine..........	9,450	......	..

President Borough of Richmond FILE Exp No 83
Bureau of Engineering, Sewage ACC Table No 17
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Oxygen absorbtion CHECKER DATE May 22 1916

Salt Water from Kill Von Kull for Exp 84

Suspended Solids 74 P.P.M.
Oxygen Consumed 14 P P M
Chlorine 9450 P P M
Tempt 19 C to 17 75 C

Two fans Wave ½"

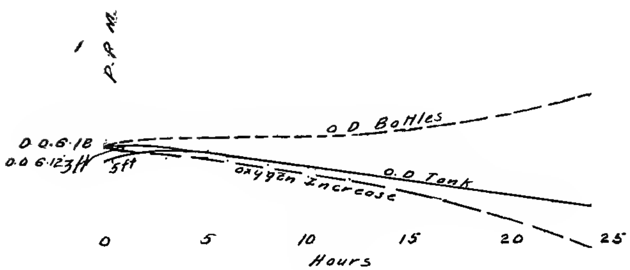


Table No. 17—Absorption of Oxygen.—Experiment No. 85.

Salt Water from Kill Von Kull for Experiment No. 86, Allowed to Stand 2 Days Undisturbed. Two Fans, Ripple ½ inch.

Date May	Time	Temperature °C. Top	Bottom	Nitrites	Bottles: Tank D. O., P.P.M.	O. D., P.P.M.	20° Incubator D. O., P.P.M.	O. D., P.P.M.	Surface: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	1 Foot: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	2 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	3 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	4 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	5 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
26...	10 A.M.	19.5	19.5	0.04	7.40	....	7.40	....	7.40	....	....	7.40	....	....	7.4	....	....	7.4	....	....	7.27	....	....	5.90	....	....
26...	12	19.25	19.0	....	7.27	.13	7.27	.13	7.35	.05	.08	7.31	.09	.04	7.27	.13	0	7.27	.13	0	7.27	0	.13	6.14	—.24	.37
26...	2	19.0	19.0	....	7.27	.13	7.27	.13	7.27	.13	0	7.23	.17	—.04	7.23	.17	—.04	7.23	.17	—.04	7.19	.08	.05	6.79	—.89	1.02
26...	4	19.0	19.0	....	7.27	.13	7.23	.17	7.27	.13	0	7.27	.13	0	7.27	.13	0	7.27	.13	0	7.27	0	.13	7.27	—1.37	1.50
26...	6	19.0	19.0	....	7.23	.17	7.19	.21	7.19	.21	—.04	7.23	.17	0	7.15	.25	—.08	7.19	.21	—.04	7.19	.08	.09	7.19	—1.29	1.46
26...	8	19.0	19.0	....	7.19	.21	7.19	.21	7.27	.13	.08	7.19	.21	0	7.19	.21	0	7.27	.13	.08	7.15	.12	.09	7.19	—1.29	1.50
26...	10	18.5	18.5	....	7.15	.25	7.11	.29	7.27	.13	.12	7.27	.13	.12	7.03	.37	—.12	7.19	.21	.04	7.19	.08	.17	7.27	—1.37	1.62
27...	8	17.5	17.5	....	6.87	.53	6.87	.53	7.35	.05	.48	7.27	.13	.40	7.27	.13	.40	7.27	.13	.40	7.27	0	.53	7.27	—1.37	1.90
27...	10	17.5	17.5	0.05	6.87	.53	6.87	.53	7.35	.05	.48	7.31	.09	.44	7.27	.13	.40	7.27	.13	.40	7.27	0	.53	7.27	—1.37	1.90

Oxygen Demand at 37.5° C.

Day	Salt Water: Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int.	7.40	....
1 day	5.66	1.74
2 days	5.13	2.27
3 "	5.74	1.66
4 "	5.58	1.82
5 "	4.57	2.83

	Total	Dissolved	Suspended	Settled
Solids	18,750	18,695	55	..
Organic Solids	5,496	5,470	26	..
Oxygen Consumed	13	......	..	..
Chlorine	8,000	......	..	..

President Borough of Richmond		FILE	Exp. 85
Bureau of Engineering; Sewage		ACC	Table No 17
Experiment Station	COMPUTER	FROM	TO
MADE IN CONNECTION WITH Absorbtion of Oxygen	CHECKER	DATE	May 26 1916

Salt Water from Kill Van Kull for Exp 86
allowed to stand undisturbed 2 days

Suspended Solids in water 55 P.P.M
Oxygen Consumed 13 P.P.M
Chlorine 8000 P.P.M
Temperature 19.5°C to 17.5°C

Two Electric fans ripple ½"

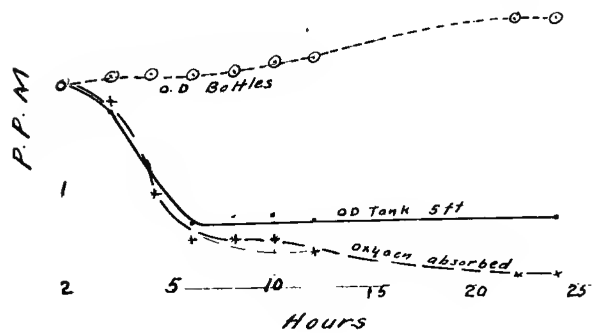


Table No. 17—Absorption of Oxygen.—Experiment No. 87.

Salt Water from Kill Von Kull for Experiment No. 88 — Two Fans, Ripple ½ inch.

Date June	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Increase	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Increase	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Increase	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Increase	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Increase	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Increase	5 Feet Oxygen Absorbed
2...	9.45 A.M.	19.0	18.5	0.06	4.45	....	4.45	....	4.45	....	....	4.45	....	....	4.45	....	....	4.45	....	....	4.36	....	....	4.12	....	....
2...	11.45	18.75	18.5	....	4.45	0	4.40	.05	4.61	.16	.16	4.61	.16	.16	4.61	.16	.16	4.61	.16	.16	4.57	.21	.21	4.57	.45	.45
2...	1.45	18.75	18.5	....	4.40	.05	4.40	.05	4.81	.36	.41	4.77	.32	.37	4.77	.32	.37	4.77	.32	.37	4.77	.41	.46	4.77	.65	.70
2...	3.45	18.75	18 5	....	4.36	.09	4.36	.09	4.97	.52	.61	4.93	.48	.57	4.97	.52	.61	4.97	.52	.61	4.93	.57	.66	4.93	.81	.90
2...	5.45	18.5	18.5	....	4.36	.09	4.36	.09	5.17	.72	.81	5.09	.64	.73	5.13	.68	.77	5.09	.64	.73	5.09	.73	.82	5.13	1.01	1.10
2...	7.45	18.5	18.5	....	4.36	.09	4.36	.09	5.33	.88	.97	5.25	.80	.89	5.25	.80	.89	5.25	.80	.89	5.25	.89	.98	5.29	1.17	1.26
2...	9.45	18.0	18.0	....	4.36	.09	4.36	.09	5.46	1.01	1.10	5.41	.96	1.05	5.41	.96	1.05	5.41	.96	1.05	5.41	1.05	1.14	5.46	1.34	1.43
3...	9.45	17.5	17.5	0.08	4.20	.25	4.04	.41	6.18	1.73	1.98	6.14	1.69	1.94	6.14	1.69	1.94	6.14	1.69	1.94	6.14	1.78	2.03	6.14	2.02	2.27

Oxygen Demand at 37.5° C.

Day	Salt Water Dissolved Oxygen P.P.M.	Salt Water Oxygen Demand P.P.M.
Int..........	4.45	....
1 day.......	4.04	.41
2 days......	3.64	.81
3 "	2.95	1.50
4 "	3.07	1.38
5 "	1.72	2.73

	Total	Dissolved	Suspended	Settled
Solids............	22,058	22,045	13	..
Organic Solids.....	8,022	8,016	6	..
Oxygen Consumed..	13	......	..	..
Chlorine..........	8,600	......	..	..

Sewage Experiment Station — FILE Exp No 87
President Borough of Richmond, Bureau of Engineering, Sewage Experiment Station — ACC Table No 17
COMPUTER — FROM — TO
MADE IN CONNECTION WITH absorbtion of oxygen — CHECKER — DATE June 2 1916

Salt Water from Kill Van Kull for Exp No 88

Suspended Solids	13 P.P.M.
Oxygen Consumed	13 PPM
Chlorine	8,600 PPM.
Temperature	19° C

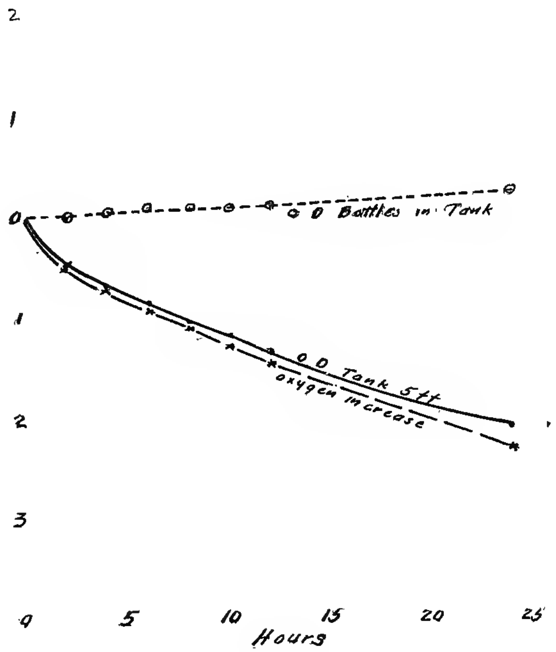


Table No. 17—Absorption of Oxygen.—Experiment No. 89.

Salt Water to be Used for Experiment No. 90.

Two Electric Fans Blowing on Surface Ripple about ½ inch.

