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METROPOLITAN SANITARY COMMISSION.

FIRST REPORT

OF THE

COMMISSIONERS

APPOINTED TO INQUIRE WHETHER ANY AND WHAT SPECIAL MEANS MAY BE REQUISITE FOR THE IMPROVEMENT OF THE HEALTH OF THE METROPOLIS,

WITH

MINUTES OF EVIDENCE.



LONDON:
PRINTED BY WILLIAM CLOWES & SONS, STAMFORD STREET,
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COMMISSION.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To Our Right Trusty and Well-beloved Councillor Robert Grosvenor (commonly called Lord Robert Grosvenor), and our Trusty and Well-beloved Edwin Chadwick, Esquire, Thomas Southwood Smith, Doctor of Medicine, Richard Owen, Esquire, Hunterian Professor at the College of Surgeons, and Richard Lambert Jones, Esquire, Greeting: WHEREAS We have thought it expedient, for divers good causes and considerations, that a Commission should forthwith issue for inquiring whether any and what special means may be requisite for the improvement of the Health of the Metropolis, with reference more particularly to the better House, Street, and Land Drainage, Street Cleansing, and Paving; the collection and removal of Soil and refuse, and the better supply of Water, for domestic use, for flushing Sewers and Drains, and cleansing Streets; and also to the best means of using existing Works, and of erecting new Works requisite, and of maintaining them in good action; and also to the most equitable provisions for regulating the Charges, or assessing, collecting, and paying the Monies requisite for such purposes, more especially in the Districts chiefly inhabited by the poorer classes of the population. NOW KNOW YE, that We, reposing great trust and confidence in your knowledge and ability, have authorized and appointed, and do by these presents authorize and appoint you, the said Robert Grosvenor (commonly called Lord Robert Grosvenor), Edwin Chadwick, Thomas Southwood Smith, Richard Owen, and Richard Lambert Jones, or any two or more of you, to be Our Commissioners for the purposes aforesaid; AND for the better enabling you to carry these Our Royal intentions into

effect, WE DO hereby give and grant to you, or any two or more of you, full power to call before you such persons as you shall judge likely to afford you any information on the subject of this Our Commission, and to inquire of and concerning the premises by all other lawful means whatsoever: AND WE do also hereby give and grant unto you, or any two or more of you, full power and authority, when the same shall appear to be requisite, to administer an oath or oaths to any person or persons whatsoever to be examined before you, touching or concerning the premises: AND WE do by these presents, Will and Ordain that this Our Commission shall continue in full force and virtue, and that you Our said Commissioners, or any two or more of you, may from time to time proceed in the execution thereof, and of every matter and thing therein contained, although the same be not continued from time to time by adjournment. AND Our further Will and Pleasure is that you Our said Commissioners, or any three or more of you, upon due inquiry into the premises, do report to us in writing, under your hands and seals, your several proceedings under and by virtue of this Commission, together with what you shall find touching or concerning the premises: AND WE further ordain that you, or any three or more of you, may have liberty to report to us your proceedings under this Commission from time to time, should you judge it expedient so to do. And for your assistance in the due execution of these presents, we have made choice of Our trusty and well-beloved HENRY AUSTIN, Esquire, to be Secretary to this Our Commission, and to attend you, whose services and assistance We require you to avail yourselves of from time to time as occasion may require. IN WITNESS whereof We have caused these Our Letters to be made Patent.

WITNESS Ourself, at Westminster, the Twenty-fourth Day of September, in the Eleventh Year of Our Reign.

By Writ of Privy Seal,

EDMUNDS.

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METROPOLITAN

SANITARY COMMISSION.

FIRST REPORT.

MAY IT PLEASE YOUR MAJESTY:

We, Your Commissioners appointed "to inquire whether any and what special means may be requisite for the improvement of the health of the metropolis, with reference more particularly to the better house, street, and land drainage, street cleansing, and paving; the collection and removal of soil and refuse, and the better supply of water for domestic use, for flushing sewers and drains, and cleansing streets; and also as to the best means of using existing works, and of erecting new works requisite, and of maintaining them in good action; and also as to the most equitable provisions for regulating the charges, or assessing, collecting, and paying the monies requisite for such purposes, most especially in the districts chiefly inhabited by the poorer classes of the population," do now present this our First Report as follows.

The first subject which we took into our consideration immediately after we had opened our Commission was the reported progress of the Asiatic cholera towards Europe, and the probability of its again visiting these Islands. The alarming character of this disease, and the impossibility of arresting its progress when it once breaks out, in a population living under circumstances favourable to its spread, seemed to require that we should at once examine the condition of the metropolis with reference to this impending danger. Our impression as to the necessity of making this the first subject of our investigation was confirmed by a communication we received on the same day from Sir William Pym, who attended from the Council Office, and informed us of the advices which had been received from the English Consuls of the steady progress of this pestilence precisely upon its former track in 1832.

We immediately called before us medical witnesses who had been in practice in the metropolis when the disease prevailed here, and whom we understood to have been the most extensively engaged in attending on the sick. From them and from other witnesses who at that time assisted in the administration of relief to the sufferers, we sought to obtain information of the past and present sanitary condition of the people, as affected by the state of the localities in which they reside, and of their dwellings, and by

other circumstances which appeared to favour the spread of the disease. At the same time we endeavoured to collect from these witnesses the result of their observations as to the effects of the measures both of prevention and of alleviation which were then recommended and adopted, and what might be the modifications and extensions suggested by subsequent reflection on the experience then obtained, in relation to a disease of a most mortal and intractable nature, and entirely new to the medical men at that time practising in England.

Concurrently with these inquiries we made it our business to ascertain the state of information and the practical skill and competence, as exemplified in their works, of the authorities charged with the direction of what all previous inquirers had agreed in representing as the chief means of prevention; namely, the works of drainage and cleansing. With this view we have examined the chief paid officers, as being the persons necessarily in possession of the greatest amount of practical knowledge and skill, of all those Commissions of Sewers for the appointment and constitution of which, "the Lord Chancellor, and the Lord Treasurer of England, and the two Chief Justices for the time being, or three of them whereof the Lord Chancellor to be one," are constitutionally responsible.

The evidence contained in extensively circulated official Reports on the sanitary condition of the population has now been before these Commissions several years. That evidence had displayed the sources of excessive disease and of premature mortality; and had elucidated the principles and demonstrated the practicability of large measures of prevention.

We directed our inquiries to ascertain whether those principles had been duly recognised, and whether any and what attempts had been made to apply them by those administrative bodies within the range of discretionary power entrusted to them for the repression of evils which were found to be so widely spread and so grievous; whether those bodies appeared to comprehend, and, from the works which they have executed and have now in preparation, were competent to carry out such measures as would satisfy the public wants, and more especially what amount of service might reasonably be expected through them to meet the impending pestilence.

On these inquiries we have to report as follows; and first with respect to the cholera.

Our earliest inquiry with reference to the cholera was to ascertain the measures which had been adopted to prevent the introduction and extension of this disease when it first approached our shores, and whether there were any and what conclusions to be deduced for future guidance from the experience of those measures.

We find that the first acts of the Government were to appoint, by order of the Privy Council, a Central Board of Health in

London; and to issue an Order in Council, dated the 20th day of October, 1831, to the following effect:—

"The measures of extreme precaution for preventing the introduction of the cholera morbus by a rigorous quarantine have hitherto been found effectual; but as the disease approaches the neighbouring shores, not only is the necessity of increased vigilance more apparent, but it is also consistent with common prudence that the country should be prepared to meet the possible contingency of so dreadful a calamity.

"To prevent the introduction of the disorder, not only the most active co-operation of the local authorities along the coast in the measures of the Government, but likewise the exercise of the utmost caution by all the inhabitants of such parts of the country, becomes indispensably necessary. The quarantine regulations established by the Government are sufficient, it is confidently hoped, to prevent the disorder from being communicated through any intercourse with the Continent by the regular channel of trade or passage; but they cannot guard against its introduction by means of the secret and surreptitious intercourse which is known to exist between the coast of England and the opposite shores. By such means this fatal disorder, in spite of all quarantine regulations and of the utmost vigilance on the part of the Government, might be introduced into the United Kingdom; and as it is clear that this danger can only be obviated by the most strenuous efforts on the part of all persons of any influence to put a stop to such practices, their utmost exertions should be used to effect this end."

In accordance with the view thus promulgated, the nation is warned that, in case of the actual invasion of the disease, "all intercourse with any infected town and the neighbouring country must be prevented by the best means within the power of the magistrates, who will have to make regulations for the supply of provisions; that measures of a coercive nature may be rendered expedient for the common safety, if unfortunately so fatal a disease should ever show itself in this country in the terrific way in which it has appeared in various parts of Europe; and it may become necessary to draw troops or a strong body of police around infected places, so as utterly to exclude the inhabitants from all intercourse with the country;" and a conviction is expressed that what is demanded for the common safety of the state, will always be acquiesced in with a willing submission to the necessity which imposes it.

It is further stated that, "as the most effectual means of preventing the spreading of any pestilence has always been found to be the immediate separation of the infected from the healthy, in order to carry this separation into effect, it will be expedient that one or more houses should be kept in view in each town or its neighbourhood, as places to which every case of the disease, as soon as detected, might be removed, provided the family of the

affected persons consent to such removal; and in case of refusal, a conspicuous mark ('Sick') should be placed in front of the house, to warn persons that it is in quarantine; and even when persons with the disease shall have been removed, and the house shall have been purified, the word ('Caution') should be substituted, as denoting suspicion of the disease; and the inhabitants of such house should not be at liberty to move out or communicate with other parties until, by authority of the Local Board, the mark shall have been removed.

During this isolation in order to avoid all unnecessary communication with the public out of doors, it is recommended that "all articles of food or other necessaries required by the inhabitants should be placed in front of the house and received by one of the inhabitants of the house, after the person delivering them shall have retired; and that until the time during which the contagion of cholera lies dormant in the human frame has been more accurately ascertained, it will be necessary, for the sake of perfect security, that convalescents from the disease, and those who have had any communication with them, should be kept under observation for a period of not less than 20 days."

In the meantime the removal of filth of every description, and the enjoining of extreme cleanliness and free ventilation are placed on the same footing as the burning of decayed articles, such as rags, cordage, papers, old clothes and hangings; and the purification of clothes and furniture by copious effusions of water and boiling in a strong ley.

It appears, however, that further and closer investigation led to a considerable modification of these opinions and recommendations on the part of the Board of Health; for in the Circular issued from the Council Office on the 14th of November, 1831, that is, in less than one month from the date of the Order in Council, it is stated that the Central Board of Health having maturely weighed all the information which had been transmitted to them relative to the progress of the Asiatic spasmodic cholera in various parts of Europe, but more especially guided by the conclusions on this head to which Drs. Russell and Barry have arrived, after a five months' careful and laborious observation of the character of the disease in those parts of Russia which they visited, beg leave to suggest:—

"With regard to precautions as to intercourse with suspected or really infected persons or places, that the Board are confident that good sense and good feeling will not only point out, but morally establish, as far as may be practicable, the necessity of avoiding such communication as may endanger the lives of thousands. But they strongly deprecate all measures of coercion for this purpose, which, when tried upon the Continent, have been invariably productive of evil.

"It is with much satisfaction that the Board feel themselves

authorized to declare, and it will no doubt be highly consolatory to the public to learn, that under proper observations of cleanliness and ventilation, this disease seldom spreads in families; and rarely passes to those about the sick, under such favourable circumstances, unless they happen to be particularly predisposed. It will not therefore be necessary, where there is space, and where due attention is paid to cleanliness and purity of air, to separate members of families actually affected by the disease, nor to insulate individual houses, unless in cases of crowded, filthy, badly ventilated habitations, and other contingencies, which involve the health and safety of all.

It is further stated, that "in order to ensure the adoption and realize the benefit of any system of sanitary arrangements in a large community, the first essential point is to divide that community into subordinate sections, and to form District Boards of Health, each to consist, if possible, of a resident clergyman, and a number of substantial householders, and of one medical man at least. These Boards should be charged with the following duties in their respective districts, viz:—

"1st. To appoint inspectors. Each inspector to visit daily, and to inquire carefully after the health, means of subsistence, cleanliness, and comforts of the inmates of, say 100 houses (more or less), according to local circumstances.

"2ndly. To receive and examine the reports of these inspectors, which should be made up to a given hour on each day.

"3rdly. To endeavour to remedy, by every means which individual and public charitable exertion can supply, such deficiency as may be found to exist in their respective districts, in the following primary elements of public health, viz., the food of the poor, clothing, bedding, ventilation, space, cleanliness, outlets for domestic filth, habits of temperance, prevention of panic.

"4thly. To report to their principal Boards, respectively, on the above heads, as well as on the actual state of health in their districts.

"The subordinate divisions of each district ought to be numbered or lettered, and each district named; the names of the members of each Board, of the medical men attached to each, and of the visiting inspectors employed, should be placarded in conspicuous places.

"The Board would recommend, when a family is reported to be in an unhealthy state by the sub-inspector, and the disease confirmed to be cholera by a medical member of the District Board, that the head of such family, if unable to afford proper accommodation at home, be advised to send the sick person forthwith to the temporary hospital, and that the other members of the family be supplied with such additional means and comforts as their state may require, to enable them to resist the influence of the infected atmosphere in which they live."

In a Circular issued on the 13th December, 1831, it is further recommended that a number of steady men, proportionate to the district in which they are to act, should be appointed to lime-wash and purify, under the direction of medical authority, such apartments as may be pointed out by the inspectors of the local Board.

Minute directions are added as to diet, clothing, and the general regimen to be adopted, with a view of obtaining and preserving a sound state of health, the medical members of the Board stating, in the most decided manner, that no specific preventive against cholera is known to exist; that the drugs hitherto offered with this pretension, in countries where the greatest ravages have been caused by this disease, not only did not possess the negative virtue of doing no harm, but were found to be absolutely injurious; and that the true preventatives are a healthy body and a cheerful unruffled mind.

Such were the measures at first proposed to protect the country against the introduction and spread of Asiatic cholera. At that time not only had no knowledge been acquired by experience of the true character of this disease, but nothing was known of the real condition of the classes which proved to be its first and easy victims, nor of the state of the localities in which they lived. The metropolis of the poor has nothing in common with the metropolis of the rich, and as the map of London exhibits no trace of the lanes and alleys of the poor, so the very names of these places would at that time have sounded as strange to the inhabitants of our great thoroughfares and squares as the names of the streets of a foreign country.

But the official inquiries which have since been made into the sanitary condition of the districts inhabited by the poorer classes have disclosed a state of things which must expose, as is now universally admitted, the vast masses that are crowded into them to the ravages of every epidemic that may chance to prevail; and if this be true of epidemic diseases in general, it is emphatically true of the special disease under consideration. We are satisfied that the importance of the measures we have to propose for disarming this pestilence of its terrors, and for arresting its progress, will be better appreciated when the evidence of this truth has been adduced.

We believe that such evidence will be found in authentic records of the rise and spread of this malady; and from an attentive consideration of the history of its progress throughout Europe we have arrived at the following conclusions:—

1. That the manner of the introduction and extension of this pestilence in the various cities of Europe which it invaded was everywhere similar.

We find the statements and descriptions to be strikingly uniform to the effect that it commonly made its first outbreak in the lowest and dampest part of the city it attacked, generally in the immediate neighbourhood of the river, and often on board of some ship lying

near the shore. Thus from the First Report of Drs. Russell and Barry, the Commissioners appointed to examine on the spot the introduction and spread of the disease at St. Petersburgh, it appears that the first case that occurred in that city "was that of a merchant who had arrived from Witagan on board a decked boat;" the second was that of a journeyman house-painter, "resident in the quarter where the barks lie, and who was taken ill about the same time as the merchant;" and the third "an invalid soldier, on duty in the same quarter, not far from the barks." The Commissioners further state that "no direct personal intercourse could be traced between any two of the first five or six cases, but that it is certain that the first three were from the same district, that in which the suspected barks are stationed. This quarter is the easternmost of the whole city, the first you arrive at coming down the stream, and during the late and present perseverance of easterly winds, the very spot from whence effluvia of any kind might be most conveniently blown over the town. We are informed by Dr. Rehman that many have been taken ill on board the barks themselves."

From the Report of Dr. Hamett on the cholera at Dantzic, it appears that the two first acknowledged cases of epidemic cholera occurred in the Neufahrwasser, or Harbour Canal, one German mile from Dantzic, in two *mud barges*, used for keeping that canal deep; that these were followed by two others, apparently in the same locality, the next day; and that these cases occurred previously to the first arrival of vessels from Russian ports.

It is stated by Dr. Becker of Berlin, that the first cases of cholera in that city occurred among the skippers in the boats lying on the river Spree, which flows through the town, and in houses in the immediate neighbourhood of the river. The disease prevailed to a considerable extent in all those streets which lie along the navigated branch of the river.

In Moscow, the place in which it principally prevailed and was most mortal was a low quarter, surrounded by a bend of the river Moskwa.

At Breslau it first attacked and principally ravaged that part of the town which is low and marshy, and which is the constant seat of intermittent fever.

It is stated by Dr. Antomarchi, that the condition of the houses in which cholera prevailed at Warsaw was little better than that of sewers.

From the Report of the Central Commission of Paris it appears that the first decided irruption of the disease was observed, and that it subsequently spread, above all other places, in the greater number of the *quartiers* situated upon the borders of the Seine such as those of the Hôtel-de-Ville, de la Cité, des Invalides (le Gros-Caillou). It is true, indeed, that there is no extensive portion of the site of Paris which is in so humid a con-

dition as to be considered marshy; but it appears from the Report of the Commissioners, that the prevalence and mortality of the disease greatly preponderated in the low, close, undrained, and uncleansed localities.

In England it first broke out in the port of Sunderland, it was rumoured on board of vessels which had brought the disease from some infected place on the Continent: but on a close examination of the facts, not only could no evidence be adduced to justify this suspicion, but on the contrary it is declared in the most positive manner that the suspected vessels had neither come from diseased ports, nor had had any cases of cholera on board.

In its progress through the country, in whatever places it attacked, it generally first appeared in the neighbourhood of rivers or marshes, and principally raged in low and damp localities, particularly where these were also the outlets of filth. In Carlisle, for example, it is stated that it first broke out "near a mill, and raged down the dam-side, all the drains and sewers in that part of the town emptying themselves into the dam-race, few cases occurring in any other part of the town."

"Cholera," says Mr. Roberton, who has reported on the sanitary condition of Manchester, "appears to have generally, in Europe, followed the track of rivers and water-courses; and in cities and towns kept, in a remarkable manner, to the neighbourhood of sewer mouths. As far as my knowledge of cholera extends, in our Lancashire towns it manifested itself, more than elsewhere, along the water-courses (including docks, wharfs, districts occasionally flooded, &c.) and with peculiar virulence near the outlets of drains. The progress of the disease in Manchester, from first to last, furnishes a comment on this remark. For example, in the New Bailey Prison, which stands within a few yards of the Irwell, there were no fewer than 60 cases; in Allen's-court, situated between Long Mill-gate and the Irk, and near the mouth of a large sewer, out of 17 seizures, in four houses, 14 died; in Back Irk-street, in which a number of cases occurred, the only houses visited by the disease were close by the main sewer, which, there, burst into day, and ran above ground; the same remark applies in reference to cases in Little Ireland, on the river Medlock. Where the cholera broke out (as often happened) in places apart from the canals and streams, it was noticed that this, in most instances, was in yards, courts, and narrow streets, polluted by offensive cesspools, pigsties, and other sources of malaria (some of which were too disgusting to be described), or by open or obstructed sewers. In Warrington, where the disease raged destructively, it located itself principally in Bank-street and other neighbouring low streets running to or near the Mersey—the whole quarter so notorious for its filthy sewers, as to receive the name of 'Sewer Island.' In Bolton the number of cases did not exceed 50: but nearly all of them occurred in closes and

entries, adjoining a stream, into which a number of offensive sewers discharged themselves. Perhaps, however, the most striking illustration on record, of the influence of ill-contrived sewerage on the origination of cholera, supposing the epidemic once prevailing, occurred in Liverpool. One morning it was discovered that several men had been seized with cholera, during the preceding night, on board a vessel lying in one of the docks. The men were sent to hospital; and the vessel having been immediately warped into the river, another ship with a healthy crew took up her station. The next morning all the hands on board were ill of cholera. On examining the dock, it was found that a large sewer discharged its contents under the spot where the vessel was placed. I give this most instructive fact on the authority of Dr. Gaulter, an accomplished physician (since deceased), the author of a valuable work on the 'Origin and Progress of Malignant Cholera in Manchester,' published 1833."

This tendency of the disease to break out first in low and damp situations is further exemplified, in a striking manner, by two observations, made at widely distant parts of the kingdom; the one being in Scotland, and the other in the west of England.

In a Report on the Sanitary Condition of the Labouring Classes of Tain and Easter-Ross, by Mr. James Cameron, it is stated that in 1832 cholera appeared in Easter-Ross during the fishing season; that it was, with few exceptions, confined to the fishing villages, where it found a field but too ripe for its fatal operations; that in the remote village of Inver, situated on the low sandy shore of the Tain Frith, and notorious for its malaria, its ravages were fearfully rapid, having cut off nearly one-half of the inhabitants; while the town of Tain, and most of the rural districts, escaped this visitation.

Precisely similar is the observation of Mr. George Sheward in the west of England, who states that he was parish surgeon at the time the cholera made its appearance in Upton-upon-Severn; that this town is situated upon the bank of a large navigable river, and is liable to a constantly changing population, many of the lower orders depending on the river for support; that the severity of that attack may be judged from the fact, that nearly three per cent. of the gross population fell victims to it within the short space of three weeks, but that its ravages were entirely confined to the lower classes; that every case fell under his notice; that the most diligent inquiries led him to believe that the disease takes generally the course of navigable rivers, and that it was so in the present instance, though its march was erratic; one case breaking out near the river, another more in the town; but in almost every one, in the houses of persons who worked by the water.

In like manner it is proved indubitably, by the evidence taken before this Commission, that when the disease reached the me-

tropolis its first eruption was on the river, and in one of the most crowded parts of it. The following is the substance of the evidence on this point, given by Mr. Bowie,* who appears to have had the first case of cholera that occurred in the metropolis. "Was practising near the river, in East Smithfield, when the cholera arrived in the metropolis in 1832. Thinks he had the first case of it. It was that of a seaman, named Daniel Barber, mate of the 'Felicity' of Limerick, which had come to London direct from that port, and had lain in the river three weeks prior to his being attacked. There was no cholera in the place from whence this ship had sailed; there was nothing particular in the condition of the ship itself; she had lain in the river three weeks before cholera broke out."

