CHICAGO SEWERAGE.

REPORT

OF THE RESULTS OF

Examinations made in Relation to Sewerage

IN SEVERAL

EUROPEAN CITIES, IN THE WINTER OF 1856-7.

BY THE CHIEF ENGINEER OF THE BOARD OF SEWERAGE COMMISSIONERS.

CHICAGO, ILL.:
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REPORT OF CHIEF ENGINEER.

SEWERAGE COMMISSIONERS' OFFICE,
Chicago, Ill., Dec. 12, 1856.

THE BOARD met. Present: Commissioners OGDEN, WEBSTER and LIND. (Extract.)

Ordered, That E. S. CHESBROUGH, Chief Engineer of this Board, proceed to Great Britain and the continent of Europe, for the purpose of examining the various methods of Sewerage adopted there, and of taking such notes and drawings of the same as he may think necessary, and of examining into their operation, and into all matters connected with them, and which may, in his judgment, aid in the further prosecution and perfection of the Sewerage of the City of Chicago; and that he may have authority to employ draftsmen, and pay for information, and purchase such books or reports as he shall deem necessary; and that such expenses, together with said CHESBROUGH'S necessary travelling expenses while absent, be paid by this Board. * * * *

WM. GAMBLE,
Secretary.

SEWERAGE COMMISSIONERS' OFFICE,
Chicago, Dec. 19, 1856.

E. S. CHESBROUGH, ESQ.,
Chief Engineer,

DEAR SIR: I hand you herewith a copy of a resolution passed by this Board on the 12th inst., instructing you to proceed to Europe for purposes therein set forth.

This duty you will please execute with all the dispatch consistent with a thorough attainment of the objects contemplated, and render to this Board a full account of your proceedings herein, including a detailed statement of all expenses incurred. * *

Very respectfully,

J. D. WEBSTER,
Acting Commissioner.

SEWERAGE COMMISSIONERS' OFFICE,
Chicago, March 25, 1858.

To the Board of Sewerage Commissioners:

GENTLEMEN,—

In detailing, so far as the proper length of this communication will permit, the information I obtained while in Europe, in obedience to the foregoing instructions,—which other engagements in your service, together with feeble health, have prevented me from presenting earlier,—I shall describe the sewerage of each city and town in the order in which they were visited.

LIVERPOOL.

The site of this city is very undulating, and in some places more than 200 feet above tide water. It consequently presents, generally, no difficulties with regard to what is considered sufficient declivity to make the sewers self-cleansing; nevertheless, some in the lower districts are very level, and require occasional cleansing, either by hand or machinery. The form of sewer adopted during the last ten years, for all sizes above 15 inches, is egg-shaped, the greatest width being two-thirds the height, and a very little less for the smaller ones. They are of brick, 9 inches thick, for all above 3 feet in height, and half this thickness for those of 3 feet or less height, where the soil is sufficiently firm. The 15, 12 and 9 inch sewers are stoneware pipes, circular in form, having socket joints and laid in cement. These are not used to receive the washings from streets, and are consequently of but short length.

The house or private drains are of circular pipes, 4 to 6 in. in diameter, of the same material, and constructed in the same manner, as the larger ones used for street drains. They are provided with syphon or bent traps, to prevent foul gases from the main sewers entering the houses.

Surface water from the streets enters the sewers through cast iron gratings, over trapped gullies, placed much nearer together than the catch-basins of the large cities of this country, forty yards being the distance apart recommended there. Most of these have small catch-basins, which are frequently emptied.

Water closets are quite extensively, but by no means universally, used. In the better class of houses they are common, and in many of the middling; but there are still many privies to be emptied by hand.

Although the site of Liverpool is so different, and much more favorable than that of Chicago, with regard to drainage, there is much in the experience of that city interesting to this.

In 1846, the Sanitary Act for Liverpool was passed. Previous to that time much had been done towards draining the city, and many miles of sewers, of square, round, oval and various combinations of these forms, of different heights and diameters, from 1 to 6 feet, were constructed. The outfalls of many of the sewers were into the docks, which, being cut off from the scour of the river, were liable to fill up and become offensive, unless frequently dredged. Many of the sewers having their outlets below high water, were liable to be flooded during heavy storms, and consequently the cellars connected with them were very unsafe for the storage of valuable property. Besides being used for receiving goods, many of these cellars were permanently inhabited, so that throughout the entire city, a population of 30,000 were accommodated in this way, but as believed then, and as subsequent experience has proved, it was at a great sacrifice of their health.

Shortly after the passage of the Sanitary Act of 1846, a system of sewerage was recommended by Mr. NEWLANDS, the present Borough Engineer, and adopted by the city council. This system looked to the ultimate abolition of privies and cess-pools, and not only to diverting the contents of sewers from the dock basins, but to keeping it out of the river itself, (except during storms,) and making use of it to fertilize the neighboring lands. Much has been done towards abolishing privies, and keeping the sewage out of dock basins, but the river is still the grand receptacle of the contents of the sewers, and likely to continue so for some time to come.

The theories so popular since 1846, with regard to the value of sewage as a manure, though apparently confirmed by the wonderful success of a few experiments on a small scale, have not yet been realized to any considerable extent. Mr. NEWLANDS, in his report of 1848, considered any plan that did not include the ultimate application of the sewage to fertilizing lands, as imperfect. Besides having had early experience on this subject at Edinburgh, he has been a careful observer of what has been done since relative to it throughout the kingdom, but up to the time of my visit, he had not

been able to find that the contents of the sewers of Liverpool had any commercial value—except, perhaps, for certain localities of limited extent in the immediate vicinity, where it could be applied by simple gravitation, as at Edinburgh.

A most useful invention for cleansing sewers has been made by Mr. BLADE, of Liverpool. After trying it for several years, Mr. NEWLANDS continues to use it; and in his report of 1853, p. 39, while comparing it with the old process of cleansing by hand, says: "Suppose a sewer is 100 yards in length, silted up to the depth of 1 foot 6 inches. Then, by the old process, the cleansing of it would occupy three men ten days; and by the new process, it would occupy eleven men one-third of a day."

"The power which the new apparatus gives of employing many men together, and of rapidly finishing the work, is a most material advantage; and this, with its obvious economy when compared with the former mode of cleansing, will, I think, ensure its general adoption."

In order to use this machine to advantage, there should be vertical man-holes into the sewers, not more than fifty yards apart. This requirement has caused the application of the machine to be limited hitherto not only to Liverpool, but to those sewers which were provided with man-holes. In the narrow and crowded streets of most of the cities of Great Britain, as well as of Europe generally, man-holes to the sewers are considered objectionable, and side entrances from the foot-ways, or sidewalks, are much preferred.

The apparatus consists of a windlass and crane combined, one placed at each man-hole over the two ends of the piece of sewer to be cleansed. A communication between the man-holes is obtained first by sending a float attached to a light string in the direction of the current, which for this purpose may be increased temporarily; then a cord; and afterwards a chain is drawn through. By means of this chain, working over pullies fastened at each man-hole, and buckets or scoops of various forms, according to the nature and depth of the deposit, the men at the windlasses, and one in the

man-hole, are enabled to cleanse the sewer very rapidly. For a detailed plan and description of the apparatus, see Mr. BLADE'S pamphlet.

Mr. NEWLANDS furnished me with copies of the Health Act, of his reports, from his first appointment to the office of borough engineer to the present time, also of all the different forms of contracts, specifications, proposals, notices, &c., &c., issued by the health committee; and made me acquainted, as far as time would permit, with the organization of his staff, the arrangement of the different yards necessary for the operations of the sewer and street departments, and the testing of gas meters, all of which are under his charge. The full and perfect record which is kept of every transaction, and the readiness with which it can be referred to in all its details, exceed anything of the kind I have ever seen in this country, and, it is to be feared, will continue to do so as long as our public officers and employees are so frequently changed.

MANCHESTER.

The sewerage of this city differs from that of Liverpool mostly in the far greater use of pipes, which serve not only for conveying house, but surface drainage from streets. Mr. FRANCIS, the surveyor of the city, commenced using them in 1845, and has continued to do so ever since. His reasons for it, together with a brief description of the sewerage of Manchester, will be found in the following extract from a letter of his, dated March 29th, 1854, to F. O. WARD, Esq., of London.

"I have had charge of the sewerage of the township of Manchester for 19 years, and began to use tubes in 1845—6 and 9 inch round tubes, from Staffordshire, being the only kind then procurable here. I perceived there was room for a great development of the system, and turned my attention closely to it. It soon appeared to me that the oval shape was better for sewer purposes than the round, and I got oval tubes made by a fire-brick maker in this vicinity, also a syphon trap

for street grids or gully holes. By exciting the competition of different makers, we got them in a year or two to glaze the tubes; since then, we have laid them in upwards of 500 streets and 250 courts and passages, making an aggregate length of about 30 miles of main drains, and 25 miles of branch drains. Mr. PAGE, in his report, while he allowed the use of tubes here to have been a favourable result, yet does not give due weight to the fact that they serve as main sewers in clusters of streets, as well as in single streets.

"The tube sewers have also to do precisely the same duty that the brick sewers have; that is, there is no difference as to the sewerage sent into them. They take all the surface drainage of the streets, &c., where they are laid, and we have a pair of gully holes in every length of about 30 yards of the street. Water closets are allowed a connection with the tubes wherever they are constructed, but their use here is not general, the great bulk of cottages being provided with privy and ashpit; the ashpit being drained into the sewer by a branch tube from a perforated tile grid placed at the side. This removal of the moisture, added to the deodorizing effect of the coal ashes, has a much better result than you would perhaps suppose. I think the idea of requiring that the main sewer of every *street* must be large enough for a man to go through, is absurd and mischievous, because it involves, if applied throughout the country, an awful waste of money. To what does the term *street* apply? Here, it means legally any place having two or three front doors of houses therein. Again, with reference to our tube drains joining brick sewers, that in the greater number of cases is a mere question of time, the brick sewers having been constructed before we began to use tubes.

"With regard to ventilation, I have to observe, that our sewers have their outlets into the rivers Medlock, Irk, and Irwell, which are not tidal, therefore the sewer mouths are never closed up, except perhaps a few in heavy floods, and there is consequently no likelihood of any pressure being exerted on the gases that may be evolved in the sewers.

We have a further aid to ventilation in the humbler streets, by means of the downspouts which convey the roof-water through wood or iron tubes, placed in the front of the houses, and discharging the water at or near the ground. When we pave and sewer a new street, we make an untrapped branch drain to each of these downspouts, which are lengthened into the drain, and they thereby act as ventilators to the sewer.

"The great blot and defect in our drainage is the circumstance that the rivers named are studded with dams or weirs, for the purpose of affording water power to certain mills, and in other cases to afford condensing water for steam engines. As the rivers themselves are now nothing but main sewers, and are becoming partially covered over, the damming up of their streams into a series of stagnant pools of filthy water, receiving the whole sewage of the town, is a monstrous evil, against which I in vain protest, and mention frequently to our authorities; but the difficulty of dealing with the vested rights of the parties interested, and the expense to be incurred, are hitherto held to be insurmountable. The removal of these dams would restore to the streams their natural scour, and would be, I think, a greater improvement than any intercepting tunnel to carry the sewage to a lower point on the river Irwell, because these waters, when they reach our city are impure from the sewage of towns and villages, and the refuse of dye works, gas and chemical works discharged into them above our city.

"With reference to our oval form, I have sent you a diagram shewing the result of experiments made with sections full size, to ascertain the equivalent sectional areas in round and oval tubes. This was done by placing a rim of iron round the sections, and measuring the equal areas with small shot. I think it clearly demonstrates that in the ordinary state of a sewer, that is, with only a stream of a few inches occupying its section, the oval shape has a greater depth of stream and a less extent of contact between the water and the tube, and therefore less friction. With any given amount of fall, this advantage is made greater than that

shewn in the diagram, because the greater depth of stream and lesser friction, will cause an increased velocity, which will produce a further diminution of the volume of the stream, and therefore still further diminish the friction. The advantage to be gained in this way for the prevention of deposit, is, I think, not to be despised, and I am surprised your engineers have not adopted it.

"I have also sent you a copy of a table which I made of the capacities of drainage of the tubes, made from the formulae published by Mr. HAWKSLEY, and which I believe were published by DU BUAT, ETELWEIN, and others before. I am quite satisfied that the tubes are sufficient for larger areas than are shown therein, and that a tube 20×15, with an inclination of half an inch per yard, will be sufficient, not for an area of 11 acres, but for 30 acres. I believe the fallacy to arise from the formula making no allowance for the effect of the gradual increments that are made to the stream in a sewer by additions to its course.

"Water is of course the motive power to keep all sewers clean, and all deposit and stoppage occur from the deficiency of this element. We have had no stoppage in tubes where a large area drained into them, but only at their upper extremities where the supply of water was least; these, however, have not been so numerous or extensive as in brick sewers; I therefore am more disposed to approach the limits of capacity to area of drainage in the larger than in the smaller tubes, and would put down for a single street, a tube 16×12, although the size would take the storm-water from an area of 15 or 20 acres, with an inclination of half an inch per yard. In my letter to HUDDERSFIELD, I have shown the increase of friction which attends the diminution of size in tubes, and hence the reason that for small areas I do not like to use tubes correspondingly small in capacity.

"With regard to inclinations, my views are as follows: Nature is the great guide. The large rivers have very slight inclinations, and as we pass up to their tributaries and the minor streamlets, the fall is found constantly increasing.

Sewerage should be a copy underground of nature's plan on the surface. The great main sewers should have slight inclinations, which are made sufficient by the large volume of stream, and thus afford more fall for the branch sewers, and still greater for the minor drains. To a sewer for a single street, I like to give an inclination of 1 in 72, or half an inch per yard, and, generally speaking, *can* do so here. This inclination will keep the sewer without deposit. A tube sewer laid in 1847, size 20 × 15, draining a cluster of streets with an area of 5 or 6 acres, with an inclination of 1 in 144, or one-fourth of an inch per yard, has kept perfectly clean. In the material of tubes, I prefer glazed fire-brick to stoneware; the former is cheaper, less brittle, will admit of being cut to suit a required length of drain, and is less liable to failure. It is made in a different manner from stoneware. The clay is finely pulverized by grinding and pugging (not washed as stoneware is), moulded and squeezed by machinery to the proper form, then burnt in kilns, and glazed with vapour of salt thrown into the kilns when its contents are in a state of incandescence.

"For some years now we have been supplied with tubes from the makers, by fixed contract for periods of six months, the cheapest tender being accepted, and the whole supply obtained from one maker. Our present scale of prices is as follows, and shews a large advance on our previous contracts, the result of a combination among the makers which I expect will not hold out at the next letting:

Tubes No. 1,	or	4 ×	2½,	9½d.	per yard,	delivered at our wharf.
" " 2,	"	6 ×	4,	11d.	"	" "
" " 3,	"	8 ×	6,	1s. 2½d.	"	" "
" " 4,	"	12 ×	9,	1s. 9d.	"	" "
" " 5,	"	16 ×	12,	3s. 3d.	"	" "
" " 6,	"	20 ×	15,	5s.	"	" "
" " 7,	"	25 ×	18,	6s. 11d.	"	" "

The previous prices were:—

No. 1,	5½d. per yard.	No. 5,	2s. per yard.
" 2,	6½d. "	" 6,	3s. 7d. "
" 3,	8½d. "	" 7,	5s. 6d. "
" 4,	1s. 2d. "		

I may add that for many years I have had only one brick sewer to construct, and that was made to enclose a brook draining an area of about 700 acres. The form was similar to the tubes, and the dimensions 5 feet 4 inches by 4 feet; with that exception, all the other sewers and drains have been of tubes, and we continue to use nothing else, indeed all opposition to them here has died away.

"I would also mention, our tubes have 'butt joints' in the more horizontal parts, that is, the oval tubes have no sockets. The round tubes placed vertically to connect surface drains with the deeper sewers, have sockets. I find the absence of sockets in the former a decided advantage, nor have I seen any case where I could have wished for them. The advantages are the ease with which connections can be made with branch drains, and the easier laying of the tubes, because the sockets, if not carefully let into the ground by special depressions made for them, will form points or fulcra of unequal pressure when the soil is filled in, and many tubes have given way, I believe, from this cause. I have not laid one sewer with sockets. Their absence also allows the tubes to be laid with a better adjustment of their water-way at their joints, because the tubes can not be burnt to a close accuracy of form, and the sockets prevent that opposition of their ends which is practicable without them."

At the time of my visit, some three years later than the date of this letter to Mr. WARD, Mr. FRANCIS had not changed his views.

RUGBY.

This town contains a population of about 6,000 within the drainage district. Its centre is about one mile from the outlet of the main sewer, and 100 feet above it. The soil is gravelly, with some clay. Before the sewers were laid, it was very wet, but it is now much dryer.

This town has been drained since 1851, by means of circular, stoneware glazed pipes, having socket joints filled with clay. The mains vary in size from 6 to 24 inches. They

receive not only ordinary house drainage, but in some cases the surface water from the streets and the contents of water closets. Some of the 7 and 8 inch sewers have inclinations of only 1 in 137, and yet have never given any serious trouble. At first no man-holes were constructed, but they find it advisable to introduce them now, as repairs become necessary or new connections are made.

The pipes cost, per yard, delivered, as follows, viz.:

3	inches,	5d.	9	inches,	1s. 1½d.
4	"	6d.	10	"	1s. 6d.
5	"	7d.	12	"	1s. 10d.
6	"	8d.	15	"	3s.
7	"	10d.	18	"	4s.
8	"	1s.			

Mr. COLBURN, the Surveyor of the local Board of Health, who gave the foregoing information, also informed me that the whole length of mains laid was about 6 miles. Total cost, about £4,500. Cost of repairs and cleansing in 1856, only £5, and the same in 1855. The number of houses connected with the sewers in January, 1857, was 1011. Average depths of sewers below the surface, 9 feet. The street cess-pools, (catch-basins, or gully-traps), are only about one foot square, and are cleansed once or twice a week. The whole cost of scavenging, exclusive of surveyor's salary, is £96 to £100, per annum, which includes street sweeping, and cess-pool cleansing, and carting away both. The sewage is sold for £50 per annum, on a 20 years' lease, with a bonus of £300 to the Board.

They are rapidly abolishing the old privies, and substituting water closets. In another year there will probably be no privies within reach of the sewers. The syphon trap is used entirely for water closets.

The streets are mostly Macadamized, a few are paved with pebbles, and a very few with granite blocks. There were more of these formerly, but the Board of Health prefer the Macadam, on account of its being smoother and less noisy. The traffic of the town is very light.

The few stoppages that have occurred in the pipes have been owing to hay, shavings, stone grit, cloths and clothes being put into the water closets.

LONDON.

This vast metropolis, no doubt, contains a greater amount of sewerage, as well as population, than any other in the world. According to the "Handbook to the Metropolitan and District Boards of Works," for 1856, there had been ascertained by the Survey Department, up to the end of May, 1855, to exist within the rated area of the commission the following, viz.:

Brick sewers, explored	658	miles.
" " not explored, approximately	150	"
Pipe " " " "	126	"
Total covered sewers	934	"
Open sewers, approximately	400	"
Grand total	1,334	"

Some of these are supposed to be of Roman origin, others are very old. As might have been expected, they present every variety of form, size, inclination, and perfection of workmanship, and a careful study of their excellencies and defects has led to valuable conclusions on the subject of town drainage. In fact, the sewers of London have furnished nearly all the materials from which have been elaborated the different theories which now prevail with regard to the best mode of draining towns and cities. This diversity of opinion has led to great diversity of practice, not only in London, but throughout the kingdom, varying as the advocates of one theory or the other have been in power; in this respect, England may be said to have been an experimental school during the last twelve or fifteen years. This experience, though dearly purchased in some instances, is of great importance, and has led to a greater or less modification of the views of nearly all parties, but has not brought them to unanimity yet.

The varieties of form in the London sewers have not all arisen from differences of opinion, but have, sometimes, been matters of necessity. In some instances, it would have been impossible to give the sewer a sufficient sectional area, and yet preserve either the egg-shape or circular form, without raising the surface of the street so high as to do great damage to existing property. The differences of size, too, have often arisen, not so much from a difference of opinion as to what a particular area required, as from the impossibility of foretelling the direction and extent of subsequent improvements. The differences of inclination were of course, in most instances, even for sewers of the same size and form, matters of unavoidable necessity. The details of the forms, sizes, and inclinations of the London sewers will be found on a copy of the plans of the same, furnished by Mr. BAZALGETTE, Engineer of the Metropolitan Commission, and a copy of the plan, showing the positions of the sewers in the city proper, together with the directions of the current in them, furnished by Mr. HAYWOOD, Engineer of the City, accompanies them.