Date June	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Absorbed Oxygen	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Absorbed Oxygen	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Absorbed Oxygen	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Absorbed Oxygen	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Absorbed Oxygen	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Absorbed Oxygen
9...	10 A.M.	18.5	18.25	0.06	5.50	....	5.50	....	5.50	....	....	5.50	....	....	5.50	....	....	5.50	....	....	5.50	....	....	3.82	....	....
9...	12	18.5	18.25	....	5.50	0	5.50	0	5.54	—.04	.04	5.50	0	0	5.50	0	0	5.50	0	0	5.50	0	0	5.50	—1.68	1.68
9...	2	18.5	18.25	....	5.46	.04	5.46	.04	5.58	—.08	.12	5.54	—.04	.08	5.54	—.04	.08	5.54	—.04	.08	5.54	—.04	.08	5.54	—1.72	1.76
9...	4	18.0	18.0	....	5.42	.08	5.42	0	5.66	—.16	.24	5.54	—.04	.12	5.66	—.16	.24	5.66	—.16	.24	5.66	—.16	.24	5.58	—1.76	1.84
9...	6	17.5	17.5	....	5.29	.21	5.42	.08	5.74	—.24	.45	5.74	—.24	.45	5.74	—.24	.45	5.74	—.24	.45	5.74	—.24	.45	5.74	—1.92	2.13
9...	8	17.5	17.5	....	5.29	.21	5.37	.13	5.82	—.32	.53	5.78	—.28	.49	5.83	—.33	.54	5.83	—.33	.54	5.78	—.28	.49	5.83	—2.01	2.22
9...	10	17.5	17.5	....	5.29	.21	5.29	.21	5.91	—.41	.62	5.91	— 41	.62	5.91	—.41	.62	5.91	—.41	.62	5.91	—.41	.62	5.91	2.09	2.30
10...	8	16.5	16.0	....	4.92	.58	4.92	.58	6.07	—.57	1.15	6.07	—.57	1.15	6.07	—.57	1 15	6.07	—.57	1.15	6.07	—.57	1.15	6.07	2.25	2.83
10...	10	16.5	16.0	0.10	4.92	.58	4.76	.74	6.15	—.65	1 23	6.11	—.61	1.19	6.11	—.61	1.19	6.11	—.61	1.19	6.11	—.61	1.19	6.11	2.29	2.87

Oxygen Demand at 37.5° C.

Day	Salt Water Dissolved Oxygen P.P.M.	Salt Water Oxygen Demand P.P.M.
Int.........	5.50	....
1 day.......	4.76	.74
2 days......	3.94	1.56
3 "	3.36	2.14
4 "	3.12	2.38
5 "	3.04	2.46

	Total	Dissolved	Suspended	Settled
Solids............	19,372	19,316	56	..
Organic Solids.....	3,414	3,383	31	..
Oxygen Consumed..	15	......	..	..
Chlorine..........	10,200	......	..	..

President Borough of Richmond — FILE Exp Nº 89
Bureau of Engineering; Sewage — ACC Table Nº 17
Experiment Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH Absorbtion of Oxygen — CHECKER — DATE June 9 1916

Salt Water from Kill Van Kull for Exp Nº 90

Suspended Solids in water	.56 P.P.M.
Oxygen Consumed	15 PPM
Chlorine	10200 P.P.M.
Temperature	18.5 C To 16.5 C

Two electric fans making a ripple about ½"

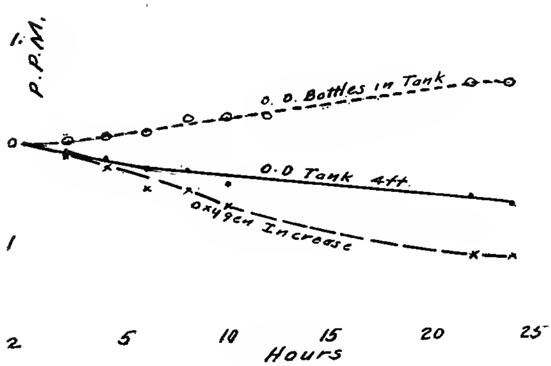


TABLE NO. 17—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 91.

Salt Water from Kill Von Kull

Electric Fans, Ripple About ½ inch

Date June	Time	Temperature °C. Top	Temperature °C. Bottom	Nitrites	Bottles: Tank D. O., P.P.M.	Bottles: Tank O. D., P.P.M.	Bottles: 20° Incubator D. O., P.P.M.	Bottles: 20° Incubator O. D., P.P.M.	Surface: Dissolved Oxygen, P.P.M.	Surface: Oxygen Demand,	Surface: Oxygen Absorbed	1 Foot: Dissolved Oxygen, P.P.M.	1 Foot: Oxygen Demand,	1 Foot: Oxygen Absorbed	2 Feet: Dissolved Oxygen, P.P.M.	2 Feet: Oxygen Demand, P.P.M.	2 Feet: Oxygen Absorbed	3 Feet: Dissolved Oxygen, P.P.M.	3 Feet: Oxygen Demand, P.P.M.	3 Feet: Oxygen Absorbed	4 Feet: Dissolved Oxygen, P.P.M.	4 Feet: Oxygen Demand, P.P.M.	4 Feet: Absorbed Oxygen	5 Feet: Dissolved Oxygen, P.P.M.	5 Feet: Oxygen Demand, P.P.M.	5 Feet: Oxygen Absorbed
14..	9.45 A.M.	17.0	17.0	0.04	5.09	....	5.09	....	5.09	....	....	5.09	....	....	5.09	....	....	5.09	....	....	4.88	....	....	4.80	....	....
14..	11.45	16¾	16¾	....	5.00	.09	5.00	.09	5.21	.12	.21	5.17	.08	.17	5.17	.08	.17	5.17	.08	.17	5.01	.13	.22	4.64	—.16	—.07
14..	1.45	16¾	16¾	....	4.92	.17	4.92	.17	5.33	.24	.41	5.29	.20	.37	5.29	.20	.37	5.29	.20	.37	5.09	.21	.38	4.51	—.29	—.12
14..	3.45	16½	16½	....	4.92	.17	4.92	.17	5.37	.28	.45	5.37	.28	.45	5.29	.20	.37	5.42	.33	.50	5.25	.37	.54	4.02	—.78	—.61
14..	5.45	16½	16½	....	4.88	.21	4.84	.25	5.42	.33	.54	5.46	.37	.58	5.50	.41	.62	5.50	.41	.62	5.46	.58	.79	5.46	.66	.87
14..	7.45	16½	16½	....	4.84	.25	4.84	.25	5.58	.49	.74	5.58	.49	.74	5.50	.41	.66	5.54	.45	.70	5.58	.70	.95	5.58	.78	1.03
14..	9 45	16¼	16¼	....	4 70	.33	4.51	.58	5.78	.69	1.02	5.66	.57	.90	5.66	.57	.90	5.66	.57	.90	5.66	.78	1.11	5.66	.80	1.19
15..	9 45	15½	15¾	....	4.51	.58	4.47	.62	5.99	.90	1.48	5.95	.86	1.44	5.95	.86	1.44	5.91	.82	1.40	5.91	1.03	1.61	5.91	1.11	1.69

Oxygen Demand of Sewage at 37.5° C.

Dilution 1 in 100

Day	Total Solids: Dissolved Oxygen P.P.M.	Total Solids: Oxygen Demand P.P.M.
Int....... ..	5.09	.00
1...........	4.27	.82
2...........	2.95	2.14
3.....	2.54	2.55
4...........	2.09	3.00
5....... ...	2.77	2.32

	Total	Dissolved	Suspended	Settled
Solids.............	32,356	32,283	73	..
Organic Solids.....	15,490	15,463	27	..
Oxygen Consumed..	15	......	..	..
Chlorine...........	10,100	......	..	..

President Borough of Richmond FILE Exp. No 91
Bureau of Engineering; Sewage ACC Table No 17
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 14 1916

Salt Water from Kill Van Kull for Exp 92

Suspended solids	73 P.P.M.
Oxygen Consumed	15 PPM
Chlorine	10100 PPM
Temperature	17° C To 16.5° C

Two electric fans ripple ½ inch

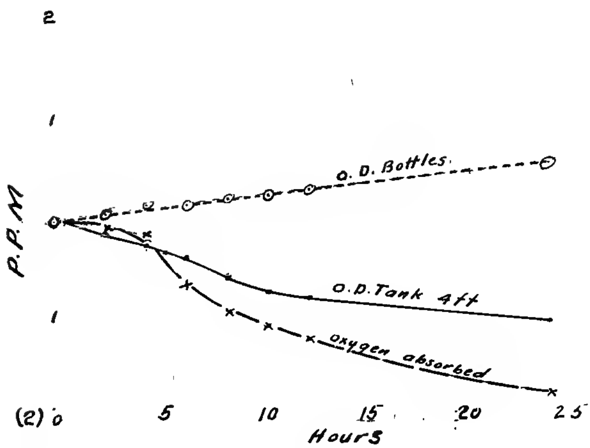


Table No. 17—Absorption of Oxygen.—Experiment No. 93.