The second case appears to have occurred in the same locality. "I am not quite certain," continues this witness, "but I think the second case was a seaman, named Thomas Skowes, of the 'Evander' of Aberdeen; and the third was the mate of a Scotch vessel, lying likewise at the Hermitage." This witness further states that the cholera, having spread from Wapping along that side of the shore, including Limehouse, crossed to the opposite side of the river, namely, Rotherhithe and Bermondsey; that it then attacked the lower parts of the borough of Lambeth; next, the lower parts of Westminster; then it extended along the Fleet ditch, and thence passed into the City.

Other witnesses confirm the correctness of these statements, as Mr. Wagstaffe,† practising in Bermondsey, Southwark, and Lambeth, who says, that he saw very much of cholera; that he observed its course along the side of the river and that it prevailed principally in low and damp situations.

This is entirely in accordance with the history of its origin and progress in the country which may be considered as its birthplace; for all accounts from India agree in stating that it first breaks out and principally prevails in low and marshy situations, and particularly near the banks of rivers; that whenever a village or military station lies upon or near low, marshy, or damp ground, the occupants suffered from this disease in direct proportion to their proximity to such a situation; and it is constantly observed that when a regiment has been encamped, one part on high and dry land and the other part on a morass, or on the bank of a river, the former has remained healthy, while the latter has suffered severely from this disease.

A century ago Sir John Pringle, in his account of the diseases of the army during the campaigns in Flanders, made the observation that humidity and fog are not only themselves the direct causes of disease, but powerful agents in the transmission of any poison that may chance to be in the air. "It was observable,"

* App. No. 1, First Part. † App. No. 4.

he says, "that when the army made a small remove to form a line along a canal, or encamped on damp and marshy ground, the effect was seen in the sudden illness of the men;" and he instances many cases in which a very short exposure to fog was followed by an attack of violent sickness; as, at the village of Dinther, where "the meadows being every evening overspread with a fog which continued till next morning after sunrise, and which had the offensive smell of a foul ditch newly drained; the men were commonly taken ill in the night time;" and at St. Michael Gestel, where "foraging parties, being obliged to set out about four in the morning, and the meadows and marshes on each side of the road being, at that early hour, covered with a thick fog of an offensive smell (which appeared to be the chief cause of the sickness), though the party generally returned before noon, several among them were already in a fever, and some actually delirious; nay, a few on their way home were so suddenly taken with a phrenzy, as to throw themselves from their trusses into the water, imagining they were to swim to their quarters."

The whole of the evidence, however, appears to lead to the conclusion that it is the combination of impurity with humidity of the air which so powerfully predisposes to cholera; cleanliness being apparently capable of counteracting the influence of mere humidity: thus the remarkable exemption enjoyed by Holland from the visitation of cholera, is generally and probably correctly attributed to the scrupulous cleanliness of the houses and habits of the people.

2. That there is no evidence that cholera spreads by the communication of the infected with the healthy.

When cholera broke out in Cairo in 1831, two cordons sanitaires were established between Cairo and Alexandria, but they proved, as was anticipated, insufficient to prevent the disease from extending to Alexandria. On the 21st of August, two or three of the soldiers were seized with the disease; on the morning of the following day the cases had increased to 22, and by the afternoon of that same day they amounted to 45. Among these, one which proved rapidly fatal, occurred in the palace of his Highness the Pacha, who immediately embarked on board a frigate, some of his Court following his example, and others shutting themselves up in their houses, and taking the usual precautions for cutting off all communication with the other inhabitants. Within the space of five days after the disease broke out in Cairo, it had spread over the whole of Lower Egypt, making everywhere nearly equal ravages, and nearly, at the same time, infecting Mansoora, Fua, Alexandria, Rosetta, Burlos, Damietta, and all the towns and villages of the Delta.

It is stated by Dr. Lefevre, physician to the English embassy at St. Petersburgh, that when once cholera broke out in that city, a few days sufficed for its dissemination over the capital, and that

so widely and so generally as to preclude all idea of mere communication with infected persons, as the cause of its propagation, and this is confirmed by the reports of the English Commissioners, Drs. Russell and Barry.

A similar account is given of the manner of its spread in Dantzic.

At Vienna the disease broke out on the 13th of September; on the 14th it had extended to six quarters of the city, and on the following day it had spread through all the rest.

In Paris it was rumoured that a case had occurred in the Rue des Lombards as early as the middle of February, but this was doubted. Four cases, however, were observed in the interval between the 13th of February and the 26th of March, all of which occurred in the neighbourhood of the Seine, in the quarter de la Cité, and in the quarter de l'Hôtel-de-Ville. On the 27th six persons were attacked simultaneously; on the 28th, 22 more were seized, on the 31st the number had increased to 300, and out of the 48 quarters of Paris the disease had invaded 35. In 18 days after the first invasion of this plague, namely, on the 14th of April, there were from 12,000 to 13,000 sick, and 7000 persons had already perished. At this terrible period of the epidemic 1000 persons sometimes perished in a single day, and to be struck with the pestilence was in general to be dead in a few hours. "It was then," says the report of the Parisian Commissioners, "that the capital of France had become the prey of a terrible evil, against which art had in vain exhausted every resource, and the duration of which could no more be indicated, than its violence could have been foreseen. When in the streets there was constantly presented the painful spectacle of the sick dying or even already dead, borne on litters to the nearest hospital; or the still more distressing sight of enormous vans, beneath the gloomy curtains of which, when displaced by the wind, were visible the coffins with which they were laden; then terror and despair became boundless, and the inhabitants, believing themselves doomed to inevitable death if they remained in this place, fled precipitately from a city which they believed to be about to become their tomb.

"The rapid progress of the disease, which leaped at one bound the distance between London and Paris,—the sudden outburst, which no one was prepared to expect,—its extreme violence, hitherto without precedent in Europe, set at nought all calculation, and rendered all the precautions already taken insufficient. It became necessary, therefore, to have recourse to new measures: magistrates and central and local Commissions redoubled their zeal, and a band of good citizens co-operated with them. By order of M. Gisquet, prefect of police, the sewers and pools in the several districts were emptied and cleansed; infected alleys were closed up; others were paved; the odour of those cesspools which could

not be repaired on the instant was neutralized. The ditches of the Boulevards, which it seemed dangerous to disturb, were watered with chlorine; the pavement of the streets as well as the market places was watered with this liquid every day; the number of stand-pipes was increased; finally, the ditches of the Ile Louviers, a receptacle for dust and filth, were flooded with the waters of the canal St. Martin, which were flushed over them."

While the manner of the invasion and extension of this disease thus precludes all thought of its propagation by the communication of the infected with the healthy, there is another fact which is altogether irreconcileable with the notion of contagion, namely, that as no human means have succeeded in excluding it from particular spots, so no extent of communication with the sick has been able to carry it into other places. "In the north," says Monsieur Londe, the author of one of the most accredited works in France on Hygiene, "while three lines of troops have been unable to arrest its progress, it has often passed over large tracts without infecting any intermediate place, and without following collateral lines. At other times it has been concentrated on a population which has continued to keep up free communication with the neighbourhood without at all extending itself to that neighbourhood. In France, for instance, where communication with the infected has been everywhere entirely free, there are departments, parishes, towns, and even villages which have never had a single case of cholera, though these different localities have been sometimes inundated with persons who had fled from places devastated by the disease. Thus, according to M. Monfalcon, during the prevalence of cholera at Marseilles in 1835, Lyons alone received upwards of 10,000 immigrants from that town, and Lyons has never been attacked by cholera. Sometimes, also, portions of certain towns, though they maintained an unrestrained communication with surrounding districts decimated by cholera, were never affected in the slightest degree. At St. Petersburgh, one of the islands in the Neva enjoyed this complete exemption from the invasion of the disease, and this was also the case with the faubourg Leopoldstadt at Vienna. Hence the non-transmissibility of cholera in any manner whatsoever, appears to us to be a demonstrated fact."

Mr. Greenhow, after refuting the notion that it was imported into Sunderland by shipping, and stating that the strictest inquiries respecting the origin of the first cases, have failed to obtain the slightest evidence of their having arisen from any infected source, observes,

"That although cases have occasionally occurred having such proximity to each other, both as to time and place, as might lead to a suspicion of contagion, yet they would always admit of a different and more probable mode of interpretation, consistent with the broad fact, which is totally irreconcileable with contagion, that

numerous cases have occurred simultaneously at distant points, where no communication could by possibility have taken place.

"That when several members of one family have been attacked, it has usually been either so precisely or nearly at the same point of time as to forbid the belief of one having communicated the disease to another. And that the true principle of the occurrence of such plurality of cases is to be found in the common existence of predisposing causes, natural or acquired, and a common exposure to the efficient cause of cholera.

"That in the hospitals at Newcastle and Gateshead, where, were there such an agent as contagion, it must have been present in its most concentrated form, no case has occurred of illness arising from attendance on the sick, either in the persons of the nurses, the resident apothecaries, or the attending or numerous succession of visiting members of the medical profession.

"That the notion of persons being infected by the dead bodies of cholera patients appears equally unfounded, since such suspected cases are referable to other causes, and those most exposed to contact with the dead, as medical men, in pursuing post-mortem examinations, have not, in any instance, suffered."

With reference to the first appearance of the disease in Great Britain, Dr. Ferguson, Inspector-general of Hospitals, observes,—

"Amateur physicians from the Continent, and from every part of the United Kingdom, eager and keen for cholera, and more numerous than the patients themselves, beset and surrounded the sick in Sunderland with all the fearless self-exposing zeal of the missionary character, yet no one could contrive, even in the foulest dens of that sea-port, to produce the disease in his own person, or to carry it in his saturated clothing to the healthier quarters of the town where he himself had his lodging.

"I take it for granted that ships proceeding from Sunderland to Hamburgh could only be colliers, and that according to the custom of such vessels, they returned, as they do from the port of London, light. And I admit, that on or about the time of their return, cholera morbus, under the severe form which characterises the Asiatic disease, made its appearance in that port, presenting a fair *primâ facie* case of imported contagion, but as at the period of its thus breaking out in Sunderland, a case equally as fatal and severe showed itself in the upper part of Newcastle, ten miles off; another equally well marked, in a healthy quarter in Edinburgh; a third not long before in Rugby in the very centre of the kingdom, and a fourth in Sunderland itself, as far back as the month of August, as well as many others in different parts of the country; it became incumbent on the quarantine authorities, indeed upon all men interested in the question, whether contagionists or otherwise, to show the true state of these vessels, as well as of the cases above alluded to, and whether the cholera morbus had ever been on board of them, either at Hamburgh, or

during the homeward voyage, so as by any possibility they could have introduced the disease into an English port."

In the two remarkable cases already stated, that of the isolated village of Inver, where it swept away nearly one half of the inhabitants, not a single case occurred in the town of Tain, in the immediate neighbourhood; and in that of Upton-upon-Severn, not a single case of infection could be traced, either to contact with the living or dead body or with the clothing.

But, perhaps, the most striking and important demonstration in England of the fact, that cholera does not spread by contagion, was afforded by the town of Birmingham. In its near vicinity, in Bilston, seven or eight miles distant, with daily and hourly communication going on by road and canal between the two places, cholera prevailed more virulently than in any town of the kingdom. The people at Bilston were obliged to send over to Birmingham for coffins, as they could not be made fast enough in that town. The disease also prevailed in the townships around Bilston, but in Birmingham, with its 160,000 inhabitants, there was scarcely a single case of cholera originating in the town; the few cases that occurred there having been imported, especially along the canal, from Bilston; the persons having been clearly attacked by the disease in those localities, and then going to Birmingham, where the symptoms broke forth; but we are informed that upon a close inquiry not a single instance could be found where the disease had spread from the infected to the healthy. Birmingham is built, for the most part, high and dry, on a most absorbent red-sand stone, and is, with some exceptions, remarkably exempt from typhus.

Every witness examined by us appears to have arrived at the most clear and decided conviction from what was uniformly observed of its progress in the metropolis, that the disease did not spread from the communication of the infected with the healthy, excepting, indeed, one witness, Mr. French,* who states that he believes cholera to be no more contagious than typhus.

These witnesses concur in stating that the belief in contagion operated unfavourably both on the sick and the attendants. "I attended a gentleman," says Mr. Bowie,† "who died during the second outbreak of cholera, and who was in a state of great alarm during the attack, and for several days preceding it. I likewise attended a captain, the master of a Bridport trader, lying near the Hermitage. Whilst attending one of his boys, whose case was one of great severity, he used to look down from the deck into the cabin, and declare he would not go into it if all London were to be given to him for doing so. All his crew assisted in waiting upon the boy without suffering from the disease, while the captain, who had never gone near him, was attacked on shore."

"I daily see," says Mr. Hooper,‡ "the pernicious effects of

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* App. No. 7. † App. No. 1. ‡ App. No. 2.

their belief in contagion. I see patients affected with typhus and other epidemic diseases neglected, and even abandoned sometimes, by relatives and friends, and always by neighbours, from the apprehension that they shall themselves become the subjects of the disease. In reply to inquiries made to me, as to the nature of the disease with which their inmate or neighbour may be effected, I am always afraid to say it is a case of fever; for if I do, the patient is sure to be abandoned."

"Do you say sure to be abandoned?—A devoted friend may continue to assist and nurse at her own risk; but this is not common; it is an exception to the rule."

3. That cholera observes in its progess the laws of ordinary epidemics, being influenced by the same physical conditions, and attacking similar classes of persons.

When that change takes place by which certain diseases become epidemic, though science has not hitherto afforded sufficient light to guide us to the knowledge of the physical circumstances in which the change consists, it is a matter of universal experience that certain physical conditions promote both the intensity and the extension of such diseases. These conditions may be comprised in impure and humid air and unsuitable food, or—what more rarely occurs amidst a population, in which upwards of 24,000,000*l.* per annum, or more than five times the amount of the poors' rates, is spent in ardent spirits alone, and nearly an equal amount in tobacco and fermented liquors—want of means to obtain sufficient food. Added to these, are unsuitable or insufficient clothing, sometimes ill-constructed dwellings, and defective appliances for the regulation of warmth or protection against cold.

The want of sufficient and proper food, by diminishing the vital energy, and thereby the power of resisting external noxious influences, renders the body the easy prey of whatever causes of disease may surround it; but it is difficult to determine its exact share in predisposing to epidemic disease; because those who from ignorance, mismanagement, and attendant poverty are destitute of proper nourishment, are generally, from the same causes, the inhabitants of the worst localities. On the other hand, the dreadful extent to which entire classes of the population who have abundance of wholesome food, but who habitually live in impure air, suffer from certain epidemics, as, for example, artizans, and the lower class of shopkeepers, from the very pestilence in question, affords a demonstration that the habitual respiration of impure air is an incomparably more powerful predisponent to epidemic disease than that which has been commonly assumed as the main cause, namely, absolute poverty. The evidence of Mr. Bowie, and that of Mr. Taylor,* in relation to the means of healthful subsistence

* App. No. 9.

possessed by the population of Spitalfields, may be cited in exemplification of this conclusion. In the present state of most towns and cities, the number of persons whose constitution is enfeebled by want of food, compared with the number whose vital energy is depressed by want of pure air, is found to be an exceedingly small minority. We have little power to deal with the former class of predisposing causes, but we have complete power by arrangements which are known, and which involve large and manifold economies, to remove from the metropolis, and from every lane, court, and alley of every town, the sources that poison the air. Here then is the true field for exertion.

The disease which may be taken as the type of the entire class of epidemic diseases that infest this country is typhus fever. The *habitat* of typhus is that of the class; and the conditions which favour the spread of this disease, and which convert it into a pestilence, and those which locate to a great extent in these very places all other pestilences that come, and which give them their fearful fatality, are, as far as we have any knowledge of them, precisely the same.

It is now universally known that in the metropolis, as in every town and city, the places in which typhus is to be found, from which it is rarely, if ever, absent, and which it occasionally decimates, are the neglected and filthy parts of it; the parts unvisited by the scavenger; the parts which are without sewers, or which, if provided with sewers, are without house drains into them; or which, if they have both sewers and house drains, are without a due and regulated supply of water for washing away their filth, and for the purposes of surface cleansing and domestic use. The evidence that the track of typhus is everywhere marked by the extent of this domain of filth has been so often adduced that it is needless to repeat it; but the evidence that during the prevalence of cholera, this was also everywhere the precise track of this pestilence, is not so well known. With the steady approach of this formidable malady towards us, it is, in our opinion, of the last importance, that public attention should be directed to the evidence of this fact.

We have already shown that while cholera manifested a decided preference to follow the track of rivers and water-courses, it made those portions of this track which were at the same time the outlets of filth the chief places of its attack; and that therefore in towns and cities it was remarkably prevalent and fatal in the neighbourhood of sewer mouths. The instances adduced by Mr. Roberton to show that this was the case in the Lancashire towns are strikingly corroborative of the evidence given by the medical witnesses examined by us, who saw the first cases of cholera in the metropolis, and who were the most extensively engaged in attendance on the sick during the prevalence of the epidemic.

"In the very instance of the 'Felicity,'" says Mr. Bowie,* "it

* App. No. 1, First Part.

was given out that the cholera had been imported into the metropolis by that vessel; but the neighbourhood where this case occurred was one of the dirtiest along the river. What were called the 'bone vessels,' vessels employed to carry old bones for manure, usually lay there, and some of them lay there at that time. The stench was exceedingly sickening, and was perceptible at a great distance. Such was the recklessness of the crews of these vessels, that I have frequently seen them using bones as fuel, and cooking their provisions with them, the most offensive smoke penetrating, meantime, into the houses along the shore. Putrid carcasses of dogs and cats, and other inferior animals, likewise the refuse from the shipping in the neighbourhood, thrown into the river, or left on the muddy beach by the tide, were allowed to remain there, deteriorating the atmosphere, until removed by Nature's scavengers. The whole of the coast, extending from St. Katharine Docks to Wapping, was very bad, with the exception of a few houses at and near the entrance of the London-Docks."

In this same locality occurred the next cases of cholera, one of the sufferers stating that he had got up early one morning and gone on deck; that the smell from the bone vessels lying a-head was so bad that it made him feel sick, and that he had never been well since.

"The condition of the houses of the labouring population in this district, through which cholera spread with great rapidity, was," continues this witness, "extremely bad. It was the practice to pump the water out of the cellars which had got up into the houses by infiltration from the river, or more frequently flowing in through the house-drains from the sewers when the tides forced back the water into the house. The stench from the water pumped out from the cellars was often intolerable; so much so that I was accustomed to go out of the way to avoid it. Cesspools were general, the contents of which percolated through the substratum, and the river water percolating through the substratum carried with it the matter of the cesspools."

This witness continues:—

"Cannot you now pronounce with tolerable certainty in what places you will not find cases of typhus?—I believe I could; I could also tell very well in what places I should find typhus.

"In case cholera should re-appear, are these the places where you would expect to find it?—No doubt of it.

"During the prevalence of cholera, did you observe much fever?—None at all, and but for the presence of that disease, London was never less unhealthy than at that time.

"Then is it your opinion that cholera took the place of typhus, affecting the same class of persons, and being influenced by the same class of circumstances?—It is."

Dr. Murdoch * gives a similar account of the state of Rotherhithe. "In this district," he says, "open ditches received the contents of the privies, the privies hanging over the ditches; the paths

* App. No. 3.

in front of the houses were unpaved and filthy; some of the dwellings were wretched hovels. Typhus fever is always most prevalent in these filthy places, when in the neighbourhood at all; and were cholera to re-appear, it would follow the law of typhus and typhoid fever, and first visit such neighbourhoods."

Of Southwark, Mr. Leadam * says:—"This was certainly one of the districts the most severely visited by cholera in the metropolis. The disease prevailed chiefly in the filthy dens which we have about us, in the close courts and alleys. The cholera track and the typhus track in this district were identical."

Mr. Hooper † states, that in the parts of this district attended by him, the majority of those attacked were the inhabitants of the narrow streets and the close courts and alleys of the parish, living in filth, and breathing a confined and impure air. Many of their habitations had not even cesspools; the soil was seen oozing through the pavements of the courts. Where there were cesspools they were in very bad condition, seldom or never emptied. Within the dwellings there was no boarding to the floors of many of the houses, the inmates sleeping on the earth on a few shavings. "I will mention," continues this witness, "Three Tuns-court, in White-street, in which there are about 15 houses, and probably 150 inhabitants. There is but one privy, and that without covering. The fluid soil is running down the court in front of all the houses. Several of the houses are entirely without windows or floors, that is, without boards on the floors. I could adduce examples of other courts not quite in so bad a condition, but still deplorable. These are the constant abodes of typhus, and these were the places where cholera prevailed. Few or no cases of typhus were observed, while cholera was at its highest; this disease taking the place of typhus, attacking the same description of persons, and prevailing in the same localities."

"In the parish of Christchurch, in this same district," says Mr. Doubleday, ‡ "and in the neighbourhood of Broadwall, there are open sewers. At Brunswick-place there is another. In these neighbourhoods the cholera was unusually severe; in one row of houses, within two yards of the sewer, houses which are very miserable as regards size, ventilation, and means of cleanliness, the mortality was excessive; as many as five died in one house. When certain atmospheric conditions prevail and typhus arises, it is always found much more in these districts, and the result is more fatal. If cholera should revisit the metropolis, it would certainly be that the cases would there be more numerous and fatal."

"In Lambeth," says Mr. Wagstaffe, § "in the streets, courts, and alleys in which cholera principally prevailed, the drainage was extremely bad; the privies were often in the cellars. I have myself passed through two feet of water to get to the houses, being obliged to walk along planks; and the doorways of houses at the time of high-tide in Fore-street, Lambeth, being blocked up with

* App. No. 5. † App. No. 2. ‡ App. No. 8. § App. No. 4.

boards and plaster to prevent the water from getting into the dwellings. This state continues occasionally at the present time. Cesspools are general in the district, and I have often seen the soil from these cesspools swimming about in the water. Whenever typhus is prevalent in the metropolis, it is invariably found in these localities, and common fever is very apt in these places to assume a typhoid type. This is the case at the present time with several cases now under my care. Scarlet fever, measles, and small-pox also are very apt to become malignant here under certain atmospheric conditions. These localities, in which typhus is constantly present, are the very localities in which cholera chiefly raged. I have at the present moment many cases of fever in the very places in which cholera was most prevalent. This autumn diarrhœa and dysentery have also been prevalent there, and some cases were so similar to Asiatic cholera, that I have asked some of my professional brethren to go and see them; two of these cases were fatal. They had in fact all the characteristic symptoms—vomiting, diarrhœa, with rice-coloured evacuations, cramps, suppression of urine, the particular sunken countenance, giving the expression of age to the patient, with a livid or even blue colour. If cholera were again to re-appear, these would be the places which it would first visit, and in which it would be most prevalent and fatal."