Plate I, will give some idea of the variety existing in the London sewers, and shows, in a striking manner, the effect of the former independent and changing jurisdictions of about fifty different parishes and districts, together with the city proper, which form this immense metropolis, and which for certain general purposes were united under "the Metropolis Local Management Act," in 1855. They are now governed, in regard to sewers, streets, &c., by a central body called the Metropolitan Board of Works, which exercises jurisdiction over about 125 square miles of territory, containing nearly 3,000,000 inhabitants. The sections of the different sewers named on *Plate I*, are placed in their natural order, and are sometimes larger at the upper end of a sewer than at its lower. Those of the sewer to the Metropolitan Sewage Manure Works show not only great irregularities in form and size, but inclinations in the bottom of the sewer the wrong way, which is sometimes the case in other sewers. The sections at present preferred by the Metropolitan Board of

Works, numbered 1 to 8, will also be found on this plate, as well as "different sections," selected for their peculiarities, from different sewers.

Messrs. BAZALGETTE and HAYWOOD also supplied me with the copies of their published reports, and printed specifications and contracts, heretofore presented to you. To the following questions, in writing, Mr. HAYWOOD gave the accompanying answers:

QUESTION. What is the commercial value of sewage as a manure?

ANSWER. "It is a much vexed question which the agricultural world has been long at war upon. Of the value of the undiluted dejecta, there is, of course, no doubt, but when mixed with an enormous bulk of water, the value is much altered, if not destroyed, for general application.

"Large crops of grass may be grown with the sewage waters, that is certain, and if the expense of the application is not great, it will pay; but it will be a nice point to determine in most part, whether the increased growth will pay the requisite interest upon the outlay for the distributary system, &c., &c.

"Upon the whole, as far as experience can be gained by collating and arranging facts and conflicting statements, I consider the application, in a liquid form, will only pay upon certain soils, and that highly concentrated manures will excel it both in actual price and result; the solid manure made by precipitation is, I fear, next to valueless."

QUESTION. Efficiency and annual cost of flushing sewers?

ANSWER. "Flushing sewers is but a palliative of the evil. Sewers should, by attention to shape and fall, in relation to the duty they have to do, keep clean with the ordinary flow and the adventitious help of storm waters.

"If flushing is had recourse to, the expense will depend upon the fall and the rapidity and extent to which the deposit takes place; in a flat district, kept in a large degree clean by flushing, 4 men suffice to work 120 gates, but no

rule can apply, nor will flushing gates alone keep sewers clean unless very close together."

QUESTION. What are the forms, dimensions, materials, mode of making joints, and extent of pipe sewers, both as an aggregate in the city, and the largest single lines? How have they answered expectation, and what is the least inclination at which a 12 inch pipe can easily be kept clean?

ANSWER. "The number of pipe sewers is 127; the greatest length at present in the City* of London is 2½ miles; the total length of sewer of every description is 48½ miles; the longest single line of pipe sewer is 397 feet; the least inclination of a pipe sewer in the city is 1 in 320. The first pipe sewer was laid in 1848; the last during the present year. They have answered very well. But eight or ten entire stoppages have occurred, and where they have occurred, the difficulty of opening and rectifying has been a serious inconvenience and expense.

"1 in 240 is the least inclination at which they should be laid, but whether they will keep clean at that or greater inclination certainly depends upon the water supply for the houses, and care taken to prevent the intrusion of improper substances.

"The pipe sewers I have laid are circular; none smaller than 9 inches, nor larger than 15 inches diameter; the joints are put together sometimes with puddled clay, sometimes with cement."

QUESTION. Side entrances; what particular advantages do they possess over man-holes immediately over the sewers?

ANSWER. "A great advantage; because they can be opened and closed, and used, without inconvenience to the traffic."

QUESTION. What improvement do statistics show, has resulted to the city from the operations of the Commission?

ANSWER. "I have no precise figures to show the reduction, and reference to one year's mortality would only lead

* The "*City* of London" is but a small part of *London* or *the Metropolis*.

to a fallacy; but there has been an undoubted improvement in the health of the city population."

QUESTION. Does experience show that all the advantages, financial as well as sanitary, that were expected from the abolition of cess-pools, and the substitution of water closets, have been realized?

ANSWER. "I cannot answer the question as to the sanitary improvement resulting from the abolition of cess-pools only, as in the city it is attributable to the improvements made in such a large variety of ways.

"In a directly financial point of view, I don't think that there is any advantage, as drains and water closets have never yet been made at the fanciful prices which have been circulated; and what it will cost to keep them, upon the average of a district, in condition, remains to be seen."

QUESTION. Are the sewers constructed with full mortar joints, or are some of them left open for the purpose of sub-soil drainage? Would not impervious sewers, and house and cellar drains, together with well paved streets (so constructed that water falling into them would be drained into the sewers immediately) be as beneficial to the sub-soil, ultimately, as sewers with open joints?

ANSWER. "The inverts are of stoneware or brick-work in cement fully flushed up the sides and crown in mortar, likewise full; but they drain the soil of water which works through the bricks, and small holes in the joints.

"I do not know whether impervious sewers will drain the soil or not; if they do, they are not impervious, and it is absurd to call them so. I have heard cases mentioned where they drain the soil, but in that case, either the material must be porous or the joints open."

QUESTION. What is the greatest depth of cellars, and how far, in any case, do they extend below the bottom of the sewers?

ANSWER. "They are in no case below the bottom of the sewers; they are not allowed to be constructed at such levels as will not enable them to be properly drained; the sewers I

have built are rarely less than from twelve to fifteen feet below the surface to the water bed; the cellars are rarely more than ten feet below the level of the street-paving, generally but nine feet."

QUESTION. If any of the kind exist, what does it cost per annum to keep them dry? What is the nature of the soil in which they have been excavated?

ANSWER. "The answer to question eight partly answers this; the soil of the city is made ground over nearly the whole area, to depths varying from nine to twenty feet, the accumulation of ages; beneath that is gravel, or in some parts clay. Owing to the depth of the city sewers and their effectually draining the soil, underground rooms, the rental of which is probably £30,000 per annum, are now used as store-rooms, offices, &c., &c., which could not formerly have been kept dry."

QUESTION. What does experience show to be the best form of water closets, for different classes of houses and persons?

ANSWER. "Syphon pans for the poor; the old-fashioned trap water closets for the better classes; the valve closets where expense is no object."

QUESTION. How do the brick sewers that have been built only four and a half inches thick stand?

ANSWER. "I never built them within the city; the closeness of the buildings, their great height, the vast mass of goods in them, the excessive traffic in the streets, and the bad soil, render it unwise to build any thing in ½ brick over 18 inches in diameter.

"I have heard of ½ brick sewers falling in; I never heard of 1 brick sewers doing so."

QUESTION. What degree of ellipticity in a sewer gives it greater strength than a circular form?

ANSWER. "This will entirely depend upon the size of the sewer and other conditions. I do not think there is any advantage, generally, in making much difference between the lengths of the conjugate and transverse axes."

QUESTION. If any, what kind of valves are used to prevent sewage from breaking into cellars and basements of houses, in case of floods, during high water?

ANSWER. "Hanging valves in the sewers with ground faces are the best, but no self-acting valves can be depended upon.

"I have seen valves shutting by a float made in traps in houses, which, when the water rises, shut off the connection with the sewer; but these require frequent attention."

QUESTION. Are there any syphon drains under your charge? If so, how long have they been in operation, and are they troublesome, or otherwise, to keep clean?

ANSWER. "None. They require attention in keeping out silt, and to have a good flow through them; their certainty of action, or rather of keeping themselves clear, depends upon this, and their dip."

In answer to an inquiry relative to cellars in the district below high water, south of the Thames, Mr. HAYWOOD says:

"It may be practicable, as an engineering question, effectually to drain the vaults on the south side of the Thames, so as to prevent the chance of the flooding of the basements or cellars, but the expense of doing so would put it quite out of the question, as nothing short of constructing large reservoir sewers so as to hold all the storm waters below the levels of the floors of the vaults could effect it.

"Cellars in such districts should, in my opinion, be prohibited by legislative enactments."

Mr. BAZALGETTE informed me that he had not been able to determine all the circumstances and conditions with regard to size, inclination, and quantity of water sufficient to make a sewer self-cleansing. He would not recommend a larger sewer than one 3 feet by 2 feet, egg-shaped, to be built less than a whole brick, or 9 inches thick, although the sewer in Wind Mill street, Westminster, which is 3 feet 9 inches by 2 feet 6 inches, is but 4½ inches thick. It is about 30 feet below the surface, generally, in a very wet and gravelly soil, and after

having been down seven years is still in excellent order. It was laid in cement throughout. He would not, however, recommend the repetition of such an experiment.

Mr. BAZALGETTE also informed me that there were many cellars on the south side of the Thames, below the level of the sewers. They were generally intended to be water tight, but were, nevertheless, damp, and subject to occasional floodings, so that goods in them were frequently destroyed or damaged.

Messrs. BAZALGETTE and HAYWOOD have, for several years, had their attention turned to the subject of intercepting the sewage of London, diverting it from the Thames through the metropolis, and discharging it at points on both sides of the river, so low down as not to become offensive again to the inhabitants. Their plan, which is described in the reports herewith presented, was approved by ROBERT STEPHENSON, Esq., and Sir WILLIAM CORBITT, but owing to the effect of public discussions, and opposition with regard to this matter on the government, the carrying out of this plan has not been commenced yet. When I was in London, a commission had been appointed to examine into, and report upon, the expediency of adopting some plan of deodorizing the sewage; but nothing had transpired to let the public know anything with regard to the engineering works that would be recommended.*

The intercepting plan of Messrs. BAZALGETTE and HAYWOOD, as last presented, would cost, for both sides of the Thames, about $15,000,000, and divert from the river, through the metropolis, the sewage of the entire population or about 3,000,000. The low lying districts, comprising an area of twelve square miles on the south side of the Thames, and

* Since my return, the report of Capt. GOLTON, R. E., and Messrs. JAMES SIMSON, C. E., and THOMAS BLACKWELL, C. E., whom the first Commissioner of Public Works directed to consider the plans for the main drainage of the metropolis, has been published, and copied into the Sept. (1857) number of the Civil Engineer and Architect's Journal, from which the following extract has been taken:—

"They consider it very inexpedient for the Metropolitan Board of Works to adopt any plan which is based upon the deodorization or utilization of sewage; that if an attempt is to be made to utilize London sewage, it should be done by private enterprise; and that, in any case, provision must be made for the continuous discharge of the liquid residue, in case of deodorization, or the occasional discharge of the sewage in case of irrigation, at some point where it would be unobjectionable."

eleven square miles on the north side, are to be cut off by intercepting sewers from the higher districts, at all times except during heavy storms, when the surplus waters of the high districts are to discharge through the present outlets into the river. The low districts are to be drained by main intercepting sewers, the contents of which are to be pumped up, and discharged with that of the high level sewers, at or near high water, to prevent it from being carried back by the flood tide into the city. This plan, besides avoiding the pollution of the Thames, would form the basis of a much more efficient system for the street and house draining of the low lying districts, than now exists. These being mostly below the level of high water, are dependent for freedom from overflow at every tide, upon self-acting gates. The consequence is that to a greater or less extent, the main sewers become filled during high water, and keep the low cellars damp. The pumping would enable them to obviate this ordinarily, but during heavy storms it is not believed that it would; hence the reason why Mr. HAYWOOD would advise the prohibition of such cellars by legislative enactment.

The sewers of London formerly discharged their contents on the shores of the river, which being uncovered at low water, became exceedingly offensive in warm weather. Several are now continued by means of pipes to low water. This, besides diminishing the nuisance on the shores, has, when the mouths of the sewers are trapped, the further beneficial effect of preventing strong winds from entering them, and forcing foul gases into the streets and houses.

The streets of London are generally very well paved, and much pains is taken to keep them clean. The principal source of expense for cleansing the sewers, is the quantity of heavy material that gets into them from the streets. Mr. HAYWOOD complains of this in his annual reports, as the following extracts will show.

In his report for 1852, pp. 9, 10 and 11, he says:

"5,038 cubic yards of ballast and rubbish have been raised and removed from the sewers, but no soil or decom-

posing refuse of any description has been lifted to the surface, nor, indeed, has it now been the custom for some years, to raise aught to the surface excepting sand, ballast, silt, or inorganic matter, or such as the force of water, with slight mechanical aid, administered in the sewer, would not carry off.

"I feel it my most imperative duty again to draw your attention to the systematic usage of gullies, as the common receptacles of rubbish of every description, and regret to state that there has been no alteration in or diminution of this usage. I have already illustrated the extent of this practice, by reference to the sewers in Middlesex street and its vicinity, and shewn that for many years past at least an annual opening of, and raising the debris from, those sewers has been required. The quantity removed during the four years, ending Christmas, 1851, was 937 cart loads, composed of every conceivable description of rubbish, and I regret to state, that at the present time, upwards of 220 cart loads are in the course of removal from them.

"Indeed, I believe that in the locality named, the practice is upon the increase rather than the decline. In past years, when the gullies were choked up, they remained frequently so for various periods, and the inhabitants near to whose houses the gullies were placed, and to whose delinquency the stoppages were most frequently attributable, suffered for a time the inconveniences resulting from the practice; but of late years, owing both to the change in the supervision of public ways, &c., &c., and to an instruction since then acted upon, which I issued to the District Inspectors of Pavements, to report daily in the complaint book of the Inspector of Sewers, whatever stoppages were noticed by them of the gullies in their respective districts, these stoppages have, I believe, been for the most part so speedily removed, that the delinquents have lost the periodical admonition of their wrong doing; and unchecked custom has, I really imagine, at length induced the belief among a multitude of the poorer classes, that a gully is a perfectly legitimate dust-shoot.

"The precise nature of the resultant evils, I last year

explained in much detail, and will only again briefly assure your Honorable Court that its effect upon the sewers is most seriously injurious.

"To verify this still further, however, I may inform you that the number of gullies which have needed cleansing during the past year, was still greater than that of former years, thus showing that whatever may be the causes for the accumulations of dirt in the gully-shoots, those causes have not diminished. The most fertile among such of the causes that appear to be preventible, are the sweeping of the mud down gullies by the scavengers, and the sweeping of rubbish and dust from shops into them—habits both extensively practised, and extensively injurious to the sewers and their appliances."

In his report for 1853, pp. 8 and 9, Mr. HAYWOOD says:

"1,098 yards of hard deposit were removed from the sewers; this deposit being of the same description as usual, *i. e.* of substances which have, for the most part, no right to be in the sewers at all.

"It will, probably, be ever impracticable entirely to prevent the intrusion of such materials as constitute the solid deposit in sewers, as much, through almost unavoidable casualties, finds its way into them; but it is impossible to consider the large quantities that have been raised from the city sewers within the last few years, without arriving at the conclusion that a large portion of it must have been deliberately forced into them, through the street gullies and ventilating grates, &c., &c.; this is, indeed, known to be the case. I have repeatedly drawn the attention of the Commission to the extent of the practice of using gullies as dust-shoots, to the magnitude of the evils resulting, the cost incurred for the remedy, and to what I conceive to be the only means of effectual prevention, and must again state that, under various Acts of Parliament, throwing rubbish down the gullies is constituted an offence; that it is specially so constituted by the City Police Act, (c. xli), and, therefore, that by the agency of the Police, the Commission have a right to

expect the prevention of the offence, and the removal of the evil."

The sewers of London are, in some instances, ventilated by openings into the streets, covered with gratings, and, in others, by trapped connections with down spouts from the roofs of houses. As the latter mode, owing to local objections, especially that of causing foul gases, in certain states of the weather, to enter the upper windows of neighboring buildings, cannot be universally practiced, the former is considered necessary, in order to make the sewers safe for workmen to enter them.

The proper maintenance of public sewers depends very much upon the condition of the public ways, hence it is the general and almost universal custom throughout Great Britain to place the construction, repairs and cleansing of public ways under the same local board or committee that has charge of the sewers.

The usual mode of paving the streets of London is with blocks of stone, irregular in length but uniform in width, and commonly known in England as the "square-set." Different kinds of stone, in some cases wood and iron, have been used, the great object being to obtain "a carriage-way paving, possessing great durability and quietness under traffic, and an absence from slipperiness and dirt." In different parts of the metropolis, Macadam pavings are found. These cost less in the first instance, and, when kept in good repair, are pleasanter to drive over than any other kind, but they are more expensive to repair and cleanse, and cause more trouble to the sewers, in consequence of the heavy detritus washing from the road-ways into them, during heavy storms. The "square-set," which are made by placing the stones lengthwise across the streets, in straight lines, on good ballast foundations, are the most durable, less expensive to keep in repair or cleanse, and less troublesome to the sewers than the Macadam; but they are the most expensive in the first instance, besides being much more noisy and slippery. Wooden

blocks have been tried, and in quiet streets possess some advantages with regard to cleanness, and freedom from noise; but they are slippery in wet weather, and where the traffic is great, they have not been found very durable. In 1853, an experiment was made at the east end of Threadneedle street, by permitting the proprietors to lay down some compound metallic paving. It was "formed of blocks of a hard cement, having an iron frame bedded on the top, enclosing a certain portion of wood." It "was taken up and relaid in January, 1854, at the end of that year it was extensively repaired, and in the month of June, 1855, it having become very dangerous to the traffic, was altogether removed."

The introduction of water closets into the private dwellings and other premises of London, has become very general, but not universal. There are still doubts and diversities of opinion with regard to their advantages, both in a sanitary and economical point of view, when applied to the lowest class of tenements. The favor which they meet in the better class of dwellings, however, is such, that nothing probably could induce their occupants to go back to the old fashioned privy, with its open cess-pool.

Mr. Beggs, of Southampton street, Strand, one of the earliest active advocates of sanitary reform, has been for several years an agent for the sale of various kinds of water closets, and has consequently had many opportunities of seeing and hearing of the excellencies and defects of each sort. He is of opinion that the kind well known as the pan closet has not been much improved upon by the host of recent inventions, and that it combines economy in the use of water, and freedom from disagreeable smell, as well as any that have been introduced into the better class of houses. For houses whose inmates cannot be made to feel the importance of keeping such conveniences neat and clean, and particularly for soldiers or large bodies of laborers, they find it better to have a long deep trough, filled with water, which is flushed out once a day. The seats used are similar to those of the old fashioned privy. (See *Glasgow* and *Carlisle.*)

During the severe frost of January, 1855, many water closets, in the best houses of London, were out of order, and, for the time, foul nuisances.

AMSTERDAM.

The houses of this city are drained into its canals, which are very numerous. Each house appeared to have its own drain, which, I was informed, could not lawfully be used for conveying anything but liquids. The canals, however, contained deposits of filth that were said to be exceedingly offensive in warm weather, especially before the custom of changing the water in them was introduced. Since then the evil has been less; but owing to the shallowness of the canals, and to the difficulty of changing the water often, offensive smells are very prevalent in summer, and are supposed to be the cause, in part, of the high rate of mortality of this city,—four per cent. in 1856,—while that of the entire Netherlands was only about three per cent.

Dr. Sarphati, the contractor for removing all the solid filth of the city, thinks a great deal is discharged into the canal that is injurious to health, and that would be profitable for agricultural purposes if saved. He enabled me to examine the arrangements for collecting and disposing of the various kinds of refuse. The ashes, being of wood and turf, are collected in a very large building, and there screened and put into bags for sale. The garbage and street scrapings are piled up near a canal, and, during warm weather, removed every day into the country; in winter less often, because they do not become offensive then. The sweepings of houses, stores, shops, &c., are collected in a separate shed, where men are employed in picking out the old rags, bits of paper, broken glass, &c., &c., which are sold to be re-manufactured. The night soil, which cannot be lawfully—though it is said to be sometimes unlawfully—conveyed into the canals, is pumped out of the privies by means of large iron tanks or cylinders,—from which the air is exhausted—then manufactured into poudrette, or mixed with ashes, and sold for agricultural purposes.

Cellars, with their floors a few inches above the level of the water in the canals, appear to be very common in Amsterdam. The first floors are frequently elevated several feet above the streets, especially when these border on a canal, which is the rule rather than the exception. Water closets are but little used, if at all.

At *Zaardam*, in the vicinity of Amsterdam, about five hundred wind-mills are in operation, performing various kinds of service, such as pumping water, sawing lumber, and grinding different substances. I visited that place for the purpose of examining the wind-mills, to ascertain if anything like them could be advantageously used in pumping water to flush our sewers; but from what was told me there and elsewhere, I became satisfied that steam would be better for our purposes than wind.

HAMBURGH.

The topographical features of this city are not so similar to those of Chicago as I had supposed previous to my visit; its sewerage, however, presents points of much interest.