Salt Water from Kill Von Kull — Two Electric Fans Blowing on Surface, Ripple About ½ inch

Date June	Time	Temperature °C. Top	Bottom	Nitrites	Bottles: Tank D. O., P.P.M.	O. D., P.P.M.	20° Incubator D. O., P.P.M.	O. D., P.P.M.	Surface: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	1 Foot: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	2 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	3 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	4 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	5 Feet: Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
20..	9.30 A.M.	21	20	.12	3.42	....	3.42	....	3.42	....	....	3.38	....	....	3.38	....	....	3.42	....	....	3.26	....	....	1.49 1.01	.... .48	.... .48 10 A.M.
20..	10.30	....	....	....	3.42	0	3.42	0	3.46	—.04	—.04	3.38	0	....	3.38	0.0	0	3.42	0	0	3.38	—.12	.12	1.85	—.36	.36
20..	11.30	21	20.5	....	3.42	0	3.42	0	3.46	—.04	.04	3.46	—.08	.08	3.46	—.08	.08	3.46	—.04	.04	3.42	—.16	.16	2.41	—.92	.92
20..	1.30	20.5	20.5	....	3.30	.12	3.30	.12	3.61	—.19	.31	3.54	—.16	.28	3.54	—.16	.28	3.54	—.12	.24	3.54	—.28	.40	3.46	—1.97	2.09
20..	3.30	20.5	20.5	....	3.30	.12	3.30	.12	3.82	—.40	.52	3.78	—.40	.52	3.78	—.40	.36	3.78	—.36	.48	3.78	—.52	.64	3.74	—2.25	2.37
20..	5.30	20¼	20¼	....	3.26	.16	3.26	.16	3.98	—.56	.72	3.94	—.56	.72	3.94	—.56	.72	3.94	.—52	.68	3.90	—.64	.80	3.90	—2.41	2.57
20..	7.30	20	20	....	3.22	.20	3.22	.20	4.18	—.76	.96	4.10	—.72	.92	4.10	—.72	.92	4.10	—.68	.88	4.10	—.84	1.04	4.10	—2.61	2.81
20..	9.30	19¾	19¾	....	3.18	.24	3.22	.20	4.30	—.88	1.12	4.26	—.88	1.12	4.26	—.88	1.12	4.26	—.84	1.12	4.22	—.96	1.20	4.22	—2.73	2.97
21..	9.30	18½	18½	.12	3.10	.32	3.02	.40	4.95	—1.53	1.85	4.91	—1.53	1.85	4.91	—1.53	1.85	4.91	—1.49	1.81	4.91	—1.65	1.97	4.91	—3.42	3.74

Oxygen Demand at 37.5° C.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	3.41	....
1...........	2.73	.68
2...........	2.17	1.24
3...........	1.93	1.48
4...........	1.77	1.64
5...........	1.93	1.48

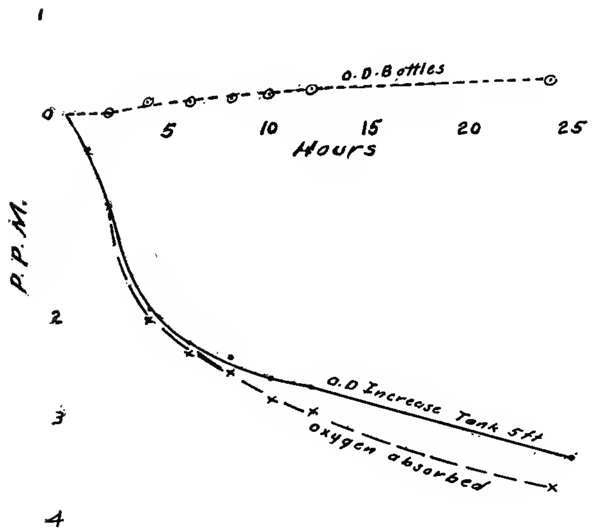
	Total	Dissolved	Suspended	Settled
Solids.............	33,818	33,750	68	..
Organic Solids......	15,722	15,678	44	..
Oxygen Consumed..	135	......	..	..
Chlorine...........	10,950	......	..	..

President Borough of Richmond — FILE Exp No 93
Bureau of Engineering; Sewage — ACC Table No 17
Experiment Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH Absorbtion of Oxygen — CHECKER — DATE June 20 1916

Salt Water from Kill Van Kull for Exp No 94

Suspended solids	68 P.P.M.
Oxygen Consumed	14 PPM
Chlorine	10 950 P.P.M.
Temperature	20°C

Two electric fans blowing on surface ripple ¼"



President Borough of Richmond Average of Exp. No.

Bureau of Engineering ; Sewage FILE 73, 75, 77, 79, ACC 81, 83, 85, 87, 89, 91, 93.

Experiment Station COMPUTER FROM Table No 17

MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 1916

Diagram of Average of Eleven Observations on Oxygen Absorbed by Salt Water from Kill Van Kull

Surfo Two Electric fans blowing on surface making a ripple abt ½ inch

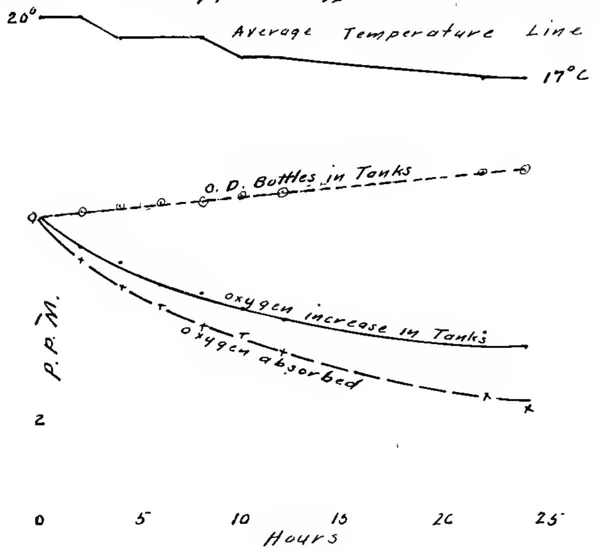


TABLE No. 18—ABSORPTION OF OXYGEN.—EXPERIMENT No. 74.

Dilution 1 in 20 with Salt Water Used in Test of April 17. | Two Fans Blowing.

		Temperature			Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
Date April	Time	Top	Bottom	Nitrites	D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxugen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P,P,M,	Oxygen Absorbed
19....	10.30	20	20	0.10	5.61	....	5.61	....	5.71	....	....	5.61	....	....	5.57	....	....	5.61	....	....	5.53	....	....	5.57	....	....
19....	12.30	19	19	....	5.41	.20	5.29	.32	5.53	.18	.02	5.41	.20	0	5.37	.20	0	5.49	.12	.08	5.41	.12	.08	5.45	.12	.08
19....	2.30	19	19	....	5.21	.40	5.05	.56	5.33	.38	.02	5.25	.36	.04	5.13	.44	—.04	5.15	.46	—.06	5.25	.28	.12	5.21	.36	.04
19....	4.30	19	19	....	4.85	.76	4.77	.84	5.09	.62	.14	5.09	.52	.24	5.09	.48	.28	5.09	.52	.24	5.01	.52	.24	5.09	.48	.28
19....	6.30	18	18	....	4.54	1.07	4.70	.91	5.09	.62	.45	5.01	.60	.47	5.01	.56	.51	5.01	.60	.47	4.93	.60	.47	5.01	.56	.51
19....	8.30	17.75	17.75	....	4.46	1.15	4.62	.99	5.09	.62	.53	5.01	.60	.55	4.93	.64	.51	5.01	.60	.55	4.93	.60	.55	4.93	.64	.51
19....	10.30	17.5	17.5	....	4.30	1.31	4.38	1.23	5.01	.70	.61	4.93	.68	.63	4.93	.64	.67	4.93	.68	.63	4.93	.60	.71	4.93	.64	.67
20....	8.30	15	15	....	3.18	2.43	3.26	2.35	4.85	.86	1.57	4.70	.91	1.52	4.62	.95	1.48	4.70	.91	1.52	4.70	.83	1.60	4.70	.87	1.56
20....	10.30	15	15	0.12	3.10	2.51	2.87	2.74	4.77	.94	1.57	4.70	.91	1.60	4.62	.95	1.56	4.70	.91	1.60	4.70	.83	1.68	4.70	.87	1.64

Oxygen Demand Dilution 1 in 100 at 37.5° C.

	Total Solids		Dissolved Solids	
Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	6.61	....	6.92	....
1..........	5.77	.84	6.21	.71
2..........	5.65	.96	6.05	.87
3..........	5.65	.96	6.05	.87
4..........	5.41	1.20	5.81	1.11
5..........	5.25	1.36	5.65	1.27

	Total	Dissolved	Suspended	Settled
Solids.............	850	792	58	0
Organic Solids......	258	210	48	..
Oxygen Consumed..	32	29	3	..

President, Barough of Richmond FILE Exp. No 74

Bureau of Engineering; Sewage Experiment Station ACC Table No 18

COMPUTER FROM TO

MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE April 19 1918 NO.

Dilution 1:20 Salt Water from Exp No 73
Suspended Solids 96 P.P.M
Oxygen Consumed 38 P.P.M
Chlorine 6800 P.P.M.
Tempt 19°C to 15.5°C

Two Elec fans Waves ½"

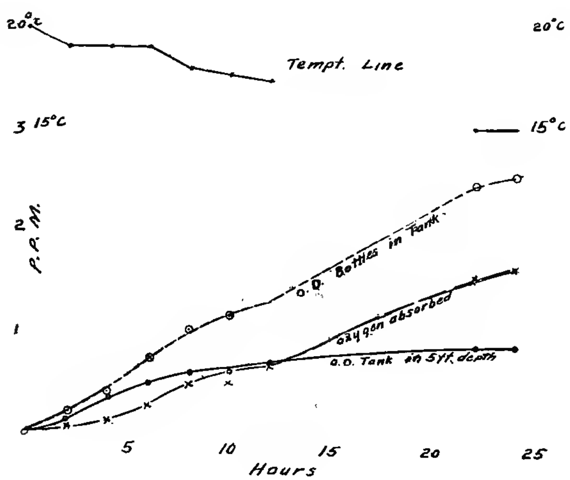


TABLE NO. 18—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 76.

Dilution 1 in 20 with Salt Water of April 24.

Two Electric Fans.