Mr. Simpson,* of Bloomsbury, being asked with reference to St. Giles's, what description of persons, and in what localities, were the chief attacks of cholera? answers, "Precisely the same description of persons and in the same localities, where typhus, influenza, and scarlatina assume the putrid type."

With reference to the manner in which the inhabitants of these districts were supplied with water, Mr. Bowie† states that in his district "the supply was very bad; it was an intermittent supply from the water Company; it was distributed in courts by standpipes, on intermittent days. The fatigue of fetching it was so great that they only used it for purposes which they deemed of absolute necessity, such as cooking; they rarely bestowed much of it on their own clothes and persons. I remember it well, as a fact, that the water, from being kept so long, and absorbing the impurities of these places, smelt very bad. I know it to be a fact that the water for all domestic purposes was pumped into many of the houses from the parts of the river where the most abominable impurities abounded."

Mr. Hooper‡ states that "the inhabitants of the streets, courts, or alleys in the locality which he has described, are almost destitute of water; that even when water is to be got, these people are unable to obtain it without very great labour. The woman is always obliged to carry it up stairs, consequently she is very sparing in the use of it; and those stairs are common to all the families in the house, so that no one thinks it her duty to wash them. I have been often struck with the filthy state of the water

* App. No. 6. † App. No. 1, First Part. ‡ App. No. 2.

in the rooms; even that for drinking and other domestic use has an offensive odour, from having absorbed the foul air of the room, though, indeed, water for drinking, or even washing the hands, is seldom to be found; if I ask for it I have generally to wait till it is fetched. Then again, I often find a tub of exceedingly filthy water, which has been used over and over again, on the landing-place outside of the rooms, the odour from which is most offensive. It is also very common to find the clothes which have been washed in this filthy water drying in the room; the evaporation from these clothes I regard as most pernicious; and in the room in which the air is poisoned in this way, there may be two or three children ill in bed, or perhaps the father or mother ill with typhus fever."

The uniform testimony of the witnesses examined by us is, that although some old open sewers have been arched over, and some additional common sewers have been made, no real improvement to any considerable extent has been effected in their respective districts; and that almost invariably the additional sewers that have been constructed, not been supplied with a quantity of water sufficient to carry off their contents, and keep them clean, they not only do not accomplish any sanitary purpose, but, on the contrary, act as extended cesspools. Thus Mr. Wagstaffe* says, that in Lambeth, though some additional common sewers have been made, and the paving and cleansing in a few places are somewhat better, yet that a large portion of the district remains without any material improvement.

Dr. Murdoch† gives a similar account of Rotherhithe.

Mr. Simpson‡ says that some of the places in St. Giles's, where cholera most prevailed, and where fever still constantly prevails, remain in the same state of horrible filth—the constant residence of typhus, and every malignant disease that sweeps through the metropolis; and that as long as those localities remain without sewers, and the present sewers remain as they are, no permanent improvement can be expected; because when the wind blows in certain directions, the stench is thrown back through the privies and water-closets, and the supply of water being limited, accumulations take place beneath the kitchens, which taint meat, and therefore taint also the blood of the living.

Mr. Rendle, of Newington Butts, says, "I cannot hear that any improvement of any consequence has been made in this district of late years. I consider it just the place the cholera might ravage, and extend it to others; witness the number of bowel complaints I return."

Mr. Doubleday§ says that the worst places in his district remain without any amendment; that they are exactly in the same state, and that when certain atmospheric conditions prevail, and typhus arises, it is in those places it continues to be found, and that it proves most fatal.

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* App. No. 4. † App. No. 3. ‡ App. No. 6. § App. No. 8.

Mr. Hooper* being asked, "Have you any instance in your district (Southwark), in which improved drainage, supply of water, and ventilation, have been followed by a diminished susceptibility to epidemic disease," answers, "I am sorry to say that I know of no places in which any material improvement of any kind has taken place: in regard to drainage, supply of water, and ventilation, the district remains in the same wretched state."

Mr. Leadam describes some of the places in his district (St. John's district, Horsleydown), as being at the present moment "nests of filth." Accumulations of filth and of decaying vegetable matter cast out from the houses lie about in front of them. Many houses have no outlet, no privies, and those that have are connected with cesspools. Fever is never absent from these places; they are pests to the neighbourhood." "With all this as a foundation," he adds, "we could hardly anticipate the approach of cholera, but with feelings of alarm, as it was in those localities that the cholera of 1832 so extensively prevailed; and these localities are worse, from the time that has elapsed, than they were then; no improvement is visible in any of those places which lie out of the main street; and even in the main street close by my own house, namely, at No. 9, Bermondsey-street, that house and the half-dozen adjoining houses are a disgrace to any main street.

We have received from the Council Office, through Sir William Pym, a return, which we subjoin, of the total number of cholera cases in the metropolis, reported to the Board of Health in 1832. This return we have compared with a return of the number of deaths from fever in 1838, which was the first year in which a return was made, under the new registration, of the causes of death; and it was a year in which fever was epidemic. The examination of this Return will illustrate the general coincidence of the cholera track with the track of typhus of which the witnesses have spoken from particular cases within their own observation. On comparing in the 30 metropolitan districts (*see* Table III.), the proportion of deaths to the population from fever and from cholera, it appears that, in the districts where the deaths from fever were the highest, cholera was the most prevalent and fatal. This is shown among others by the returns from St. George's-in-the-East, Bermondsey, Southwark, Lambeth, Whitechapel, Stepney, and Bethnal Green. In some of these places, it will be seen, that the deaths from fever and cholera were nearly equal, as in Whitechapel. In other places, the excess on the side of cholera was somewhat greater; as in Bermondsey, Southwark, and Lambeth. But, on the other hand, there were places in which the deaths from fever absolutely exceeded those from cholera, as in Holborn, where the deaths from fever were 1 in 227, whereas from cholera they were only 1 in 594. In St. Pancras they were still further in excess, the deaths in this district from fever being 1 in 269, from cholera 1 in 933, and in

* App. No. 2.

Shoreditch still further in excess, being from fever 1 in 256, and from cholera 1 in 1203 of the population, so that in the first case the deaths from fever were more than double the deaths from cholera, in the second case more than treble, and in the latter case they were nearly five times the number.

Comparing the total amount of deaths from fever with that from cholera, in the two groups of districts, it appears that in the 15 districts in which the mortality was greatest, the deaths from fever were 1 in 237, and from cholera 1 in 253, whilst in the 15 districts of lowest mortality, from fever there were 1 in 494, and from cholera 1 in 358; the general average of the whole of the districts being from fever 1 in 319, and from cholera 1 in 296; so that the whole difference between the mortality produced by cholera, and that produced by fever, is under 8 per cent.

The Registrar-General obtains no return of the number of attacks; but the Fifth Annual Report of the Poor Law Commissioners contains a return of the number of fever cases that occurred among the pauper population of the metropolis for the same year (1838), as that from which the deaths from fever for the whole of the population in 20 metropolitan districts has been taken (*see* Table IV). This return does not indeed exhibit an accurate account of the whole number of paupers attacked with fever during that year; because it is well known that considerable numbers of these persons apply for relief to public dispensaries and hospitals; neither does it include any account of the number of cases of fever among independent labourers, artizans, and the humbler class of shopkeepers; or of any other of the classes immediately above the line of pauperism; though it is notorious, that as these persons live in the fever districts, so they form, together with the pauper population, the principal subjects of fever whenever this disease becomes epidemic.

From this return it appears, that in a population of 851,229, there were of in-door and out-door paupers, 77,186; and that out of this number of paupers, 13,972 were attacked with fever; whereas from the Cholera Return, it appears that out of a population of 1,489,500, only 11,020 were the subjects of cholera, being the total number of the registered cases of cholera occurring in the metropolis during the year 1832 (*see* Table I).

While the total number of attacks of fever is thus enormously in excess of the total number of attacks of cholera, the *absolute* mortality from cholera, is not very materially in excess of that from fever, being, as already stated, under 8 per cent.; but the *comparative* mortality of cholera is very large; nearly one-half of those that are attacked by this alarming disease inevitably perishing, the utmost range between its lowest and highest mortality being, that whereas in some cases there die only 1 in 3·6, in others there die 1 in 1·1.

The following are the tables we have been able to obtain from the former cholera returns, which, for reasons that will be obvious on inspection, we can only submit as approximations:—

TABLE I.—CHOLERA CASES in London and Vicinity, reported in 1832.

	Places.	Population.	Cases.	Deaths.	Recoveries.
Metropolitan Registration Districts.	Bethnal Green	62,018	304	170	134
	Bermondsey	29,741	516	210	306
	Camberwell	28,231	217	107	110
	Clerkenwell	47,634	143	65	78
	George, St., Hanover Square	58,209	125	74	51
	George, St., in the East	38,505	224	123	101
	Giles, St.	52,907	628	280	348
	Greenwich: Deptford	19,795	93	55	38
	Greenwich	24,553	94	54	40
	Woolwich	17,661	56	40	16
	Greenwich total	62,009	243	149	94
	Hackney: Hackney	3,846	5	5	..
	Hackney: Stoke Newington	3,480	5	3	2
	Hackney total	7,326	10	8	2
	Holborn	27,334	165	46	119
	Islington	37,316	60	39	21
	Kensington: Chelsea and Brompton	32,371	186	82	104
	Kensington: Fulham	7,317	24	8	16
	Kensington: Kensington	20,902	18	15	3
	Kensington: Paddington	14,540	85	29	56
	Kensington total	75,130	313	134	179
	Lambeth	87,856	565	337	228
	*London, City	55,798	614	359	255
	London, East and West	No return.			
	Luke, St., Middlesex	46,642	258	118	140
	Marylebone, St.	122,206	516	224	292
	Newington, Surrey	44,526	476	200	276
	Pancras, St.	103,548	186	111	75
	Poplar: Bromley	4,846	8	..	8
	Poplar: Poplar	16,849	179	101	78
	Poplar: Stratford	3,371	21	6	15
	Poplar total	25,066	208	107	101
	Rotherhithe	12,875	21	19	2
	Shoreditch	68,564	107	57	50
	Southwark: Christchurch	13,705	85	35	50
	Southwark: St. George the Martyr, St. Olave's, St. Saviour's	77,796	2,160	856	1,304
	Southwark total	91,501	2,245	891	1,354
	Stepney: Limehouse	15,695	183	83	105
	Stepney: Mile End	40,282	5	1	4
	Stepney: Ratcliffe	9,741	158	62	96
	Stepney: Shadwell	9,544	108	55	53
	Stepney: Wapping	3,564	28	24	4
	Stepney total	78,826	487	225	262
	Strand: St. Mary-le-Strand	2,052	28	8	20
	Strand: St. Paul, Covent Gard.	5,203	30	18	12
	Strand: Rolls Liberty	2,682	26	11	15
	Strand total	9,937	84	37	47
	Westminster: St. James, Sts. Margaret & John, St. Martin's	124,585	545	325	220
	Whitechapel: Botolph without Aldgate	3,453	275	100	175
	Whitechapel: Spitalfields	17,949	196	97	99
	Whitechapel: Tower and Liberty	713	30	10	20
	Whitechapel: Whitechapel	30,733	421	263	158
	Whitechapel total	52,848	922	470	452
	Total Metropolitan Districts	1,451,138	10,182	4,885	5,297
Not included in Metropolitan Districts, &c.	Bartholomew, St., the Great	2,923	9	6	3
	Brentford, Old and New	2,085	70	30	40
	Chiswick	4,994	21	18	3
	Highgate	2,172	6	2	4
	Afloat in River		270	139	131
	Hospital, Greville Street	Not known.	141	68	73
	Sundry Prisons		245	81	164
	Wandsworth and Clapham: Battersea	5,540	9	6	3
	Wandsworth and Clapham: Clapham	9,958	27	17	10
	Wandsworth and Clapham: Putney	3,811	15	9	6
	Wandsworth and Clapham: Wandsworth	6,879	25	14	11
	Wandsworth and Clapham total	26,188	76	46	30
	Total Metropolis and Vicinity	1,489,500	11,020	5,275	5,745

* Since the publication of the folio edition of the Report, it has been stated that the population of the City of London here given, which is correctly copied from the return received from the Council Office, is errroneous, and that the 614 cases occurred in the City, within and without the walls, comprising a population of 123,683. There appears, however, to be much uncertainty as to the correctness of this statement, and attention had already been called to the fact (in a note to Table III.) that the return received from the Council Office was incomplete.

Note.—The parishes and places from which returns of Cholera were obtained, have been arranged into the Registration Districts adopted by the Registrar-General, in order to facilitate comparisons with Fever cases, as shown by Table III. The places last-named above are excluded from the calculations, as not forming part of the Metropolitan Districts, or being otherwise defective in the returns.

Though cases of fever were always present in certain localities in the metropolis, yet several years commonly intervened between one epidemic season or year and another; but fever assuming a severer character and spreading more extensively than usual in 1838, fever has prevailed as an epidemic ever since. The admissions into the London Fever Hospital since April have exceeded by several hundreds those of any corresponding period; the hospital having been constantly full, and many applicants having been refused admission for want of room.

TABLE II.—DEATHS from TYPHUS in LONDON in each Week, and the Averages for each Quarter of the Years 1845, 1846, and part of 1847.

Weeks ending Saturday.	Deaths from Typhus.			Weeks ending Saturday.	Deaths from Typhus.		
	1845	1846	1847*		1845	1846	1847*
1st week	39	41	49	28th week	18	28	52
2nd ,,	27	37	39	29th ,,	18	29	64
3rd ,,	33	34	40	30th ,,	29	36	57
4th ,,	23	35	28	31st ,,	17	25	54
5th ,,	32	28	32	32nd ,,	18	23	55
6th ,,	24	37	28	33rd ,,	19	37	70
7th ,,	25 >28	24 >32	26 >34	34th ,,	22 >21	26 >31	62 >66
8th ,,	30	22	32	35th ,,	22	37	74
9th ,,	18	27	41	36th ,,	17	26	77
10th ,,	35	34	28	37th ,,	23	40	81
11th ,,	21	29	32	38th ,,	29	34	111
12th ,,	24	26	33	39th ,,	27	34	77
13th ,,	31	36	34	40th ,,	23	38	79
14th ,,	19	28	18	41st ,,	19	41	79
15th ,,	26	33	43	42nd ,,	22	45	93 >80
16th ,,	23	36	29	43rd ,,	33	61	78
17th ,,	23	23	41	44th ,,	28	55	73
18th ,,	26	23	40	45th ,,	31	47	80
19th ,,	22	15	34	46th ,,	31 >27	48 >48	
20th ,,	20 >24	25 >28	52 >44	47th ,,	29	58	
21st ,,	27	20	54	48th ,,	32	42	
22nd ,,	17	28	52	49th ,,	20	48	
23rd ,,	28	32	51	50th ,,	28	59	
24th ,,	29	38	44	51st ,,	34	34	
25th ,,	19	33	52	52nd ,,	28	43	
26th ,,	29	30	58				
27th ,,	14	28	61	Total .	1301	1796	

Weekly average derived from Deaths of 1842-3-4-5 and 6, and corrected for increase of Population to middle of 1846 . . . . . } 32

* The deaths in the district of Lewisham and sub-district of Hampstead added to metropolis for the first time in 1847.

The steadily increasing prevalence of fever in the metropolis is further shown by the Registrar-General's return of the weekly deaths from typhus during the last three years. From this Table (*see* Table II.) it appears that the weekly deaths from typhus in 1846 very generally and greatly preponderated over those in 1845, being in several weeks nearly double, and in some few more than double; that the deaths in 1847* were still more in excess of those

* Though the districts of Lewisham and Hampstead are included for the first time this year, the deaths from fever in these districts are too few to affect the comparison.

in 1846, being in numerous instances considerably more than double the number in the corresponding weeks of 1846, and in one instance more than treble; and that generally from the month of August of the present year the mortality has been considerably greater than at any previous period since the commencement of the registration. It is clear, therefore, that whatever may have been their intensity in former years, the causes of epidemic disease continue to operate in the metropolis with unabated and even with increased force at the present time; and the reasonable inference to be deduced from this fact is, that were cholera to re-visit it at the present time, with the existing predisposition to epidemic disease, it would come at a period peculiarly favourable to its extension.

TABLE III.—CHOLERA.

	Districts.	*Deaths from Fever in 1838 to Population.	†Cases of Attack of Cholera in 1832, to Population.	†Deaths from Cholera in 1832, to Population.	Proportion of Deaths to Cases of Attack of Cholera.	Average of each Group.			
						Deaths from Fever in 1838	Attacks of Cholera in 1832.	Deaths from Cholera in 1832.	Deaths to Attacks of Cholera.
		1 in	1 in	1 in	1 in				
15 Districts in which Deaths from Fever in 1838 were Highest.	St. Saviour and St. Olave	160	45	114	2·5				
	Whitechapel	165	57	113	1·9				
	East and West London	206	..	..	..				
	Bermondsey	206	58	142	2·5				
	St. George-in-the-East	208	172	313	1·8				
	Holborn	227	166	594	3·6	1 in	1 in	1 in	1 in
	Bethnal Green	239	204	365	1·8	237	116	253	2·1
	Shoreditch	256	641	1203	1·9				
	Westminster	260	229	384	1·7				
	St. Giles	261	84	189	2·2				
	St. Pancras	269	557	933	1·7				
	Stepney	288	162	171	2·2				
	Rotherhithe	302	613	678	1·1				
	Greenwich	304	255	417	1·6				
	St. George, Southwark	321	36	91	2·5				
15 Districts in which Deaths from Fever in 1838 were Lowest.	St. Martin	352	228	385	1·7				
	Lambeth	396	155	261	1·7				
	Poplar	412	120	234	2·0				
	St. George, Hanover Square	424	466	786	1·7				
	St. Luke	458	181	395	2·2				
	Strand	463	118	270	2·3				
	Clerkenwell	478	333	733	2·2				
	Marylebone	479	237	546	2·3	1 in	1 in	1 in	1 in
	City of London	507	91	155	1·7	494	183	358	1·9
	Islington	518	622	957	1·5				
	Kensington	522	240	561	2·3				
	Camberwell	638	130	264	2·0				
	Newington	688	94	223	2·4				
	St. James, Westminster	781	229	385	1·7				
	Hackney	999	733	916	1·3				
	Average of Totals	319	142	296	2·0				

* Taken from the Second Annual Report of the Registrar-General, p. 201.
† From Returns of Cholera Cases made to the Privy Council Office.

Note.—No Returns of Cholera Cases appear to have been made to the Council Office from the East and West London Districts, and portions of other districts, comprising altogether a population of about 160,000.

TABLE IV.—CHOLERA.

PROPORTIONS of ATTACKS and DEATHS, of FEVER and CHOLERA, in 20 Metropolitan Districts.*

Districts in which attacks of Fever amongst the Pauper Population, in 1838, were—	Metropolitan Districts from which Returns of Fever were made in 1838.	Number of Paupers relieved.	Number of Paupers attacked with Fever.	Proportion of Paupers attacked with Fever in 1838, to Total Number of Paupers.	Proportion of Cases of Attacks of Cholera in 1832, to Population.†	Proportion of Deaths to Population.		Average of each Group.			
								Attacks of		Deaths from	
						In 1838, from Fever.‡	In 1832, from Cholera.†	Fever.	Cholera.	Fever.	Cholera.
				1 in	1 in	1 in	1 in				
Highest.	St. George Southwark	1,467	1,276	1·15	36	321	91				
	Whitechapel	5,856	2,405	2·4	57	165	113				
	Bethnal Green	3,632	1,209	3·0	204	239	365				
	Holborn	2,339	705	3·3	166	227	594				
	Lambeth	7,911	1,658	4·8	155	396	261	1 in	1 in	1 in	1 in
	Camberwell	1,158	238	4·9	130	638	264	3·4	85	263	185
	Rotherhithe	1,745	356	4·9	613	302	678				
	Bermondsey	3,000	593	5·0	58	206	142				
	Hackney	2,620	428	6·1	733	999	916				
	St. Saviour's	1,856	294	6·3	54	160	136				
	Stepney	8,596	1,348	6·4	162	288	171				
	Strand	1,692	231	7·3	118	463	270				
	St. Olave's	1,949	264	7·4	36	160	91				
	West Ham	3,041	326	9·3	..	626	..				
	Kensington	6,114	573	10·7	240	522	561				
	St. George-in-the-East	6,869	627	10·9	172	208	313	1 in	1 in	1 in	1 in
	Wandsworth and Clapham	2,553	234	10·9	345	573	569	9·5	157	324	326
	Poplar	6,039	520	11·6	120	412	234				
	Greenwich	6,607	522	12·7	255	304	417				
Lowest.	St. Martin's	2,142	165	13·0	228	352	385				
	Total	77,186	13,972	5·5	110	291	234				

* Taken from the Fifth Annual Report of the Poor Law Commissioners, 8vo., p. 162.
† From Returns of Cholera Cases made to the Privy Council Office.
‡ From the Second Annual Report of the Registrar-General, 8vo., p. 201.

From the whole then it appears, that though cholera presents a much more alarming aspect than fever, from the inevitable destruction of the large proportion of those whom it attacks, and from the rapidity with which it proves fatal, yet that the mortality from both is equalized by the speedy exhaustion of the powers of cholera, and the persistence of fever in the localities where it has originated.

Difference of social grade less exempts the individual from the attack of cholera than of fever, and cholera more often, and apparently more capriciously, bursts its usual boundaries, and attacks the inhabitants of comparatively healthier districts, amongst whom it then proves little less mortal than when it ravages its accustomed haunts. If, as is justly observed by the Registrar-General, in the present social condition of the civilized world, the vast populations of different and distant nations are intimately united; if it be true, that were the health of India sound, Europe might be safe, and hear no more of the epidemic which is now traversing

Russia; if the lives of thousands in England depend on the condition of the pariahs of Jessore,* much more in one and the same town or city must the health of the wealthiest portion of the inhabitants depend on the salubrity of the poorest. By past experience, we are taught that if the Asiatic cholera should again appear amongst us, no district would be secure from its ravages, and although those in which the system of sewerage and cleansing is the worst would be most liable, the nidus so afforded would be a source of peril to all classes.