After the fire of 1842, which destroyed a great part of the city, the government employed Mr. LINDLEY, their present engineer, to lay out anew the burnt portion, and to devise a system of sewerage for the whole city. The objects sought, but difficult to attain, were the diversion of all filth and refuse from the canals and basins into which it had previously been discharged, to the Elbe below the city; and the drainage of the lowest cellars, which were 9 feet below the highest known floods of that river. For this purpose, the city was divided into three parts, the central and lowest of which alone, could not be drained into the river at the highest stages of water. The canals, and the large basin called the Binnen Alster, are situated in this portion of the city, and like other and vastly greater extents of surface along the shores of the German ocean, and the banks of rivers that empty into it, are kept from overflow by means of dykes and guard locks. They consequently serve as reservoirs for such storm water as may fall during the very high stages of the river.

To drain the central portion, Mr. LINDLEY devised a main sewer, 6 by 7 feet, semi-circular at top and bottom, and having its outlet 2 feet above low water, in the river. The inclination of this main sewer is 2.07 feet per mile on an average, varying from 1 in 1,200 to 1 in 4,500, and extending a distance of $3\frac{4}{5}$ miles, to a point on the south-east side of the Aussen Alster, where its bottom is 3 feet below the general level of its surface, thus affording a good head and an abundant supply of water at all times for flushing purposes. In order to make this sewer accomplish all that was important, and at the same time to conform as much as possible to the peculiar circumstances, both natural and artificial, of Hamburgh, it was necessary that its length should be much greater than that of a straight line from one end to the other; the latter being to the former about as 5 to 8. The size with which it commences, is reduced at different points, first to 6 by 5 feet, and finally down to 2 feet circular at the inlet. At one point the sewer is 40 feet below the surface, and was made by tunneling about half a mile. At two other places it was tunneled. At two points its bottom is depressed $3\frac{1}{2}$ feet below the regular grade, to pass under two canals, which lead from the Binnen Alster to the Elbe. The principal branch sewers have inclinations of not less than 1 in 500, and the smaller ones not less than 1 in 150; and the house drains not less than 1 in 100; the elevation of the surface being sufficient generally to admit of these inclinations, and in many instances much greater. (See *Plates II* and *III.)*

The sewers were constructed of brick and hydraulic cement, and presented a better appearance, with regard both to materials and workmanship, than anything of the kind I have ever had an opportunity of examining.

The surface water from streets is let into the sewers through grated gullies, placed about 40 yards apart. These have neither traps nor catch-basins, and consequently serve as ventilators to the sewers.

There was much opposition to the plan of sewerage adopted for this city, and many pamphlets were published on

the subject. Its success, however, has been complete, and, so far as I could learn, it gives almost, if not quite universal satisfaction, and its former opponents have either became its friends, or remain silent. The most important feature objected to in the plan, was the slight inclination in the main sewer, and the insufficiency of flushing, to keep it from filling up with deposit; but the result has so fully confirmed Mr. LINDLEY'S calculations, that he informed me he would now rather have a perfectly level sewer, with plenty of water to flush it, than one of considerable inclination, without any means of flushing. I had an opportunity of examining different parts of this sewer, also of seeing the flushing apparatus at work, and felt satisfied that the latter was sufficient to remove all substances that ought ever to be permitted to enter a sewer. Fragments of building materials, however, are sometimes improperly thrown down the gullies, as in London, and have to be removed from the sewer by hand. This was foreseen, however, and shafts were provided for the convenient removal of such substances. The flushing gates are placed at irregular intervals, in some instances,—according to the profile herewith presented—less than 500 feet apart, and in others, more than half a mile. They are about three feet high, so that a head of two feet, above the ordinary height of water in the sewer, may be obtained. And this, Mr. LINDLEY informed me, was all that was ever needed; in fact, that when the sewer is uniformly filled to a depth of three feet, the velocity is sufficient to cleanse it. The principal and smaller branch sewers—most of which are too high to be flushed from the Alster—have such inclinations as to render that operation unnecessary in most cases; but whenever it is needed, the hydrants connected with the water works of the city, afford an abundant means.

Pipes have been introduced to some extent for house drains in Hamburgh, but, I believe, have never been used there for public sewers in any of the streets.

The arrangement of street gullies already mentioned, although different from any system I am acquainted with in

this country, had, as Mr. LINDLEY informed me, given no serious trouble, either from the escape of foul gases into the streets, or the introduction of heavy substances into the sewers, although he had been exceedingly annoyed by the improper use made of the gullies for disposing of substances that should have been removed in the scavenger's cart.

Water closets appeared to be very generally used in the better class of houses; and it was said that domestics frequently refused to enter the service of families, whose dwellings were not supplied with them.

On the easterly side of Hamburg, there is a tract of land some three miles long and two-thirds of a mile wide, called *Hammerbrook*. Its general level is only about 4¼ feet above ordinary low water in the Elbe, and 2¾ feet below the level of ordinary, and 16¼ feet below extreme, high water. Like many other similar tracts in Northern Europe, it was reclaimed for agricultural purposes, and protected from overflow by dykes and sluice gates. It remained, however, subject to slight inundations, for when heavy rains, or the melting of ice and snow occur during high stages of the Elbe, the river does not fall low enough, even at ebb tide, to allow the district to be relieved through the sluice gates. To improve the cultivation still more, and to afford a site for residences in that portion of the district which adjoins the city, a twenty-horse steam engine was erected.

This engine was made to drive a scoop wheel, 29½ feet in diameter, and sixteen inches broad, with its bottom placed four feet below ordinary low water. By means of this machinery, and two reservoirs—one higher than the other, or six feet above low water—the surface of the water in this district was generally kept about one foot above the level of low tide, or fifteen inches below the surface of the lowest meadows, and, of course, rendered the lands much more valuable.

In the portion of this district, so near Hamburgh as to make it desirable for residence purposes, streets were laid out and houses erected. At first, in 1840, owing to the scarcity of material, it was intended to raise these streets to

a height of but seven feet above low water; but the desirableness of having cellars, and the occurrence of the great fire of 1842, which caused immense quantities of rubbish to be carried out of Hamburgh, led to the raising of the streets in some cases to twelve and thirteen feet above low water. Mr. LINDLEY, the Engineer of the Drainage Works, recommended that the bottoms of the cellars should be not less than seven feet above low water.

In February and March, 1850, an extraordinary occurrence of high water, both within and without this district, showed that further precautions against flooding were necessary or advisable, such as raising and strengthening the dykes, raising the surfaces of the streets, and keeping the cellar floors strictly seven feet or more above low water. Some parties, in consequence of neglecting this, had suffered from it. Mr. LINDLEY informed me that the streets were to be raised to a height of ten feet above the natural surface of the ground.

BERLIN.

This city is, in many respects, more like Chicago than any other I visited. Its site is almost a dead level throughout, having been originally a wet, sandy plain. The Spree flows through it, and a few canals exist there also. Low water in the river, is about 20 feet below the general level of the city, high water about 13 feet below the same level, and the ordinary or average level about 18 feet; but this varies very much in different seasons.

The streets of Berlin are generally straight, wide, and paved with cobble stones. They were very clean when I saw them, and there were none of the offensive smells which are said to exist in that city in the summer season. These proceed from the house drainage being allowed to flow into the street gutters, just as it does now in a large portion of Chicago, for the want of underground drainage. But in Berlin, the gutters are well paved to regular inclinations, and frequently cleansed, especially since the recent introduction of a copious supply of water.

There are scarcely any sewers in Berlin; one, however, nearly a mile in length, and having a fall of 16 feet 3 inches in this distance. Its lower end is 7 feet 4 inches below the level of high water, and its upper end so near the surface of the street as to leave room for a covering of flag stones only. The form of this sewer is like that of some of the older English ones, with upright sides, curved bottom, and arched top, where there is room. The sub-soil being a wet, running sand, made the construction of the stone foundations, adopted for the sewers, very expensive. The bottom and top arches are generally of brick.

In 1841, Mr. WICKSTEED, of London, was requested to devise a system of sewerage for Berlin, and he recommended the digging of a deep well on the outside of the city, and the maintenance in it, by means of a steam engine and pumps, of a sufficiently low level to allow all parts of the city to be drained into it. The sewage, when pumped up, was to be used in fertilizing the arid, sandy lands of the vicinity. This plan, principally for the want of funds, I believe, was not adopted, nor has any other been up to this time, though there has been much discussion on the subject. Mr. WICKSTEED himself has changed his opinions somewhat with regard to the general policy of disposing of the sewage of large cities in this way, although he thinks it may work well in particular localities. He had not then looked into the cost of distributing the sewage over an extensive surface, together with the many objections that are likely to be made to it in the vicinity of a large city, as he has since.

In his report of 1854, "upon the most advantageous mode of dealing with the sewage matter of the metropolis" (of England), he says, p. 17:

"In 1845, I was called upon by the projectors of the London Sewage Company to report to them upon the practicability of carrying out a scheme for distributing the sewage water of London in agricultural districts, by the application of steam power and pipes, and was further instructed, that if I found it could not be carried out thus, so as to prove profitable, to

suggest, if possible, some other mode for effecting the object; and it was at that period that I entered into the calculations as to the cost of such a scheme, which led me to form the opinion that it could never be made a remunerative speculation. I then considered a scheme for arresting the fertilizing matter held in suspension in sewer water, and found that even had it been as valuable as the matter held in solution (which is by no means the case), the quantity to be obtained, having regard to its quality, was too small to be remunerative."

Water closets are exceedingly rare in Berlin. The night soil is used for agricultural purposes in the vicinity, and its value in this respect is said to have been one ground of objection to a system of sewerage with water closets discharging their contents immediately into the public sewers.

PARIS.

The present system of drainage in this city, with regard to rain, kitchen and waste water, is to let it into the gutters on the sides of the streets, and thence along these to the nearest gully connected with the public sewers.

The ancient sewers of Paris, as described by PARENT DUCHATELET, and M. GERARD, in his Memoires du Canal de l'Ourcq, together with those of a more recent date, constructed so as to empty at all times into the Seine, have been partially, and are to be wholly, intercepted by large sewers, one on each side of the river, so that, except in cases of heavy storms, the sewage of the city is now partly, and will be wholly, discharged into the Seine at points entirely below all the important residences of Paris. In times of heavy rains, the sewers will discharge their surplus water into the river by means of over-falls, and through their ancient outlets, or new ones, constructed for the purpose.

At present it is not lawful for private individuals to empty the contents of water closets into the public sewers, though exceptions in favor of public institutions have become numerous; but under the new system under trial, pipes parallel with the main sewers will, in some cases, be provided for the

liquid portion, and all the other drainage from houses will be discharged directly into the public sewers low down, and not into the street gutters, as at present. This is to be in operation all over Paris in 1862. Early in February of this year, (1857) it was decided by the Conseil des Ponts et Chaussées to construct an intercepting sewer sufficiently large to convey the sewage of all that portion of the city, which is situated on the right bank of the river, to a point between Clichy and Neuilly, tunneling for this purpose under the high ground north of the Faubourg St. Honoré. By this means advantage is taken of a fall of 5½ feet in the river, thus placing the outlet sufficiently low to prevent the sewers in the central portion of the city from being filled with back water, except in times of the highest floods, which last, on an average, but two days in a year, and in extreme cases only ten.

The smallest public sewer constructed under the present or new system, in Paris, is 6¼ feet high and 4⅛ feet wide, the cross section being semi-circular on top, curved with arcs of circles on the sides, and having a segment of a circle 1⅝ feet long, and depressed two inches for the bottom. This size, as well as the large ones, is built mostly of a very hard kind of stone (such as is used for mill stones in this country), laid without dressing of any kind, in lime, and coated over on the inside with cement, to give them a smooth surface, which is afterwards white-washed to make them lighter. The thickness of the walls is generally about one foot. In some instances, by way of experiment, principally to save time in construction, they have turned the upper arch with a single, but very hard brick, laid in cement, and 4⅜ inches thick; the cost being about the same as that of the stone one foot thick. They perceive no yielding, after a trial of three or four years, with a covering of not less than 3¼ feet of earth, or paving, above the top of the arch.

The house drains emptying into the sewers are to be of such sizes as the proprietors may choose; they being obliged to pay for them. I noticed tubular outlets, varying from four to eight inches in diameter, left for them in the new sewers.

One reason for making the smallest class of public sewers in Paris, so much larger than they are in every other city, is the practice which, till within ten years, existed only there, of placing the water mains in them. With smaller sizes, it would be difficult and painful for workmen to introduce or repair water pipes. The same practice has recently been introduced into Dijon, with regard to the principal sewers. Originally it was intended to include the gas mains also, but experience soon showed that leakage from them was so great as to make it dangerous for workmen to enter the sewers, especially with lighted lamps.

Under the new system, there are eight classes of sewers; the smallest having already been described. The largest class is 13 feet 5 inches high, 16 feet 5 inches greatest width across the top arch, about four feet wide across the cuvette, or ordinary water way, which has straight sides, 18 inches high, with a segmental bottom, depressed 5 inches in the middle. There is, on each side of the cuvette, a horizontal ledge about 5 feet 9 inches wide. The upper arch is semicircular, (as are the upper arches of all the sewers,) and 1 foot 8 inches thick on top, and 2 feet 7 inches on the sides. The side walls, on a level with the ledge, are 3 feet 1½ inches thick, and the segmental portion below, 1 foot thick. The character of the masonry is the same as that in the smallest class. There is an iron rail placed on each angle of the cuvette and ledge. These rails are angular in shape, fitting close to the masonry, and adapted to cars which are to be used in the various kinds of service these large sewers are destined for; more particularly for transporting deposits it may be necessary to remove from the sewers to boats in the Seine.

The following tabular statement gives the cost, in detail, of the different sizes of Paris sewers, except for No. 1:

See Plate II.

Cost per running foot of Sewers, in Dolls. and Cts.

Variable Expenses:	No. 1.	No. 2.	No. 3.	No. 3. bis.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Excavation	.....	2.49	3.28	2.49	1.82	1.35	1.14	.83	.73
Replacing pavement	.....	1.11	1.15	1.01	.91	.83	.75	.68	.52
Foundations	.....	.35	.45	.33	.27	.27	.27	.22	.21
Bracing	.....	.65	.68	.65	.34	.28	.24	.18	.06
		4.60	5.56	4.48	3.34	2.73	2.40	1.91	1.52
Fixed Expenses:									
Transporting excavated materials	.....	1 20	.42	1.05	.85	.63	.53	.42	.34
Stone Masonry	.....	9.02	12.54	7.83	7.30	4.96	3.98	3.32	2.48
Plastering top and sides of interior.	.....	1.01	1.06	1.06	.94	.86	.76	.74	.63
Plastering bottom	.....	1.07	1.18	.98	.70	.58	.58	.34	.22
" outside	.....	.73	.79	.63	.54	.50	.44	.39	.32
Centering	.....	.35	.35	.35	.35	.29	.23	.17	.17
Guard fences	.....	.07	.07	.07	.07	.07	.07	.07	.07
		13.45	16.41	11.97	10.75	7.89	6.59	5.45	4.23
Accessories, Gullies, Man-holes.	.....	.81	.81	.81	.81	.81	.81	.81	.81
TOTALS Tunneling..	30.	18.86	22.78	17.26	14.90	11.43	9.80	8.17	6.56
TOTALS Open cutting	31.50								

There were in Paris, a year ago, about 170 kilometres, or 106 miles of sewers, some of which are very old. The inclinations of the smallest class vary from 1 in 1,000 to 1 in 400, and those of the largest class from 1 in 2,000 to 1 in 1,000.

The gutters and sewers are flushed daily with water from the hydrants, 2¼ hours in the morning, and the same length of time in the afternoon.

The soil of this city is generally gravelly and dry down to the level at which water stands in the wells. The cellars have no connection with the sewers, and are sometimes much lower.

The mode of constructing, as well as of emptying privy vaults, is carefully regulated by law. They are laid in cement, and made impervious, to prevent the soil from becoming contaminated by exudations from them. They are emptied by means of strong air-tight casks, which, after

being exhausted of air, are connected by pipes and hose with the semi-fluid matter in the vaults, which, after the simple turning of a cock in the connecting pipe, rushes into the cask. It is done, they say, without creating any unpleasant smell; but Mr. NEWLANDS, of Liverpool, however, who visited Paris while I was there, partly to gain information relative to this very process, and who sat up one night to witness it, told me that the smell was very offensive.

The night soil, except from some of the public buildings, is still carted to the Voirie, and there manufactured into poudrette.

WORTHING.

This is a small watering town on the southern coast of England, a few miles west of Brighton, and contains about 5,000 inhabitants. Until quite recently it was drained at all times directly into the sea, in front of the town, but owing to offensive smells caused by this practice, and the consequent injury to the reputation of the town as a watering place, upon which its prosperity very much depends, it was determined to dispose of the sewage in some other way, so as to get rid of the nuisance of mingled sea weed and town filth in their immediate vicinity.

In carrying out the new system of draining this town, water and sewerage works have been combined, and the same engine is made to pump both water and sewage, the former to a height of 80 feet, and the latter 25 feet. The sewage is now conveyed from the pumping station by a 15 inch pipe, to a point on the sea shore, about two miles eastward, where the prevailing winds take it still farther from the town.

The main sewer is of brick, and the branches are of stone-ware pipes, varying from 15 to 6 inches in diameter.

The tide rises ordinarily 18 feet, at Worthing, and the system of drainage is so arranged, that at present the pumps do not work during the night; the sewage, not being very impure then, is discharged through the old outlets by a self-acting valve. At high water they have the power of thoroughly flushing the main sewer from the sea.

The sub-soil of the town is somewhat varied, but generally porous. One effect of the works has been to lower the ordinary water level in the ground some 5 or 6 feet. The deep basements have added to the difficulties and expense of the works. Mr. HIDE, Surveyor of the Local Board of Health, thinks it will be necessary, in some instances, to have *screw-down* valves, as a security against flooding from the sewers, in case of accident to the engine, or excessive storm water at high tide.

At the time of my visit, scarcely one-third of the inhabitants enjoyed the benefit of the new works, but they were rapidly extending them everywhere. The system includes the abolition of cess-pools or privy vaults, and the substitution of water closets for them. So far as they had been introduced, they appeared to give great satisfaction.

CROYDON.

As this town was, in the latter part of 1852, the seat of an extensive and fatal epidemic, which was attributed to defects in the system of drainage just then carried out, and as much attention was directed towards it at that time, by those interested in sanitary matters, I thought it would be interesting to know what changes had actually been made since, and what conclusions they had arrived at with regard to their system as a whole, and to the modifications proposed by Messrs. ARNOTT and PAGE.

The population of Croydon is about 18,000. Previous to 1851 there were some brick sewers in the principal streets. In that year the construction of the present system of combined water and drainage works was commenced, and it has been in operation since 1852. For the new sewers, pipes varying from 4 to 21 inches diameter, with grades varying from $2\frac{1}{4}$ inches to $7\frac{1}{4}$ feet in 100 feet, have been used, to convey house drainage; but for surface water, the old brick sewers are still used where there are any, and in some instances new ones have been built for the purpose. The introduction of water closets and abolition of privy vaults is a

part of the new system. The sewage of about three-fourths of the population is collected at the filtering house described by Mr. PAGE; and most of the remainder is discharged into a mill pond on the Wandle.

It was the intention of the General Board of Health to have this town sewered according to the views of the school headed by Mr. EDWIN CHADWICK, whose extensive and persevering efforts to ascertain and make known the sanitary state of populous towns and districts, including their systems of sewerage and drainage, have done so much to direct public attention to this subject. These investigations led Mr. CHADWICK and others to adopt views differing very much from those which had before obtained, and to recommend the use of pipe sewers of 4 inches and upwards in diameter, but much smaller than other sewers before used for the same kind of service. They believed that glazed pipes were sufficient to carry off not only all liquid discharges from houses and water closets, together with all substances that could be suspended in water, but that even the washings of streets should be admitted into them; and, that the sewers thus used would not require flushing to cleanse them from deposit, nor ventilation to free them from foul air, provided they had proper inclinations. For this reason, no provision appears to have been made at Croydon for flushing, examining or ventilating the sewers. The alarming sickness of 1852, led to the discovery that the sewers were in some places obstructed with deposit, causing the most offensive smells, which escaped from them into houses; hence the very general belief that either in the plan or the execution, or both, the works were a complete failure.