Date April	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D.O., P.P.M.	Bottles Tank O.D., P.P.M.	Bottles 20° Incubator D.O., P.P.M.	Bottles 20° Incubator D.O., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P,P,M,	5 Feet Oxygen Absorbed
26....	10.30	19.0	19.0	0.07	6.02	....	6.02	....	6.02	....	....	6.02	....	....	6.02	....	....	6.02	....	....	6.02	....	....	6.02	....	....
26....	12.30	19.0	19.0	....	5.69	.33	5.52	.50	5.85	.17	.16	5.94	.08	.25	5.94	.08	.25	5.98	.04	.29	5.94	.08	.25	5.81	.21	.12
26....	2.30	19.0	19.0	....	5.36	.66	5.36	.66	5.57	.45	.21	5.48	.54	.12	5.48	.54	.12	5.48	.54	.12	5.48	.54	.12	5.40	.62	.04
26....	4.30	18.5	18.5	....	5.03	.99	5.03	.98	5.28	.74	.25	5.11	.91	.08	5.11	.91	.08	5.19	.83	.16	5.19	.83	.16	5.15	.87	.12
26....	6.30	18.0	18.0	....	4.78	1.24	4.78	1.24	5.11	.91	.33	5.11	.91	.33	5.11	.91	.33	5.11	.91	.33	5.11	.91	.33	5.11	.91	.33
26....	8.30	17.25	17.75	....	4.54	1.48	4.54	1.48	5.11	.91	.57	5.03	.99	.49	4.95	1.07	.41	4.95	1.07	.41	4.95	1.07	.41	4.95	1.07	.41
26....	10.30	17.0	17.25	....	4.37	1.65	4.37	1.65	5.11	.91	.74	4.95	1.07	.58	4.95	1.07	.58	5.03	.99	.66	5.03	.99	.66	5.03	.99	.66
27....	8.30	14.75	15.5	....	3.30	2.72	3.17	2.85	4.99	1.03	1.69	4.78	1.24	1.48	4.78	1.24	1.48	4.78	1.24	1.48	4.78	1.24	1.48	4.78	1.24	1.48
27....	10.30	14.75	15.5	0.14	2.97	3.05	2.89	3.13	4.87	1.15	1.90	4.78	1.24	1.81	4.78	1.24	1.81	4.78	1.24	1.81	4.78	1.24	1.81	4.78	1.24	1.81

Oxygen Demand 1 in 100 at 37.5° C.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.	Dissolved Solids Dissolved Oxygen P.P.M.	Dissolved Solids Oxygen Demand P.P.M.
Int..........	6.76	....	6.76	....
1...........	5.69	1.07	5.69	1.07
2...........	4.99	1.77	5.19	1.57
3...........	4.91	1.85	4.99	1.77
4...........	4.87	1.89	4.87	1.89
5...........	4.45	2.31	4.87	1.89

	Total	Dissolved	Suspended	Settled
Solids.............	1,040	944	96	0
Organic Solids......	336	264	72	..
Oxygen Consumed..	38	25	13	..
Chlorine..........	6,800	......	..	..

President Borough of Richmond — Exp No 76 — FILE
Bureau of Engineering, Sewage — ACC Table No 18
Experiment Station — COMPUTER — FROM — TO
MADE IN CONNECTION WITH absorbtion of oxygen — CHECKER — DATE April 26 1916

Dilution 1:20 Salt Water Exp No 75
Suspended Solids 96 P.P.M.
Oxygen Consumed 38 P.P.M
Chlorine 6800 P.P.M
Tempt 19C to 15.5°C

Two Elec fans

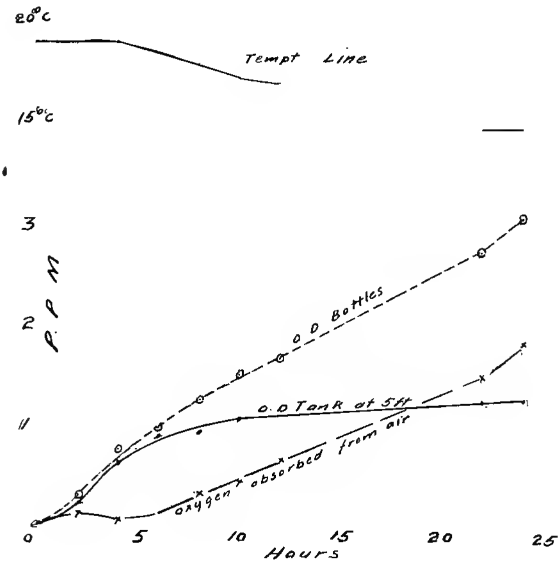


Table No. 18—Absorption of Oxygen.—Experiment No. 78.

Dilution 1 in 20. Salt Water from Experiment No. 77. Two Electric Fans, Wave ½ inch.

Date May	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
		Top	Bottom		D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand,	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand,	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
3.....	10	21.0	21.0	0.09	5.94	....	5.94	....	5.94	....	....	5.94	....	....	5.94	....	....	5.94	....	....	5.94	....	....	5.86	....	....
3.....	12	20.5	20.5	....	5.73	.21	5.73	.21	5.73	.21	0	5.73	.21	0	5.73	.21	0	5.73	.21	0	5.73	.21	.00	5.65	.21	0
3.....	2	20.25	20.25	....	5.44	.50	5.44	.50	5.44	.50	0	5.44	.50	0	5.44	.50	0	5.44	.50	0	5.36	.58	—.08	5.19	.67	—.17
3.....	4	20.0	20.0	....	4.78	1.16	5.03	.91	5.03	.91	.25	4.95	.99	.17	4.95	.99	.17	4.95	.99	.17	4.95	.99	.17	4.87	.99	.17
3.....	6	19.75	19.5	....	4.16	1.78	4.25	1.69	4.62	1.32	.46	4.54	1.40	.38	4.54	1.40	.38	4.54	1.40	.38	4.54	1.40	.38	4.54	1.32	.46
3.....	8	19.5	19.5	....	3.88	2.06	3.96	1.98	4.54	1.40	.66	4.45	1.49	.57	4.45	1.49	.57	4.45	1.49	.57	4.45	1.49	.57	4.45	1.41	.65
3.....	10	19.0	19.0	....	3.67	2.27	3.79	2.15	4.45	1.49	.78	4.41	1.53	.74	4.41	1.53	.74	4.41	1.53	.74	4.41	1.53	.74	4.41	1.45	.82
4.....	8	17.5	17.5	....	1.98	3.96	2.23	3.71	4.04	1.90	2.06	4.0	1.94	2.02	4.0	1.94	2.02	4.0	1.94	2.02	4.0	1.94	2.02	3.96	1.90	2.06
4.....	10	17.5	17.5	0.14	1.98	3.96	2.14	3.80	3.96	1.98	1.98	3.96	1.98	1.98	3.96	1.98	1.98	3.96	1.98	1.98	3.96	1.98	1.98	3.96	1.90	2.06

Dilution 1 in 100 of Oxygen Demand at 37.5° C.

Day	Toltal Solids		Dissolved Solids	
	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	6.84	....	7.17	....
1 day.......	5.52	1.32	6.27	.90
2 days.......	4.78	2.06	5.94	1.23
3 days.......	4.78	2.06	5.69	1.48
4 days.......	4.78	2.06	5.61	1.56
5 days.......	4.49	2.35	5.36	1.81

	Total	Dissolved	Suspended	Settled
Solids.............	1,076	964	112	0.3 c.c.
Oxygen Consumed..	50	32	18	..
Organic Solids......	460	364	96	..
Chlorine...........	6,600	..	..	..

President Borough of Richmond .... Exp. No 78 FILE

Bureau of Engineering Sewage .... ACC Table No. 18

Experiment Station .... COMPUTER FROM .... TO ....

MADE IN CONNECTION WITH absorbtion of oxygen .... CHECKER .... DATE May 3 1916

Dilution 1:20 Salt Water Exp No 77

Suspended Solids 112 PPM
Oxygen Consumed 50 PPM
Chlorine 6600 PPM
Tempt. 21°C to 17.5°C

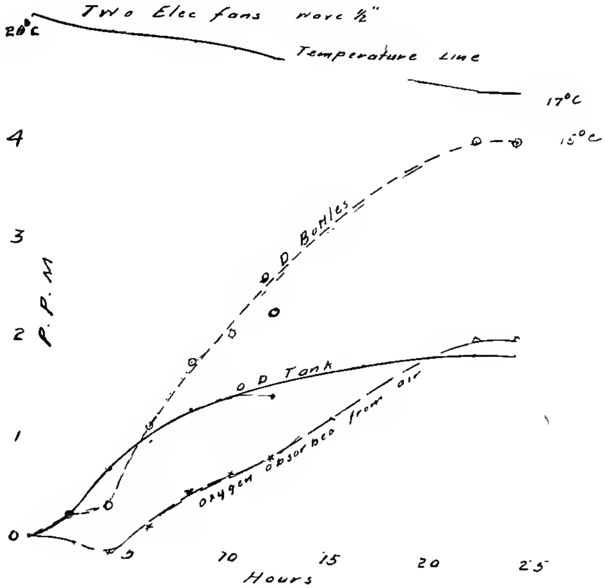


TABLE NO. 18—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 80.

Dilution 1 in 20. Salt Water Experiment No. 79 — Two Electric Fans, Wave ½ inch.

Date May	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Absorbed Oxygen	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Absorbed Oxygen	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Absorbed Oxygen	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Absorbed Oxygen	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Absorbed Oxygen	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Absorbed Oxygen
10	10.30	22.0	22.0	0.14	5.73	....	5.73	....	5.73	....	....	5.73	....	....	5.73	....	....	5.73	....	....	5.65	....	....	5.65	....	....
10	12.30	21.0	21.0	....	5.36	.37	5.44	.29	5.36	.37	0	5.36	.37	0	5.36	.37	0	5.36	.37	0	5.28	.37	0	5.28	.37	0
10	2.30	20.5	20.5	....	5.04	.69	5.20	.53	5.04	.69	0	5.04	.69	0	5.04	.69	0	4.96	.77	—.08	4.96	.69	0	4.96	.69	0
10	4.30	20.0	20.0	....	4.55	1.18	4.83	.90	4.55	1.18	0	4.55	1.18	0	4.55	1.18	0	4.55	1.18	0	4.47	1.18	0	4.47	1.18	0
10	6.30	20.0	20.0	....	3.98	1.75	4.18	1.55	4.14	1.59	.16	4.14	1.59	.16	4.14	1.59	.16	4.14	1.59	.16	4.06	1.59	.16	4.06	1.59	.16
10	8.30	19.5	19.5	....	3.53	2.20	3.90	1.83	4.06	1.67	.53	4.02	1.71	.49	4.02	1.71	.49	4.06	1.67	.53	4.06	1.59	.61	4.06	1.59	.61
10	10.30	19.5	19.5	....	3.49	2.24	3.70	2.03	3.98	1.75	.49	3.98	1.75	.49	3.98	1.75	.49	3.98	1.75	.49	3.98	1.67	.57	3.90	1.75	.49
11	8.30	18.5	18.5	0.14	1.58	4.15	2.56	3.17	3.05	2.68	1.47	3.05	2.68	1.47	3.05	2.68	1.47	3.05	2.68	1.47	3.01	2.64	1.51	3.01	2.64	1.51
11	10.30	18.5	18.5	....	1.54	4.19	2.19	3.54	2.92	2.81	1.38	2.92	2.81	1.38	2.92	2.81	1.38	2.92	2.81	1.38	2.88	2.77	1.42	2.76	2.89	1.30

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.	Dissolved Solids Dissolved Oxygen P.P.M.	Dissolved Solids Oxygen Demand P.P.M.
Int.	6.82	....	6.82	....
1 day	5.89	.93	5.89	.93
2 days	5.28	1.54	5.56	1.26
3 days	5.22	1.60	5.39	1.43
4 days	4.49	2.33	4.86	1.96
5 days	4.41	2.41	4.74	2.08

	Total	Dissolved	Suspended	Settled
Solids	992	922	70	0
Organic Solids	346	280	66	..
Oxygen Consumed	37	30	7	..
Chlorine	8,200	....	..	..