Before giving the results of our inquiries into the most efficient and economical plans of sewerage and cleansing, in their relation as the main preventives against the Asiatic Cholera, we shall advert to measures alleviative of its attack, since this may require to be met before the effective proceedings of prevention can be carried out.

We have already stated that the Central Board of Health in 1832, recommended that a number of steady men proportionate to the districts in which they are to act should be appointed to lime-wash and purify, under the direction of medical authority, such apartments as may be pointed out by the Inspectors of the local Boards, and we are of opinion, that by some modification of this plan, an efficient agency might be formed for the thorough cleansing, both of particular localities, and of individual houses. Of the nature and extent of the additional arrangements which may be necessary, we are, however, unable as yet fully to judge, not having received a sufficient number of returns to the circulars we have addressed to the medical officers, and the Board of Guardians of the metropolis.

The measure of alleviation chiefly relied on during its last visitation was the establishment of district cholera hospitals; but the experience of the results of these establishments is by no means favourable to their re-adoption, except under particular circumstances and modifications. The prostration of all the vital powers which characterises a severe attack of cholera is often so extraordinary that the mere assumption of the erect position for a few minutes appeared often to deprive the patient of the slightest chance of recovery. The medical testimony is uniform in representing the fatigue of removal as highly injurious in great numbers of instances. It is often strikingly so in the advanced stage even of typhus. It not unfrequently happens that when a patient is removed to the fever hospital in an advanced stage of this disease, on opening the door of the carriage in which he has been conveyed he is found dead; and still more frequently it occurs that when he has not actually expired before he reaches the ward, and is placed in bed, he is cold, pulseless, and insensible, and never rallies, notwithstanding all that can be done to restore ani-

* The epidemic cholera, which reached England in 1831, broke out at Jessore, near Calcutta, in 1817, and destroyed 10,000 persons.

mation. In typhus this extreme debility does not take place for many days; often not until the end of the second or third week; but in a severe attack of cholera it occurs in two or three hours, and is sometimes present, in its highest degree, before there is time for the medical attendant to reach the bed-side of the patient. This circumstance places the extensive employment of any remedy which involves exertion, or even slight motion, out of the question. The medical witnesses who have had the greatest experience on this subject give the following statements as the results of their observation:—

Mr. Bowie* is asked—

What were the public means of alleviation adopted?—Removing the sick to cholera hospitals.

What was the character of the hospitals that were provided?—They consisted of dwelling-houses, taken for the purpose of affording temporary accommodation; the one that came particularly under my notice was very badly ventilated, and situated in a bad locality; that is, close to the Hermitage, and near the bone-vessels already spoken of.

What was your impression as to the benefit derived from those temporary hospitals?—That they did no good, but much evil. The cases that were treated, as far as I had an opportunity of observing, at their own houses, however wretched those houses might be, did far better. For example, in the particular hospital to which I have just alluded, of those sick two only out of eleven recovered; whereas out of 21 or 24 treated at their own houses only three died. The very fatigue of removal seemed to me to do much harm. I have known the mere circumstance of patients sitting upright in bed in their extremely feeble state, reproduce the worst symptoms of the disease. Some of the Commissioners, in the practice of their profession, must have observed a similar result in advanced stages, even of common fever.

Mr. Hooper† is asked—

What were the means adopted as measures of alleviation during the prevalence of cholera in your district?—A local Board of Health was appointed, consisting of persons who had passed the office of church-warden or overseer; the vestry clerk assisted them as the clerk to the Board, and the two parish surgeons, Mr. Evans and myself, undertook the medical duties. This Board engaged an isolated house, situated opposite Bethlehem, completely surrounded by a wall. The Board fitted up the hospital with beds and other necessaries for the reception of cholera patients.

From what you saw of the effect of this cholera hospital, what was your impression as to its influence on the disease?—Little or no advantage was obtained in the cure of the disease, although every suggestion made by science at the time was put into operation there; and the poor had certainly many comforts and appliances which they could not obtain at their own homes. As I have already stated, the mortality was far greater in the hospital than in private dwellings.

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* App. No. 1, First Part. † App, No. 2.

Mr. Wagstaffe * says—

It is certain that the disease proved more fatal in those hospitals than in private houses, however poor.

Dr. Wright † is asked—

What was the result of your observation as to the beneficial result of the cholera hospital?—We had a very efficient staff; that is, very efficient comparatively; we had the means of giving much greater attention to the cases than the poor could have received at their own houses; and I certainly think some degree of benefit was experienced by this alteration. I should, however, deprecate the removal of a person in cholera in the stage of collapse; and, indeed, unless in cases of extreme destitution, I think they would have a better chance of recovering if treated at their own houses.

Little advantage can be expected from a measure of relief to which the classes who are to be benefited have a decided aversion; and it is certain that the poor entered these hospitals with reluctance and regarded them with a degree of terror which must have greatly diminished their chance of doing good.

Mr. Wagstaffe * says—

They were very unwilling indeed to go.

Dr. Wright † states—

They said they were going there to be slaughtered.

Mr. Hooper ‡ says—

In consequence of the number of deaths that took place there the hospital obtained a bad reputation, and many positively refused to go. Still the hospital was generally full, partly from those who were quite destitute of friends, and partly from those who were sent there by families that were afraid of contagion. But they had no faith in the cholera hospital, and entered it with the greatest reluctance. My colleague and myself, who were attached to this hospital, lost nearly all our practice at the time, for the poor said we killed them, and the better classes were afraid we should kill them by contagion.

On the other hand the same witnesses express a decided opinion that these very classes would willingly co-operate in carrying out the essential measures of prevention.

Mr. Hooper ‡ is asked—

Do you think the description of persons who now live in those places, and who would probably become the first victims of cholera, should it again visit the metropolis, would appreciate the value of these means of prevention?—I am persuaded the great majority of them would.

The persons who reside in the streets and courts in your district appear to be among those that live in a state of the greatest filth and wretchedness to be found in the metropolis. Do you think that even those persons would avail themselves of the means of greater cleanliness, if they were afforded them?—I think they would to a very considerable extent. I think the fault is not in the people, so much as in their want of means.

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* App. No. 4. † App. No. 10. ‡ App. No. 2.

You have had many opportunities of becoming acquainted with the dispositions and habits of the poorer classes, what is your opinion as to the effect which the general adoption of the means of prevention compared with the adoption of the means of alleviation would have upon their minds?—I think the means of prevention, that is, the means of putting their localities and houses into a cleaner and more wholesome state, would have the best effect upon their minds, and that they would enter into these measures with great alacrity. Certainly they would do so if they understood that they were adopted with a view to prevent cholera or any other epidemic disease. They would readily assist in carrying out any measures suggested for their protection and safety against that disease.

Mr. Bowie* is asked—

In case such a calamity were to happen as the return of the cholera, if the people saw that combined and systematic means were taken by public authority to make the places in which they live as clean and wholesome as the main streets and great thoroughfares of the town, and particularly to afford them a constant supply of water, not only sufficient for their domestic use, but also to keep the surface of their lanes, courts, and alleys clean, to wash away their filth, and to cleanse their privies and cesspools, do you think that such measures would give the poorer classes confidence, and prevent that fear and terror which you regard as powerful predisposing causes of the disease?—I think it would be attended with a highly beneficial effect. On the former visitation of cholera, they looked on what was attempted for their relief with suspicion and apprehension; and that especially was their feeling with regard to the plan of placing them in separate hospitals.

From the knowledge which the great intercourse you have had among the poorer classes must have given you of the circumstances which influence their minds and feelings, do you think that they would appreciate the value of those preventive measures, and that such measures would have a beneficial influence on the internal economy of their houses, and in promoting habits of internal and personal cleanliness?—I think it would operate very beneficially in this way.

Then from what you have observed and know of the dispositions and intelligence of these classes, you do not coincide with the popular notion that they love dirt, and that they cannot be trained to habits of cleanliness?—I do not. I think this is a most erroneous opinion, and has been most completely refuted by the circumstance of the bathers and washers, and ironers of clothes in Glasshouse-yard, as by the fact of there being such a cleansing and whitewashing of houses, rooms, and courts, in Rosemary-lane during 1828, when pails and brushes were lent to the poor, and a present made to them of whitewash, that to those formerly accustomed to some of the black dirty-looking places it seemed almost as if a snow-storm had taken place. And the same inclination for cleansing their apartments was again manifested last year.

Mr. Wagstaffe† is asked—

If general and systematic measures of prevention were adopted, do you think the poorer classes would place greater confidence in them,

* App. No. 1, First Part. † App. No. 4.

and co-operate in carrying them out more readily than experience has shown they did with reference to the measures of alleviation which were proposed?—Yes, I think they would most decidedly. If, for example, comprehensive and efficient means were taken to cleanse the surface of their streets and courts, to wash out their cesspools, to supply them with abundance of water for cleansing the interior of their houses, and for the immediate removal of all descriptions of filth, I think they would have more confidence in measures of this kind than in anything which was formerly suggested or tried for their relief.

And do you think they would co-operate in promoting the success of such measures?—I feel very confident that they would.

Experience having thus shown that cholera hospitals failed in accomplishing their object, we would recommend that the best provision practicable should be made for rendering effectual assistance to the individuals who may need it at their own houses. This, in our opinion, would be best effected by the selection of proper persons, who may be instructed as nurses, and engaged to devote their whole time to attendance on the sick at their own habitations, under the directions of the medical officer. Prompt assistance might thus be given to the patient without subjecting him to any risk from bodily fatigue, and without anything being done calculated to excite apprehension or alarm. At the same time the curative measures employed by the medical attendant would be administered under circumstances peculiarly adapted to ensure their success. Instances have been brought under our notice in which the treatment of the sick without removal, and under the superintendence of a competent nurse, was attended with the best effect both on the patient himself and on the people about him. Thus Mr. Bowie* says—

I saw one striking example of the advantage of non-removal. A captain of a large vessel lying near the West India Docks called upon me one morning. He stated that two or three of his seamen had been attacked with cholera, and sent to the cholera hospital-ship at Limehouse, where they had died. That another of his men—to the best of my recollection his mate—had been seized with the disease, and that all the crew had threatened to leave the ship if he died too. Under these circumstances, he said he had been recommended to apply to me to advise him what to do. I at once told him I did not at all approve of cholera patients being subjected to the fatigue of removal. He then asked me if I would take charge of the sick man, which I agreed to do. Taking a man with me upon whom I could place dependence, I went on board. The case was a severe one, quite as much so, it was said, as any of the others who had been removed. My patient recovered; the alarm ceased; all the seamen who had left the ship returned on board, and not another case of cholera occurred in that vessel. So great was the panic at the time, that the attendant I left on board told me there had been no one but himself and the patient in the ship for several hours.

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* App. No. 1, First Part.

The adoption of the principle here indicated, that of sending competent persons to attend the sick, under medical direction at their own abodes, would be attended with this further advantage—that all the means recommended for cleansing the interior of the house, and for maintaining the atmosphere of the sick room in the highest attainable state of purity might be most efficiently carried out by the same agency.

With respect to medical assistance, we may observe, that since the last visitation of cholera considerable progress has been made in the organization of the local administration for relief in the metropolis, calculated to meet the recurrence of that event. The service of the medical Union officers, however wide the room for improvement, is yet more efficient than the parochial medical service resorted to on the former occasion, especially in the extent and regularity of attendance on out-door patients; and the Union medical officers might be aided by the relieving officers.

Though, for the reasons just assigned, we deprecate the removal of cholera patients to separate cholera hospitals, yet, should the pestilence become prevalent, cases will probably occur of such extreme destitution, in abodes so exceedingly unfitted for the curative treatment of the sick, that some better provision must be made for them. To send cholera patients to houses already crowded, would be obviously improper; but the new Union houses have generally separate fever wards; and where the isolation is sufficiently complete, it is possible that these fever wards might be adapted for the reception and treatment of such persons as it may be indispensably necessary to remove from their own abodes. Where there is adequate provision for fever cases, there will probably be sufficient provision for cholera cases; because, as has been shown, fever is always more prevalent than cholera; and, as far as we yet know, when cholera becomes epidemic, fever ceases to be so. But we do not feel that we are in possession of sufficient information to offer any opinion on the kind or degree of accommodation which existing establishments are capable of affording to meet the contingent necessity. We think, however, that this information should be obtained, and we therefore recommend that those establishments should be immediately inspected, by officers specially conversant with warming, ventilation, and other structural arrangements, to advise and report upon the alterations, adaptations, and additions requisite, in case the necessity for them should arise.

In our opinion there is but one safeguard against this malady, as against other diseases of the same class. That safeguard consists in sanitary arrangements; and sanitary arrangements to be efficient must be such as will secure the purity of the atmosphere, particularly by the immediate and complete removal of all filth and refuse, and that not only from the principal squares and thoroughfares, but also from the streets, courts, and alleys of the

lowest portion of the population. But this requires a general and proper system of street and house drainage, and a supply of water sufficient for keeping the drains and sewers clean, for surface cleansing, and for domestic use. Were the arrangements and the administration for cleansing thus complete, we might still not be able to obtain an absolute exemption from the visitation of cholera, but we should have done what might and must be done to deprive it, should it come, of the means of support and strength.

The whole tenor of the evidence which has come before us shows that it is only by measures of prevention that we can hope to obtain any real protection from this disease, and that no measures of alleviation can materially avail against a malady which almost sets at defiance the resources of medical art, which begins and ends its mortal course in a few hours, and which destroys one-half of those whom it attacks.

The chief measures of prevention on which reliance can be placed are arrangements for cleansing and ventilation; but cleansing and ventilation, to accomplish sanitary objects, must be combined operations, and must be skilfully performed. If the external atmosphere is not maintained in a state of purity, the ventilation of houses may be the very means of producing and aggravating disease; and instances have come before us in which the external air in certain ill drained, badly cleansed, and confined streets, courts and alleys, is in so offensive a state that the inhabitants are obliged to close up their doors and windows, and to exclude the air by every means in their power, in order to avoid the annoyance of a constant nuisance.

The overcrowding of the living without due attention to ventilation, appears, when carried to a great extent, to create a nidus of disease, apparently without the influence of the miasma from decomposing filth. Overcrowding, however, is so rarely found in this country apart from filth, that it would be difficult to determine here the seperate influence of each. The Commissioners who investigated the cholera track at Paris were disposed to ascribe great influence to the predisposition to disease from overcrowding in ill-ventilated residences. They cite the instance of Breslau, where the separation of overcrowded populations was added to the other sanitary measures chiefly of cleansing; and this measure of separation, if it did not extinguish the epidemic, at least promptly diminished its ravages.

To illustrate further the efficacy of separation, they give an instance of two companies, or 300 soldiers, who were crowded into a guard-house, sufficient only for half that number. "The windows were so constructed, as to render the renewal of air difficult and its circulation impossible. The cholera spread amongst these crowded men. In the first days of April, 17 were attacked, and 11 killed. Haste was made to separate the two companies, who ought never to have been brought together. From

that moment, the violence of the epidemic was arrested in that guard-house."

The evidence as to the preventive efficiency of cleanliness is everywhere very cogent. It was remarked that the German colonists in Gallicia, who are distinguished by habits of regularity and cleanliness from the Sclavonic population, were also distinguished amidst that population by an immunity from cholera.

There appear to be no available legal means for the immediate prevention of overcrowding; all we can do is to point it out, as a source of evil to be dealt with hereafter.

External and internal ventilation, however, may be promoted, and we may, by a proper system of cleansing, diminish the impurity of the confined air which the overcrowded population are compelled to breathe.

Of the unskilful manner in which the operation of cleansing is sometimes performed, and as a proof that from ignorance of the proper mode of accomplishing this object the very evils may be extended and increased, which it is the intention to prevent, Mr. Bowie,* gives the following instance—

What were the means adopted in your district to improve its cleanliness?—Cleaning the drains, and the surface of the streets.

Were any means taken to remove the filth?—Yes, but this was done very unskilfully, and under the influence of great alarm. Cesspools were emptied; drains and sewers opened and cleaned out. The contents of the drains and sewers, if not of the cesspools likewise, were accumulated on the streets, and left in small heaps, for the convenience of cartage, opposite houses where patients at the time were laid up with cholera. This matter was highly offensive when first placed on the surface, and produced, in some cases, an intolerable stench; so that I thought the very means taken to lessen the disease tended to increase the evil. The stench from these heaps being peceptible in the houses of patients labouring under cholera at that very time.

From what you relate, from the aggravation of the evil which you represent followed the unskilful attempts at cleansing on the former appearance of the cholera, may we conclude that preventive means for the future should be systematic and comprehensive?—Yes; and they should be adopted at once; and you may be quite certain that, if cholera do not come, the public will have the benefit of them in the prevention of typhus.

On the other hand, the same witness gives an example of the beneficial effects of sanitary regulations, although very imperfect, when tried upon one of the worst conditioned populations—the occupiers of a common lodging house, situated in one of the most contaminated localities. After having described the means adopted to secure effective cleanliness as well as ventilation in the model lodging house in Glasshouse-yard, Mr. Bowie† is asked:

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* App. No. 1, First Part. † App. No. 1, Second Part.

What has been the result of the ventilation, as practised in the lodging-house?—The absence of unpleasant smells, the possession of an agreeable temperature, and an almost total exemption from febrile disease.

What is the state of health as compared with that of the adjacent population?—Whilst fever has been prevailing to a very great extent in Glasshouse-street and its adjacent courts and alleys, and the verdict of a coroner's jury has been given that disease and death have been the consequence of breathing impure air, there is not at present an individual under medical treatment in the building, nor has there been a single case of fever there for upwards of four months. The only deaths which ever occurred among the lodgers were two children, labouring under hydrocephalus internus when they were admitted, and an aged mutilated seaman, who had long been affected with hydrothorax and disease of the heart.

Judging from your present experience of the habits of the labouring population, do you believe it will be practicable, with available appliances, to put an end to typhus originating spontaneously in other dwellings?—I believe that it might be as completely put an end to in houses, villages, and towns, as the ague has been in many parts of the country where it usually prevailed.

In the cases which he describes, if the refuse had not been removed in suspension in water, and if the cesspools and drains had not been trapped, the ventilation would often only have carried rapidly through the dwelling a greater quantity of impure air.

The correctness of the above conclusion, as to the dependence of typhus on defective sanitary arrangements, and the possibility of removing this disease by improving those arrangements, is confirmed by the observation and experience of other witnesses. Thus Mr. Liddle, the medical officer of Whitechapel Union, states, "that Hairbrain-court consists of 13 houses; that in this court he has attended 22 cases of typhus within the last six months; that during the prevalence of fever, this place was without drainage and without water, and very badly paved and cleaned; but that recently "it has been drained into the new sewer in Blue Anchor yard," and that since this was done not a single case of fever has occurred in this court. In like manner in Cooper's-court, which consists of 12 houses, he has attended 29 cases of fever within the last six months; the condition of this court was precisely similar to that of Hairbrain-court; but Cooper's-court having been drained, fever has taken its departure from this place also. This witness further states that many of the cases of fever which have come under his notice during the present epidemic, having been removed to the workhouse, had recovered in that establishment; but that on returning home and again breathing the poisoned atmosphere of the place, they had relapsed in a few days, and it has been necessary to remove them a second time.

Taking the works of cleansing as they now are, the preventive measure to which those works may be immediately applied with

the greatest advantage is that of flushing. But to the general and effectual application of this most important operation, the state and separation of the several districts under the District Commissions, presents itself as an insuperable obstacle; and, in fact, the operation of cleaning out the sewers by flushing them with water is in systematic use in only one of the upper districts, the Holborn and Finsbury district.

One district may flush its sewers, but the operation will be at many points only a removal of a portion at least of the refuse into the sewers of the adjacent districts, unless the operation be continued through the intermediate districts to the outfall. The lower districts complain of being encumbered by the flushing operations in the upper districts.

In the lower districts, which are flat, there are generally accumulations of refuse, and if in an upper district, which is under a separate jurisdiction, a part of the line of sewer is flushed to keep it free from deposit, the effect upon the lower district in which the flush exhausts itself, is to disengage more copiously the offensive emanations, for a time, by disturbing and adding to the deposit there, without removing it. Whilst the sewers of one district are left unflushed, or uncleansed, the emanations are driven by the wind into other districts, particularly from the deposits at the mouth of sewers in the lower to an upper district. When the sewers in the Holborn and Finsbury division have been clean flushed, it is stated that the inhabitants of that district, even up to the New River Head, have been annoyed by the currents of offensive gases up the sewers from the accumulations in the lower districts, where the same cleansing operations have not been carried on. For obvious reasons, additional supplies of water would require to be provided in the upper districts, and regulated, for application throughout the whole lines to the outfalls, without staying for separate and intermediate co-operation.

Arrangements connected with the principle of flushing, may be immediately applied to the draining of courts and alleys, and the rapid and safe removal of decomposing refuse; but such extensive and effectual cleansing can be effected only by operations superintended by one competent executive body.

With the agents of such a body, voluntary associations of district visitors, or local Boards, might co-operate with effect in carrying out measures for the removal of nuisances.

Under such an authority, competent officers, now employed under the district Commissions, would at once act with confidence in the exercise of an increased and efficient power, and submit views of detailed measures of relief or prevention which might be speedily tested, and if found efficient, be immediately put in operation throughout the whole of the metropolis. They could, without confusion as to districts, make early agreements with the several water companies for the necessary supplies of water. At all

events, the cleansing operations would be thus more safely and extensively carried out than they were in 1832; and we have had detailed measures placed before us, which induce the belief that, with the application of proper supplies of water, cesspools and privies in the worst localities, and the collections of filth in their dirtiest courts and alleys, might be promptly and safely removed, and that in this manner highly important and extensive preventive effects might in a few weeks be produced. And these effects we have ground for confident expectation, if the apprehension of the return of cholera should be dissipated, will be no less important in arresting the progress of typhus and of other diseases.

Having compared the condition of the districts of the metropolis that were visited by cholera in 1832, with their present condition, and closed that special inquiry, we took up the inquiry into the administration of the drainage works at the points at which they were left by the Commissioners of Inquiry into the means of Improving the Health of Towns.