The causes and extent of this failure were subjects of controversy and investigation. Messrs. ARNOTT and PAGE, already mentioned, and afterwards Mr. WICKSTEED, were requested to examine and report upon the causes of, and to propose remedies for, the evils complained of. They all condemned the small sizes of the sewers, their want of ventilation, and means of examination, and the mode of disposing of the sewage; and suggested, or recommended, important

enlargements of the sewers, thorough ventilation, and a complete deodorization of the sewage. The discharge of the sewage into the Wandle was declared a nuisance, not only to the town, but to the whole population below on that stream. Mr. WICKSTEED says, (page 20 of his report): "As regards the sewers in town, you cannot do better than I am informed you are doing, namely, taking up small pipes and replacing them with larger ones, and introducing ventilating pipes; but, I would urge you most strongly to cleanse the sewers frequently and thoroughly, with water from the water works; it will not only clear away the deposit which now takes place in your sewers, but will dilute the sewage, and render it less offensive when it is discharged at the present out-falls."

Mr. Cox, the Surveyor of the Local Board, informed me that they had taken up 1,530 feet of 4 inch pipe, and 3,300 feet of 6 inch, or, which is equivalent, have substituted for them 12 and 8 inch pipes in the same, or in other streets. They have constructed several man-holes, which have been found necessary, to avoid opening the streets and breaking into the sewers, whenever the latter require examining or cleansing. For the escape of foul air from the sewers, they have also erected three inch iron pipes to the tops of houses, in places where it would not be likely to find its way into upper windows.

Mr. Cox would not advise the use of less than 4 and 6 inch pipes for house drains, nor less than 9 inch ones for street sewers. Formerly they used 3 inch house drains, and 4 inch street sewers, as already mentioned, in some cases. He would not use pipes for sewers where a greater size than 12 inches is required, but prefers brick. The system of back drainage,—that is, of laying common sewers through private property, in the rear of houses, to avoid the expense, and sometimes loss of declivity, caused by laying drains under houses to streets in front, is seldom practised now; the front or street system of drainage being preferred.

There are in one case, certainly, as many as 16 houses draining into one 6 inch pipe, without giving trouble or

requiring alteration: Mr. Cox thinks even more, in some cases, drain into pipes of the same size.

The repairs and cleansing of sewers, including not only labor, but a proper proportion of superintendence and tools, does not exceed £100 per annum.

At the time of my visit, about one-fourth of the sewage was used for irrigating fields, at an expense of only £26 a year, paid by the town, to a farmer for taking it. After being used in this way, the sewage flows off quite clear and inodorous. Mr. Cox likes this mode of disposing of it, where it can be carried out, better than any other.

By a recent decision of arbitrators judicially appointed, the town was required to change the out-fall of the sewage, so that it should not flow into the river at all, without being first purified in some way. The mode of doing it had not been fully decided upon, but it was probable that it would be by a system of irrigation.

There was much less dissatisfaction with regard to the sewerage then, than at the date of Mr. Page's report; still there were some that complained. The bills of mortality for the year 1856 are very favorable.

During the arbitration above mentioned, every clergyman and every medical practitioner, but one, in the district, bore testimony to the improvement in its health.

Jointed bamboo rods, 100 yards long, have been used in cleansing the pipes, with success in most cases.

The two lines of 12 inch outlet sewers, with a fall of only 2 feet in 1,800, are troublesome to keep clean, and actually take a hydraulic inclination of 3 feet generally, more sometimes. Ordinarily, the outlets are half full.

The smell of the filter house was very disagreeable to me, although my visit was in the winter season.

After leaving Mr. Cox, I went into several houses, and inquired about the working of the sewers. The answers in every case were, that the public sewers were working well. The keeper of the Crown Hotel said his house drain, which was only 4 inches in diameter, had been stopped twenty

times during the last three years, and it was then being replaced by a 6 inch one. Two gentlemen, whom I afterwards met in the cars, and who informed me they were residents of Croydon, said the sewers were carrying off the drainage very well; but, in their opinion, the works, as a whole, had not improved the health of the town.

LEICESTER.

Towards the close of the last century, the river Soar became the common sewer for the drainage of this town. At first the nuisance occasioned by this practice did not appear to be very great, but about twenty years ago, in consequence of the increase of population, and, more especially, of the dye houses and factories, in which large quantities of soap were used for the washing of wool, the sluggish waters of the Soar became so corrupt that fish could not live in them, and consequently disappeared entirely. The river, which was used for the navigation of canal boats drawing four feet, became like ink almost in color, and evolved in summer so much sulphuretted hydrogen as to tarnish silver watches. A few years since some residents on the banks of the river, below the town, who felt that they were seriously injured, and, in some cases, it was thought, had lost members of their families by fevers caused by the foul state of the stream, commenced legal proceedings against the town corporation. This caused the authorities to inquire what could be done to remedy the existing evils, and they invited Mr. WICKSTEED, of London, to aid them.

Leicester contains about 65,000 inhabitants, who reside mostly on ground quite elevated above the river—in some places upwards of fifty feet; but the houses of many of the laboring classes, as well as the principal manufacturing establishments, are situated on the meadow, which is subject to inundation, and portions of which used to be covered with water a great part of the year. The low grounds were frequently the seat of fatal diseases, of a kind which, in England, are considered preventible.

The principal details of the plan recommended by Mr. WICKSTEED, and afterwards carried out by the town, are as follows:—

The sewage is disposed of by pumping it up, then deodorizing it by drying, and afterwards manufacturing the deposit into solid manure. The sewage of all the town is pumped up ordinarily about 18 feet, although a very large portion of it might have been made to flow into the basin which now receives it, by simple gravitation; but according to Mr. WICKSTEED'S estimates, the cost of two lines of sewers, one from the high part of the town, and the other from the low, would have exceeded the cost of the single line, by a sum which would have been sufficient to erect and maintain the necessary pumping power to raise that portion of the sewage which could have been disposed of by simple gravitation. The outfall is of course ordinarily into the well of the pumping station, but during heavy rains, it is into the river, some distance below, there being to this point from the pumping well, a continuation of the main sewer, so arranged as to discharge into the river whatever excess of storm water the engine cannot pump up. At such a time the main sewer in the low part of the town must be gorged, till it attains a level above that of the river.

The section of the sewers is circular, this form being preferred on account of superior strength, economy and efficiency under ordinary circumstances, wherever it is not necessary to enter the sewers for examination, cleansing or repairs. In order to avoid this necessity as far as possible, Mr. WICKSTEED so arranged the diameter and inclinations of the sewers, that they might frequently be half filled, and the current through them at such times have a velocity of three feet per second, sufficient to remove all non-concreted substances likely to get into sewers. The material used in all the sewers is brick, radiated for the smaller ones. The smallest street sewer is 1 foot in diameter, the largest main, 4½ feet. For courts and alleys requiring sewers of less than 12 inches diameter, it was thought pipes would be preferable; and for

house drains, Mr. WICKSTEED had no doubt they would. The least general depth for the main sewers is 12 feet below the surface. A sufficient supply of water is considered essential for the cleansing of the sewers.

The Patent Solid Sewage Manure Company made an agreement with the town to pump up and deodorize the sewage for 30 years, for the right to manufacture it into manure. This contract was entered into by the Company, in the belief, supported by the estimates and experiments of Mr. WICKSTEED, that the manure, including the cost of pumping up the sewage, could be made for 20*s.* a ton, and sold for twice that sum.

The drainage works of this town had been in operation about ~~ten~~ two years, at the time of my visit, and the following results had been ascertained, viz.: a marked improvement in the health of the town, as shown by the bills of mortality, and especially in that portion of the low grounds which were formerly overflowed so frequently; a cessation of complaints from the neighboring population for miles below the town, on account of the state of the river, which was formerly so offensive; and such a purification of the river as to restore the water to its original clearness, and cause the reappearance, in the summer of 1856, of fish, which had not been seen in it for twenty years before. No case of stoppage had occurred in any of the sewers, and no expense in cleansing them had been necessary, except in three cases, where small sewers, near their summits, did not have sufficient water flowing through them. The people expressed themselves, so far as I could learn, entirely satisfied with the system. The cost of manufacturing the sewage into manure was scarcely one-half the original estimate; but, unfortunately for the Company, its market value was less than its actual cost, instead of four times as much. The cost of the works for pumping and deodorizing the sewage, and manufacturing it into manure, was originally £30,000. New ones, capable of performing the same amount of work, quite as efficiently, could now be constructed, it is believed, for less than £10,000; depending, however, upon

the price of land, which was included. This great reduction was owing to improvements made in the mode of manufacturing the manure, requiring far simpler machines than those first made, and much less space for the different processes. From a quarter to a third of a ton of lime was commonly required in the manufacture of each ton of manure, in order to make the sewage water perfectly clear. In March, 1857, they were making experiments with one-fourth the usual quantity of lime, believing that the product would be a stronger manure, and the sewage water deodorized, but not so thoroughly clarified as by the larger quantity. The mode of using the lime was first to mix it thoroughly with water, and then to pump it up with the sewage. The cost of lime, delivered at the works, was 13*s.* 6*d.* per ton (of 2,240 lbs.).

About 22,000,000 imperial gallons of sewage and lime water are pumped up weekly, requiring about 12½ horse power, working night and day. From 15 to 18 tons of slack (coal), costing 6*s.* to 7*s.* per ton, delivered at the works, are used weekly, for pumping up the sewage and driving the machinery for manufacturing it into manure, but not for moulding it into the shape and size of bricks and drying it, to include which, about 20 tons a week would be necessary. The moulding and drying process, which costs about 2*s.* 6*d.* per ton, was then omitted, and the manure sold in a damp state, for four shillings a load, equivalent to about 15 cwt. of dry manure. This was at a loss of about 29 per cent. on the cost of manufacturing it; but it was believed that further reductions in the cost would be made, and all loss eventually avoided. The whole sewage of Leicester yielded annually a quantity of manure equivalent to about 45,000 tons in the dry state; but, as before mentioned, it was then sold damp, that is, with as much moisture as possible thrown off by centrifugal machines; which are the same in principle as those used as a substitute for the hand method of wringing clothes in the public wash-houses of London and other European cities.

There are very few cellars in the low grounds, and they are liable to be flooded during heavy storms. Not more than

one house in fifty had water closets; the old fashioned privy and ash-pit being retained, it being found that when they were properly constructed, and rain water excluded from them, the ashes were sufficient to prevent any unpleasant smell. The compost was carted away without direct cost to the householders, by a town rate. The total cost of scavenging the town, including street cleaning, and removal of the soil from ash-pits and privies, was about £500 a year.

EDINBURGH.

The principal points of interest that caused me to visit this city, were its experience with regard to pipe sewers and the use of sewage for irrigating meadows.

It was mentioned in a discussion before the members of the Institution of Civil Engineers, held in London, November 30th, 1852, that the pipe sewers of Edinburgh had proved a failure. Mr. McPherson, the Superintendent of Streets and Buildings, having also charge of the public sewers, informed me, that so far from his considering pipe sewers a failure, he was laying them at that time, and that, in August, 1856, there were 10¼ miles of them in the streets and closes of this city. In two cases, owing to unskilful workmanship and mismanagement, there had been temporary failures. In one case, a 9 inch pipe had been laid, with two sharp angular bends, a short distance apart, with the gradient between, either level or sloping the wrong way. The defect was entirely remedied by putting in curved pipes where the angles were, and relaying the portion between them on a proper inclination. In another case, the difficulty was owing to placing traps ten feet under ground without any provision for cleansing them, and then allowing night soil, and other kinds of filth, to be thrown into gullies, which were covered with immovable grates.

About 130 acres of meadow are irrigated by the sewage from that part of the city which is drained *directly* eastward. Another meadow is irrigated from a district sloping westward. The meadows thus fertilized have become exceedingly

valuable, producing enormous crops of coarse grass, which is used for feeding cows, but not horses. They rent, in some instances, for upwards of £30 per acre a year.

The irrigation is effected by simple gravitation, for most of the meadows. As, however, only a very small portion of the sewage is used even in the summer, the surplus is made to pump up a part, and thus the district irrigated is somewhat enlarged beyond what it otherwise would be. Most of the meadows are formed into ridges, with small canals along their summits. Little or no use whatever is made of the sewage for irrigating purposes in winter.

Both Mr. McPherson, and Mr. Cousin, City Architect, informed me that the inhabitants of Edinburgh were much annoyed at times by vapors from the irrigated meadows, and would gladly have broken up the system if they could; but prescriptive rights which would make a change exceedingly expensive, stood in the way.

GLASGOW.

This city, which contains about 400,000 inhabitants, is drained by means of stone and pipe sewers, into the Clyde and its tributary, the Kelvin. All of the first and middling class, together with many of the lowest class houses, are provided with water closets, which discharge their contents directly into the public sewers. In consequence of this, and the house and factory drainage emptying into the rivers, they had become so offensive three years before, in the summer, that a scheme was proposed for constructing large intercepting sewers along each bank of the Clyde, to a distance of several miles below the city, and there discharging their contents into the river. After deliberate consideration, this project was rejected, because, in the first place, it would have thrown the nuisance upon others; and in the next, would not entirely have freed the river from pollution, on account of the tide, the effect of which is very similar to that of the Thames, at London.

The next plan for purifying the river was that of filtering

the sewage ; but this was also rejected, because it had been found impracticable to filter the water of the Clyde in sufficient quantities to supply the city, when that stream was made turbid by rains.

A short time before my visit some experimental works had been constructed near the Kelvin for the purpose of ascertaining the practicability of deodorizing the sewage. The first trials were made a few days before, and it was, of course, too soon to say much about results. But one patented process had been used, and seven others were to be tried. They had succeeded in making the sewage very clear and inodorous, but the deposit was very offensive, and valueless as a manure.

In Mr. CARRICK'S opinion the use of water closets was carried too far. He was in doubt as to what extent they should be allowed, but felt satisfied, after an experience of several years, that for the lowest class of houses (and probably for some others), a return to the use of ash-pits, properly constructed, would be wise, both on account of the value of the soil mixed with ashes, for manure, and the great consumption of water thereby saved—a consumption already alarmingly great in large cities.

There were fifteen public privies in Glasgow, made of cast iron, and so constructed that they could easily be emptied into carts daily, which is practiced, and their contents taken into the country. These are kept neatly painted, and are found to continue free from offensive odors, differing in this respect very much from the wooden ones which throw off very offensive gases after being used a few months.

The plying of steamboats on the Clyde, in the summer season, stirs up the foul deposit on its bottom, causing sickness to the passengers sometimes. This is considered a very serious inconvenience, as it is very desirable to have the steamers come as far up into the city as possible.

The tide rises about 7 feet at Glasgow. The outlets of the sewers are at half tide. Cellars in the lowest part of the city are liable to be flooded during heavy storms, especially

if they occur at very high tides. Had the city to be laid out anew, Mr. CARRICK would have the grades of the streets raised in the lowest parts, at least 6 feet above their present level, for the benefit of cellars and basements. He thinks it very important to keep up the grades of the streets of new towns and cities, when they are on low ground.

CARLISLE.

This city, which contains about 30,000 inhabitants, and is one of the oldest in Great Britain, is sufficiently elevated above the river Eden, to drain all parts of it efficiently at all times, except the lowest portions in high stages of the river. From Mr. RAWLINSON, Chief Engineer of the Sewerage, and from Mr. MCKIE, the local Surveyor, the following information was obtained:—

Tabular Statement concerning the Sewerage of Carlisle.

KIND OF SEWER.	Diameter.	Av. Depth.	Length.	Av. Cost.			Total Cost.		
			Yards.	£	s.	d.	£	s.	d.
Brick	3f9 x 2f6	10f1½	2,285	1	9	1½	3,326	19	10
do	3f4½ x 2f3	10f11	1,993½	1	4	8	2,455	6	8
do	3f x 2f	9f2	1,385⅔	1	1	6	1,491	16	2
do	2f3 x 1f6	10f1½	3,209		16	6	2,644		11
Earthenware Pipe	1f6	6f	646		9	7	310	2	4
do do	1f3	8f6	4,352		8	5½	1,842	6	4
do do	1f	8f1½	6,509		6	8	2,167	11	9
do do	9	6f	2,509		4	10	608	18	
do do	6	8f4½	168		3	10	32	4	
Cast Iron do	2f3	10f	297	3	1	3½	910	3	2
do do	1f6	6f4½	677	1	9		981	6	9
do do	1f	8f	48		18	2	43	10	9
			NUMBER.						
Man-holes			131	14	7	4	1,882	3	3
Lamp-holes			99	1	17	10	187	10	9
Flood Outlets			.....	..	..	...	445	16	9½
Flushing Valves			.....	..	..	...	341	14	6
Gullies			366	2	19	4	1,086	2	
Crossing Rivers, and Sundries			.....	..	..	...	747	3	7½
				TOTAL,			21,504	17	7

The inclinations of the sewers are as follows, viz.:

PIPES.

9 inch Pipes, from $\frac{1}{50}$ to $\frac{1}{200}$.
12 " " " $\frac{1}{50}$ " $\frac{1}{400}$.
15 " " " $\frac{1}{50}$ " $\frac{1}{408}$.
18 " " " $\frac{1}{50}$ " $\frac{1}{408}$.

2	feet	3	inch	by	1	foot	6	inch	Brick	Sewers,	$\frac{1}{50}$	to	$\frac{1}{400}$.
3	"		"		2	feet			"	"	$\frac{1}{50}$	"	$\frac{1}{400}$.
3	"	$4\frac{1}{2}$	"	"	2	"	3	"	"	"	$\frac{1}{200}$	"	$\frac{1}{508}$.
3	"	9	"	"	2	"	6	"	"	"	$\frac{1}{943}$	"	$\frac{1}{943}$.

The brick sewers 3 feet by 2 feet, and larger, were built 9 inches thick; those under that size, but $4\frac{1}{2}$ inches thick.

The iron sewers were intended to resist internal pressure during high stages of the river, and have stood severe tests since their completion.

The general character of the soil through which the excavations for the sewers were made, is locally termed "forced ground," or the accumulated rubbish and ruins of nearly twenty centuries. The main out-fall of the sewers is the river Eden below the city.

The city is supplied with water by a company, and arrangements were made for a sufficient quantity to flush out the sewers twice a week, at their summits. Advantage was also taken of the Caldew and Petterill, tributaries of the Eden, to obtain a copious supply for flushing the larger and lower lying sewers.

At the time of my visit, the works had been in operation about twenty months, and it had not been necessary, during all that time, to cleanse a single sewer by hand. Flushing alone proved sufficient to remove all deposits, and this was not necessary more than once a month. An examination by means of the lamp and man-holes a very short time before, showed that the only portion of the sewers likely to be obstructed by deposits, was entirely clear. Either a man-hole or a lamp-hole is placed at every change of direction or inclination in the sewers.

Surface water from the streets is received into double-trapped gullies, placed seldom more than 150 feet apart. These gullies are ordinarily emptied twice a week; but in some parts of the town, where night soil is unlawfully thrown into them, they are emptied once a day. The cast iron box

(see *Plate III*,) which contains the deposit, is easily lifted out when full, and emptied by a man of ordinary strength. Their cost, including grates and stone work, and labor of putting them in, is 36*s*. each; this does not include the necessary drain pipes leading from them to the main sewers. They have given such satisfaction in Carlisle, as to cause them to be adopted in North Shields, Chorley, in Lancashire, in South Shields, partially, and in other places not sewered under the direction of Mr. RAWLINSON.

Not more than one-fourth of the houses have water closets yet. It was intended, however, to introduce them, under the "Health Act," into every confined court or place, but not (compulsorily) into those which were open and well ventilated. For the lowest class of cottages, and for bodies of workmen, Mr. MCKIE recommended a cast iron tank, &c., like those adopted in Glasgow for public convenience. To some extent, these are already used.

The streets are paved with cobble stones, laid in rows at right angles with the direction of the street, and are kept in good order, and well scavenged. The weekly average cost of scavenging the city was, in 1856, £9 10*s*.; and for cartage, £4 more. The value of the manure, nearly £2 a week, should be deducted.

Mr. RAWLINSON furnished me with copies of reports on the drainage of this and other towns he has sewered; and with plans, herewith presented, of structures carried out under his direction.

It will be seen from the foregoing statements, that I am greatly indebted to the gentlemen whose names have already been mentioned. Their kindness much exceeded my expectations. The readiness with which they answered my questions, and aided me to procure information, was no doubt prompted by their desire to contribute towards the advancement of sanitary knowledge in our country.

Syndicus MOERCK and Senator BUSCH, of Hamburgh, and M. VATTEMARE, of Paris, also assisted me much, either by

their personal influence or labor. Mr. VATTEMARE left other engagements to go for and with me to the proper offices, especially to that of M. BELGRAND, Engineer in Chief of Sewers and Water Works, who furnished the information already given concerning Paris.