President Borough of Richmond FILE Exp. No 80
Bureau of Engineering Experimental ACC Table No 18
Station COMPUTER FROM TO
MADE IN CONNECTION WITH absorbtion of oxygen. CHECKER DATE May. 10 1916

Dilution 1:20 Salt Water from Exp. No 79

Suspended Solids. 70 P.P.M
Oxygen Consumed 37 P.P.M.
Chlorine 8200 P.P.M.
Temperature 22° to 18.5°C

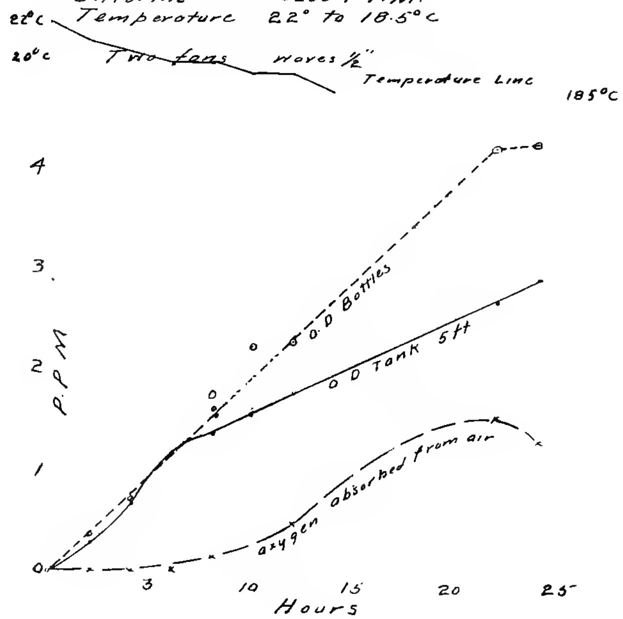


Table No. 18—Absorption of Oxygen.—Experiment No. 82.

Dilution 1 in 20. Salt Water of Experiment No. 81. Two Fans, Ripple ½ inch.

Date May	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D.O., P.P.M.	Bottles Tank O.D., P.P.M.	Bottles 20° Incubator D.O., P.P.M.	Bottles 20° Incubator O.D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Oxygen Demand, P.P.M.	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Oxugen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Oxygen Absorbed
18....	10.30	17	17	0.06	6.00	....	6.00	....	6.00	....	....	6.00	....	....	6.00	....	....	6.00	....	....	6.00	....	....	6.00	....	....
18....	12.30	17	17	....	5.80	.20	5.8	.20	5.88	.12	.08	5.80	.20	0	5.80	.20	0	5.8	.20	0	5.80	.20	0	5.80	.20	0
18....	2.30	16½	16½	....	5.67	.33	5.67	.33	5.76	.24	.09	5.76	.24	.09	5.76	.24	.09	5.76	.24	.09	5.71	.29	.04	5.67	.33	0
18....	4.30	16½	16½	....	5.55	.45	5.47	.53	5.67	.33	.12	5.67	.33	.12	5.67	.33	.12	5.67	.33	.12	5.63	.37	.08	5.63	.37	.08
18....	6.30	16	16	....	5.22	.78	5.06	.94	5.47	.53	.25	5.47	.53	.25	5.47	.53	.25	5.47	.53	.25	5.47	.53	.25	5.43	.57	.21
18....	8.30	15.5	15.5	....	4.98	1.02	4.82	1.18	5.35	.65	.37	5.31	.69	.33	5.31	.69	.33	5.31	.69	.33	5.31	.69	.33	5.31	.69	.33
18....	10.30	15	15	....	4.86	1.14	4.65	1.35	5.27	.73	.41	5.27	.73	.41	5.27	.73	.41	5.27	.73	.41	5.27	.73	.41	5.22	.78	.42
19....	8.30	13.5	13.5	....	4.00	2.00	3.51	2.49	5.27	.73	1.27	5.27	.73	1.27	5.27	.73	1.27	5.27	.73	1.27	5.27	.73	1.27	5.27	.73	1.27
19....	10.30	13.5	13.5	0.06	3.96	2.04	3.22	2.78	5.27	.73	1.31	5.27	.73	1.31	5.27	.73	1.31	5.27	.73	1.31	5.27	.73	1.31	5.27	.73	1.31

Oxygen Demand of Sewage at 37.5° C. Dilution 1 in 100.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.	Dissolved Solids Dissolved Oxygen P.P.M.	Dissolved Solids Oxygen Demand P.P.M.
Int.	6.90	....	7.14	....
1	5.96	.94	6.41	.73
2	5.55	1.35	6.25	.89
3	4.64	2.26	5.71	1.43
4	4.04	2.86	5.71	1.43
5	4.04	2.86	5.33	1.81

	Total	Dissolved	Suspended	Settled
Solids	846	784	62	.03 c.c.
Organic Solids	326	268	58	..
Oxygen Consumed	38	24	14	..
Chlorine	10,600	....	..	..

President Borough of Richmond — FILE Exp. No. 82
Bureau of Engineering, Sewage — ACC Table No 18
Experiment Station — COMPUTER — FROM. — TO.
MADE IN CONNECTION WITH absorbtion of oxygen — CHECKED — DATE May 18 1916

Dilution 1:20 Salt Water from Exp. No. 81
Suspended Solids 62 P.P.M.
Oxygen Consumed 38 P.P.M
Chlorine 10600 P.P.M
Tempt. 17°C to 13.5°C

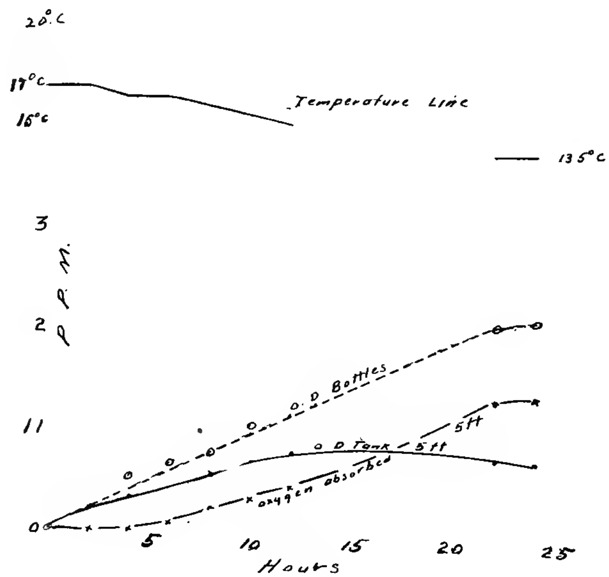


Table No. 18—Absorption of Oxygen.—Experiment No. 84.

Dilution 1 in 20. Salt Water Experiment No. 83. Two Fans, Rippe ½ inch.

Date May	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Absorbed Oxygen	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Absorbed Oxygen	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Absorbed Oxygen	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Absorbed Oxygen	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Absorbed Oxygen	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Absorbed Oxygen
24	10.30	19.5	19.5	0.05	5.90	....	5.90	....	5.90	....	....	5.90	....	....	5.90	....	....	5.90	....	....	5.90	....	....	5.90	....	....
24	12.30	19.25	19.25	....	5.82	.08	5.82	.08	5.82	.08	0	5.82	.08	0	5.82	.08	0	5.82	.08	0	5.82	.08	0	5.82	.08	0
24	2.30	19.0	19.0	....	5.66	.24	5.66	.24	5.66	.24	0	5.66	.24	0	5.66	.24	0	5.66	.24	0	5.58	.32	—.08	5.58	.32	—.08
24	4.30	19.0	19.0	....	5.41	.49	5.41	.49	5.50	.40	.09	5.46	.44	.05	5.41	.49	0	5.41	.49	0	5.41	.49	0	5.41	.49	0
24	6.30	19.0	19.0	....	5.09	.81	5.09	.81	5.25	.65	.16	5.17	.73	.08	5.17	.73	.08	5.17	.73	.08	5.17	.73	.08	5.17	.73	.08
24	8.30	18.75	18.75	....	4.85	1.05	4.85	1.05	5.17	.73	.32	5.09	.81	.24	5.09	.81	.24	5.09	.81	.24	5.09	.81	.24	5.09	.81	.24
24	10.30	18.5	18.5	....	4.77	1.13	4.77	1.13	5.09	.81	.32	5.01	.89	.24	5.01	.89	.24	5.01	.89	.24	5.01	.89	.24	5.01	.89	.24
25	8.30	18.0	18.0	....	3.64	2.26	3.56	2.34	4.61	1.29	.97	4.45	1.45	.81	4.45	1.45	.81	4.45	1.45	.81	4.45	1.45	.81	4.32	1.68	.68
25	10.30	18.0	18.0	0.06	3.31	2.59	3.23	2.67	4.53	1.37	1.22	4.45	1.45	1.14	4.36	1.54	1.05	4.36	1.54	1.05	4.36	1.54	1.05	4.16	1.74	.85

Oxygen Demand Dilution 1 in 100 at 37.5° C.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.	Dissolved Solids Dissolved Oxygen P.P.M.	Dissolved Solids Oxygen Demand P.P.M.
Int.	6.95	....	7.19	....
1 day	5.74	1.21	6.23	.96
2 days	5.41	1.54	6.06	1.13
3 days	5.09	1.86	5.90	1.29
4 days	4.52	2.43	5.58	1.61
5 days	4.00	2.95	5.58	1.61

	Total	Dissolved	Suspended	Settled
Solids	976	884	92	0.5 c.c.
Organic Solids	386	370	16	....
Oxygen Consumed	43	31	12	....
Chlorine	9,400	....	..	....