A primary objection raised under the sanitary inquiry to the system of drainage carried out in the metropolis was, that it retained and accumulated decomposing refuse in the sewers. Any system which does this effects the result which sewers were intended to prevent. In the evidence given before the Commissioners of Inquiry into the means of Improving the Health of Towns, the means of remedy were pointed out and demonstrated. The chief means indicated were such alterations of the forms of house-drains and sewers as would increase the rate of flow of the sewer water and diminish the amount of deposit, and keep them clearer with the existing supplies of water; but it was also proved and urged that for the perfect attainment of these objects the command of artificial supplies of water was requisite. It may be averred that the principles of these remedies were demonstrated with a degree of clearness which admits of no misapprehension by well-informed minds earnestly directed to the attainment of the object. One of our first topics of inquiry was how far these expositions of evils and principles of remedies, which had now been made known several years, had influenced the subsequent administration of the authorities charged with this class of public works in the several districts.

We find that two Acts have been obtained, the one for the Surrey and Kent Commission of Sewers, to give the Commissioners greater powers, and the other for the Westminster Commission; and that the Court of Commissioners for the Tower Hamlets, and that for the Holborn and Finsbury Division of Sewers have proposed to apply for local Acts to carry out such improvements as they conceived were required to meet the public wants and complete their works. Now, neither the Acts obtained, nor the measures sought for, up to the time of our examinations of the witnesses, contain any application whatsoever for the supplies of water

requisite to make the sewers act properly. Mr. Roe, the Surveyor, and Mr. Stable, * the Clerk of the Commission in which the most important improvements have been introduced, the Holborn and Finsbury Division of Sewers, were asked—

(To Mr. *Roe.*) What may be the probable expense of the works you have at this time under consideration?—12,254*l.*; besides which, a very large sum of money will be required for the drainage of courts and alleys not yet ascertained; and applications have been made for the extension of sewers, to effect a proper drainage for the north part of Kentish-town and Hampstead.

(To Mr. *Stable.*) Since it appears, from the surveyors' well-considered Reports, that the control and application of the supply of water will admit of extensive reductions of the sizes of sewers and drains, and a reduction of the expense of sewers to more than one-half, do you think it warrantable to go on whilst there is any reasonable prospect of obtaining such a reduction, putting the public to a double expense for a less efficient system of drainage?—Were the Commissioners of the Holborn and Finsbury Sewers aware of such improvements being under consideration, I have no doubt they would suspend all such works as are not of immediate necessity. The Commissioners themselves had intended to apply to Parliament for extended powers.

But did they propose to go for powers to obtain control over additional supplies of water?—No, they had not the least idea of it.

Unless they possessed a full knowledge of the necessity, and the effects which might be produced by the application of water to the cleansing of a system of sewers, failure, and worse than the waste of the public money indicated in the question, must be the inevitable consequence. But no steps appear to have been taken by any one of the governing bodies to obtain such knowledge.

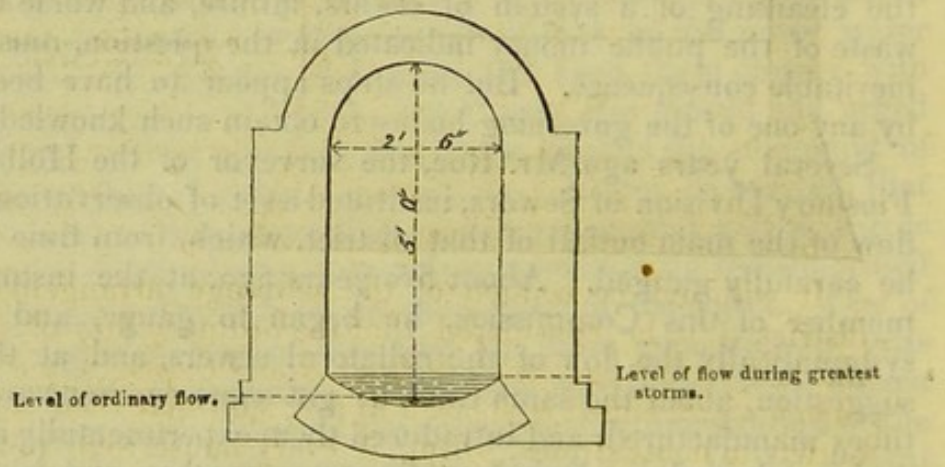
Several years ago Mr. Roe, the surveyor of the Holborn and Finsbury Division of Sewers, instituted a set of observations on the flow of the main outfall of that district, which, from time to time, he carefully gauged. About five years ago, at the instance of a member of this Commission, he began to gauge, and observe systematically the flow of the collateral sewers, and at the same suggestion, about the same time, he got some earthenware glazed tubes manufactured, and introduced them experimentally as house drains, adapted to discharge the water quicker, and keep those most important parts of a general system of drainage clear from decomposing deposits. This form of house drain was subsequently introduced by Mr. Phillips, the surveyor of the Westminster district, to the extent to which the regulations of the Court enabled him, and these forms of drains have been used in other parts of the country, with success proportioned to the limited extent to which sound principles of construction and arrangement have as yet been applied. Mr. Phillips has also gauged and

* App. No. 17.

made concurrent observations on the flow of sewers in different districts.

The results of these gaugings and observations, with much corroborative evidence from practical and competent witnesses, have been brought under our consideration; and they afford demonstrations of the practicability of more important improvements in town drainage, and more extensive alterations in the present descriptions of work than have yet been presented to the public notice. These we shall endeavour to point out.

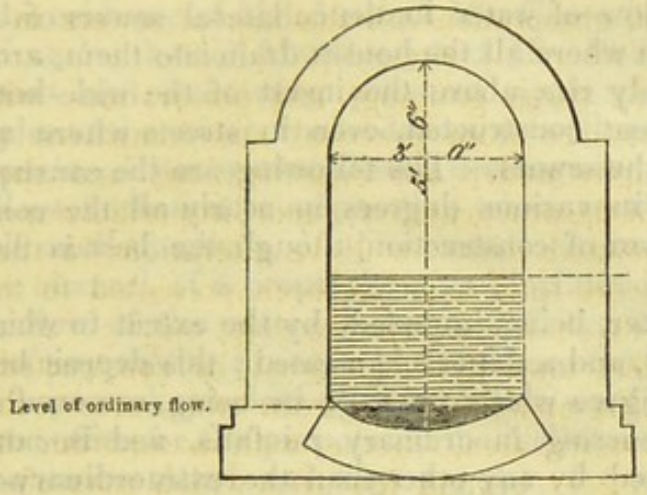
Works to effect town drainage must be constructed for the removal of surplus or waste water from two sources; the natural rain-fall on the town area, together with water from the springs derived from sources beyond the area which may often require separate arrangements; and the pipe-water, brought into the town, and any refuse matter which it may have received in suspension or chemical combination. Setting aside for the present the consideration of the house drainage, and taking in the first instance, the secondary sewers, we give the following cross section of a sewer draining two or three streets comprehending between one and two hundred houses, with the view of the depths of the ordinary run of sewer-water when there is no rain, and the depth of the increased run of water on the occasions of the greatest storms.*



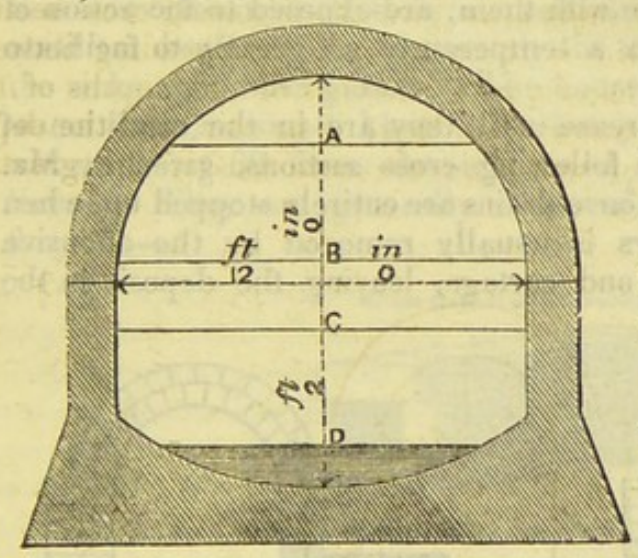
The following cross section, exhibits the ordinary depth of flow, not in a collateral, but, in a main line of sewer in the Westminster district, draining about 90 acres of town area. This cross section also exhibits the depth of flow in the same line of sewer, on the occasion of the greatest thunder storm of which there is any historical record in the metropolis, namely, that on the 1st of August, 1846.

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* App. No. 13.



The following cross section, furnished by Mr. Roe,* exhibits the ordinary depth of flow in the river Fleet, which drains upwards of 4400 acres, of which 1888 acres are covered, or town area, and 2512 are uncovered, or rural area.



Thunder storm, August 1, 1846. Area occupied, 108 feet.

Thunder storm, July, 1844. Area occupied, 79 feet.

Extraordinary thaw, after fall of snow, 1841. Area occupied, 54 feet.

Level of ordinary flow.

It will aid conception of the sewerage arrangements of the district, if it be considered that the ordinary flow of sewer water marked in this section is derived from 60 sewers, the sum of the capacities, of which is about 550 feet, and that these again are the outlets to house drains, which, if every house were provided with the smallest sized drains in use, would be, at the least, 16 times greater than the capacity of the sewers, and 75 times greater than the capacity of the main outfall which is to receive them.

Any one who will observe the run of rain-water in the kennels of collateral streets in a town district, even those which receive the water in the gutters from the house tops (to which they may add the conception of any probable quantities of water discharged from the kitchen sinks, &c., at the same time), may form a proximate notion of the height to which all the water in the two kennels would rise in filling up a sewer of four or five feet deep, and of a sectional area of eight or ten square feet.

* App. No. 18.

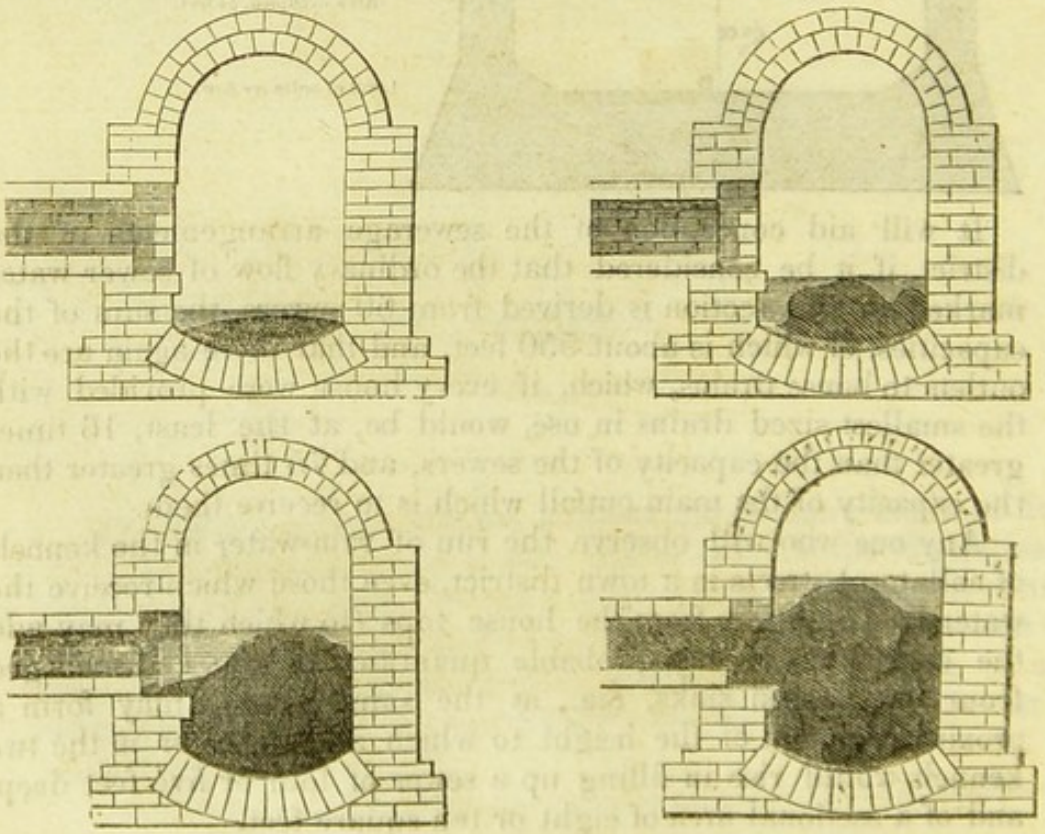
In general the flow of water in the collateral sewers of branch lines of street, even where all the houses drain into them, are mere dribbles, and rarely rise above the invert of the wide-bottomed sewers as at present constructed, even in streets where all the houses drain into the sewers. The following are the consequences which take place in various degrees in nearly all the collateral sewers of every form of construction, though the best is the egg-shape form.

The flow of water, being impeded, by the extent to which it is spread, is retarded, and a deposit is created; this deposit becomes indurated to a degree which prevents its being removed by the flow of water occurring in ordinary rainfalls, and is not often considerably affected by any other than the extraordinary storms which occur in intervals of several years.

The accumulations continue, and during the process, the deposit from the house drains spreads on the sides, and decomposition ensues.

The accumulations in the sewers, as well as in the large house drains which communicate with them, are exposed to the action of much air, usually at such a temperature as greatly to facilitate decomposition.

The accumulations increase until they are in the condition of those represented by the following cross sections, given by Mr. Phillips,* and until the house drains are entirely stopped up, when the deposit in the sewers is usually removed by the offensive process of hand labour and cartage, leaving the deposit in the house drains untouched.



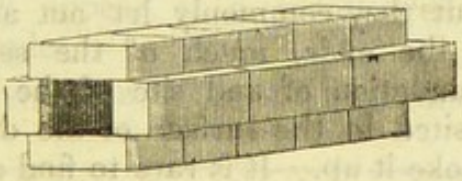
* App. No. 13.

In the evidence of Mr. Austin,* Mr. Cresy,† and Mr. Ranger,‡ as well as in that of Mr. Roe,§ and Mr. Phillips,‖ will be seen important and interesting practical applications of hydraulic principles to the minor house drains, as well as to the larger, but not more important works of main drainage in towns.

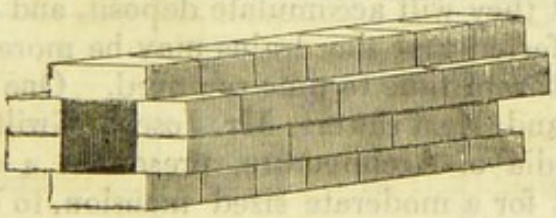
It is set forth as a principle that where matter is conveyed by several small currents, if those small currents are united into another channel, of a proper form and inclination, the quicker will be the flow of the united currents and the more powerful the sweep of any matter in suspension. From the practical observations of sewers kept clear of deposit, it is manifest that very small currents suffice for the purpose, if the inclination be good and the flow be concentrated and kept regular, for which additions of small quantities of water, at particular intervals and seasons, it is considered would be sufficient.

The reverse of these principles generally obtains in practice in the majority of the districts of sewers. In the first place the house drains are so constructed as to spread and impede the streams, and are often kept running separately for unnecessary distances from the sinks and house gutters. The house drains, too, receiving the water from the small 1½-inch leaden pipes of kitchen sinks, are sometimes of 60 times the capacity of these pipes in the smaller houses. They are generally made of bricks in the following forms :—

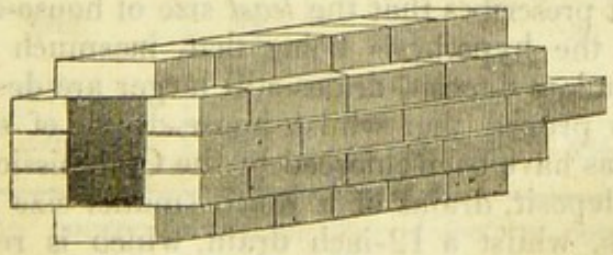
6*d.* per foot run, exclusive of digging.



9*d.* per foot run, exclusive of digging.



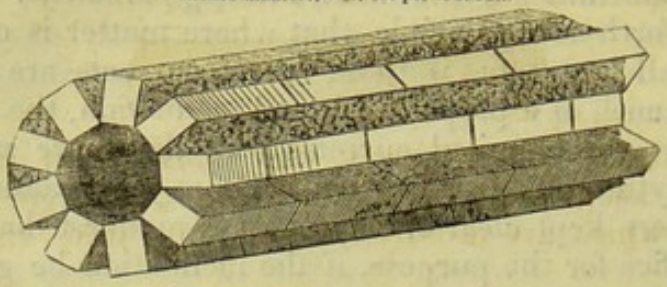
11*d.* per foot run, exclusive of digging.



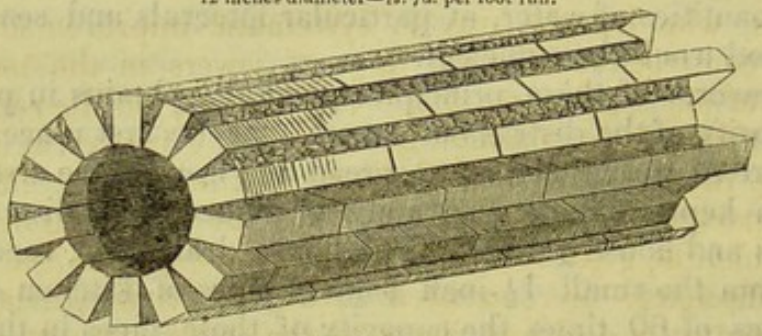
* App. No. 23. † App. No. 24. ‡ App. No. 25. § App. No. 18. ‖ App. No. 13.

The architects and builders generally put in barrel drains to the larger houses in the following forms, made of brick, with porous mortar in the upper portions:—

9 inches diameter—1*s.* 4*d.* per foot run.



12 inches diameter—1*s.* 7*d.* per foot run.



(Bottom joints without mortar or cement.)

These and the flat brick house-drains are generally put in "dry" at the bottom, or without mortar, to let in the water of the land drainage, but they commonly let out at their bottoms or sides, instead of the ends, much of the sewer water, which permeates the foundation of and site of the house, leaving the solid refuse deposited in the surface of the drain to decompose, and ultimately choke it up. It is rare to find any house-drains of this description without deposit. They are, indeed, made on the hypothesis that they will accumulate deposit, and the construction of brick is preferred that the drains may be more readily opened and the deposit from time to time removed. One of the surveyors of the Surrey and Kent sewers, Mr. Joseph Gwilt,* the author of an Encyclopædia of Architecture, prescribes a size of drain of five square feet for a moderate sized mansion, to enable a man to get at it to cleanse it from time to time. The Metropolitan Building Act prescribes that the *least* size of house-drains shall be nine inches; the hypothesis being that, inasmuch as even these drains accumulate deposit, drains still larger are desirable.

Now, it is proved that whilst house-drains of such sizes and construction as have been enforced by the Commissioners of Sewers accumulate deposit, drains of a much smaller size keep perfectly clear. Thus, whilst a 12-inch drain, which is required by the Kent and Surrey, and the Tower Hamlets, and the City Com-

* App. No. 20.

missioners, accumulates deposit and generates noxious gases, a tubular earthenware drain, of nine times less capacity, or of four inches in diameter as here represented, or proportional to the house of from three to six inches, keeps perfectly clear. Even



three-inch drains convey away the refuse from middle-sized houses, and keep perfectly clear, whilst the larger permeable brick drains which are usually charged three times the price, are choked up.

Mr. Roe,* the surveyor of the Holborn and Finsbury division of sewers, who led the way in systematic improvements in the form of construction of main lines of sewers in the metropolis, recently, at our suggestion, made experiments on the rate of flow of water through the common brick drains for houses, as compared with the rate of discharge through earthenware drains of the same capacity, and with the same run of water. The general results which he gives are, that through the earthenware tubes the rates of discharge are increased to an important extent—in the smaller and more frequent forms to the extent of more than one-third. In other words, an economy of one-third the quantity of water to obtain the same result is effected by them, and the general efficiency of the drainage in ordinary runs proportionately augmented, as will appear, at a greatly reduced price. The following are examples:—

TABLE of COMPARATIVE TIME of RUN of WATER through BRICK DRAINS and GLAZED PIPES.

Inclination.	Depth of Water.	Time through Glazed Pipes.	Time through Brick Drain.
	Inches.		
Level	5	38	50
2 inches in 50 feet	4½	16½	25
1¾ ditto	5½	19	27
2¼ ditto	3	18	26
1½ ditto	3½	25	36
3¼ ditto	4	15	22
2¾ ditto]	6	13½	21½

Some of the consequences of the defective constructions in question, as well as the principles of amendment, are displayed in the following evidence. And first as to the expense of house-

* App. No. 18.

drains of the defective construction, Mr. Hertslet,* the Clerk to the Westminster Court of Sewers, was questioned :—

The Commissioners requested you to make some inquiries as to the prices charged by private builders for laying drains into the sewers. Have you done so?—I have taken out of our books the first cases that occurred in the neighbourhood of our office; and out of a considerable number I have only been able to obtain the following, in consequence of the way in which the drains have been mixed up by the builders with other charges :—

Oxford Street . . .	17*l.* for drain from house to sewer.
Ditto	About 10*l.* for ditto.
Ditto	About 15*l.* for ditto.
Ditto	10*l.* to 12*l.* for ditto.
Drury Lane . . .	22*l.* for 2 drains from house to sewer.
Ditto	9*l.* 7*s.* 3*d.* for 1 ditto, ditto.
Ditto	16*l.* to bricklayer, and 1*l.* 1*s.* for opening, &c., besides frontage for the sewer at 10*s.* per ft.
Mount-street . . .	23*l.* 10*s.* for drain to sewer.
Warwick-street . .	25*l.* for drain from sewer through house, exclusive of office charges.
Tottenham Court Road,	16*l.* 1*s.* for 1 drain from house to sewer.
Ditto	16*l.* 16*s.* for 1 ditto, ditto.
Ditto	13*l.* for 1 ditto, ditto.

Do you know at what rate the contractors of the Sewers' Office charge for their private drains?—The charges have always been extremely high: but the following prices charged in Berwick-street, where the sewer has just been rebuilt, show some improvement in that respect, though they are still much too high, viz. :—

Berwick-street . .	3*l.* 17*s* for pipe from house to sewer.
Ditto	3*l.* 17*s*, ditto (besides time of owner).
Ditto	2*l.* 15*s.* ditto.
Ditto	4*l.* 10*s.* ditto.
Ditto	4*l.* ditto.

Formerly these matters never came into my department, but recently I have advised several parties not to pay above half the sum demanded.