The foregoing account of what was learned in different cities and towns, is believed to be sufficiently full for the objects of this report. Volumes might easily be filled with interesting facts and descriptions of the sewerage of London alone. It is deemed best now to speak of different subjects connected with sewerage, without reference to particular places, except by way of illustration. The first in natural order and greatest in importance, is the

Disposal of Sewage.

At the foundation of all plans for the sewerage of cities and towns, what shall be done with the contents of the sewers, is felt to be the question, upon the answer to which depends in a great measure the plan to be carried out.

Previous to the introduction of sewers and drains, it was customary to remove all kinds of offal and filth, by means of carts or hand conveyances, either to the country or to some water course or other general depository. This was sometimes done by the occupants of the houses, who took it directly from their premises, or it was thrown by them into the streets and thence removed by the public authorities, sometimes not for days or weeks. To this latter practice was attributed the dreadful ravages of the plague and other diseases, during the middle ages and even the last century.

Until within about fifteen years, the practice was to discharge sewage into the nearest available stream or body of water, with but little doubt as to the propriety of such a course, certainly with no effectual remonstrances against it.

Even now this practice is well nigh universal, for the reason that all plans for avoiding it have involved very serious objections in the way of expense, and have amounted, in most cases, to depositing the nuisance at the doors of others. This is so, whether the sewage is conveyed by intercepting sewers to a point below the town, as proposed for London, and being carried out at Paris; or whether it is used in a liquid state to irrigate neighboring lands, as frequently proposed for all the large towns and cities of Great Britain, but not yet satisfactorily carried out for any.

Public sentiment in favor of sanitary reform has been so thoroughly aroused, that a problem so important as this will not be suffered to rest till a satisfactory solution is obtained. The feeling is becoming very general, that wherever practicable, sewage should not be allowed to pollute water courses of any kind, and the efforts to avoid it have resulted in presenting to the public three classes of projects, viz., the *intercepting*, the *irrigating* and the *deodorizing*.

There can be no doubt that intercepting sewers sufficiently large and long, will effectually keep out of the streams or harbor of a city its own sewage matter. The determination of the size and length of such sewers involves not only their inclination, the position of their outlets, and the amount of mechanical power, if any, required to raise their contents, but the cost, which so generally exercises a controlling influence over the adoption of any plan. The intercepting plan for London, as already mentioned, has been recommended by the most distinguished engineers in the world. Last year, the details, prepared with great labor, were referred to a new Commission, consisting mostly of government engineers, who have reported in favor of such alteration as would change its character very much, by substituting open canals for the principal portions of the main channels nearest the river, and increase the estimated cost from $15,000,000 to upwards of $25,000,000; but the advocates of the first plan believe the second not only very objectionable, wherein it differs from the other, but that it would prove much more expensive than the

estimate. It is to be feared that it will be some time before this project will be carried out, which is to be regretted by us as well as others; for the successful completion and satisfactory operation of it might induce most of our large cities to free their docks and water fronts from a great portion of the filth which now creates so great a nuisance.

The principal, if not the only, serious objection to intercepting sewers, aside from their first cost and subsequent maintenance, is that while they remove nuisances from large communities, they inflict them upon smaller ones. This, however, must depend entirely upon local circumstances.

With regard to irrigating schemes, they are numerous, and vary in their character from the primitive method adopted at Edinburgh, to the costly works proposed by some for pumping up into reservoirs, and distributing, by means of cast iron pipes and hose, all the sewage of a city as large even as London. These were very popular a few years ago, and have advocates still; but the more intelligent and practical have modified their opinions with regard to them, and no city, containing as many as 50,000 inhabitants, is yet known to convey the whole of its sewage through pipes, and distribute it through the surrounding country. Milan and Edinburgh are the only large cities that are known to make a profitable use of sewage to a considerable extent, and they do it with open canals and drains, and without pumping, except where the sewage water itself furnishes the power. Some experiments with the sewage of small towns, favorably situated, have given very satisfactory results, but they have not been deemed sufficient to justify the application of similar plans for large towns or cities, at least in the estimation of those who were responsible for appropriating the necessary means for carrying out such works.

The objections to irrigating schemes are:

The expense, especially when they require pumping engines, reservoirs and distributing pipes;

The nuisances they create, particularly on non-porous soils;

The inapplicability of liquid sewage, daily or weekly, to

most crops except grass, to any advantage; because it is impossible with its use to keep most soils in so friable a state as is desirable for several of the most important crops;

And the utter uselessness of liquid sewage in cold climates during winter, for irrigating purposes.

What has already been said concerning Leicester, shows that deodorizing may be successfully carried out, so as to produce the most satisfactory sanitary results; but as a remunerating or self-sustaining process, it has hitherto proved a failure. The manures obtained are too weak to bear transporting any considerable distance; for the most valuable fertilizing substances in the sewage water not being precipitated by the action of lime, are lost. The sanitary benefits obtained by this process, however, are very encouraging, and it is hoped that the time will soon come when it will be attended with no pecuniary loss. Already it is no doubt cheaper than intercepting plans would be for some places, that is, the interest on the greater cost of the latter, would more than equal the greater annual expense of maintaining the former.

In some places, it would probably be found advisable to combine two or all three of these methods of disposing of sewage together.

The difficulties that present themselves in the discussion of this question, show the importance of determining

What should be admitted into the Sewers.

It is believed that sewers were originally intended to convey surface water only, and resulted from the necessity of covering or arching over open ditches, which would naturally be first resorted to. Gradually the practice, at first unlawful, of admitting liquid refuse of houses and various substances from streets, was introduced in some cities and towns, till at last the General Board of Health of Great Britain recommended using them for the conveyance not only of all kinds of refuse and filth from houses, but as the cheapest mode of getting rid of the washings of streets, and thus saving much of the expense of scavenging. Such an exten-

sive use has never prevailed, however, nor is it now recommended by that Board, but the most recent experience shows that the surfaces of streets should be kept clean enough to permit nothing but water to be carried into the sewers, and that where this is not practicable, catch-basins, or trapped gullies, should prevent the heavy materials from road surfaces from entering the sewers, and retain them till they can be carted away.

The greatest actual innovation upon the original use of sewers is the immediate connection of water closets with them, and the consequent abandonment of privy vaults. This, however, has not become universal in any large city yet, though very general throughout Great Britain, for the upper and middling classes of houses ; but the experience of the last ten years has led many to doubt the propriety of its adoption in all cases. The character and habits of the population, the facilities for flushing the sewers, and the nature of the out-fall, in regard to becoming offensive, should be carefully considered. On the continent, water closets, according to the English fashion, appeared to be comparatively little used, except at Hamburgh ; the objection to them being the loss of so much valuable manure, and the fear of creating nuisances at the out-falls of the sewers.

It is very evident that no classification of substances, proper to admit into sewers, would be equally applicable to all cities. In some, the heaviest kinds of house refuse, and even street sweepings, might be admitted, without causing much trouble or expense ; but from many should be excluded everything that will not be suspended in or dissolved by water ; and where this is not practicable, it is necessary to provide means for flushing and cleansing. Melted grease is very objectionable, but this is an evil likely to cure itself without public intervention, because those who permit such a practice in their houses, very soon find that it is much cheaper to make hot pot-liquor pass through a small catch-basin filled with cold water, where the grease is retained, and can be removed occasionally with little trouble, than to be at

the expense, once or twice a year sometimes, of taking up parts of their drain pipes to remove an obstruction formed in them by the hardened grease. Sand, especially quicksand, should be carefully excluded, except where the velocity of current is very great, and even then sewers have been known to be obstructed by it, owing, probably, to a deficiency of water.

Form, Inclination and Materials used in the Construction of Sewers.

Hydraulics teaches, beyond all doubt, that the greatest velocity, and consequently scouring effect, of a stream of water, is produced when its cross section is that of a semi-circle, other things being equal. Hence the circular form which, for a given amount of material, is the strongest and most economical, is also the best for conveying water. However, there are several reasons for departing from the circular form, especially for sewers intermediate in size, between 1½ and 6 feet in diameter. The quantity of water flowing through them is not always the same, for it varies both with the weather, and with the hour of the day ; hence it is now very generally thought best to adopt such a form as makes the section of water in the ordinary greatest daily flow, semi-circular. It is desirable to be able to enter sewers for the purpose of examining, repairing or cleansing them, whenever practicable. It is also very desirable to have them sufficiently large to carry off storm waters. No form combines these desiderata so well as the egg-shape, with its point downward, hence its very general adoption both in Europe and this country. Mr. Francis, of Manchester, (see his letter to Mr. Ward, of London), has adopted the egg-shape, for even the smallest sizes of pipe sewers, in which, however, with but one or two exceptions, and they only slight in extent, he does not appear to be imitated by others.

The *sizes* necessary for sewers has been, and still is, a subject of more controversy than their forms. The great diversity of opinion is owing to different views with regard

to the provision necessary for receiving storm water, some thinking they should be but a few times as large as would be sufficient to carry off the greatest ordinary daily flow, and others considering it necessary that they should carry off, without being surcharged, all the water that may flow into them during the heaviest storms. Some would provide for ordinary storms, but not for extraordinary ones. It is very evident, that all cellars connected with surcharged sewers must be liable to flooding, unless carefully guarded by valves, and if they contain valuable goods, these are liable to be damaged, for valves may be neglected and get out of order. The per centage of rain fall flowing from a given district into the main channel that drains it, depends so much upon the season of the year, the geological and topographical features of the district, the character and extent of improvements, and the condition of the ground as to moisture or dryness previous to a rain fall, that it is exceedingly difficult to ascertain correctly this element so important in determining the sizes of sewers. The belief which some have, that all public sewers should be large enough for men to enter, and of others, that large sewers are great nuisances, together with the perplexities above mentioned, account for the great diversity of practice to be found in this respect, in different parts of the world; leading to the construction, in Paris for instance, of sewers 6½ feet high, to drain districts no more extensive than are sometimes, but not always satisfactorily, drained in English towns with 6 inch pipes.

The inclination of sewers is a necessary element, not only in determining their size, but their efficiency. Mr. WICKSTEED, who has been so successful in relieving Leicester of the nuisance it formerly suffered by the pollution of the Soar, would give to all sewers so much fall as would be necessary to make the greatest ordinary daily flow through them, sufficient to cleanse them, without any additional water to flush them, even if in order to obtain this fall, he should be obliged to pump up the sewage. Others would give them such fall as would cause them to be cleansed by every

ordinary storm; while others prefer to give such inclination as the ground will admit, and to pump water for occasional flushing if necessary, rather than pump up the whole of the sewage. Or if, owing to the lowness of the district, they are compelled to pump up the sewage at all, they raise it as little as possible, and depend upon occasional flushings to cleanse the sewers. This diversity of opinion is not confined to theorists merely, but exists among distinguished engineers, who have been successful in draining cities or towns. Both Mr. LINDLEY, of Hamburgh, and Mr. RAWLINSON, of London, told me they believed even level sewers could be kept clean by flushing, judging from their experience with those of very slight grades. Of course, they and all others prefer sewers with as much inclination as properly graded streets will allow, to very flat ones. Mr. WICKSTEED, who is opposed to any provision for flushing, in planning for new works, recommends the following as the least gradients for sewers of different sizes, viz.:

For	6	inch.	diameter,	a gradient	of	1 in	65,	producing a curreut of	240	feet per minute.
"	9	"	"	"		1 in	98,	" "	220	" "
"	12	"	"	"		1 in	175,	" "	190	" "
"	15	"	"	"		1 in	244,	" "	180	" "
"	18	"	"	"		1 in	294,	" "	180	" "
"	24	"	"	"		1 in	392,	" "	180	" "
"	30	"	"	"		1 in	490,	" "	180	" "
"	36	"	"	"		1 in	588,	" "	180	" "
"	42	"	"	"		1 in	686,	" "	180	" "
"	48	"	"	"		1 in	784,	" "	180	" "
"	54	"	"	"		1 in	882,	" "	180	" "

The recommendation is based upon the supposition that the sewers are to be circular, and filled half full by the greatest flow through them during the day from all sources except storm water.

The materials with which sewers should be constructed, must vary according to circumstances. Stone, brick, cast-iron and pottery ware, are all very suitable when of good quality. Concrete and wood are frequently used, but, except in first cost, are objectionable. In Paris and Edinburgh stone is generally preferred for the whole sewer; but in most cities bricks are used, on account of being much more economical,

and equally suitable when well made. For all sizes of sewers under fifteen inches in diameter, pottery ware pipes are preferred in most places, especially throughout Great Britain, when they are well made of durable material, and can be furnished and laid at less cost than brick. Radiated bricks for sewers of small diameters are frequently used. For the inverts of egg-shaped sewers, hollow pottery ware is often used, while the upper portions are made of brick. The mortars used are of various kinds, according to the requirements of the case or the judgment of the engineer. Some use hydraulic cement, some common lime, and some a mixture of the two, or hydraulic lime; while some lay the lower portions of the inverts in hydraulic cement, and the rest in common lime mortar. For making the joints of pipes tight, some use cement, some lime, and some clay, varying according to the nature of the soil and the judgment of those in charge of the work.

Many of the failures of pipe sewers, when the system was first tried, were attributed, and no doubt justly, to defective materials and workmanship employed in the manufacture of the pipes. This has been very much improved since, so that failures from this cause are very rare now. Pipes, like our red earthen ware, are not much used for sewers or house drains, a heavier and harder material being found necessary, what we call stone ware, being very generally employed.

Socket joints for pipes, for all sizes up to twelve inches in diameter, appear to be more generally preferred than any other; but great diversities of opinion have prevailed with regard to the best mode of making and securing the joints of pipes, and considerable diversity of practice still exists. For the larger sizes, butt joints or half sockets are used more than all others. Some advocate separate chairs and saddles.

Catch-Basins and Gullies.

Apertures through which surface water is led into the sewers, are placed much nearer together in the European cities than in those of America. In the former they are gen-

erally from 120 to 150 feet apart, while in this country they are seldom placed nearer together than the corners of the blocks, and are consequently often 400 feet or more apart. In portions of London, and in Hamburgh, surface water passes through grates into untrapped gullies, and thence into the sewers. In such cases the gullies act as ventilators to the sewers, besides letting into them all substances, however objectionable, that can pass through the grates. This annoyance led Mr. HAYWOOD, of London, to wish the gullies of that city were provided with catch-basins, while Mr. LINDLEY, of Hamburgh, though much annoyed at first by the practice of throwing improper substances down them, did not find any serious inconvenience from it. Throughout Great Britain, catch-basins, wherever used, are much smaller than those built in the cities of New York, Philadelphia and Boston. The principal reason for this, is the much greater quantity of dirt we allow to accumulate in the streets of our cities, than is permitted in the principal cities of the old world, at least in those already mentioned. (For plans of different kinds of catch-basins and gully-traps, see *Plates II and III.*)

Ventilation.

The best mode of ventilating sewers has been, and still is, a matter of some doubt, which naturally results in diversity of practice. In London and Hamburgh, the main sewers are ventilated through air shafts and gratings over them in the streets, and in some cases are connected with the rain water spouts from houses; but it is necessary to trap these, when they might otherwise conduct foul air to the windows of sleeping rooms, in which case they cease to act as ventilators. Some are very much opposed to air shafts communicating directly with the streets; and, besides taking advantage of rain-water spouts wherever they can, they seek to make connections with the tall chimneys of furnaces, chemical or other kind of works. Connections with furnaces, however, should be made with great care, as the gases of sewers sometimes explode.

The cleaner sewers are kept, the less need there is of ventilating them; but it has been found utterly impossible in practice thus far, to prevent entirely the generation of foul gases in them, no matter what their mode of construction may be.

House Drains.

However perfect a system of sewerage may be, if house drainage is not properly carried out, it must fail to produce the beneficial effects promised by its projectors. It is a very common thing to find houses, whose owners have been assessed for public sewers in front of them, but which nevertheless remain without proper drains, because of the expense of putting them in.

Circular pipes are now almost universally admitted to be the best for house drains. In England, the prevailing sizes are 4 and 6 inches, although formerly 3 inches, and even less, was advocated as sufficient by some, while others contended for house drains as large as 12 inches, and such were often built with flat bottoms and straight sides.

Unless main sewers have abundant fall, it is very important to make the connections of the house-drains with them curved, so that the current in the main sewer will be accelerated, instead of retarded, by the discharges through the house drains, as would be the case if the connections were made square. Because this has not been necessary in many cases, some have questioned its utility; but with one who has carefully studied the subject, no arguments are needed to convince him that all angles or bends, that would produce eddies, should be avoided in artificial water-courses. A striking illustration of the importance of applying this to sewers has been communicated to me by Mr. Craven, the Chief Engineer of the Croton Aqueduct Board. One of the New York sewers was complained of as being inefficient, and a petition was made to have a larger one built in the place of it. The Engineer was satisfied that the sewer was large enough and had sufficient inclination; but knowing that the connections of the

lateral drains with the sewer were square, he had them changed to curved ones, after which all complaints with regard to the inefficiency of the sewer ceased.

All changes of directions in house drains, as well as in sewers, should be made with curved pipes, and branches from them should follow the same rule as branches from main sewers, that is, care should be taken to avoid eddies, and the consequent formation of obstructions.

To avoid the free introduction of offensive and often deleterious gases into houses, it is necessary to trap the drains leading from them. The simplest, most economical, and generally the best mode, is by means of a bent pipe, forming what is usually called the syphon-trap, and sinking below the general level of the drain, so that when filled with water, the passage of air is entirely obstructed, except as it may be absorbed on one side and given out again on the other.

Melted grease, sand, and all heavy substances should be carefully excluded from house drains, and when this cannot be done by means of strainers, small catch-pits should be provided, as it is much less troublesome and expensive to keep them clean than to be obliged occasionally to open the drain to remove obstructions.

Cellars.

The great value and convenience of sufficiently deep, dry and well ventilated cellars, especially in cities, has led to many attempts to obtain them, even in unfavorable situations. Where the sub-soil is naturally dry for a sufficient depth, as in Paris, or where it is porous and elevated enough to be thoroughly drained to the proper depth, it is very easy to obtain good cellars, but they often prove very troublesome and expensive where these requisites do not exist, and are generally unfit for the storage of all kinds of property liable to be injured by dampness, and of course, are very unsuitable for families to live in.

As before stated, under the head of Paris, the cellars of that city are not connected with the public sewers at all,

because they would be liable to flooding if they were. Mr. Haywood's opinion against allowing them to be made in the lowest parts of London has already been given. (See p. 21.) Mr. Rawlinson, in his report on the completion of the sewers of Carlisle, says, (page 14): "The Board must not be responsible for cellar-flooding in these low districts, and all parties so situated ought to have notice, that any connection made by them with the sewers, will be at their proper risk." Besides carrying out this suggestion with regard to old cellars, the digging of new ones in the low district is forbidden by law.

The Legislature of South Carolina passed a law, Dec. 21, 1839, which was recently in force, and, no doubt, is yet, prohibiting the digging or constructing of any cellar or subterranean excavation, except for wells, cisterns, ice houses, privies or drains, in any city, town or village, within twenty miles of the ocean, under a penalty of not less than $500 nor more than $1,000, for each offence. The same law empowers the municipal authorities of such cities, towns or villages, to fill up any cellar afterwards dug, at the expense of the offending parties.

Double System of Sewers.

The expediency of having two sets of sewers, one for surface or rain water, and the other for house drainage, has been much discussed. As already mentioned in a previous report of mine to you, the article on Drainage, in the Encyclopædia Brittanica, contains the statement that no city could be perfectly drained without the two sets. The advocates of such a system appear to have diminished in number, and the general opinion now appears to be that it would be exceedingly difficult to carry it out; and that besides its great expense, it would not result in freeing the sewers intended for surface water from the introduction of substances that render them offensive, especially during protracted dry and warm weather. No city or town that I am aware of, has carried out such a system, as yet, and there is consequently no evidence that it would give any more satisfaction in its actual working, than

the present sewers, for taking off all that can be drained in a single set. At Croydon there is something like a double set, the old sewers being used for street surface drainage; but the rain water from houses and yards does not appear to enter them. The old sewers were complained of as being very foul during the epidemic of 1852.

Sub-Ways.

To avoid the frequent opening of streets for sewers, water and gas pipes, it has been proposed to build large subterranean ways, which might also be used for the transportation of various articles or substances, and thus relieve the streets themselves to some extent. The great expense, and practical difficulties that are presented when such a work is considered, have prevented sub-ways from being actually constructed, at least systematically, in any city as yet. The largest class of sewers in Paris may be considered as sub-ways; but they do not, for reasons already mentioned, admit gas pipes into them; besides, it is so short a time since they commenced the construction of this class, that the expected advantages to be derived from them, have not yet been so clearly demonstrated by actual results, as to induce other cities to adopt them. It will probably be many years before this can be a matter of practical importance to Chicago.