President Barough of Richmond Exp. No 84 FILE

Bureau of Engineering Sewage ACC Table No 18

Experiment Station COMPUTER FROM TO

MADE IN CONNECTION WITH absorbtion of Oxygen CHECKER DATE May 24 1916

Dilution 1:20 Salt Water from Exp No 83
Suspended Solids 92 P.P.M
Oxygen Consumed 43 P.P.M
Chlorine 9400 P.P.M.
Tempt 19.5 C to 18°C
Two fans wave abt ½"

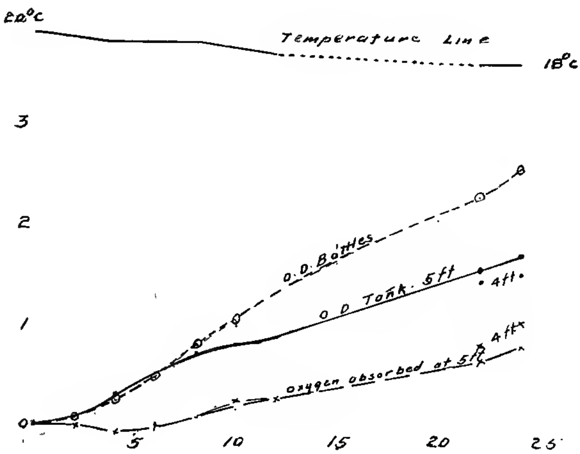


Table No. 18—Absorption of Oxygen.—Experiment No. 86.

Dilution 1 in 20. Salt Water Experiment No. 85

Two Fans, Ripple ½ inch.

Date May	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D.O., P.P.M.	Bottles Tank O.D., P.P.M.	Bottles 20° Incubator D.O., P.P.M.	Bottles 20° Incubator O.D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Absorbed Oxygen	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Absorbed Oxygen	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Absorbed Oxygen	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Absorbed Oxygen	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Absorbed Oxugen	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Absorbed Oxygen
29....	9.45	19.5	19.5	0.04	5.82	....	5.82	....	5.86	....	....	5.82	....	....	5.82	....	....	5.82	....	....	5.82	....	....	5.82	....	....
29....	11.45	19.5	19.5	....	5.58	.24	5.58	.24	5.74	.12	.12	5.70	.12	.12	5.66	.16	.08	5.66	.16	.08	5.66	.16	.08	5.54	.28	—.04
29....	1.45	19.5	19.5	....	5.41	.41	5.41	.41	5.58	.28	.13	5.58	.24	.17	5.54	.28	.13	5.50	.32	.09	5.41	.41	.00	5.17	.65	—.24
29....	3.45	19.5	19.5	....	4.93	.89	4.93	.89	5.29	.57	.32	5.25	.57	.32	5.17	.65	.24	5.17	.65	.24	5.13	.69	.20	4.61	1.21	—.32
29....	5.45	19.5	19.5	....	4.36	1.46	4.36	1.46	4.93	.93	.53	4.85	.97	.49	4.85	.97	.49	4.77	1.05	.41	4.77	1.05	.41	4.16	1.66	—.20
29....	7.45	19.5	19.5	....	4.20	1.62	4.20	1.62	4.77	1.09	.53	4.77	1.05	.57	4.77	1.05	.57	4.77	1.05	.57	4.73	1.09	.53	4.12	1.70	—.08
29....	9.45	19.5	19.5	....	4.04	1.78	4.04	1.78	4.73	1.13	.65	4.73	1.09	.69	4.69	1.13	.65	4.69	1.13	.65	4.69	1.13	.65	4.69	1.13	+.65
30....	9.45	19.0	19.0	0.06	2.18	3.64	2.34	3.48	3.96	1.90	1.74	3.96	1.86	1.78	3.96	1.86	1.78	3.96	1.86	1.78	3.92	1.90	1.74	3.80	2.02	1.62

Oxygen Demand at 37.5° C. Dilution 1 in 100

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.	Dissolved Solids Dissolved Oxygen P.P.M.	Dissolved Solids Oxygen Demand P.P.M.
Int.	6.87	....	6.95	....
1 day	5.66	1.21	5.74	1.21
2 days	5.33	1.54	5.54	1.41
3 days	5.25	1.62	5.82	1.13
4 days	5.17	1.70	5.50	1.45
5 days	4.93	1.94	5.46	1.49

	Total	Dissolved	Suspended
Solids	1,074	990	84
Organic Solids	342	270	72
Oxygen Consumed	41	28	13
Chlorine	7,600	....	..

President Borough of Richmond FILE Exp No. 86
Bureau of Engineering; Sewage ACC Table No 18
Experimental Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE May 29 1916.

Dilution 1:20 with Salt Water used in Exp. 85

Suspended Solids 84 PPM
Oxygen Consumed 41 PPM
Chlorine 7600 PPM
Tempt 19.5 To 19°

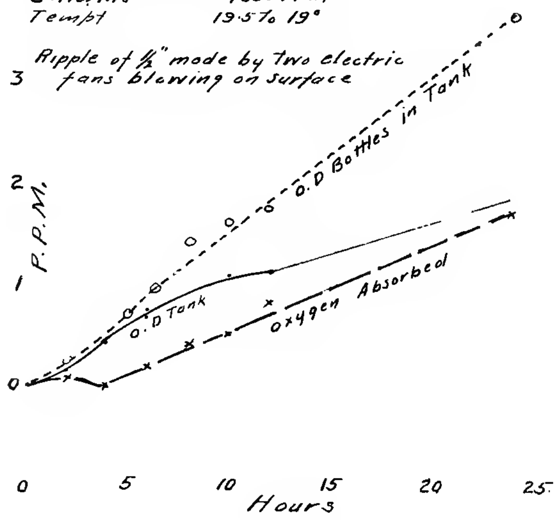


TABLE No. 18—ABSORPTION OF OXYGEN.—EXPERIMENT No. 88.

Dilution 1 in 20 with Salt Water from Kill Von Kull, Used in Experiment No. 87.

Date June	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
		Top	Bottom		Tank		20° Incubator																			
					D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
5.....	10.20	19.5	19.5	0.07	5.01	....	5.01	....	5.05	....	....	5.01	....	....	5.01	....	....	5.01	....	....	5.01	....	....	4.85	....	....
5.....	12.20	19.5	19.5	....	4.85	.16	4.85	.16	4.97	.08	.08	4.93	.08	.08	4.93	.08	.08	4.93	.08	.08	4.93	.08	.08	4.93	—.08	.24
5.....	2.20	19.5	19.5	....	4.69	.32	4.69	.32	4.85	.20	.12	4.81	.20	.12	4.81	.20	.12	4.81	.20	.12	4.81	.20	.12	4.81	.04	.28
5.....	4.20	19.5	19.5	....	4.53	.48	4.53	.48	4.73	.32	.16	4.73	.28	.20	4.73	.28	.20	4.73	.28	.20	4.73	.28	.20	4.65	.20	.28
5.....	6.20	19.5	19.5	....	4.20	.81	4.28	.73	4.61	.44	.37	4.57	.44	.37	4.61	.40	.41	4.61	.40	.41	4.61	.40	.41	4.57	.28	.53
5.....	8.20	19	19	....	4.04	.97	4.12	.89	4.61	.44	.53	4.57	.44	.53	4.61	.40	.57	4.61	.40	.57	4.57	.44	.53	4.53	.32	.65
5.....	10.20	19	19	....	3.96	1.05	3.96	1.05	4.61	.44	.61	4.53	.48	.57	4.53	.48	.57	4.53	.48	.57	4.53	.48	.57	4.53	.32	.73
6.....	8.20	18	18	....	2.95	2.06	2.95	2.06	4.61	.44	1.62	4.53	.48	1.58	4.53	.48	1.58	4.53	.48	1.58	4.53	.48	1.58	4.45	.40	1.66
6.....	10.20	18	18	0.10	2.91	2.10	2.91	2.10	4.61	.44	1.66	4.61	.40	1.70	4.61	.40	1.70	4.61	.40	1.70	4.57	.44	1.66	4.57	.28	1.82

Total Solids Oxygen Demand at 37.5° C. Dilution 1 in 100.

Day	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int.	6.79	....
1	5.62	1.17
2	5.29	1.50
3	5.01	1.78
4	4.76	2.03
5	4.59	2.20

	Total	Dissolved	Suspended
Solids	1,014	914	100
Organic Solids	362	282	80
Oxygen Consumed	40	27	13
Chlorine	8,400	....	....

President Borough of Richmond FILE Exp. No. 88
Bureau of Engineering; Sewage ACC Table No 18
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 5, 1916

Dilution 1:20

Salt Water from Kill Van Kull used Exp. 87

Suspended solids in Sewage		100 P.P.M
Oxygen Consumed		40 PPM
Chlorine		8400 PPM
Temperature	19.5°c to 19°	

Two electric fans ripple ½ inch

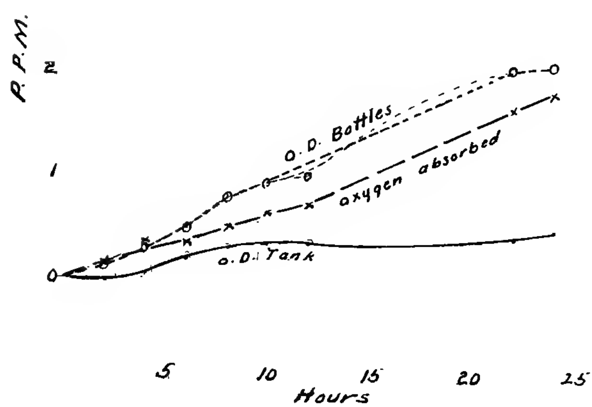


Table No. 18—Absorption of Oxygen.—Experiment No. 90.

Dilution 1 in 20. Salt Water Used in Experiment No. 89 — Two Fans, Ripple about ½ inch.