Have you made any inquiries as to the advantages derived from the sewers when rebuilt?—I have taken one case 10 years old, and one quite recent case in the same neighbourhood. The replies have been very conflicting indeed. In many cases, an evident fear of incurring additional expense prevented a full and explicit statement. There were great complaints of smell in some cases, when the back-door was shut and when the house was closed at night; and generally it would seem that very much remained to be done, the old drains at the back being left as they were before the sewers were rebuilt; the new system had however a decided advantage. In one instance, about four years ago,

* App. No. 12.

it appears that in Wardour-street, a man, whilst cleansing out a drain, was taken suddenly ill, and died in three hours, and that the medical man attributed it to the noxious effects of the work he was engaged in.

Do you not consider that it is most wasteful to go on driving sewers without provision for the house drainage?—It must be so. If earthenware pipes instead of the brick and mortar drains recommended by architects, had been put in during the progress of the works in Drury-lane, Tottenham Court-road, &c., under a proper system, the prices above-mentioned would, I believe, have been half-crowns, and in some cases even shillings, instead of pounds.

Mr. W. Simpson,* the surgeon of Bloomsbury, gives the following account of the same system, in relation to the openings made by the formation of new streets through St. Giles's.

Have the late alterations improved the general health of the neighbourhood?—I should say yes, so far as we have now greater currents of pure air from above; but so long as these localities remain without sewers, and the present sewers remain as they are, I do not expect any permanent improvement.

Why so?—Because when the wind blows in certain directions, the stench is thrown back through the privies and water-closets, and the supply of water being limited, accumulations take place, particularly in the months of July and August, beneath the kitchens, which taint meat, and therefore taint also the blood of the living.

From what you state, the private houses of tradesmen and shopkeepers, &c., are not much better than those of Church-street?—I should say very little better; but the wholesome diet, clothing, and fuel, along with better ventilation, and more light, cause the diseases to assume a less malignant type, and, therefore, fewer die of typhus, &c., but more of pulmonary diseases and scrofulous affections. The number of children with deformed legs and spines is incredible, and all from the same causes.

Have no attempts been made to remedy these evils?—If you will allow me to state what happened to myself within the last three or four years, it will apply to nearly all my neighbours. About three years ago I went to the expense of about 15*l.* to have a sewer opened which runs beneath my kitchen. I was advised to have it lined with cement, and all the rat-holes filled up, supposing that, the old mortar having fallen off, the stench penetrated up through the interstices. Little improvement took place. I then went to the office of the Commissioners of Sewers, in Greek-street, Soho, and inquired if they could do anything for this? They said no; but if I chose to go to the expense of 3*l.*, they would put a trap-door at the mouth of this branch sewer, where it empties itself into the main sewer; this, on consideration, I declined, as the drains from three or four other houses would still be running into mine, the *cause* would not be removed. The men at the office tried to console me, because Earl Spencer was situated the same as myself. He complained on the same day of the same nuisance as I did, and they could not assist him.

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* App. No. 6.

Mr. Phillips,* the surveyor of the Westminster district, was asked,—

Have you, in passing along the sewers, ascertained which way the currents of air were flowing, either into or out of the sewers?—In going along the sewers, I have been always anxious to ascertain that fact. The light which I had in my hand I have placed immediately by the side of and into the house-drains, and I found almost invariably the flare carried into the mouths of the drains, so that there must have been direct currents from the sewers through the house-drains, and so into and through the houses themselves. I rarely met with any instances where there was not a current from the sewer into the house-drain, and also from the sewer through a large number of the gully drains into the streets. Of course, some gullies have a down draught.

Then it is to be presumed that your experience justifies the general description given of the existing sewers in the Sanitary Report of 1842, as retorts with necks carried into the houses for the conveyance of the gases there?—Yes, unfortunately, such I have found to be the case. The sewers are in a very great degree ventilated by the house-drains, which are badly trapped. It was in consequence of finding that to be the fact, by repeated observations and experiments in the sewers, that I was induced to lay before the Court their real and absolute state, in order that so grievous an evil might be remedied without delay.

What was done upon your representations?—I cannot say that any steps were taken to remedy the defects; but I can say that it was considered that I was too bold, and that I said too much.

Are not the gases in the sewers at times in such a state of partial dilution that they may escape into the houses without any very disagreeable smell being observed by the inmates?—In some degree probably that may be so. The air from a sewer is anything but agreeable, however much it may be diluted with fresh air, and people who are used to it do not feel or complain of its disagreeable effects so much as those who are not used to it. The fact is, that very much of the filth does not find its way into the sewers as fast as it is produced, but lies decomposing in the large and flat house drains and in the cesspools for days, indeed I may say for weeks and months together, so that the most virulent portion of the gases pass off before the filth gets into the sewers.

But still the most virulent portion of the gases of which you have spoken, in escaping from the drains and cesspools, infect the atmosphere of the houses?—Yes, that is the case. Wherever there are cesspools and defective drains, the atmosphere of the houses is being constantly tainted with deleterious gases. Persons going in a morning from the fresh air into defectively-drained houses, or into drained houses where there is a current of air from the sewer into the house, cannot help feeling something disagreeable in the state of the air.

In another part of his evidence, Mr. Phillips* says that the sewers are bad in construction, but the house-drains are far worse.

"It would seem from their form, arrangement and construction, that they had been built expressly for retaining matter rather than carrying it away. More than two thirds of the existing house-drains in old

* App. No. 13.

localities require to be periodically broken into to clear out the soil. I am of opinion, that not one half of the entire filth produced in the metropolis finds its way into the sewers, but is retained in the cesspools and drains in and about the houses, where it lies decomposing, giving off noxious effluvia and poisonous sulphuretted hydrogen and other gases which constantly infect the atmosphere of such houses from bottom to top, and which, of course, the inhabitants are as constantly breathing. In thousands of cases, I have no doubt, fevers and a large class of diseases result from this cause."

But the expense of these bad forms of drains increases with their size and inefficiency. The following evidence is with but little modification, applicable to a large proportion of the private house drains constructed since the Commissioners for inquiring into the means of Improving the Health of Towns made their reports, and to the descriptions of house-drainage, which a majority of the district Commissioners are prepared extensively to enforce. The immediate consequence of such constructions is to raise formidable obstacles to sanitary improvements, on the ground of expense, as well as just grounds of objection, on account of their inutility, especially in the poorer, and for the present objects of the Commission, the most important districts.

We submit to attention, the descriptions we have received from competent witnesses, of the improvements immediately practicable, and of their effects, and then we shall present the statements defensive of the present constructions of the house-drains in the extensive districts where little or no change has been made for the regulation of their construction.

Mr. Phillips* thus displays the former practice, and the present state of much of the drainage of courts and alleys inhabited by the labouring classes.

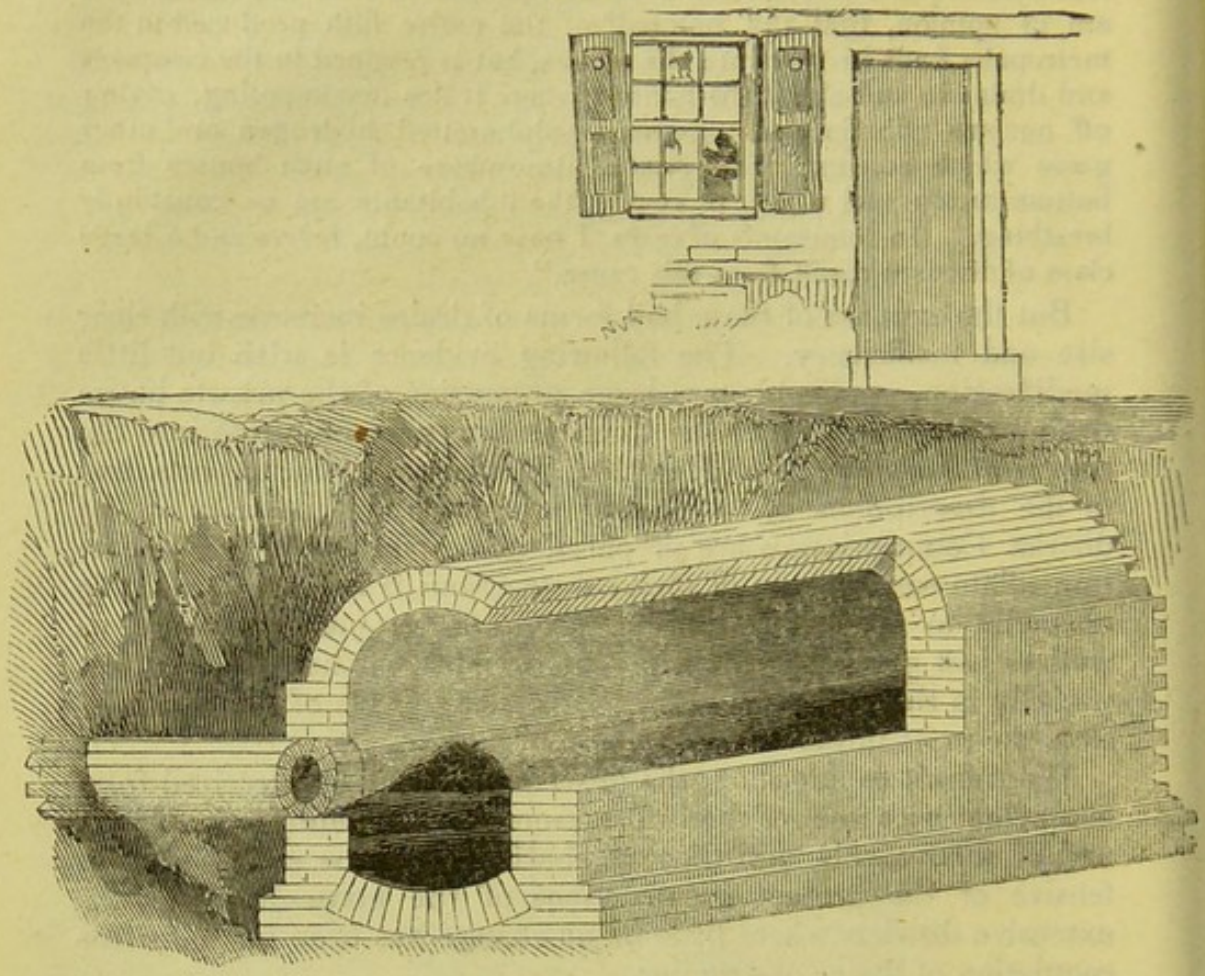
Public attention was recently attracted to the case of the death of a poor man who had been suffocated in the privy of an ill-drained court in Long Acre. You made an examination of the drainage of that court, did you not?—Yes, I did.

In what state did you find the drainage?—On examining the drainage of this court, Langley-court, I found that the houses on the east side of the court drained backwards into an old drain or sewer, constructed probably when the houses were built. This was a small sewer, 18 inches wide by 2 feet high, and had a good fall. The water running through it was sufficient to keep this small sewer nearly clean. I found that another sewer had been built in the court under the authority of the Westminster Commission of Sewers. This sewer was one of the ordinary sewers, 5 feet 6 inches high by three feet wide, and contained an average depth of 3 feet of soil. This, though an imperfect instance, was an instance of the effect of a run of water in a small sewer, and of the common operation of a large sewer without a constant and sufficient supply of water. I hand in a section of the sewer showing the condition in which I found it.

* App. No. 13.

KING'S COLLEGE LONDON

Sewer constructed in Langley Court, Long Acre.



Does this exhibit the common size of a sewer formerly used for courts, and their condition?—Yes.

According to your experience, can you state what form or size would have been sufficient for the drainage of this court?—The form and size are shown by this sketch, and the sewer and drain are drawn to the same scale.



Are you quite sure that even this small sewer is not too large?—There are 16 houses in the court, and, in my opinion, a 6-inch tubular drain properly constructed, would carry off all the drainage as fast as produced.

Supposing each house to be 15 feet frontage, what would the cost of the large sewer be per house?—About 7*l.* 10*s.* per house for one side of the sewer.

How much would the reduced size be?—About 1*l.* 12*s.* 6*d.* per house, being a difference of 5*l.* 17*s.* 6*d.*

What would be the difference of cost for the whole court?—99*l.*

That is to say, nearly six times greater for the sewer which acts as an extended cesspool than for the efficient drain?—Yes.

And this is not a singular instance as to the cost of court sewers?—It is not. In fact it is in consequence of these sewers being so enormously large and expensive that I believe there are so few courts drained at all.

This large sewer then was nothing more than an extended cesspool?—That is the observation I was about to make. The sewers of this sort are only elongated cesspools; and not only is almost every house infested with one or more cesspools somewhere within or about the premises, but probably the inhabitants and the public generally are not aware of the existence of such enormous cesspools under the streets. If the whole of the sewers of this description could be uncovered and seen, their horrible condition, I feel assured, would almost stagger belief that such a state of things could be, and that the authorities having control over them could allow them to continue so even for a single day longer.

If the houses in such courts having no house drains, but having cesspools, were required to be drained into such sewers, in which soil is retained, are you confident that the sanitary condition of the houses would be benefited by the work?—The more fluid portion of the drainage would certainly flow away, and the solid be left behind to decompose; and the noxious gases evolved would certainly infect the houses nearly to the same extent as if the houses had no drains whatsoever. In fact, in many cases, the drain would merely be turned from the private cesspool in the house into the public cesspool in the street.

Are you not aware that some neighbourhoods are at times afflicted with more noxious effluvia from the sewers than if there were no sewers whatsoever?—I have no doubt that that is the case; but the evil admits of remedy in various ways, and amongst others, by the constant supply of water and constant circulation of it throughout the sewers. I have found that the atmosphere of districts contiguous to the outlets of the sewers was liable to be affected with effluvia when the wind happened to blow up the sewers, but the remedy for this evil would be to carry all the outlets under the side beds of the river to discharge into the main stream below low-water level. The air along the shores of the river would thus be much purified, inasmuch as there would be considerably less or no deposit, and no formation of filthy mud banks, for myriads of worms to revel in as at present.

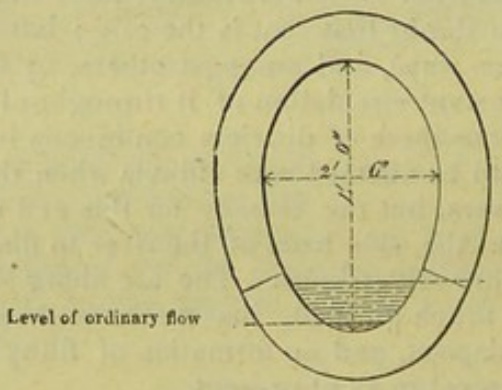
Until proper and constant supplies of water are obtained for the cleansing of sewers, it would follow from your evidence, that going on with the system of large sewers constructed on the intermittent supply of water, and for men to go through them, is going on upon a system of at least double expenditure, often of very doubtful sanitary benefit?—Yes, undoubtedly; that is my firm conviction.

Supposing that you were the owner of the district you superintend, or were a builder; or that you were an agent, or had the management of the district, and had the control, as agent, of the rate-payers' money, should you think yourself justified in going on with any expenditure of money until you had the means of altering the system, and applying the money efficiently?—I should consider it an absolute waste of money, and could not honestly proceed with such an expenditure either of other people's money or my own, until I had the means of expending the money efficiently and frugally.

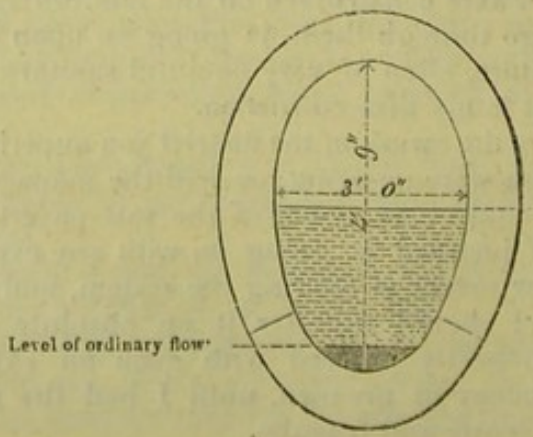
The position in which the subject was left by the Inquiry into the means of Improving the Health of Towns was, that the general superiority of the egg-shaped sewer in efficiency was established, and the principles for the reduction of the sizes of house-drains, and the combination of the management of supplies of water for cleansing them, and flushing sewers, were indicated.

Since then, the use of the improved form of sewers appears to have been greatly extended both in the Holborn and Finsbury and the Westminster division of sewers; but the sewers constructed are in general of the same internal capacity as those of the old form—the same proportions of sizes to the run of water. They accumulate less deposit, but the small streams and dribbles of water which pass through them, leave deposit, and they are still constructed of a size to allow men to go down them, and loosen the accumulations, in order that they may be removed by flushing. The run of water shewn in the first cross section of the collateral sewer, and the run of water in the main sewer (*vide ante*, pp. 40, 41) would appear thus in the amended forms of egg-shaped sewers, which are still generally constructed of a size to allow a man to go up them and cleanse them, in all places except courts and alleys:—

Collateral Sewer of the egg shape.



Main Sewer of the egg shape.



The mere view of the ordinary run of sewer-water in the sewers, or of the run of water on the occasion of heavy storms, might have led to some amendment in the construction of sewers without any gauging, had a view been taken of the flow in the lateral as well as in the main lines of sewer; but the sizes of all classes of sewers have been maintained on the view of the main lines alone. Mr. Hertslet* was asked,—

Have you inspected the sewers yourself?—I have traversed within-side all the principal main lines from one end to the other; and I do not think that any work exceeding 100*l.* in value has been executed that I have not visited several times.

What has been the result of your observations as to the sizes of the sewers?—I have been perfectly at a loss to conceive why such immense sewers should be built to carry off such mere threads of drainage. I have often thought, and have so stated in Court, that the Commissioners generally, from viewing only the main lines, have a very false impression as to the sizes required. I have seen sewers 5 feet 6 inches high by 3 feet wide, being built where, even during heavy rain, a 3 or 4-inch pipe would evidently have carried off all the water.

The following are tables of the result of the gaugings of the run in sewers of different sizes obtained by Mr. Roe,† in which will be seen examples where the run of water in the sewers in the greatest storm on record (a case that ought not to enter into consideration in determining the sizes) occupied only a third, a fourth, and even a sixth of the capacity of the sewers. All except the first are collateral sewers, not receiving any drainage but from the houses named in the streets or courts.—[*See* Table, p. 54.]

It appears that in the second or third-rate class of streets, the run of water from the houses to the sewers is about 45 gallons per diem; but that in the streets of the first class of houses, all of which have water-closets, and all drain into the sewers, the daily run of water is, on the average, about 75 gallons per diem per house, except on the days on which the intermittent supplies are on, when the run increases in the third-rate streets from 45 gallons to about 78 gallons, and in the first-rate streets from 75 gallons to upwards of 100 gallons, during the day, affording an example of the waste incurred under that system. So far as the observations have proceeded, they are in corroboration of the opinion that the prospective estimate of a supply of 25 gallons per head of the population per diem, or 125 gallons per house, would effect all that at present appears necessary to keep a properly devised system of house-drains and sewers of a town in salubrious action.

From what we have stated, it will be seen that we contemplate the alteration of the system of sewers constructed to accumulate deposit and for men to enter and cleanse them, and the general substitution of a much smaller and more economical system of collateral sewers, kept in action by regular supplies of water.

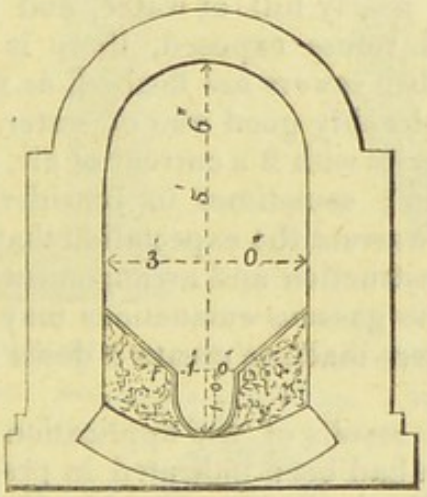
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* App. No. 12. † App. No. 18.

Area drained.	No. of Houses.	Form of invert of Sewer.	Capacity.	Run of Water. Average common run.	Run of Water. Area occupied.	Run of Water. When Water let on from Pipes.	Area occupied.	During greatest Rain, in 1846, Area occupied.	Water-closets or not.	Distance from the Thames.	Height of surface above Thames high-water Mark.	Inclination.
Acres.			Feet.	Inches.	Feet.	Inch.	Feet.	Feet.		Chains.	Feet.	
110	..	Circular .	13	3	..	..	..	13·00	..	120	36·0	½ inch in 10 feet, a main line.
5	100	Egg-shape .	9·0	1½	0·08	2	0·13	2·50	None.	150	47·0	3 inches in 50 feet, collateral sewer.
2·70	69	Ditto .	7·65	¾	0·024	1¼	0·06	2·10	None.	166	52·0	
5·15	104	Ditto .	9·65	..	..	1¾	0·11	2·70	Closets.	145	47·0	5 inches in 100 feet.
1·09	49	Circular .	9·09	..	..	2½	0·33	1·43	Closets.	265	120·0	
0·25	32	Ditto .	..	..	..	1	0·04	0·33	Closets.	157	110·0	
1·36	41	Egg-shape .	7·65	..	..	2¼	0·23	1·40	None.	151	46·0	
2·16	50	Ditto .	7·65	..	..	1	0·034	1·13	None.	160	51·0	
4·16	120	Ditto .	9·65	..	..	3	0·23	4·17	Closets.	140	49·0	2 inches in 100 feet, current impeded by height of water in outlet sewer.
0·25	16	Circular .	9·09	..	..	¾	0·03	0·30	Closets.	155	102·0	
19·10	482	Ditto .	9·09	3	0·23	..	..	6·33	None.	140	50·0	2½ inches in 100 feet, current impeded by height of water in the outlet sewer.
1·00	22	Egg-shape .	7·65	¾	0·03	..	..	1·13	None.	147	47·0	
1·36	37	Ditto .	..	..	0·05	..	..	1·25	None.	149	47·0	
1·08	31	Ditto .	..	..	0·04	..	..	1·20	None.	151	46·0	
3·42	65	Circular .	3·14	..	0·09	..	..	1·60	None.	180	118·0	12 inches in 100 feet.
0·84	40	Ditto .	1·22	..	0·17	Engine waste water.		1·22	None.	92	48·0	5½ inches in 100 feet.
SEWERS NOT REQUIRING FLUSHING.												
82·00	..	Class 2. .	..	5¼	..	..	..	..	Closets.	58	77·50	9 inches in 100 feet (a little obstructed at outlet).
86·00	..	Class 1. .	..	3¾	..	..	..	..	Closets.	55	75·00	10½ inches in 100 feet.
5·35	..	Class 2. .	..	1	..	..	..	..	Closets.	105	59·00	14 inches in 100 feet (a drop at outlet).