Flushing Sewers.

This term is technically applied to the cleansing of sewers by means of water dammed up behind gates, which, being suddenly opened, allow the water to flow with a velocity of more than three feet per second, carrying along not only light substances, but, in some cases, bricks and stones. The less the inclination of a sewer, the nearer together will it be necessary to place the flushing gates. For plans of the kind used in London and Hamburgh, see *Plate II.*

Temporary wooden dams, however, may be made to answer the same purpose, and, unless required for use very often, may, even in the long run, be quite as economical. Some engineers object to flushing, altogether, and say that the

sewers should have such inclinations and forms as to render it unnecessary; but, after all, water must be depended upon for keeping the sewers clean; and it is a singular, though by no means unaccountable fact, that, even in Leicester, which was sewered under the direction of Mr. WICKSTEED, who is opposed to plans that require flushing, two or three of the sewers having the greatest inclination required cleansing at their upper ends, because the ordinary flow through them was not sufficient. The same could be said of sewers with steep inclination, near their summits, in many other towns.

The views of Mr. LINDLEY, of Hamburgh, and Mr. RAWLINSON, of London, in relation to the sufficiency of flushing for perfectly level sewers, have been recently confirmed by some works at Charleston, S. C. In the new system of sewerage lately commenced for that city, which is very flat and slightly elevated above tide, they have adopted perfectly level sewers, with bottoms 20 inches above tide. They have a line $2\frac{5}{8}$ miles long, and 3 ft. 6 in. wide, by 4 ft. 6 in. high, with brick sides and semi-circular top arch, and plank bottom, already completed, with an outlet at each end, one of which, however, is used as an inlet. Each end is provided with a gate, opened or closed at will. "The Committee on Health and Drainage report to Council," September 1, 1857, among other things, that

"It is true, that the force of the current is strongest at the mouth of the drain, where the flow commences, and that it diminishes in velocity as you recede, being always proportionate to its depth; nevertheless, there is power enough in it at all parts of its course to produce all the washing and scouring effect that is needed for removing sand, mud, and even brickbats of as large size as are likely to find their way in. Of this there has been ample demonstration, *and the Committee confidently announce to Council, that the calculations made in reference to this point have been more than realized.* The drains are now rapidly clearing themselves, not only of such matters as are to form the mass of the accumulation necessarily gathering in sewers, but of the bars made by the workmen during the process of construction, and

left by them; which bars are composed of brickbats, sand and clay, and which were built purposely to resist the water, and keep it from them while at work. Under the washing process, or flushing, these bars crumble and melt, leaving nothing behind but the solid material, and even the brickbats are found rolling out with the torrent at the mouth of the drain."*

According to the tide tables, published in the Coast Survey Report for 1856, mean high water must be 3 ft. 8 in. above the level of the sewers, and spring tides must rise one foot higher. It was found, after repeated observations made during spring tides, that the whole line of sewer could be filled from *one* end in just two hours, and emptied in the same length of time.

If some substances, especially detritus of stone pavements, building materials, and certain kinds of sand, are allowed to harden or pack closely in sewers, flushing will do but little or nothing towards removing them. Parent DUCHATELET, in his Hygiene Publique, said much, upwards of twenty years ago, in favor of flushing, both on sanitary and economical grounds; but came to the conclusion, from what he saw of the Paris sewers, that flushing alone would not cleanse them; and to this day a considerable force is employed in removing, by hand, solid substances from them. The same is true with regard to many of the London sewers.

An abundant supply of water is essential for the main-

* Dr. WM. T. WRAGG, Chairman of the Committee, in a letter received since this report went to press, says: "Our drains work well, and are gradually commending themselves to the favorable consideration of those who were at first opposed to them. There now seems to be no doubt that the plan we have been inaugurating will become generally employed, not only in the district for which it was devised, but for the old parts of the city. In this (old) part, the drains now in existence are laid down without any plan, and are not only on different levels, and so quite unfit for passing water from one to the other, but many of the individual drains themselves are on undulating planes, and so incapable of venting their own water. These errors of construction have long been apparent, but no plan of remedying the evil has been devised. There now seems to be a growing disposition to commence a gradual system of substitution of the new for the old, by removing, from time to time, portions of the most important of them, and rebuilding them. The washing of the tide through the new drains has proved so conducive to cleanliness, and so convenient as a supply of water for fires, that public opinion is settling down in favor of them." This extract is from a private letter, and is published without the knowledge of the writer, because there is not time for further correspondence.

tenance of sewers in a healthy, as well as a clean, state. Wherever natural reservoirs or streams can be made to supply water for flushing sewers, they are generally used; and where these do not exist, water-works are considered indispensable.

The Romans appear to have understood this subject upwards of 2,000 years ago, quite as well as the moderns do. They used the water of their aqueducts, not only for flushing out substances from the sewers, but for purifying the air in them; for they learned, by sad experience, that the neglect of this was followed by outbreaks of malignant fevers. They, too, like the moderns, found it necessary to remove substances from the sewers by hand occasionally, notwithstanding the free use they made of water.

Cost of Sewers.

So much depends upon local circumstances, that it is almost impossible to make a fair comparison of the cost of sewers in different cities and towns; or even in the same city, but built in different years. The prices of labor and materials, and the extra expense caused by heavy rains, vary so much, that the actual cost of work one year, compared with that of another, affords no just criterion of the relative degrees of care and economy exercised. In Europe, materials of all kinds, for building sewers, and the requisite labor, are much cheaper than with us; but, in their larger cities, owing to expensive pavements, and the necessary removal of gas and water pipes, and the great precautions requisite in their narrow streets to avoid disturbing the foundations of buildings, their sewers often cost more than ours of the same size. In the smaller cities and towns of England, however, in Carlisle, for instance (see page 51), they generally cost much less than with us. The cost of the Paris sewers, as furnished by M. BELGRAND, will be found, in detail, on page 38. The following statements relative to the cost of Liverpool sewers, will show how impracticable it is to establish a scale of prices for different sizes of sewers, even in the same city.

Average Cost of Liverpool Sewers, constructed during the following periods.

Class or Number.	Size of Sewer.	1847,'48, '49, '50.	1851.	1852.	1853.	1854.	1855.
	Ft. In. Ft. In.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	6 0 by 4 0	2 8 9	1 19 4	.....	3 2 4	.....	2 12 7
2	4 6 " 3 0	1 17 5½	.....	.....	1 19 11	1 11 6	.... ..
3	3 6 " 2 3	1 12 4½	1 6 1	1 1 3	1 6 5	1 3 1	1 9 4
4	3 0 " 1 10	1 3 7	16 8	14 11	19 7	1 0 3	19 6
5	2 9* " 1 6	1 1 2	15 1	15 3	16 3	18 10	19 7
6	0 15 pipe	14†	.....	.....	.....	.....	... ...
7	0 12 "	15 9½	12 8	8 4½	10	.....	17 5
8	0 9 "	.....	7 6	6 1½	9 8	7 8	10 7

The depth of the Liverpool sewers below the surface, and the character of the soil, vary very much in different localities; but these are not the only items that prevent a uniform scale of prices from being established. The cost of inspection, watching, and altering gas and water pipes, alone, for six sewers, laid in 1854, was 23 per cent. of the total cost.

Effect of Sewerage upon the Health of Towns and Cities.

Very much has been said and written upon this subject, and a vast amount of valuable and interesting information has been obtained, as will be seen by referring to the printed documents of the General Board of Health of Great Britain, procured by their Secretary, Mr. TAYLOR, for the Commissioners. The same gentleman also furnished information, in writing, relative to the nature and effects of sanitary improvements in the following towns, viz.: Banbury, Coventry, Croydon, Darlington, Derby, Dover, Dudley, Durham, Epsom, Leicester, Little Hampton, Macclesfield, Newark, Newport, Ormskirk, Otley, St. Mary, Penzance, Rugby, Swanzea, Tottenham, Tunstall and Wanstead. The reports from Darlington, Macclesfield and Penzance are copied below, for the purpose of showing not only the beneficial effects of their

* In 1855, this dimension appears to have been changed to 2 ft. 3 in.

† The apparent anomaly of No. 6 costing less than No. 7, this year, was owing to the small extent of No. 6 constructed, not affording a proper average.

operations, but how much more extensive the jurisdiction of the General and Local Boards of Health of Great Britain is, than that of similar bodies in this country, especially than that of Sewerage Commissioners. These reports will also show that much of the improved health of towns which have carried out sanitary reforms, is owing to causes that could scarcely have been set in operation by sewerage simply.

Darlington.

"Mr. PIPER, Medical Officer of Health, reports that the public and private works of drainage and water supply, and other sanitary improvements in this district were begun in 1852, and completed in 1855.

"In the former year, the few sewers and drains which then existed were, generally, worse than useless. There was no water supply, except from pumps, at far distant intervals; the paving was wretched, and two of the streets (Brunswick and Green streets) were like ploughed fields; here, as elsewhere, open ditches of stagnant mud, flanked whole rows of houses; uncovered ash-pits, dung-hills, and filthy pig-sties abounded; the oozings of slaughter houses, and stables, flowed unheeded over the pavement, and the river was the receptacle of every abomination. Princess Square had been for years the seat of endemic and epidemic diseases, and the place, and the people, exhibited the most abject and degraded appearance, when, in 1852, it was drained, cleansed, and supplied with water. Since that time endemic diseases have entirely disappeared, and, moreover, the inhabitants have become much more cleanly and orderly.

"Previous to the completion of the works, *typhus* was always present. In the year 1848 there were ten deaths in Darlington from typhus; in 1849, 18; in 1850, 8, and in 1851, 21. Sanitary reform commenced in 1852, in which year there were 7 deaths from that disease; in the following year, 6; in 1854, 5; and last year but 2. Thus proving that as sanitary works advance, in the like ratio do epidemic and endemic diseases retreat.

" As an example of the change effected in the low lying district of the Skeine, the death rate has fallen from 68 to 23 per 1,000."

Macclesfield.

Extracts from the report of the Local Board of Health and Improvement Committee, of their fourth year's proceedings.

The report states that since the powers of the Board in prescribing regulations for the *erection of new houses* were first exercised, " the necessity of providing better domestic accommodations for the poor has been very generally urged as one of the social requirements of the times;" and the Committee " have devoted much attention to this duty, having already exercised their powers in this respect upon 1,489 houses. As evidences of the value of a well appointed cottage, combining the essentials for health and domestic comfort, the Board need only point out the 287 new houses which have been built acording to the regulations. This year 31 plans have been approved of, comprising 56 houses and buildings, including 2 factories and a chapel."

" As to *Lodging Houses*, the Committee remind the Council of the difference between a four years' reign of cleanliness, limited numbers, with a division of sexes, and that state of things in existence previously, which degraded human nature and shocked every sense of virtue and propriety. The Police records and Medical reports bear similar testimony to their comparative freedom from crime and disease. No idea can be formed of the blessings of such a change, and the Board sincerely believe that if all their labors, and all their expenditures had been concentrated and devoted to the accomplishment of this single duty, the results in this short period would have richly compensated for all."

* * * * * " There are now 30 registered *Slaughter Houses* in this borough, and although they are principally surrounded by dwellings, and were formerly the subject of so much complaint by neighbours, not a single complaint has been made during the year."

* * * * * "Besides their experience of *the benefits of drainage* which are reduced to a certainty, and daily attested by plain facts and figures, they have the testimony of a resident medical gentleman to this particular case, who stated in a public lecture in February last, that 'the evils of stagnant water, and the good results of drainage were very evident from the admirable sanitary arrangements in the borough of Macclesfield; as an example he would say, that Nixon's yard, Water street, and that neighbourhood, which used to be so unhealthy, have now scarcely ever a fever in them. Yet Bond street, which stands higher, with a quicker fall, is seldom free from a low type of fever, arising, he felt convinced, from the want of drainage; because water on, or a little below, the surface in a stagnant condition, produces exhalation, and that again a low degree of temperature, with other evils resulting in sickness.'

"In four years, 43 streets and 247 courts have been sewered, paved and flagged; every privy and ash-pit belonging to them, numbering 290, have been drained, repaired or rebuilt, and new ones have been erected where none existed before; 1,489 houses have been drained. In the execution of these works the Board have expended £15,416; and when it is stated that in the same period nearly £36,000 has been the entire expenditure, and that the efforts of the Board, and the means at their command, have uniformly been first directed where they could be best applied for the removal of the most pernicious evils, and principally amongst that class of persons whose condition, habits of life, and tone of morals were the most miserably wretched, the Council cannot fail to contemplate the great sanitary change that has been accomplished, and the vast amount of sickness, suffering and human degradation that has been thus prevented.

"To make these observations the more obvious, and in accordance with former practice, the Board must refer to their *Tables of Mortality*, and causes and ages of death, brought down to the present period. These tables show the rate of mortality before the operations of the Board, to have been 33

deaths in a thousand, whilst the average of the last three years has been reduced to 26 in a thousand. So with the average age at death of all persons, which was formerly 24 years, is now 29 years.

"And a freedom from the former excess of preventable deaths is shown in the registered 'causes of deaths,' and singularly confirmed by the nearly uniform numbers dying in the last three years, namely,

In 1854, 775; In 1855, 797; In 1856, 774;

In all previous years there appeared to have been no such uniformity, because, no doubt, those influences were in existence which rendered life more precarious, contagion more certain, and epidemics more frequent and malignant.

"Throughout England the mortality of children under 5 years of age is 39 per cent. of all the deaths; in Macclesfield it is 40 per cent., and the reductions have successively been from 11 to 13 per cent.

"To sum up the benefits, therefore, it will appear that 812 lives have been saved, the proportionate number of cases of sickness to each death have been prevented, and the consequent expense avoided, the mean duration of life has been lengthened 5 years, and infantile mortality, one of the certain tests of the absence or otherwise of sanitary improvement, has been reduced 13 per cent.

"These results are the daily observation of the Medical man, the Clergy and Ministers of religion, and other dispensers of charity and relief, but it is only through the medium of this report that their extent and value can be made palpably evident to the public, so as to command that attention and general coöperation which would not only treble these physical benefits, but would also strengthen the defences against vice, intemperance and crime. And that sanitary measures are a defence against the latter, is clearly shown in a former report which exhibits a decrease in magisterial convictions of 50 per cent. in streets popular on the Police records, after the usual constructive improvements have been perfected and cleanliness secured. In the old haunts of fever, Wood street,

George street and Nixon's yard, not a single fatal case has occurred."

The remainder of the Macclesfield report relates to the management of the public park, and to the bowling and cricket games practiced upon it.

Penzance.

The return made by Mr. E. H. RODD, the Town Clerk, states that

"The works under the Public Health Act were commenced in 1851; the water supply in that year; and house draining in 1854; concurrently with which, water closets were supplied to each house, and the court yards thoroughly paved and levelled. During the five years ending with 1856, the number of deaths were:

1852,	1853,	1854,	1855,	1856,
218.	240.	210.	176.	152.

"These figures are remarkable, as shewing the very healthy state of the town during the last two years."

"Again, if we look at the district in which the drainage works were *first* commenced, and where efficient drainage has been in full operation for about two years, we find that the mortality has steadily diminished. Thus in 1852, the deaths were 31; in 1853, 33; in 1854, 25; in 1855, 21; and in 1856, 16.

"Mr. BOASE, Union Medical Officer of the town, speaks also of the manifest improvement in the sanitary condition of the district."

"It may not, therefore, be too much to assume that the healthful influences of an ample supply of water, and efficient drainage have already been felt, and will continue to be more manifest as the works advance."

So much is due to local circumstances, natural, industrial and social, in deciding upon the effects of sanitary measures, that it is very unsafe to rely upon comparisons between towns or cities of equal population, and similar in many respects,

the one being sewered and the other not. It might be supposed, however, that a comparison of the bills of sickness and mortality of a city, before it is sewered, with those of the same city after it is sewered, ought to show the effect of sewerage on public health; and there can be no doubt that it ought, if everything else remained the same. Here is the difficulty, however. No two seasons are alike, either in changes of temperature, or amount and distribution of rain and consequent moisture; yet these affect public health more than the absence or presence of sanitary works. Observations, sufficient to form the basis of a reliable statement of definite numerical results, must extend over a longer series of years than we have yet had for any important city.

In this connection it is believed the following tabular statement will prove interesting:

Year.	NUMBER OF DEATHS PER 100 IN THE POPULATION OF																	
	England.	London.	Liverpool.	Leicester.	France.	Paris.	Prussia.	Berlin.	Hamburgh.	Massachusetts.	Boston.	New York City.	Philadelphia.	Baltimore.	Charleston.	New Orleans.	St. Louis.	Chicago.
1830	....	....	.....	....	....	....	3.01	3.22	3.97	....	1.66	2.56	....	....	....	4.06	.....	....
1	....	....	.....	....	....	....	3.55	3.83	4.23	....	2.08	2.80	2.64	....	....	3.61	.....	....
2	....	....	.....	....	....	....	3.21	3.15	4.70	....	2.45	4.43	3.16	....	....	14.70	.....	....
3	....	....	.....	....	....	....	3.13	3.22	3.43	....	1.91	2.23	2.20	....	....	8.62	.....	....
4	....	....	.....	....	....	....	3.14	3.46	3.58	....	1.91	3.48	2.46	....	....	6.11	.....	....
5	....	....	.....	....	....	....	2.79	2.77	3.07	....	2.31	2.95	2.67	....	....	6.15	.....	....
6	....	....	.....	....	....	....	3.68	2.79	2.96	....	2.07	2.79	2.18	2.33	....	4.17	.....	....
7	....	....	.....	....	....	....	3.11	3 90	3.79	....	2.16	2.92	2.28	2.64	....	7.04	.....	....
8	....	....	3.22	....	....	....	2.75	3.00	3.66	....	2.21	2.59	2.10	2.53	....	3.68	.....	....
9	....	....	3.52	....	....	....	2.98	2.91	3.32	....	2.23	2.44	2.08	2.26	....	5.35	.....	....
1840	....	....	3.90	....	....	....	2.80	2.82	3.27	....	2.16	2.52	1.78	1.99	....	3.91	.....	....
1	2.16	2.40	3.39	....	2.35	....	2.75	2.64	3.51	....	1.96	2.63	2.00	2.14	....	5.72	3.20	....
2	2.17	2 35	3.24	....	2.43	....	2.84	2.75	3.72	....	2.33	2.52	1.93	2.31	....	4.15	2.12	....
3	2.12	2.47	.....	....	2 34	....	2.87	2.52	3.37	....	1.95	2.30	1.70	2.08	....	4.82	3.05	....
4	2.16	2.50	.....	....	2.22	....	2.57	2.56	3.27	....	1.89	2.25	1.63	2.28	....	5.33	3.67	....
5	2.09	2.32	.....	....	2.15	....	2.72	2 54	3.24	....	2.04	2.19	1.76	2.38	....	3.34	3.54	....
6	2.31	2.33	.....	....	2.35	....	2.94	2.41	3.37	1.58	2.59	2.61	1.70	2.35	2.09	4.13	3.80	2.30
7	2.47	2.69	7.16	....	2.41	....	3.16	2.16	3.48	1.80	3.10	3.46	1.89	2.58	1.82	8.31	4.62	2.88
8	2 31	2.58	3.79	....	2.37	....	3.34	2.92	4.32	1.70	2.84	3.25	1.92	2.76	2.32	6.95	3.86	2.60
9	2.51	3.01	5.22	2.88	2.76	....	3.05	3.33	3.42	2.19	3.79	4.64	2.28	2.84	2.75	8.05	10.62	5.30
1850	2.08	2.10	2 96	2.37	2.17	....	2.75	2 62	3.17	1 67	2.64	3.07	1.96	2.74	2.85	6.03	5.04	4.66
1	2.20	2.34	3.31*	2.54	2.28	2.62	2.64	2.41	2.83	1.90	2.68	4.10	1.91	2.57	2.25	5 25	4.39	....
2	2.24	2.26	.....	2.88	2.26	2.63	3.29	2.60	3.20	1.82	2.52	3.86	2.47	2.30	3.59	5.88	4.44	....
3	2.29	2.43	3.18	2.68	2.21	3.14	3.05	2.87	....	1.94	2.80	3.91	1.84	2.70	2.39	10.24	3.32	2.00
4	2.35	2.93	3.94	2.48	....	3.88	2.91	2.45	....	1.99	2.82	4.74	2.13	2.87	4.27	6.57	5.35	5.26
5	2.27	...	.....	2.32	....	3.42	....	....	....	1.90	2.51	3.69	1.77	2.66	2.18	.....	.....	2.50
6	2.05	....	2.99	2.16	....	....	....	....	....	1.85	2.54	....	2.05	2.67	2.86	.....	.....	2.50
7	....	....	.....	....	....	....	....	....	....	....	....	....	1.77	2.34	2.36	....	....	2.50

* From Registrar General's Report.