Date June	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
		Top	Bottom		D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
12	10.30	18.5	18.5	0.08	4.55	....	4.55	....	4.55	....	....	4.55	....	....	4.55	....	....	4.55	....	....	4.51	....	....	4.51	....	....
12	12.30	18.5	18.5	....	4.39	.16	4.39	.16	4.51	.04	.12	4.47	.08	.08	4.43	.12	.04	4.43	.12	.04	4.43	.08	.08	4.43	.08	.08
12	2.30	18.5	18.5	....	4.27	.28	4.18	.37	4.51	.04	.24	4.47	.08	.20	4.47	.08	.20	4.47	.08	.20	4.43	.08	.20	4.43	.08	.20
12	4.30	18.5	18.5	....	4.10	.45	4.10	.45	4.43	.12	.33	4.43	.12	.33	4.43	.12	.33	4.39	.16	.29	4.39	.12	.33	4.39	.12	.33
12	6.30	18.5	18.5	....	3.86	.69	3.86	.69	4.35	.20	.49	4.31	.24	.45	4.27	.28	.41	4.27	.28	.41	4.18	.33	.36	4.10	.41	.28
12	8.30	18.25	18.25	....	3.53	1.02	3.45	1.10	4.10	.45	.57	4.10	.45	.57	4.10	.45	.57	4.10	.45	.57	4.10	.41	.61	4.02	.49	.53
12	10.30	18.25	18.25	....	3.36	1.19	3.20	1.35	4.10	.45	.74	4.10	.45	.74	4.06	.49	.70	4.06	.49	.70	4.08	.45	.74	4.02	.49	.70
13	8.30	17.75	17.75	....	1.76	2.79	1.64	2.91	3.69	.86	1.93	3.61	.94	1.85	3.61–	.94	1.85	3.61	.94	1.85	3.61	.90	1.89	3.61	.90	1.89
13	10.30	17.75	17.75	0.12	1.72	2.83	1.48	3.07	3.69	.86	1.97	3.61	.94	1.89	3.53	1.02	1.81	3.53	1.02	1.81	3.53	.98	1.85	3.53	.98	1.85

Oxygen Demand of Sewage at 37.5° C. Dilution 1 in 100.

Day	Total Solids: Dissolved Oxygen P.P.M.	Total Solids: Oxygen Demand P.P.M.
Int.	6.97	....
1 day	6.36	.61
2 days	5.13	1.84
3 days	4.72	2.25
4 days	4.68	2.29
5 days	4.18	2.79

	Total	Dissolved	Suspended	Settled
Solids	932	784	148	1.5
Organic Solids	382	266	116	....
Oxygen Consumed	51	28	23	....
Chlorine	9,950	....	....	....

President Borough of Richmond FILE Exp No 90
Bureau of Engineering ; Sewage Experiment Table No 18
Station COMPUTED FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 12 1916.

Dilution 1:20 with Salt Water used in Exp 89

Suspended Solids	148 P.P.M.
Oxygen Consumed	51 P.P.M
Chlorine	9950
Temperature	18.5°

Two Electric fans making ripple abt ½"

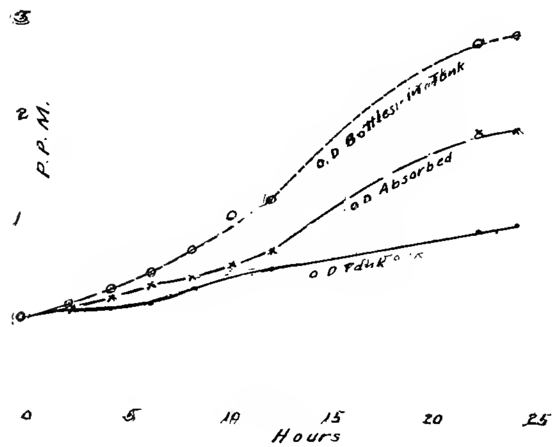


TABLE NO. 18—ABSORPTION OF OXYGEN.—EXPERIMENT NO. 92.

Salt Water from Kill Von Kull, Experiment No. 91. Diution 1 in 20. Two Electric Fans, Ripple About ½ inch.

Date June	Time	Temperature		Nitrites	Bottles				Surface			1 Foot			2 Feet			3 Feet			4 Feet			5 Feet		
					Tank		20° Incubator																			
		Top	Bottom		D. O., P.P.M.	O. D., P.P.M.	D. O., P.P.M.	O. D., P.P.M.	Dissolved Oxygen, P.P.M.	Oxygen Demand,	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand,	Ocygen Absorbed	Dissolved Oxygen P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed	Dissolved Oxygen, P.P.M.	Oxygen Demand, P.P.M.	Oxygen Absorbed
16....	10	22	21.75	0.22	4.66	....	4.66	....	4.66	....	....	4.66	....	....	4.66	....	....	4.66	....	....	4.58	....	....	4.54	....	....
16....	11	21.5	21.5	....	4.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16....	12	21.5	21.5	....	4.62	0.04	4.42	.24	4.54	.12	—.08	4.50	.16	—.12	4.50	.16	—.12	4.58	.08	—.04	4.54	.04	0	4.54	0	0
16....	2	21	21	....	4.26	.40	4.26	.40	4.38	.28	.12	4.34	.32	.08	4.34	.32	.08	4.34	.32	.08	4.30	.28	.12	4.26	.28	.12
16....	4	21	21	....	3.94	.72	4.22	.44	4.18	.48	.24	4.18	.48	.24	4.18	.48	.24	4.10	.56	.16	4.10	.48	.24	4.10	.44	.28
16....	6	20.75	20.75	....	3.62	1.04	3.70	.96	3.94	.72	.32	3.78	.88	.16	3.78	.88	.16	3.78	.88	.16	3.70	.88	.16	3.70	.84	.20
16....	8	20.5	20.5	....	2.89	1.77	3.14	1.52	3.38	1.28	.49	3.42	1.24	.53	3.46	1.20	.57	3.38	1.28	.49	3.42	1.16	.61	3.38	1.16	.61
16....	10	20	20	....	2.53	2.13	2.89	1.77	3.34	1.32	.81	3.26	1.40	.73	3.30	1.36	.77	3.30	1.36	.77	3.26	1.32	.81	3.26	1.28	.85
17....	10	20	20	0.20	0.24	4.42	0.56	4.10	3.06	1.60	2.82	2.98	1.68	2.74	2.98	1.68	2.74	2.98	1.68	2.74	2.93	1.65	2.77	2.73	1.81	2.61

Oxygen Demand of Sewage at 37.5° C. Dilution 1 in 100.

Day	Total Solids	
	Dissolved Oxygen P.P.M.	Oxygen Demand P.P.M.
Int..........	7.00	....
1..........	5.11	1.89
2..........	5.03	1.97
3..........	4.42	2.58
4..........	3.54	3.46
5..........	4.26	2.74

	Total	Dissolved	Suspended	Settled
Solids............	1,160	994	166	2.0 c.c.
Organic Solids......	470	330	140	....
Oxygen Consumed..	57	29	28	....
Chlorine..........	10,200	....	....	....

President Borough of Richmond FILE Exp No 92
Bureau of Engineering; Sewage ACC Table No 18
Experimental Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 16 1916

Dilution 1:20 with Salt Water used in Exp No 91

Suspended solids 116 P.P.M.
Oxygen Consumed 57 PPM
Chlorine 10 000 PPM
Temperature 21.5 to 20° C

Two electric fans blowing on surface making a ripple about ½ inch

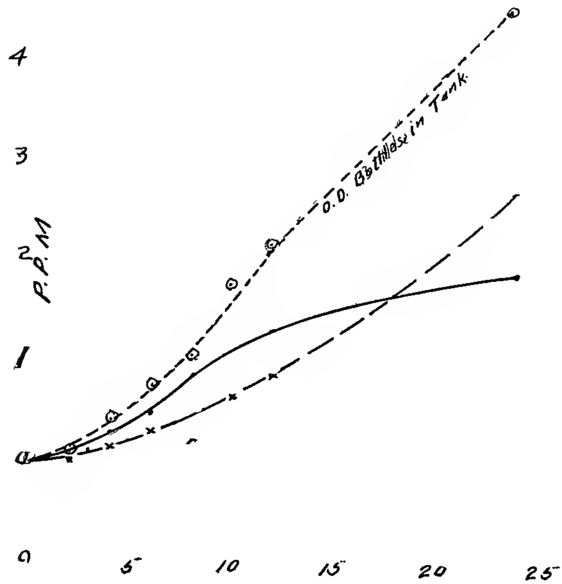


Table No. 18—Absorption of Oxygen.—Experiment No. 94.

Dilution 1 in 20.

Salt Water from Kill Van Kull Used in Experiment No. 93.

Date June	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Oxygen Absorbed
22....	10	17.5	18	.20	4.22	....	4.22	....	4.30	....	....	4.18	....	....	4.22	....	....	4.22	....	....	4.18	....	....	4.18	....	....
22....	12	17.5	17.5	....	4.10	.12	4.10	.12	4.22	.08	.04	4.18	0	.12	4.22	0	.12	4.22	0	.12	4.22	—.04	.16	4.14	.04	.08
22....	2	17.5	18.5	....	4.02	.20	3.98	.24	4.22	.08	.12	4.18	0	.20	4.22	0	.20	4.22	0	.20	4.18	0	.20	4.18	0	.20
22....	4	17¼	17¼	....	3.94	.28	3.82	.40	4.18	.12	.16	4.14	.04	.32	4.22	0	.28	4.18	.04	.24	4.18	0	.28	4.10	.08	.20
22....	6	17	17	....	3.70	.52	3.61	.61	4.22	.08	.44	4.22	—.04	.56	4.18	.04	.48	4.18	.04	.48	4.18	0	.52	4.10	.08	.44
22....	8	17	17	....	3.22	1.00	3.38	.84	4.18	.12	.88	4.18	0	1.00	4.10	.12	.82	4.14	.08	.92	4.10	.08	.92	4.10	.08	.92
22....	10	17	17	....	3.22	1.00	2.81	1.41	4.02	.28	.72	4.02	.16	.84	4.02	.20	.80	4.02	.20	.80	4.02	.16	.84	3.94	.24	.76
23....	10	16	16	.15	.88	3.34	....	....	2.73	1.57	1.77	2.73	1.45	1.89	2.73	1.49	1.85	2.73	1.49	1.85	2.73	1.45	1.89	2.73	1.45	1.89

Oxygen Demand of Sewage at 37.5° C. Dilution 1 in 100.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.
Int.	7.08	....
1	4.74	2.34
2	4.18	2.90
3	3.78	3.30
4	2.73	4.35
5	3.06	4.02

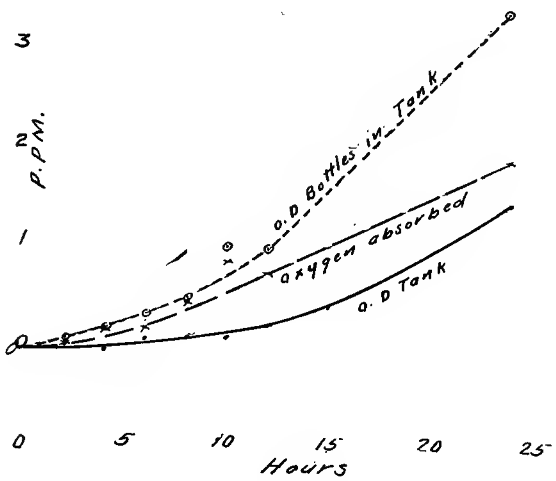
	Total	Dissolved	Suspended
Solids	1,084	972	112
Organic Solids	552	468	84
Oxygen Consumed	64	11	53
Chlorine	10,100	....	....