We have directed some inquiries as to the practical modes of amending and adapting the old and badly constructed sewers to the improved system, for keeping them clear of deposit. The following evidence conveys the suggestion of Mr. Phillips* on this topic.

What size of ordinary or constant current—that is to say, a current independent of rain, would suffice to keep cleansed an ordinary-sized sewer?—I take my data from practical experience and observation, rather than from theory or calculation. In passing through the sewers, I have observed that the currents of water running through very many of the branch and collateral sewers were mere dribbles, and that from being diffused over a large flat surface they were not of sufficient strength to remove the soil. Looking at these currents, and comparing them with the extraordinary sizes of the sewers, I should say such currents might be passed through pipes varying from 3 to 9 inches in diameter. In a large number of the sewers, the currents have cut narrow and deep channels through the soil, and by so doing, it appeared to me that nature was endeavouring to correct the faults of art. I think it would be desirable to take a lesson from nature in this respect, and form the bottoms of all the sewers which have a tendency to choke up in accordance with the following sketch.



It has sometimes been the practice to cut similar channels through the soil for the drainage to run through, and they have acted for a time very well indeed, so well as to give me entire confidence in the working of narrow and reduced sizes of sewers.

I propose to bed channel tiles, of various diameters, along the bottoms of the sewers, and fill in behind them with concrete. I am satisfied that if the currents could be doubled in quantity, concentrated on smaller-sized channels similar in form to the above sketch, and kept regularly in action, most of the sewers would keep themselves clean by this means. Egg-shaped sewers, varying in capacity according to the area, the number of houses to be drained, and the quantity of water to be discharged, from 9 inches wide by 1 foot 3 inches high, to 1 foot 6 inches wide by 2 feet 6 inches high, would

* App. No. 13.

suffice for sewers on summit levels, and also for branch or collateral sewers which had to receive the drainage of from one to twelve or more ordinary-sized streets. Of course the secondary mains which would have to carry off the water from these branch or collateral sewers, as well as the principal main lines into which the secondary ones would discharge themselves, must be larger in proportion; but under a proper arrangement, fewer principal lines would be required.

Then, instead of discharging a large body of water uselessly, as to any power of sweep, you would, under the system of constant and concentrated supplies and smaller sewers, economize the water by using it to scour several small sewers instead of one large one?—Yes, I would. For this reason I would prefer having more outlets, or at least more catchwater sewers, instead of discharging all the drainage by one large main sewer throughout, although at or near the outlet, I might probably be obliged to lead the whole of the water into one main line; but I should not like to part with it into a main line until I had made it serviceable in sweeping as many sewers as possible. The sewers themselves, as they progress towards the outlets, would of course require to be of larger capacity. Running water is the cheapest, best, and most effectual means for conveying away the filth and refuse of a town.

It is stated as a matter of practical experience, that from sewers which are full, or nearly full of water, and have no surfaces of solid or semi-fluid refuse exposed, there is comparatively little smell; and that when sewers are flushed, or when they are partly full and have a tolerably good run of water, the friction of the stream of water carries with it a current of air, proportionate to the rapidity of the run; sometimes in considerable volume. The observations made warrant the expectation that, by attention to this principle in the construction and arrangement of the smaller-sized sewers, much of the gaseous emanations may be removed, and in some cases the sewers made to create a down draft of air from the house-drains.

The economical results of the application of supplies of water to sewerage, which had been indicated in preceding inquiries, are displayed in the following evidence of Mr. Phillips:*—

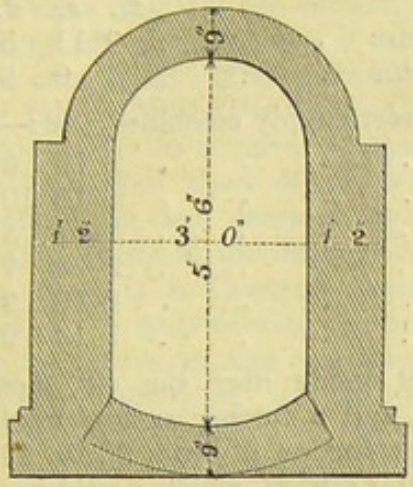
Will you contrast the expense of the general drainage of streets, courts, and alleys, with the expense at which an improved drainage might be carried out?—I have already stated that the cost of a first-class sewer of the upright-sided form was about 22*s.* 6*d.* per foot run, that the present first-class egg-shaped form ordinarily costs about 14*s.* 2*d.* per foot run, and that I think the expense, under an entirely different system, with constant supplies of water to keep the sewers clean, might still be further reduced to about 7s. per foot run for the larger class of branch sewers, and to about 6*s.* 4*d.*, 5*s.* 7*d.*, 5s. 3*d.*, 4*s.* 6*d.*, and 4*s.* per foot run for the smaller ones. The annexed sketches, show the past, present, and future forms and sizes:—

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* App. No. 13.

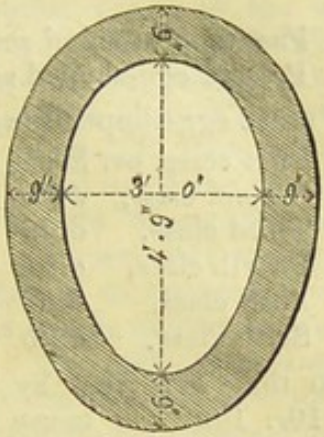
Past Form, First Size.

Cost 22*s.* 6*d.* per foot run.
Area, 15·5 ft.



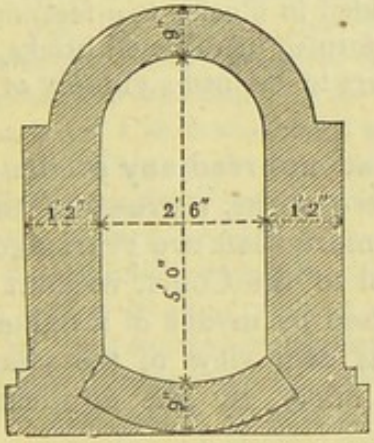
Present Form, First Size.

Cost 14*s.* 2*d.* per foot run.
Area, 11·2 ft.



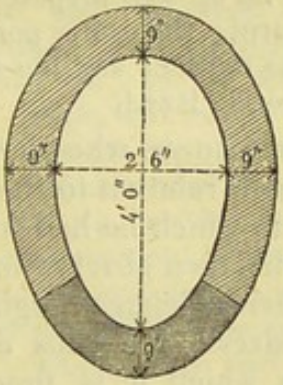
Past Form, Second Size.

Cost 19*s.* per foot run.



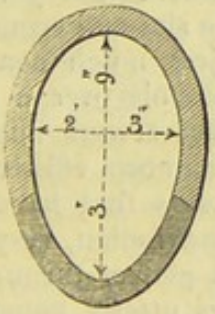
Present Form, Second Size.

Cost 12*s.* per foot run.
Area, 7·85 ft.

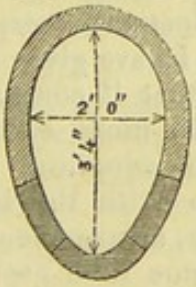


Future Forms and Sizes, with regulated supply of Water.

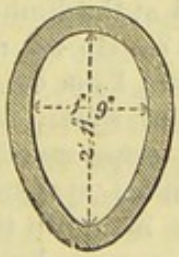
First class, 7*s.* per foot run.
Area, 6·6 ft.



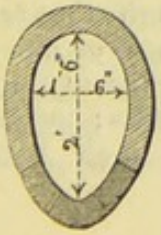
Second Class, 6*s.* 4*d.* per foot run.
Area, 5·2 ft.



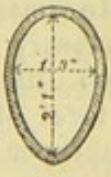
Third class, 5*s.* 7*d.* per foot run.
Area, 4 ft.



Fourth class,
5*s.* 3*d.* per foot run.
Area, 2·9 ft.



Fifth class,
4*s.* 6*d.* per foot run.
Area, 2 ft.



Sixth class,
4*s.* per foot run.
Area, 1·3 ft.



Seventh Class,
3*s.* per foot run.
Area, ·736 ft.



Taking a house of 17 feet frontage, the cost for one side of the sewer would be as follows, viz. :—

	£.	*s.*	*d.*
Past upright-sided sewer, per house . . .	9	11	3
Present egg-shaped sewer, ditto . . .	6	0	5
Future egg-shaped sewers, with water supply combined, viz :—			
First class, per house	2	19	6
Second class, ditto	2	13	10
Third class, ditto	2	7	5
Fourth class, ditto	2	4	7
Fifth class, ditto	1	18	3
Sixth class, ditto	1	14	0

So that a saving by the present mode over the old mode of 3*l.* 10*s.* 10*d.* per house is effected, and a further saving might be effected over the present mode of construction of from 3*l.* 0*s.* 11*d.* to 4*l.* 6*s.* 5*d.* per house, and with far better sewers, which would be kept constantly clean, and which would scarcely or never get out of order. I propose that the darker portions of the bottoms of the larger sewers should be of well-prepared clay, moulded in blocks two feet long, and well burnt; the upper portions to be formed of radiated bricks, laid in blue lias mortar; and the smaller sewers to be made entirely of brown stone-ware glazed.

This witness, who says that he had not read any of the official reports in relation to the state of these works, represented the condition in which he had found them more than two years ago; and upon his own observation suggested to the Court, without effect, that their efficiency might be increased by means of a reduction of their sizes. He thus expresses his own view of the change of system which it is practicable to effect by the application of regulated supplies of water:—

From your statement, it appears that a considerable saving of expense has already been effected in the building of sewers, and that the working has been greatly improved. Are you confident that you have arrived at the limits of reduction in respect to the size and economy of sewers?—By no means. I have given this subject much consideration, and I am convinced, that if control be obtainable over a proper supply of water, the present mode of constructing sewers might be wholly superseded by the adoption of a far more efficient and economical system. Even with the improvements that have been already made in their form, arrangement, and construction, very many of the sewers built for some time past are not perfect through not having a proper supply of water. Indeed it is utterly hopeless to expect that house drains and sewers can keep themselves, or be kept clean, and in perfect condition, without having, at the same time, control over a supply of water. In passing through the sewers, deposit appeared to me to be the necessary consequences of one or all of the following causes,—namely, too little fall; inefficiency in the supply of water, or deficiency in the force of the currents; too large a capacity of the sewers, or the improper form of their bottoms,

they being flat and wide; abrupt angles which produce eddies in the currents; and heavy substances which had either been thrown, or had found their way into the sewers. In dry weather nearly all the water running along the sewers is due to the supplies from the different water companies. The quantity due from springs or land drainage is very little. With drains and sewers the whole filth of a town is dependent for its removal on the supply of water. If that supply be deficient, or fall short of its proper quantity and so of the necessary power to lift and carry away the filth, it must of course deposit and accumulate in the drains and sewers. A proportional supply and force of water is therefore essentially necessary to ensure its entire removal. A considerable proportion of the supply is lost in various ways for cleansing and scouring purposes. The more abundant the supply, and the better the drains and sewers are proportioned thereto as to size, form, and fall, the more rapid will be the removal of the filth, and the less liability will there be to deposit. Indeed, I feel sure that, by a systematic arrangement of the house drains and the sewers, and application of a proper quantity of water, no deposit will take place. For the short collateral branches of the sewers in streets, courts, &c., the smaller they are (provided they be large enough to receive and carry off storm waters in addition to the ordinary run,) the less chance will there be for them to choke up. In the course of my experience I have examined hundreds of drains, and I have always found small drains and sewers which had a moderate fall, and anything like a good supply of water, quite clean and perfect in that respect. I anticipate, indeed I confidently entertain an opinion founded on observation and practical experience, that with a combination of the water supply, and a tubular system of sewerage and house drainage, the whole of the annoyance now experienced by the public from defective drains and sewers may be made to cease. The greater part of the duties of the officers of sewers is taken up by attending to complaints of the stoppage of drains and sewers, and in superintending the removal of the soil. Now, with such a system of sewerage and house drainage, nearly the whole of the duties in this respect will cease. I apprehend that it would be far better for a staff of officers to be constantly engaged in making examinations in order to prevent filth from depositing and accumulating, than to wait for it to collect, and so annoy the public with its noxious emanations, perhaps for weeks and months, before complaint is made and steps are taken to remove the evil. The public who pay rates for paving, sewerage, water, and lighting, have a right to expect that their health and comfort are cared for, that the money is expended frugally, and that both the works and the management are carried on in a scientific and systematic manner.

From your experience it appears that the public may expect quite as large a reduction in the expense of town drainage as, by attention to the forms and capacities of pipes for the discharge of water, from land drainage, where the one-inch tubular drain has extensively superseded the flat-bottomed and upright-sided drain with circular top, so closely resembling the old form of sewer recently in use in the Westminster Commission?—Yes, it is so.

The reduction of the expense of agricultural drainage to a third

or a fourth of its former expense, since 1842, when the same forms of land drains were in use that were then condemned in sewers, has been obtained by close attention to details of the form of pipes, and their capacity for the discharge of water. Agricultural drains, like sewers, were commonly made large to keep them from stopping up; at present they are used of one-fourth, or even less than one-fourth, the former size, with a better effect.

A part, and a part only, of the practicable economies is displayed in the following evidence, in relation to one depressed district for the drainage of which, under the system carried on for a long time after the publication of the evidence obtained by the Commissioners of Inquiry into the means of Improving the Health of Towns, upwards of 40,000*l.* of the public money might have been expended for a far less efficient drainage.*

You have given into the Court of Sewers a plan for the drainage of the depressed district of All Souls in the parish of Marylebone; what is your estimate of the expense of draining that district?—About 20,000*l.*; that is for an entire re-construction of the sewers. The area of this district is equal to about 130 acres.

But still it is for a construction of sewers on the intermittent system of supply, and with sewers sufficiently large for men to pass through them?—Yes.

What number of houses are there in that district?—About 3000 houses.

That is to say, the cost of rebuilding the sewers will be nearly 7*l.* per house?—Yes.

But inasmuch as upon an improved plan of sewers, the expense of new sewers may be reduced more than one-half, to proceed at present is to subject each house (or other districts who derive no benefit from the drainage work) to a tax of 3*l.* 10*s.* per house for a drainage which would be less efficient?—Yes, that is so; and moreover, the house drainage of the district is very bad, almost every house having a cess-pool; and the saving on the house drainage on an improved plan would be as great as the saving from an improved sewerage with the constant supply of water.

When it is considered that, in the Court of Sewers, for the chief district, that for Westminster for example, these reductions and amendments of the house drains, and other proposed amendments, have been met by the positive opposition of a large minority of Commissioners, which is sometimes a majority, whose proceedings are described by the witnesses and displayed in their acts,—when the important results of the regulated application of supplies of water, to which attention was directed by the Commissioners of Inquiry have been passed over without any practical notice, not only in this one commission but in every other,—it will be perceived how slight are the grounds of any expectation of the

* App. No. 13.

principle of action in question being followed out, and of being accurately determined and applied by these authorities as at present constituted. Passing by the Holborn and Finsbury division, in which it is due to mention that the officers' propositions for the amendment of the forms of sewers and drains were fairly accepted, and supported by the Court, we take the following portions from the evidence of Mr. Beek,* the surveyor of the Tower Hamlets division of sewers, which contains the depressed districts of Spitalfields, Whitechapel, Bethnal Green, and other similar districts often described by the witnesses :—

Have you ever gauged the quantities of water which pass through your sewers when there is no rain, and when there is rain?—No.

You have no system of that kind?—No, nothing at all.

Having stated that the Commissioners of Sewers would, nevertheless, require to be used for the drainage of a court or alley, what they call a third-rate sewer, that is to say, a half-brick sewer two feet six high by two feet three wide, he was asked—

What is the usual expense of that size?—We are now building 2000 feet of that, and the expense of it is under 6*s.* a-foot. If I estimated it I should make it 7*s.* or 8*s.* What they are done for it is impossible to tell.

In a court with a dozen houses upon either side this is the sewer which would be introduced?—Yes.

Why do you require so large a class of sewer for so small a number of houses?—It is not that the requirement would be equal to that, but it is the custom.

Is it done more for the purpose of communicating with it by men?—That was the object originally, no doubt.

You use that size of sewer in order to put a man down it?—Yes, I reported to that effect. Before it was introduced I gave that as the reason why that should be the smallest sized sewer.

What was the reason, do you consider, that the people did not join on to your sewers before?—Because of the expense; I do not know any other cause.

Do you charge the whole of the expense upon the owner?—We have no power of compelling him to do it. There is a charge made for the first three feet; that charge is, I think, 17*s.*; that includes the drip-stone.

What size have you been accustomed to require in those cases?—12 inches.

And that size you still adhere to?—Yes.

Supposing it is a house in a court or an alley?—That would make no difference.

Have you any survey specifying the courts and alleys in your district which are drained, and those which are undrained?—No; we are not in the habit of *draining* courts and alleys. The Commissioners are in the habit of introducing *sewers* in that situation.

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* App. No. 29.

Can you give the Commissioners any idea of the expense of draining courts?—It must depend upon circumstances; the court may be ten feet wide, or twenty feet wide.

Have you made any estimate of the expense of draining courts and alleys?—No.

As to private drains you have made no estimate?—No.

Nor does it enter into your calculations for the future?—No.

Nor any adaptation of supplies of water?—No.

And yet with such a use of the existing powers thus in part displayed by the chief officer of the Commission, and in this state of information, after the demonstrations of improved principles set before them, in the evidence collected under the Commission of Inquiry into the Health of Towns, they still go on, and, as they have stated to us, contemplate applying to Parliament for a Bill to give them powers for the direction of increased amounts of expenditure in house as well as main drainage. This intention having been avowed by the Chairman* of the Commission, the following questions were put to him in respect to the increased powers they proposed to take:—

Do not you think that that power should be coupled also with some real responsibility as to the quality and the expense of the works which might be executed; supposing Commissioners to go on for a series of years constructing sewers at double the necessary cost, or putting in very inefficient work, do not you think that there should be some responsibility attached to their doing so?—There should be responsibility, I think. I may also say, that the power being vested in the Commissioners to construct those drains, they ought to be protected against being called on to make good what injury to the house may be necessary in constructing them, otherwise the landlord would call upon the Commissioners after the construction is done, to repair his flooring, or to put up his skirting and other matters connected with the interior of the house. I think, where the Commissioners observe a drain is absolutely necessary for the protection of the health of the inhabitants of the house, having constructed the drain, they ought not to be answerable for the reparation of the house.

Supposing it occurs in a district that the outlay for a bad system of sewers—emitting pestilential smells—appears to have been double or treble the outlay necessary upon a better system free from such objections, what sort of responsibility do you think ought to be attached to persons who have pursued that system of waste?—It would be difficult to define the sort of responsibility, because the Commissioners, acting under the direction of their surveyor, would necessarily perform the work upon as economical a plan as it could be done, it being done at all times by contract. For instance, we have generally contracts every year for doing certain works, that is to say, 12-inch drains of such materials shall be done at all times and in all places at so much per work, and done to the satisfaction of the surveyor of the Commis-

* App. No. 28.

sioners. With such regulations it would be difficult to incur any responsibility in the way suggested.

Supposing those 12-inch drains to be nine times the size which is actually required for the work, or that upon full and competent consideration would have been found necessary to do the work, do not you think that the public, or the rate-payers, whose money has been so misspent, ought to have some redress?—Supposing it to be so, but it appears to me to be a case not likely to occur. I cannot conceive of a body of Commissioners allowing a surveyor to build a drain so totally at variance with the public advantage. The man would be discharged.

On inquiry what had been done since 1843 for the relief of the Surrey district, we found the same system of main drainage, and of house and court drainage, still maintained, and the condition of the houses, as dependent on the works of drainage, described by the medical officers to be very little if at all improved by any subsequent expenditure. The condition of the drainage is thus described by the medical witnesses, part of whose evidence we have before quoted:—

Dr. Murdoch* of Rotherhithe, describes the district as altogether "excessively ill drained, intersected with ditches and stagnant water. Many of the places are below high-water mark, and the houses are subject to inundations from these *sewers* when the Thames overflows. The neighbourhood is always more unhealthy for a considerable time after such inundations, catarrhal and rheumatic affections prevailing."

Mr. Doubleday,† the medical officer of St. Saviour's parish, in the Borough, when speaking of the former cholera and the common typhus track, says that the great defect of the district

is the state of the sewers and the house drains. When we visit the houses of the lower classes in these districts, we are met, or, as the expression is, almost knocked down by offensive smells; on inquiring we find that there is some house-drain stopped up, some cesspool deranged, or the cellar flooded. The lower offices of the houses in the neighbourhood of Holland-street and the water-side are subject to periodical floodings, and that with very filthy water. It appears that in the district of St. Saviour's the average age of death is the lowest in any part of the metropolis. I must attribute it chiefly to the *open sewers* and the general bad drainage of the place.

Mr. Leadam,‡ the medical officer of St. Olave's Union, Southwark, thus describes the continued condition of a part of his own district, in respect to the drainage works of the Surrey Commission:—

What is the condition of the place in respect to house and street drainage?—Cesspools are general; the house drainage is excessively bad; we are surrounded by open ditches, frequently filled with black offensive matter, the water sometimes washing it away, sometimes not,

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* App. No. 3. † App. No. 8. ‡ App. No. 5.

and sometimes, on the occasions of high floods, running *into the houses.* The water used to flow up further, and wash better; but on one occasion it overflowed a great extent, and means were taken to confine it; and those means have diminished the run of water, and the ditches are at times stagnant, although this has nothing to do with the flow of water in the sewers, the latter taking off the deep drainage, the former the superficial. The effluvia given off from the gully grates is very offensive indeed. I can speak now particularly of one before my own house. It really makes me sick to go out of my door at times. This effluvia is generally productive of disordered health; it induces a low nervous condition and chronic dyspepsia.

Mr. A. L. Hooper,* surgeon of the parish of St. George, Southwark, who, as already stated, had described to us the former cholera and typhus track, was asked—

What is the condition of the district in respect to house and street drainage?—The houses are very badly drained; they have mostly cesspools, very few draining into any sewers; but the most depressing influence upon the health arises from the number of open sewers which surround and intersect the district; these ditches and sewers are sluggish, and evolve noxious gases. Typhus fever is always prevalent in the vicinity.

What is the condition of the covered sewers?—They emit very offensive effluvia. In the house in which I live we have experience of it. When the wind is in particular directions we have a severe experience of it.