☞ The ratios for Chicago in 1853, 4, 5, 6 and 7, have been estimated approximately by Dr. N. S. Davis.

It is to be regretted that the foregoing table could not embrace more of the results that have actually been obtained by statistical inquiries; but incomplete as it is, much more labor has been expended in its preparation, and much more trouble has been given to persons in other cities, than was at first thought necessary. Had the formation of this table been thought of earlier, far more extensive information might have been obtained in Europe. Unfortunately, statistics of this kind, if they exist to any extent in the public libraries of this country, are very difficult to find.

The rates of mortality of all England and of London, are taken from reports of the Registrar General; and those of Liverpool and Leicester, from reports of the Health Officers of those cities. Those of France and Paris, are obtained from the Annuaries published by the Bureau of Longitudes, for 1853, 4, 5, 6 and 7, by dividing the reported number of deaths by the number of inhabitants, which of course must be estimated for the years occurring between the censuses; those of Prussia and Berlin, from Reports of the Statistical Bureau, in Berlin; those of Hamburgh, from statistical tables relative to the condition of that city from 1816 to 1852; and those of Massachusetts, New York and Boston, from their official Annual Reports of Marriages, Births and Deaths. Those of Philadelphia, Baltimore, Charleston, New Orleans, St. Louis and Chicago, from the most authentic sources that could be reached. There is much doubt, however, with regard to the accuracy of the rates of mortality for most American cities, on account of the rapidity and irregularity of their growth, and the consequent difficulty of knowing their population, between the times of taking the census. For instance, two rates of mortality for Baltimore have been found in medical journals, differing from each other considerably; and an attempt on my part to deduce the rate from official reports of deaths and estimated population, between the censuses and since 1850, the date of the last census, has only resulted in something different from the other two.

The most healthy region of country embraced in the table

is Massachusetts, England next, France next, and Prussia last. The most healthy European city, apparently, is London ; but as the mortality of Berlin given in the table, includes the still-born, and that of London most probably does not, the difference between the two cities is only apparent. According to the Hamburgh statistical tables, which, though not having any mark of official sanction, appear to have been derived from authentic sources, the average mortality of Berlin, leaving out the still-born, for the ten years ending with 1852, is a very small fraction less than that of London. London, Paris, Liverpool, Hamburgh, New York and Boston, are all built mostly on elevated ground, all however having some low and flat portions; all are comparatively well sewered; but are more unhealthy than the countries or states in which they are situated. Berlin, on the other hand, is entirely flat, elevated at most but a few feet above the river Spree, has a wet sub-soil, and is very deficient in thorough drainage, and yet this city appears to have as small a rate of mortality as London, and a decidedly less one than the whole of Prussia.

Of the American cities, Philadelphia appears to be the most healthy. This city, though much more elevated above the level of tide than Chicago is above the lake, is very nearly as flat. It has had sewers for a long time, but according to Mr. KNEASS, Chief Engineer and Surveyor of the City, nothing like a system has ever been followed. Large sewers sometimes discharge their contents into smaller ones, and occasionally others have either slopes or steps up when they should be down ; and yet with all this imperfection, Philadelphia, according to official statistics, is the healthiest large city in our country. If this is really so, may it not be owing to her having so many wide and straight streets, which afford such perfect ventilation, resembling in this respect Berlin. Chicago, no doubt, has much that is favorable to health in its wide and straight streets.

The next generally most healthy of the American cities, according to the table, is Charleston, S. C. It is as flat, and but little, if any, more elevated above tide, than Chicago is

above the Lake. It has had sewers for a long time, but they are said to be laid without order or system, even more so than those of Philadelphia.*

Baltimore appears to stand about as well as Charleston, with regard to health; but it has no public sewers at all, connected with house drainage, and only a very few to relieve particular streets of storm water. Its site is elevated and undulating.

The experience of Boston is peculiar. It has been, and probably is still, the best drained city in our country. Its site is partly elevated, affording ample declivity for the sewers, and partly very flat, being scarcely above high tide. According to the table, Boston was the most healthy of the American cities to the end of 1837; it then fell behind Philadelphia; and after 1845, not only Philadelphia, but Baltimore and Charleston surpassed it. As constant improvements were made during this time, calculated to promote its healthfulness, the change can only be accounted for by the fact that the foreign population—too often a most improvident one—increased very greatly.

In order to ascertain, with as much precision as possible, the effect of neglecting or of carrying out sanitary measures, the English have taken great pains to separate the deaths caused by zymotic (or what is supposed to be preventable, such as endemic, epidemic and contagious) diseases, from all others; and in this way they show a marked improvement during the last few years, in some towns, especially Liverpool and Leicester. In the former, much is attributed to prohibiting the use of damp and unventilated cellars for habitations, besides other sanitary measures; and in the latter, to the draining of low and wet grounds by the new sewers. The high rate of mortality in Liverpool has excited much observation, and has been clearly traced to dwelling in cellars, over-crowding, bad ventilation, and the usual want of cleanliness accompanying such a state of things; but the operation of the Health Act has done much towards removing or abating these causes of disease.

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* See extract from letter of Dr. W. T. Wragg, foot of page 69.

Cholera.

To the dreadful ravages of this disease, are we indebted for the awakened interest now so widely felt, especially by the inhabitants of large cities, in all matters connected with sanitary reform. The spread of Cholera in its first attacks, seemed to be so generally connected with the neglect of proper drainage, scavenging of streets, and cleansing of houses, privies, &c., that due attention to these, it was supposed, would prevent its future ravages, as well as the prevalence of typhus and other fevers, found so often in neglected localities. Many reports, and a very large amount of information on the subject, have been printed and circulated. Nothing probably on the cholera can be found so complete as the Report of the Royal College of Physicians, London, 1854, a copy of which the Board now have. It is believed the following extracts from it will be interesting. (See pp. 224 to 228.)

"The ultimate object of an inquiry into the subjects treated of in this report is, of course, the discovery of the means by which the onward progress of cholera may be stayed, its increase and diffusion moderated, and individuals protected from its attacks. The partial attainment of this object is all that at present can be hoped for, but the principles by which endeavours to attain it thus partially should be guided, are for the most part free from doubt.

"From among the great features of a cholera epidemic, three stand forth as of paramount importance: one, the undoubted influence of locality and of the sanitary condition of towns and dwellings, on the degree of severity with which the epidemic visits them; a second, the equally certain influence of season and temperature, together with some unknown condition of the atmosphere on the general prevalence, and rate of extension of the epidemic; and a third, the share taken by human intercourse in determining not only the progress of the epidemic, and the direction of its advance across a continent, but also its extension from continent to continent, and most probably its communication from one

town to another in the same country, and from one locality to another in the same town."

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"But it is also true that the power of the disease through a town is increased in proportion to the degree in which the conditions of insalubrity referred to are present in various parts of it; and not merely the poor, who live in the spots where moisture and foul air feed the cause of the disease, but all the inhabitants, are exposed by the existence of these evils to a greater risk of becoming its victims. And further, it is certain that the more intensely the epidemic prevails in a large town, the more does the whole district for miles around suffer, and the more danger is there of its being propagated to other districts. By improving the drainage of low parts of the town, opening close courts, thinning the buildings in the more crowded parts, putting a stop to the burial of the dead in large cities, keeping even the smallest streets constantly free from filth, covering drains and sewers, and abolishing cess-pools, and other sources of foulness in the air and soil; by improving the dwellings of the poor in respect of ventilation, giving them the means of maintaining a due warmth in their rooms without excluding the external air, promoting the general substitution of good water-closets for open privies, inculcating cleanly habits among the poor, and affording them that most important requisite, an abundant and constant supply of good water, by means of which they may attain cleanliness; by adopting these measures it cannot be doubted that the public authorities would not only lessen the ravages of the disease amongst the people dwelling in the localities thus improved, but also greatly weaken the force of the epidemic over a far wider space. All these things should be done before the pestilence comes, and in the time of its presence it would further be wise to enforce cleanliness and ventilation even in the interior of houses, by a house-to-house inspection.

"These principles seem now to be more generally understood, and happily are being more widely acted upon, than at any former period. But as public functionaries are apt to

direct their efforts too exclusively to the removing evidences of dirt, and to think all must be well where the eye finds cleanliness, it may not be superfluous to call especial attention to the fact, that mere overcrowding and want of ventilation has in several instances enabled cholera to exert its worst effects. This want of ventilation is especially common in work-houses and other pauper establishments, and in public lodging-houses, in which the number of inmates ought to be strictly limited, and in a time of pestilence reduced."

That low sites and other unfavorable local conditions do not always bring upon a city the destructive effects of this epidemic, is singularly illustrated in the case of Amsterdam. Situated as it is, below the mean level of the sea, with no covered sewers, its canals, as Murray says, sending forth noxious effluvia in the summer, when stirred by the passage of boats, and surrounded by a low, flat, moist country, it escaped, almost entirely, when London, Paris, Hamburgh and other cities, were severely visited.

On page 22, of the Report of the Royal College of Physicians, they say: "It is undoubtedly true that cholera rarely prevailed with great intensity except in badly drained and foul spots, or in dirty and badly ventilated houses, such as are inhabited by the poorest classes. But it is equally certain that in some public institutions, and even in some private houses, where, excepting, perhaps, the want of ventilation, the conditions of insalubrity did not exist in a marked degree, the disease caused a large mortality in proportion to the number of persons exposed to its ravages; and further, that in the towns visited by it, some of the localities which presented the worst features of insalubrity escaped altogether, or suffered in the slightest degree." Same page, a quotation from the report of Messrs. LEIGH and GARDNER, who after describing the severe ravages of cholera in 1849, in Gaythorn, a part of Manchester, say: "On the bank of the Medlock, and lying on the south-east of Gaythorn, but separated from the latter by the Manchester gas-works, some large manufactories, and a curve of the river, is the district called 'Little

Ireland.' It is occupied almost entirely by the most squalid and indigent Irish immigrants; has numerous pig-sties, undrained houses and cellars, a population crammed to suffocation; has the exhalations from the river rolled over it by an opposite high bank, and has long been known to be one of the most unhealthy localities, and in the worst sanitary condition of any in Manchester. In a straight line it is but a few hundred yards, scarcely more than three hundred, from Gaythorn, and yet a very few cases of cholera only have occurred in this locality; indeed but five cases, and four of these happened when the disease was generally declining." Mr. Simon, in his Second Annual Report on the Sanitary Condition of the City of London, says: "It is unquestionably true, that many habitual seats of fever were visited by cholera; on the other hand, many of the worst fever-nests in the whole metropolis were unaffected by it." The late Dr. Taylor, in his History of Epidemic Choleral in Huddersfield, observes that, "One of the most remarkable singularities of the epidemic is this, that after attacking one, two or three persons in a bad locality, it will cease there; again it will altogether pass by other spots as bad or worse than the one visited. One house will be invaded, whilst others, much nearer to the nuisance supposed to be concerned in the production of the disease, will escape."

Mr. Haywood, in his report to the Commissioners of Sewers of the City of London, for 1849, says, page 24: "It is a somewhat singular circumstance, that none of the men employed in the city sewers in flushing and cleansing, have been attacked with, or have died of, cholera during the past year; this was also the case in 1832–3. I do not state this to prove that the atmosphere of the sewers is not unhealthy. I by no means believe an impure atmosphere is not unhealthy; but I state the naked fact, as it appears to me a somewhat singular circumstance, and leave it to pathologists to argue upon."

Perhaps too large a portion of this report has already been occupied with extracts and statements relative to the health of cities, as connected with sanitary measures; but as the Sewerage Law and public expectation look for a great deal to

be accomplished in the way of freeing Chicago from preventable diseases, by the simple construction and operation of sewers, it is not necessary to apologize for dwelling upon the very subject which gave birth to that law, and which lends to public opinion the force requisite to carry it out.

It will be seen that far too much may be expected from sewerage alone. It is indeed a very important and essential link in the chain of sanitary improvement, but only a link. A city may have no sewers; yet if it has a sufficiently undulating surface to drain off rain water, and all accumulations of filth are prevented, or speedily removed, it may escape an outbreak of cholera, as was the case in Baltimore, in 1849, when there was most undoubted proof of the presence of this epidemic in and about that city; and yet Baltimore was severely visited by the same scourge in 1832. On the other hand, places may escape cholera when unprovided with sewerage, and suffer from it, after being sewered, as was the case with Sandgate in England, which during the first visits of cholera, had only surface drainage, and escaped, but after being provided with sewers it suffered severely. The sewers however were found to be defective, and some think this was the cause of the epidemic, while others believe the outbreak would have occurred had there been no sewers.

A city may have the most complete system of sewerage it is possible for man to devise, and it may be maintained in the most perfect order, yet if not accompanied by the prompt removal of all decaying substances from houses and lots, and the frequent and faithful scavenging of streets and other thoroughfares, it would be difficult to appreciate its beneficial effects in a sanitary point of view. If streets are permitted to remain filthy for weeks and months at a time, and open ditches become the receptacles for garbage and kitchen refuse, exposed to the action of a hot sun, equally long, it is idle to expect sewers to avert the natural consequences of such a state of things.

As a striking instance of the false security that may be felt in consequence of having carried out needed and

undoubtedly beneficial sanitary improvements, the following extract is made from page 226 of the third edition of Dr. Edw. H. Barton's "Cause and Prevention of Yellow Fever:"

"*Norfolk* was once one of the sickliest cities on the sea-board, and frequently subject to yellow fever. By draining, paving, and filling up of her low lots, the collecting reservoir of humid filth of all kinds, she has ultimately become entirely salubrious. From a letter from Dr. Upshur, with which I have been favored, I quote freely. He says: 'Many years ago, miasmatic fever was a very common disease in Norfolk, during the autumnal months. *No case, however, originated in the paved parts of the town.*

"'Within the last five years a vast amount of paving has been done, and we now have very little intermittent or remittent fever. Indeed, our sanitary condition has improved *pari passu* with the *paving of streets, filling up of lots*, and increased attention to the cleanliness of our streets, and other sanitary regulations; so that from having been the most unhealthy of the southern ports, our city has of late become a proverb for its healthiness. Our mortality averages only twenty per month, out of a population of 'sixteen thousand,' which is only one and a half per cent., or fifteen in a thousand, which, if true, exceeds that of any town of its size, either on the sea-board or in the interior, and confessedly wrought from being one of the sickliest, by *sanitary regulations*.'"

The above extract appears to have been written in 1854. It is well known that, the very next year the most alarming outbreak of yellow fever ever heard of in our country occurred in Norfolk. The committee of six physicians, appointed by the council to investigate the cause and origin of the fever, state, in their report, that out of a population reduced from its ordinary number to 8,000 or 10,000, by flight, there were about as many cases of sickness, and 2,000 deaths; that very few deaths took place among the blacks, while, among the whites, more than one in three became victims of the pestilence. One of their conclusions is this:

"That the city, if not in as good sanitary condition as

could have been desired, was probably in as good order as most towns of the same size, and certainly as clean as it had been for the last twenty-nine years, during which we had the fever but once. There had been no recent filling up, and no excavation for gas or water pipes, etc. During the progress of the epidemic, the cleanest, dryest and best ventilated places enjoyed no greater exemption than the dirtiest and most crowded; which would not have been the case, if the disease were owing to the decomposition of animal and vegetable matter."

Conclusions with reference to the Chicago Sewerage.

After having presented, without intentional bias towards the views of any theory in matters of sewerage, such information obtained abroad as seemed necessary to give an outline of what is done and believed in Europe in regard to this subject, it remains for me to make an application of it to our own city.

One of the questions that troubled me very much before visiting the old world, was that of pipe sewers. The General Board of Health of Great Britain, as already mentioned, had recommended them to an extent never heard of before, completely revolutionizing the opinions relative to sewerage that had previously obtained; while the most experienced members of the engineering profession objected strenuously to so radical a change. As only the continued satisfactory working of any new system, after it has been carried out, can convince the public of the correctness of the views of its projectors, it was natural that in this case, both parties should appeal to actual results, to sustain their theories, and as a consequence, we have had most conflicting accounts of what those results were. Under such circumstances it is very difficult to satisfy others, or even one's self, where the exact truth lies; but the effect of observation and inquiry abroad,

and of our short experience here since laying the first pipe sewers, shows that we have pursued a safe course, and that it would not be advisable to change in this respect for the future. In consequence of the slight declivity we have for the pipe sewers—only 1 in 500—we took unusual precautions to avoid failure, or the necessity for digging up streets to remove obstructions from the pipes. These precautions consisted in having the pipes laid as carefully as possible to the required inclination, making the joints with hydraulic cement, and placing man-holes at distances rarely exceeding one hundred feet apart. These man-holes are circular wells, 3 feet in diameter, curbed with brick 4 inches thick, laid in cement, and covered with wood, which, in the present state of our streets, is not only a very economical, but suitable material. The slight depth, seldom as yet over 8 feet, at which the pipe sewers are placed below the surface, makes the cost of the man-holes slight. We find upon actual trial, that where the pipe sewers receive the rain water from all the houses on each side, they keep clean, without ever flushing; where a large portion of the rain water is not let into them, they can be flushed clean with a hose from the fire hydrants; and where there is very little or no rain water let into them, it is necessary sometimes to stir up deposits by a hoe and jointed rods while flushing. In no case has any matter remaining in the public sewers caused inconvenience to private individuals, or rendered it necessary to dig up the streets. It would be presumptuous to say that such never will be the case; but we have great reason to believe that it will very rarely occur.

Complaints have been made from time to time, by individuals, that not only the pipe but the brick sewers were stopped up, and their premises flooded in consequence. Whenever such complaints have been made, we have always examined the sewers and drains, and have, in every instance, found the house drain obstructed by substances which it is unlawful or improper to put into them, such as sand, shavings, sticks, coal, bones, rags, garbage, or grease, which, though fluid when in a hot state, soon cools in the drains and closes them up, gradually, but certainly.

Whenever the rain spouts are all properly connected with the pipe sewers, judging from past experience, they will cause very little trouble or expense to keep them in order. The greatest, in fact the only important, item of expense incurred thus far, in keeping the pipe sewers clean, has been the removal of quicksand from them in some parts of the city, especially near the lake. Parties digging cellars in such localities have been very much troubled with water, and in order to get rid of it, have sometimes let it rush into their drains so rapidly, as to carry sand into the sewers. Though generally done through carelessness, to a certain extent, this is perhaps unavoidable; and in most cases, the parties who do so are willing to pay the expense of removing the sand.

Another question that perplexed me, was the expediency of placing the sewers generally one to two feet lower than we were doing; which, in the estimation of some who had lived long in Chicago, and had observed the general height of water in the lake, should be done. Nothing which I saw or learned abroad justifies the laying of sewers so low as to have back water constantly in them; and the high water of the past year, shows that our principal ones are already full low enough; for it has been difficult to flush or cleanse them near their outlets, except at favorable times, that is, during the prevalence of southerly winds.

With regard to the form, sizes, and mode of constructing our brick sewers, which were arranged with reference to the peculiar circumstances of Chicago, no change seems advisable. The circular form is certainly the most economical for the same strength and capacity, and when half filled or more, discharges more efficiently than any other. The egg-shape, however, has other advantages, as already mentioned.

The English make their catch-basins and gully-traps much smaller, and consequently less expensive, than those of this country generally are. Ours are similar, but rather smaller, than those of New York, Philadelphia and Boston. There

is a necessity for the American being larger than the English, especially in our northern cities. We are troubled with ice and snow much more than they are. With such frosts and ice as we have, moveable traps near the surface, like those of Carlisle for instance, would be exceedingly troublesome. With unpaved streets, and the imperfect scavenging practiced in our cities, the amount of earth and other solid matter that would flow into small catch-basins like the English, would render them useless in a single heavy storm. The Carlisle gully-trap holds less than a cubic foot, while about *thirty* cubic feet have entered one of our catch-basins, during two storms that occurred within a week of each other. See *Plate III.*

It was hoped that valuable information relative to water closets might be obtained, but in this respect, too, owing to the great difference of climate, our own experience is worth more to us than that of the English. They have found that except in well regulated families, a water closet is liable to become a greater nuisance than an ordinary privy. The experience of Glasgow in this respect, already mentioned, probably corresponds with that of most other large cities.