President Borough of Richmond FILE Exp No 94
Bureau of Engineering, Sewage ACC Table No 18
Experiment Station COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 26, 1916

Dilution 1:20 with Salt Water, used in Exp No 93

Suspended solids 112 P.P.M
Oxygen Consumed 64 PPM
Chlorine 10100 PPM
Temperature 17.5°C

Ripple of ½ inch made by two electric fans blowing on the surface



President Borough of Richmond — Average of Exp No. 74, 76 78, 80, 82. 84, 86, 88, 90, 92 Acc 94

Bureau of Engineering, Sewage

Experimental Station — COMPUTER — FROM Table No 18 TO

MADE IN CONNECTION WITH Absorbtion of Oxygen — CHECKER — DATE June 1916

1:20

Average of Eleven observations of dilution of Sewage with Salt Water from Kill Van Kull in proportion of 1 part sewage to 20 parts water used in previous investigations of absorbtion of salt water without dilution.

Two electric fans blowing on surface made a ripple of about ½ inch

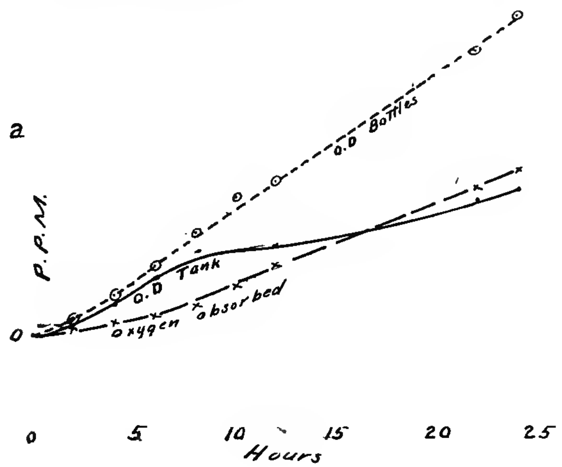


Table No. 19—Absorption of Oxygen.—Experiment No. 95.

Salt Water from Kill Van Kull. Wave Movement about 4 inches.

Date June	Time	Temperature Top	Temperature Bottom	Nitrites	Bottles Tank D. O., P.P.M.	Bottles Tank O. D., P.P.M.	Bottles 20° Incubator D. O., P.P.M.	Bottles 20° Incubator O. D., P.P.M.	Surface Dissolved Oxygen, P.P.M.	Surface Oxygen Demand, P.P.M.	Surface Oxygen Absorbed	1 Foot Dissolved Oxygen, P.P.M.	1 Foot Oxygen Demand, P.P.M.	1 Foot Oxygen Absorbed	2 Feet Dissolved Oxygen, P.P.M.	2 Feet Oxygen Demand, P.P.M.	2 Feet Oxygen Absorbed	3 Feet Dissolved Oxygen, P.P.M.	3 Feet Oxygen Demand, P.P.M.	3 Feet Oxygen Absorbed	4 Feet Dissolved Oxygen, P.P.M.	4 Feet Oxygen Demand, P.P.M.	4 Feet Oxygen Absorbed	5 Feet Dissolved Oxygen, P.P.M.	5 Feet Oxygen Demand, P.P.M.	5 Feet Oxygen Absorbed
26....	10	22	22	.07	5.31	....	5.31	....	5.39	....	....	5.31	....	....	5.31	....	....	5.31	....	....	5.31	....	....	5.31	....	....
26....	11	22	22	....	5.31	0	5.23	.08	6.27	.88	.88	6.27	.96	.96	6.19	.88	.88	6.19	.88	—.88	6.27	—.96	—.96	6.27	—.96	.96
26....	12	22	22	....	5.23	.08	5.23	.08	6.71	1.32	1.40	6.67	1.36	1.44	6.67	1.36	1.44	6.67	1.36	—1.44	6.67	—1.36	—1.44	6.67	—1.36	1.44
26....	2	22	22	....	5.07	.24	5.07	.24	7.24	1.85	2.09	7.24	1.93	2.17	7.24	1.93	2.17	7.24	1.93	—2.17	7.24	—1.93	—2.17	7.24	—1.93	2.17
26....	4	22	22	....	4.94	.37	4.95	.36	7.48	2.09	2.46	7.48	2.17	2.54	7.48	2.17	2.54	7.48	2.17	—2.54	7.48	—2.17	—2.54	7.48	—2.17	2.54
26....	6	21½	22	....	4.74	.57	4.74	.57	7.72	2.33	2.90	7.56	2.25	2.82	7.56	2.25	2.82	7.52	2.21	—2.78	7.52	—2.22	—2.79	7.48	—2.17	2.74
26....	8	21½	21½	....	4.50	.81	4.50	.81	7.56	2.17	2.98	7.56	2.25	3.06	7.48	2.17	2.98	7.48	2.17	2.98	7.48	—2.17	—2.98	7.48	—2.17	2.98
26....	10	21½	21	....	4.26	1.05	4.22	1.09	7.52	2.13	3.18	7.52	2.21	3.26	7.48	2.17	3.22	7.48	2.17	—3.22	7.48	—2.17	—3.22	7.48	—2.17	3.22
27....	9	21	21	....	3.22	2.09	2.98	2.33	7.16	1.77	3.86	7.43	1.82	4.21	6.63	1.32	3.41	6.63	1.32	—3.41	6.03	—0.72	—2.81	6.59	—1.28	3.37

Oxygen Demand at 37.5° C.

Day	Total Solids Dissolved Oxygen P.P.M.	Total Solids Oxygen Demand P.P.M.
Int..........	5.21	....
1...........	3.62	1.59
2...........	1.05	4.16
3...........	....	....
4...........	....	....
5...........	....	....

	Total	P.P.M. Dissolved	P.P.M. Suspended
Solids............	684	651	33
Chlorine...........	11,000	....	....

President Borough of Richmond Bureau of FILE No 95
Engineering, Sewage Experiment Station ACC Table 19
COMPUTER FROM TO
MADE IN CONNECTION WITH Absorbtion of Oxygen CHECKER DATE June 26 1916

Oxygen absorbed by Salt Water from Kill Von Kull for Exp 96

Agitator making surface waves abt 4"

Temperature of water 21.5°C
Suspended solids 33 P.P.M
Chlorine 11000 P.P.M

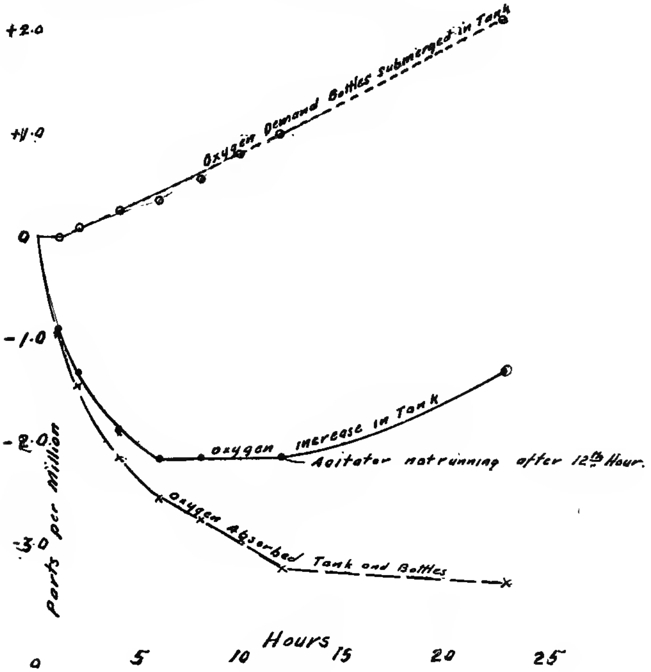


TABLE No. 20—ABSORPTION OF OXYGEN.—EXPERIMENT No. 96.

Dilution of Sewage with Salt Water Used in Experiment No. 95. Sewage Run in Until no Dissolved Oxygen was present.

Surface Agitated, Making a Wave Movement about 4 inches.

Day June	Time	Temp. Deg. C. Top	Temp. Deg. C. Bottom	Dissolved Oxygen at Surface	Dissolved Oxygen at 1 Ft.	Dissolved Oxygen at 2 Ft.	Dissolved Oxygen at 3 Ft.	Dissolved Oxygen at 4 Ft.	Dissolved Oxygen at 5 Ft.
28......	9.30	21	21	0	0	0	0	0	0
28......	10.30	21	21	2.73	3.14	2.89	2.81	2.89	2.89
28......	11.30	21	21	4.82	4.78	4.82	4.83	4.66	4.74
28......	1.30	21	21	6.59	6.59	6.43	6.56	6.59	6.55*
29......	9.30	21	21	4.50	4.46	4.38	4.46	4.06	4.34

* Agitator stopped.

Chlorine, 10,000 P.P.M.