With regard to flushing sewers, the provisions made in our plan for effecting this, appear to me to be very abundant. In fact the little trouble we have had with what comes from house drains, including water-closets, where the rain spouts have been generally connected with the sewers, shows that there is a probability of our not being obliged to resort to so expensive a system as the plan provides for, that is, one that furnishes a constant stream through the sewers. As a matter of necessity, owing to the want of funds, nothing has been done yet, towards constructing the flushing engines, or laying the pipes from them, and we have thus been obliged to ascertain what trouble there is in getting along without them ; and it has been found that by using hydrant water a few times a year, the sewers can be kept in a very good state, sufficiently so it is believed for all necessary purposes. The system of pumping up a constant supply of water for flushing, separate

from the Water Works, was recommended, to meet the objections that would naturally, and with good reason, be made to sewers of such little inclination as ours, and it may be necessary to resort to it yet; but the experience of the past year justifies me in recommending that it be put off for a year or two at least; and that in the meanwhile, so much of the interest on the estimated cost of the flushing works as may be necessary, be paid to the Water Board.

The experience of the cities of the old world, with regard to discharging the contents of sewers into their rivers and harbors, attracted much of my attention, and led me to review with care and anxiety the views upon which our plan is based.

The whole of the London sewage is emptied into the Thames, and although this great metropolis boasts of a more favorable rate of mortality than any other large city can show, the condition of their river has been a subject of much complaint for many years, and various schemes have been devised for removing the nuisance. As these have already been described, or alluded to, under the heads of "London" and "disposal of sewage," no further mention will be made of them here. The similarity and the difference of situation between London and Chicago, should be understood, however. The Thames averages, through the metropolis, about 1,000 feet in width. The tide rises there about 20 feet. At low water extensive portions of the bed of the river are exposed, and a rapid current up and down caused by the tide, stirs up the foul deposits necessarily found in such localities in the midst of so large a population. In Chicago, we have a river of only one-sixth the average width of the Thames, but with an average depth of 13 feet, which from one year's end to another seldom varies 2 feet from the average, and ordinarily not one. We have no tide, and usually a very feeble current, which, owing to the effect of winds on the lake, is quite often reversed. This keeps up a slight, but almost constant change in the river. This change is also assisted by the natural flow from the area drained by the river, and by the leak-

age and waste-water from the canal, when it is not necessary to supply the summit level by pumping from the river; so that offensive smells from the river are rare, except when propellers stir up the bottom near the shores. During the last two years there has been very little or no complaint from this cause.

As yet most of the sewers of Paris empty into the Seine, which varies very much between high and low water; but not being a tidal river there, its time of low water naturally comes during the warmest months, when large portions of its bed on either side are frequently exposed to the action of the sun and winds. It was found that the sewage of the city, though containing a very small amount of excrementitious matter, compared with that of London, became exceedingly offensive in dry, warm weather; hence the cause of commencing the system of intercepting sewers, already described under the head of Paris.

The sewers of Glasgow discharge their contents into the Clyde, and have produced a nuisance, which, together with proposed schemes for removing it, will be found mentioned under the head of Glasgow. The Clyde is a tidal river, but was formerly much narrower there than it is now. The present harbor of Glasgow has been obtained by widening and deepening the river, at a cost of about $10,000,000, and can only be maintained in its present state, by dredging and at great expense. This expense, however, is small, compared with the importance of a good harbor to so populous and flourishing a city.

No one of these great cities furnishes an exact criterion by which to judge of the effect of discharging the sewage of Chicago into our river and branches; and yet their experience leads me to fear we may yet, like them, conclude that it will be necessary to keep it out. Our plan is based upon the supposition that the natural state of the river during the summer months will require artificial aid to keep it in a healthy state, and therefore provides for driving fresh water into the upper portion of the south branch from the lake.

The question then arises, what should be done in case this

provision should prove inadequate? Should it prove so, Chicago will be in as good a position, all things considered, as either London, Paris or Glasgow, to construct intercepting sewers, and discharge all its sewage into the lake, at some point in the south part of the city. Nothing we have done so far, and nothing we intend to do would interfere with a perfect system of intercepting sewers. Such a scheme seems to me the most feasible one within the power of the city to carry out for freeing the river; and appears to be liable to but two objections. The first is probable cost, which, however, ought not to be allowed to stand in the way of what might promote the public health; the second is, the possibility of creating on the lake shore as great a nuisance as would be taken from the river. The experience of Worthing, a small watering town on the southern coast of England, already described in this report, and of a similar place on the coast near Liverpool, mentioned to me by Mr. NEWLANDS, of that city, shows that the mere discharge of filth into the sea gives no security against its being cast back in a more offensive state than ever, especially when the prevailing winds are toward the shore. In such a case the intercepting sewer might be carried two or three miles further south; but aside from the serious additional expense of such an extension, the nuisance would only be removed from the many to the few; for no doubt the lake shore will yet be lined with choice residences for several miles south of the present city limits.

The various projects for utilizing the sewage of cities have already been considered, and the reason for not recommending any steps towards using it for irrigating purposes in our climate and present state of agriculture, need not be repeated here. The deodorizing process, in connection with short, intercepting or collecting sewers, may yet prove to be the best plan for relieving the river; but it would not be advisable to attempt anything of the kind here, until there shall be more agreement on the subject, among the English, who have made such advances already in this direction.

Before deciding upon any course for the future, with regard to our river, it would be well to consider its condition for a

few years past, and thus be able to judge of what it will probably be for a few years to come, if no special means beyond those already in existence, should be adopted for its relief. It is remembered by many, that the river became quite offensive about thirteen years since, in consequence of blood and other refuse from slaughter houses being thrown into it. Since these substances have been kept out of it, however, the nuisance has been comparatively slight, and has not increased perceptibly, notwithstanding the remarkable growth of population, and corresponding increase of sewage discharged into the river. When the spring freshets scour the river well, disagreeable smells the next summer are perceptibly less, than when there are no spring freshets. For instance, last year there was little if any complaint from the state of the river, and yet the amount of sewage discharged into it was never so great; but the scouring it received, when the snow and ice passed off in February, was unusually good, making the channel an average of two feet deeper than it was fifteen months previous, besides removing the deposit formed during that time.

Under these circumstances it seems advisable to do nothing with regard to relieving the river at present, nor towards carrying out that portion of the plan which provides for forcing water from the lake into it, during the summer months. Should the Canal Company not be obliged to pump enough during warm weather to keep the river from being offensive, it is understood that they would pump as much as they could for a reasonable compensation. This would furnish some criterion by which to judge of the probable effect of a still greater quantity driven in from the lake, according to the plan. In the estimation of some, no provision is necessary for relieving the river, while others think that embraced by the plan would not be sufficient. The thorough cut for a steamboat canal, to the Illinois river, which the demands of commerce are calling more and more loudly for, if ever constructed, would give as perfect relief to Chicago, as is proposed for London by the latest intercepting scheme; that is, it would furnish a constant and abundant stream from the

lake, flowing westwardly throughout the season of navigation, and consequently during the warm and sickly portion of the year.

Another, and the only remaining point of importance it seems desirable to mention, is that of enabling the owners of property here, to obtain basements or cellars of a satisfactory height without being obliged to raise the grades of the streets, as we are now doing in many parts of the city. This was urged very strongly, in the original planning of our system, as a reason for laying the sewers low, and pumping up their contents. While abroad, I neither saw nor heard of a single city or large town, the sewers of which were placed below the general level of the principal bodies of water near them, for the purpose of constructing cellars below such water level; on the contrary, even when they deemed it best to pump up the sewage, for the purpose of obtaining greater declivity, or of draining districts that could not be raised, I found they were opposed to the construction of such cellars; and, in some cases, recommended their prohibition by legislative enactments. Their reason was, the certainty of such sewers being filled to the level of their outlets during heavy and protracted storms, and the uncertainty of being able to keep in order the valves, which must be relied upon at such times, to prevent the cellars from being flooded. But if a person is sure of being able to keep his valve, whether self-acting or not, in perfect order, it is necessary that his premises should be surrounded by a water-tight wall, otherwise the carelessness of his neighbor might prove as injurious as his own.

In preparing the foregoing report, it would have been easy to extend it to a thousand pages, by drawing from the voluminous sources of information now in your possession. The difficulty has been to select and condense what seems to have some present or prospective bearing upon the sewerage of this city.

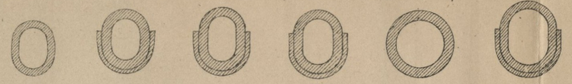
Respectfully submitted.

E. S. CHESBROUGH,

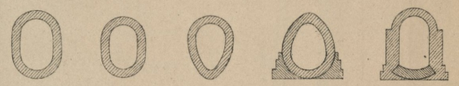
Ch. Eng'r Board of Sewerage Com'rs.

Pl. I

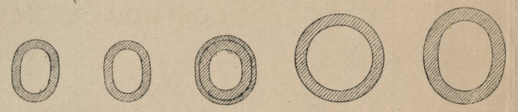
LIMEKILN DOCK SEWER



SAVOY ST. SEWER



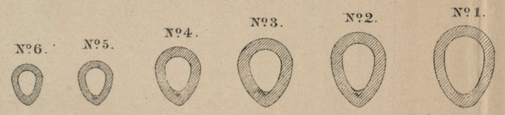
REGENT ST. SEWER



From end of Sewer to Low Water

CAST IRON

SECTIONS ADOPTED BY THE METROPOLITAN SEWERAGE COMMISSIONERS



LONDON SEWERS

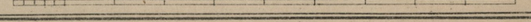
FROM SECTIONS PUBLISHED BY THE

METROPOLITAN BOARD OF WORKS

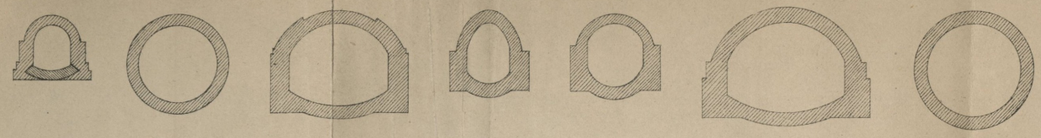
J.W Bazalgette
Engineer 1857

J. Comm. H. Lith. 132 Lake St. Chicago.

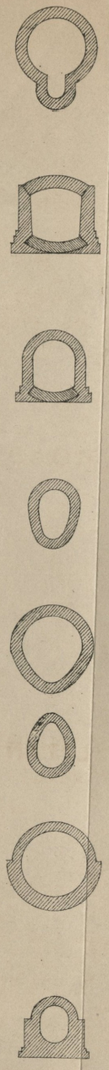
Scale 16 Ft. to one inch for Sections



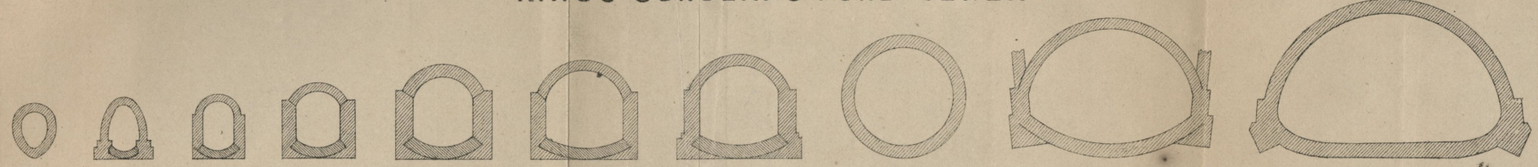
RANELAGH SEWER MAIN LINE



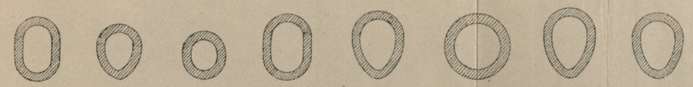
DIFFERENT SECTIONS



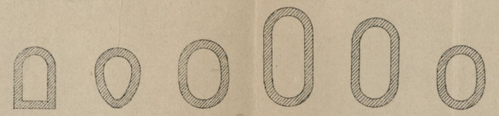
KINGS SCHOLARS POND SEWER



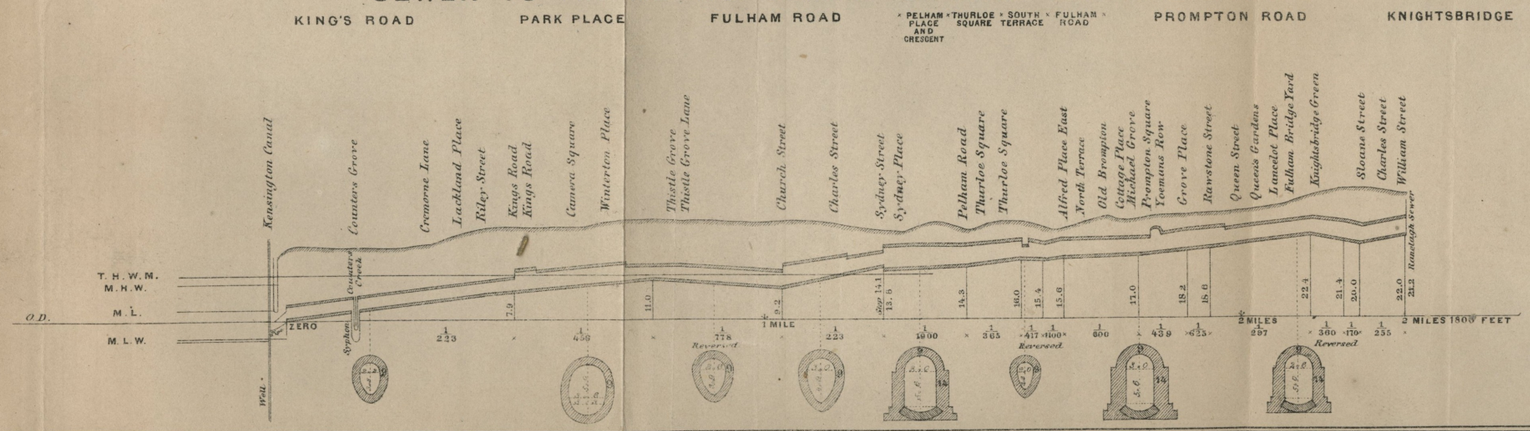
LONSDALE SQUARE BRANCH



CITY ROAD BRANCH

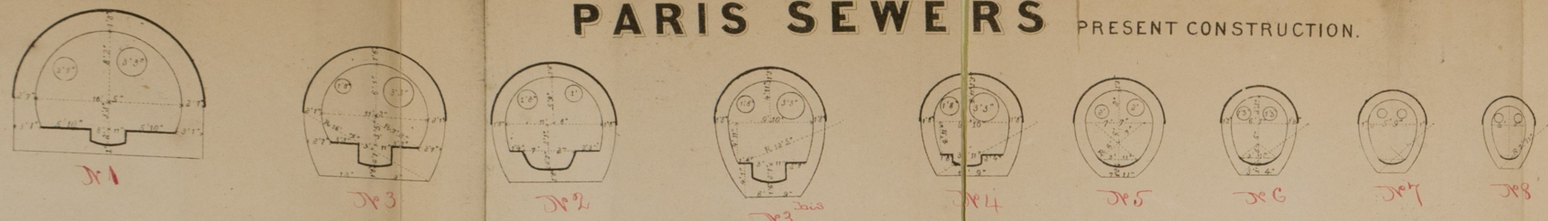


SEWER TO THE METROPOLITAN SEWAGE MANURE WORKS

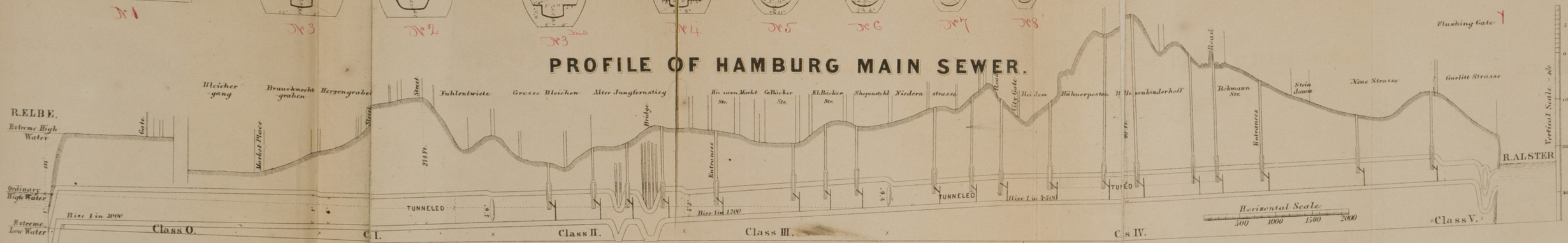


Pl. II.

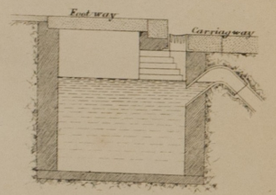
PARIS SEWERS PRESENT CONSTRUCTION.

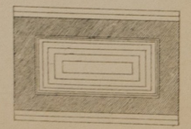


PROFILE OF HAMBURG MAIN SEWER.

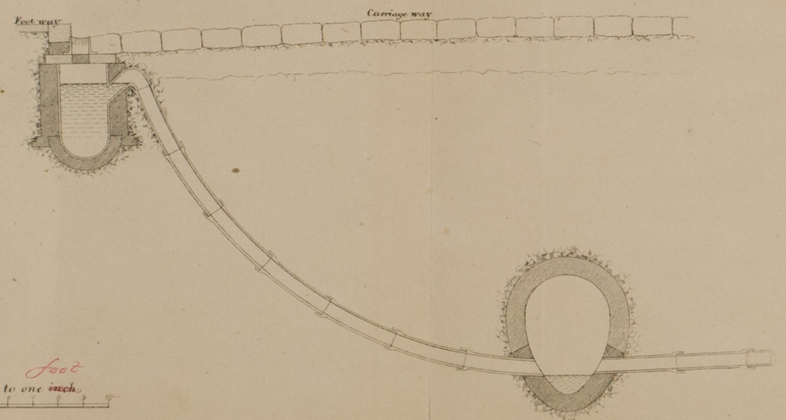


GULLIE.

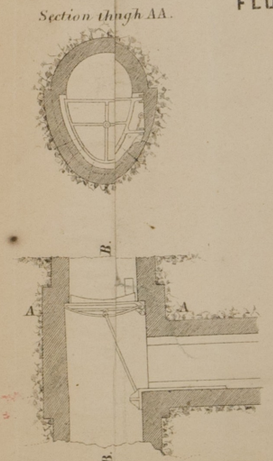




SECTION OF STREET.



FLUSHING GATE.



Pl. III.

MAP OF HAMBURGH, Shewing MAIN & PRINCIPAL BRANCH SEWERS.

Explanations.

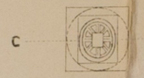
The district included within the lines shaded thus ▨ was originally Marsh-land and subject to over flow. The dotted lines thus ····· indicate the boundary of the city. The main sewer is marked thus ▬▬

The branch sewers thus ——

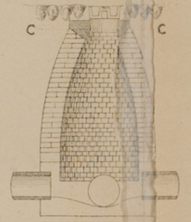
Wm Lindley Engineer 1857.

J. Connell, lith. 132 Lake St. Chicago.

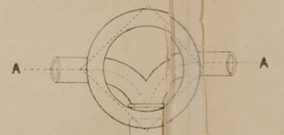
MANHOLE WITH JUNCTION.



PLAN AT TOP



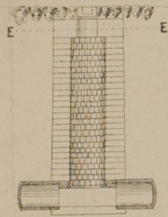
SECTION A.A.



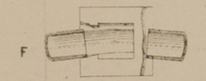
PLAN

LAMP HOLE.

PLAN AT TOP

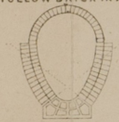


SECTION F.F.



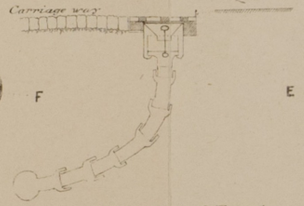
PLAN.

SECTION OF SEWER WITH HOLLOW BRICK INVERT.



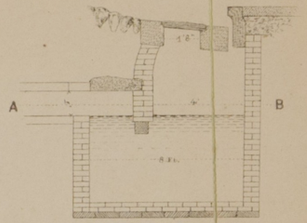
CARLISLE GULLY

COVER

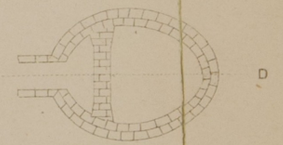


Scale: 1 inch to 6 Ft. = ft

BOSTON CATCH BASIN.



SECTION ON E.D.



PLAN ON A. B.

Wm Rawlinson Engineer 1857.

Pl. IV.

PLAN SHEWING SEWERS LAID UNDER THE CHICAGO SEWERAGE COMMISSIONERS TO THE END OF 1857.

Main Sewers
Sub Main do
Pipe do
Man Holes
Catch Basins

J. Gemmell, Lith. 132 Lake St. Chicago.