Do you consider it of advantage, in the present state of the sewers, to open any communication with them?—I have been led to consider that point, and to doubt it very much; more particularly since the storm of August, 1846, *when the water from the sewers was* conducted from the drains into the houses, and burst through them. A number of houses were flooded with *sewer water; mine was saturated throughout four feet deep;* the walls have not yet got rid of the stench.

What was the condition of those houses which had no drains to join on with the sewers?—They were certainly better off; they had none of the sewer water.

Similar experience, it may be observed, was obtained throughout the whole of the metropolis on the occasion of that storm, the greatest that had been known as occurring during any historical period. Such extraordinary events have of late been assumed as the justification for the construction of enormous house drains, and collateral as well as main sewers, (in high as well as low levels,) for ordinary and every-day use. On that occasion the districts which were undrained generally sustained the least damage, or where they were flooded were only flooded with pure storm water, whilst the most grievous damage, such as that above described, was done to many of those houses connected with the sewers, which were flooded with sewer water.

Mr. Wagstaffe,† the medical attendant at Lambeth, who had

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* App. No. 2. † App. No. 4.

described the cholera and the fever track in Bermondsey and Lambeth, was asked,—

Are the houses in these localities in general damp and dirty?—Yes, they are; and it is quite impossible for the inhabitants, under such circumstances, to keep them dry and clean.

Whenever typhus is prevalent in the metropolis, is it in these localities that you constantly find it?—Invariably, and common fever is very apt in these places to assume a typhoid type. This is the case at the present time with several cases now under my care. Scarlet fever, measles, and small-pox also are very apt to become malignant here.

Under certain atmospheric conditions, for example, when I arose in the morning, and found the atmosphere warm and moist, I could always foretell that there would be an increase of malarian disease of some sort in these places, and that they would be more intense in degree; so that in this state of the atmosphere I always knew I should have more to do in these low, close, undrained, and crowded places.

Have you observed in houses communicating with the sewers any instances of noisome smells arising from their foul condition?—Yes, I have.

Is this common in the district?—I have very frequently noticed it.

Are not the houses frequently flooded with sewer-water, as well as subjected to poisonous smells?—Yes, they are.

In such cases, is not the communication of the house with the sewers of very doubtful benefit?—In these cases it is certainly of doubtful benefit.

The Clerk* to the Commissioners of Sewers for Surrey and Kent was asked,

With relation to the new sewers which you have executed, what proportion of house drains have joined on to them?—I am sorry to say that they are not numerous.

What is the reason that they are not numerous?—I believe it arises from the effluvia of the sewer.

Have not you heard it stated, as a matter of fact, that in those cases where house drains have joined on to your sewers, the people who have so joined have not found it a benefit?—I have.

In consequence of its giving an opening to effluvia which they were previously free from?—Yes.

In answer to further questions he states, that the Commissioners

Do feel that there is a just complaint made by parties who make communications to the sewers of the effluvia arising from them, which is hardly to be stopped. They make foul-air tubes, but it does not always succeed.

The Commissioners consider that, by compelling the owners of houses to join, they would be making them pay for that which might inflict a nuisance upon them?—Yes.

Have you had complaints to that effect, that a communication by drain from a house into the sewer has really made the house more disagreeable to live in or more unhealthy?—More disagreeable I have. I know the fact myself that it is so. I have recently had a communi-

* App. No. 19.

cation made at our own office with the sewer, and at times it is so offensive that we hardly know how to sit there.

Such being the actual results of the outlay upon sewers, new as well as old, we have learned that it is now proposed by this Commission to raise upwards of 100,000*l.*, and expend it upon the extension of the same system of main sewerage. They inform us that they contemplate no change of the present, or of the past forms of their works; and it is proved that the new as well as the old sewers accumulate deposits. The only step they appear to have taken for the prevention of the evils arising from the sewers constructed under their direction is to make inquiries, certainly of proper authorities: of Professor Faraday, and of Mr. Philip H. Holland of Manchester, as to the means of ventilating these sewers. We were sorry to learn that Professor Faraday had been unable to devote himself to the important task, which he declined in the following terms:—

Dundee, 14th August.

Sir,—My health will not permit me to enter into the consideration of the many points that are offered to me, nor, I regret to say, into the important one contained in your letter. I have the strongest conviction that of all the ways of sweetening the air passages of sewers in a large town, that of casting the vapours and miasma by myriads of passages into the midst of a dense population is the very worst; it is a return in part to the practice of leaving the sewers open. You will, by inquiry, easily find out those who have thought on the question. I have not, and cannot now, closely consider it; but I have often thought that the many furnace and engine flues that rise up so abundantly in various parts of London, might be made to compensate in part for the nuisance which their smoke occasions by being turned to account in ventilating the sewers and burning the putrid vapours generated in them.

I am, Sir, your very obedient Servant,

M. Faraday.

Mr. Holland in effect pointed out the removal of decomposing substances as the most efficient course.

No doubt is entertained that, by means of large chimney shafts in different parts of the district, and currents of air, created by heat in the mode which has been in use for ventilating the Houses of Parliament, and has been applied in Paris to the ventilation of sewers, or by other modes of creating a current of air, the sewers might be ventilated, and even the house-drains brought within the influence of such ventilation. It is indeed probable that even under an improved system of drainage, such appliances might be occasionally resorted to as means of removing the emanations from common sewer water; but in the present state of those works, acting as extended cesspools, or reservoirs of decomposing refuse, even if fires were used, we are apprehensive that the chimneys would distribute much of the products of combustion, so as to add to the pollutions of that atmosphere which from a distance may be

seen covering the metropolis, and diffuse the gaseous products over a wider district.

If, however, nothing more could be done for the southern district than is now done by means of the present works, or than is proposed to be done by the Commissioners of the district, we apprehend that no private individual would proceed with such an expenditure as that which the Commissioners have been advised to make of the rates. We have caused that district to be inspected and its position considered, by officers in whom we have confidence, and we are assured,* on data which we deem sufficient that the evils in respect to the drainage of that district are remediable; and that the greater part of the works for which it is proposed to expend 100,000*l.*, will obstruct future remedies, and will be required to be undone. We therefore submit this as a case in which it is specially incumbent on the Crown to interpose in behalf of the public, as it would be incumbent on a Court of Equity to interpose in behalf of a minor or other unprotected person whose property was so dealt with, and restrain waste, by placing the property under other management.

We proceed to the consideration of the arrangements made or proposed to be made in relation to the drainage of houses under the jurisdiction of this Commission. Being desirous of comparing district with district on points of detailed as well as general management, we requested the officers of one district to visit the others, that they might themselves compare their works and modes of management, and ascertain with precision what the differences were. Three of the officers of the Surrey division went to the office of the Westminster division, and saw the earthenware drain tubes which had been introduced there by Mr. Phillips. One of these officers, the surveyor, Mr. I'Anson,† was asked,

Have you recently been to the Westminster Sewers, and seen what they have in use?—I went there about a fortnight ago.

Were you not satisfied that smaller drains than you had been accustomed to use were desirable?—Only desirable on account of the expense.

Not on account of anything in regard to the flow?—I think not.

You still think that a 12-inch drain would be a good size in respect of the flow?—I do.

Will you state the grounds for that opinion?—It would be more easy to state the grounds why I doubt the advantage of the 9-inch. Theoretically we know that a tube which presents the greatest area or the greatest friction to fluid passing through it, is that form of tube which is the least adapted for the conveyance of water. Take a 9-inch tube and fill it three-parts full, I apprehend there will be more friction upon the sides there than with a 12-inch tube containing the same quantity of water.

Will you describe the capacities of the ordinary inlets to this house drain; will there not be the sink in the kitchen, and occasionally the

* App. No. 23, and No. 26. † App. No. 21.

soil of the water-closet, supposing there to be a water-closet?—Yes.

Of course, the flow from the water-closet is occasional?—Exactly.

For that you use a 4-inch soil-pipe?—Yes, vertical.

Why then do you use a 12-inch outlet, an outlet nine times greater than the inlet?—The outlet in some parts of it is nearly level, and it has other things to take besides the soil from the water-closet.

Take the inlet from the sink: through what sized pipes do the water sinks in use in your districts drain?—About an inch and a half, or two inches at the outside.

What is the proportion of the size of the inch and a half pipe as compared with the 12-inch outlet?—A 64th part of it.

Do you think that an outlet 64 times larger than the ordinary and most frequent inlet is necessary?—No. There is one reason I may state for laying 12-inch brick-drains, and that is that a great many of the drains are tunnelled under the roads. The men sink a shaft; the man creeps into the hole, and lays the bricks as he goes on, or he even pulls the bricks under him, and so lays the bricks. The bore in which he lays the bricks could not well be much smaller than of sufficient size to take a 12-inch drain.

You would not make a 12-inch drain for one house in a court, would you?—It has been our practice.

Another surveyor of the Kent and Surrey district, Mr. Joseph Gwilt,* the author of the "Encyclopædia of Architecture," was questioned on this topic, on which so important a part of the drainage of the town district depends.

It appears that there were in the metropolis, in the year 1841, 270,000 houses. Now, if each were to have at the least a 9-inch drain, as you and architects in general recommend, it appears that the area of the stream or river required to keep them full and flowing would be a stream 1132 feet in width by 105 feet in depth?—Yes.

It is estimated that a supply of water for the whole of the metropolis, supposing each house to have a supply of 125 gallons per diem, or 25 gallons per head, would be given by a circular tunnel or aqueduct 12½ feet diameter. There are in the Kent and Surrey district 55,000 houses, and the supply there would be given by an aqueduct of proportionate size to your number of houses, say, one-fourth. Such being estimated to be the size of conduits required to bring in water, it is presumed that the sectional areas of the drains and sewers would not be required of vastly greater size, supposing them to have as good a fall, to carry away that same water. Can you prove any addition of rain water, or even of extraordinary storm water, requiring a system of drainage of a sectional area more than five times that of the Thames at Waterloo Bridge at high water, or nearly a thousand times the area of the aqueduct that would furnish the whole supply of water to the metropolis?—I apprehend in providing drains for a house, you are to provide against accidents. Therefore, I should say it would be prudent always to have drains larger than are actually necessary to guard against stoppages. A stoppage in a small drain stops up the whole orifice; a stoppage in a large one is partial. There may be most likely a means of its running off in some way or other.

* App. No. 20.

It has been stated that the smaller the pipe is, generally, the less likely will deposit be to accumulate, the greater will be the force of water concentrated upon the resisting medium, and the less likely is the resistance of that medium to be effectual. What is your opinion upon that subject?—My opinion is this: I will take the case of a washer to a sink being open and the cook throwing down anything that comes to hand. It comes against a 4-inch pipe and blocks it completely up, but the end of a cabbage-stalk will pass into a 9-inch drain and there it will lie and decompose.

Do not you know that sometimes servants, or persons living in attics, will throw out substances of all kinds into the gutters? Would not that equally be a reason for making the water-spouts of 9 inches, a diameter as large as chimneys, to carry off accidental substances so thrown in?—Perhaps it would be better in many cases; but we cannot remedy that.

The witness sets forth in the "Encyclopædia of Architecture," that "for a moderate-sized country mansion," a drain with an area of 5 feet is requisite. This is a capacity sufficient, with a moderate fall of water, to discharge 2000 cubic feet of water per minute, and he justifies the use of the space as requisite, "not merely for the sake of carrying off the water, but that the conduit may be cleaned out at times without breaking the whole sewer to pieces." On such justifications of the sizes of construction for the minor drains, Mr. Austin* was asked—

Would there not be constant danger of choking up, in the small system of drains that you propose, from the numerous large substances of all kinds that are now found in the sewers?—Under proper regulations, I am satisfied that no stoppage whatever would occur in any case. It is true that large substances of various kinds—broken china, cinders, oyster-shells, vegetable refuse, brushes, rags, and a host of other matters—are constantly found in the sewers, being thrown, either carelessly or mischievously, down the yard drain into the sink, or down the water-closet. It would be rather surprising if it were otherwise, for not the slightest precaution is used to guard against it. No immediate inconvenience results, and there is plenty of room and to spare, we may be sure, when we hear from the City Surveyor of Sewers, in his evidence before the Health of Towns Commission, that even coffins and tombstones, a bedstead, and the beadle of the parish, lie in them, to be detected only in general explorations. Under a proper regulated system, how easily would these abuses be prevented! Yard drains would not be left unprotected; sink gratings would be effectually secured; surreptitious openings would be impossible; and that form of water-closet basin which will admit of such an abuse, either from the carelessness of servants or the mischief of children, would be at once abolished. The common pan basin, as it is called, is subject to this inconvenience, by reason of its direct communication; but the syphon trap basin, which is equally efficient with a good supply of water, and considerably cheaper, will not admit of the intrusion of such matters.

We need not repeat that the practice of making drains as well

as sewers sufficiently large for men to enter and cleanse them, was in the evidence given before the Commissioners of Inquiry into the means of improving the Health of Towns, demonstrated to be erroneous and mischievous, occasioning the very evils intended to be prevented, and requiring immediate alteration, even if such works were to be had gratis. By structures on these erroneous scales the expense is so enhanced as to lead to denials of any necessity for works of drainage, and opposition to them, through fear of the expenses which they would entail. But, in addition to the expenses of works so much larger than are proved to be requisite, we find retained up to this time a fee of 10*s.* from the person draining, to the surveyor, on each house-drain put in; a fee which, in the poorer class of those in courts and alleys, would be equal to the expense of putting in the drain to be superintended. Every such piece of work is held to be, moreover, liable to the charge of another fee of equal amount, to be paid to the district surveyors under the Building Act.

Our attention was, however, called to other points in the management of the public expenditure in this Commission, by information of a very pregnant question put by one of the surveyors, who when shown the tubular earthenware drains, at reduced rates of charge, proposed by Mr. Phillips, asked whether he (Mr. Phillips), the proposer of the economy, had any commission on the works executed?

On inquiry we learn that only 50*l.* per annum is given as salary to each surveyor of the Surrey and Kent district, and that their chief compensation must be sought for, less in fees—the produce of which is so small (sufficiently accounted for in the nature of the works), that it is now proposed to give them up—than in the commission upon the expenditure for new works.

In the course of a recent inquiry before the surveying officers, on an application for a local Act, the question was put to Mr. Drew,* the clerk to the Commission, whether these gentlemen, the surveyors, were not paid by a commission on the works executed? He answers—

Yes.

A certain per centage?—Yes.

The more the work comes to the better they would be paid?—Yes, the more work that is done, the better they are paid.

The following questions were put to Mr. Gwilt:†—

Have you any other emolument besides the salary and the fees on these openings?—Oh, yes. I have a commission upon the works.

A commission on the estimate that you make, or upon the amount of works executed?—The amount at which the work is done.

And that commission is upon the new works in the district?—Upon the new works of the district. I have no commission on the general

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* App. No. 19. † App. No. 20.

expenditure of the district, the cleansing of the sewer, the superintendence of cleansing of all sewers, and every matter of that kind is included in the 50*l.* a-year.

The commission is only on the new works executed?—Yes; in short, if it was not for that, I could not undertake to do the work. It would be impossible. I should be a loser by it.

By this arrangement of the administrators of the sewers-rates in the Kent and Surrey districts, the officer is apparently made a loser, and has placed before him a prospective penalty, closely adjusted to every measure of economy, on all new works or extensions of existing works, that he may render to the public. The direct practical bearing of the arrangement is denoted in the questions put to the clerk* to the Westminster division.

We understand that under some of the Courts of Sewers the surveyors are paid by a commission upon the sums expended for works? —I believe that is the case.

Has not the reduction of the price of sewers in your Commissions been very considerable lately: in some cases even to three-fourths or four-fifths?—Yes.

Then if your surveyor had been paid by commission he would have proposed the reduction of his own income in the same proportion as the works were reduced, for example, from 400*l.* or 500*l.* a-year to 100*l.*?—No doubt. The greater the economy effected the less the income that would accrue to the surveyor.

The union of the private interest of all public officers with their public duties, is deemed the great problem of administrative improvement, to be intently sought, and practically solved. But whatever may be the difficulties in resolving that problem, we trust there can be no difficulty or hesitation in determining on the discontinuance of a system of management which arrays the private interests of an officer directly against his duty.

We are assured that the proposed lines of new sewers in this district, may be executed in improved forms of construction, for about two-thirds of the expense, 100,000*l.*, which the surveyors estimate as requisite. Any of the three surveyors who might propose, and establish, the practicability of such an economy would incur upon them the loss of the third of their shares of the 5000*l.* commission for the proposed works.

Bearing in mind the direction in our commission, that we should especially regard the districts chiefly inhabited by the poorer classes of the population in the metropolis, we have endeavoured to inquire closely as to the present expenses of draining courts and alleys, and the expenses at which it may be practicable to accomplish those objects efficiently, under an improved system of management. We find that the present regulations of the several Commissions, and the forms of work which they prescribe, subject the owner or the occupier who would drain his premises, often to

* App. No. 12.

more than three times the outlay, and rarely less than double the outlay for inefficient works, that would suffice for works of a degree of efficiency which is unknown under any method of house drainage or sewage now in operation. Some of the details and specifications on this important subject, are given in the evidence of Mr. Phillips* and Mr. Billing.† We have confident assurances that cesspools may be abolished, and a complete system of house drainage maintained in houses of this class for a rate of 2½*d.* per week, including a constant supply of water carried into each house.

However perfect may be the forms and construction of drains and sewers, yet if they are laid down separately without reference to one fixed datum, extensive waste must be committed. The investigations set forth in the Sanitary Report, and in the Reports of the Commissioners for Inquiry into the means of Improving the Health of Towns, shew that extensive waste has in this way been committed.

Mr. Roe estimated that it would require an expenditure of upwards of a quarter of a million sterling to lower the outlets of the sewers of one district, the Holborn and Finsbury district, to act properly as a part of one system of drainage for the whole of the natural area. The importance of systematic surveys as the foundation of systematic work, was variously illustrated; specimen maps were made and published for general information, and have been in the possession of the officers of these Commissions, and have been placed within the reach of the Commissioners. The importance of obtaining trustworthy surveys has, it appears, been repeatedly urged upon them by several of their most intelligent officers. The state in which we find the administration in that part of the metropolis which comprehends the most extensive house property, viz., the Westminster district of sewers, is described in the evidence of officers of the Commission, and their evidence shows that as extensive works are now carried out, without such guidance, extensive waste continues to be committed. Mr. Hertslet,‡ the clerk to the Westminster Commission, was asked—

Have you a set of levels from any fixed datum line?—No, we have not. Our surveyor is trying to remedy the evil, so far as he can do so by taking plans of fractional portions of the district.

Of what proportion have you completed such plan?—Not one-twentieth part of the district is complete; that is to say, of the active jurisdiction. Until lately, I had heard and believed, what has been so generally stated, that our plans were tolerably complete; but since I have been admitted to a more intimate acquaintance with the surveyor's department, I find that the case is as I have now stated it. There is a vast collection of books containing plans, with very little practical information in them.

Of what description are these plans?—They are plans of all scales, sorts

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* App. No. 35. † App. No. 36. ‡ App. No. 12.

and sizes. Very few of them bear any signature whatever, and have been made generally without reference to any fixed datum line. In most cases what is shown upon them is the old and not the present state of the sewerage.

How, in the absence of a proper general plan, and sections to a fixed datum line, can you proceed with any certainty that works laid down in separate places will fall in with a general system?—We cannot proceed with any certainty at all. The surveyor is daily deploring to me the want of such a plan; and with a list of about 70 matters already referred to him for reports, and accumulating each Court day, it is no wonder he should do so. We have urgently pressed upon the Commissioners at various times, in and out of Court, the absolute necessity of such a plan; and the surveyor is at present engaged in obtaining information as to the cost of one, and other particulars.

What are these reports upon?—Principally complaints of inefficient drainage.

Do these complaints come from the poorer districts?—The greater part of them do not. The poor, being used to the want of drainage, and never having heard of the value of it till very recently, bear their lot most patiently, and seldom make any serious complaint, except perhaps to the collectors of the rates. The complainants are for the most part, of another class; such as from Bryanstone-square, Montague-square, Norfolk-street, Park-lane, Upper Brook-street, and also with reference to some of the principal main lines being uncovered.

Are you aware that it has been stated that there have been typhus fever cases in Bryanstone-square?—No; but I have heard of fever in Montague-square. In Bryanstone-square, there is a sewer on each side, but not sufficiently deep to drain the houses. Complaints have recently been made, that the water does not freely flow from the drains, and that the gully gratings are excessively noxious. The sewers in Montague-square do not extend much above half the length of the square, and run northward. These were evidently sewers built without regard to any fixed datum line; and had reference only to what was believed to be the nearest and most ready outfall.

If you amend that drainage now, can you be sure that you will not have to undo it again before long?—Every care would be taken by our present surveyor, no doubt; but we can never act with confidence until a general survey is made.

Would it not be expedient for the public good to suspend all your important works for a year or some such period, to have the security of a general plan and sections?—I think the most urgent works only should be allowed to proceed, in any district, till a general plan of that district, at least, shall have been completed. I believe no means could be adopted more necessary or advantageous for the public service, than to suspend all works of magnitude till the survey shall have been made. During the progress of the survey, in order to keep the workmen in employment, the house-drainage (of which, at present, we know nothing, but which by the recent Act is placed under the control and supervision of the Court) might be examined, and brought into some state of preparation for the improved sewerage. The saving which would be effected by the survey would be immense. The existing volumes and rolls of plans, with the books and registers of depths, the lists of sewers,

&c., &c., might be all thrown aside, and the facility of reference to an engraved plan and sections, corrected regularly, would be so great that the staff of officers required to refer to the present books and plans, to take disconnected levels, to prepare detached portions of plans from time to time as is now done, and to make out fresh lists and registers of such detached portions would be no longer needed.

Would not the dangers, and the expense of these doings and undoings of works, and the loss of health and comfort, as well as of money, from bad works, be also saved?—They would.

Might not a very close approach be made to the cost of a complete system of sewerage and drainage, and street cleansing, on such a plan being completed?—A very close approximation might be attained to, and I should think it might be done as each level was completed.

Until such a survey be made, can any good estimates be reasonably expected?—It would be out of the question. If made they would totally mislead.

The following is the account given by the surveyor* himself, of this state of things:—

How are you now able to go on without any survey?—That is a subject of the first and greatest importance; and I am confident that until a complete survey of the metropolis is made, showing every street, every court, every alley, and every house, with a system of levels, referable to a fixed datum line, (say Trinity high-water mark, which is the datum I use in all sections, showing the sewers,) it is impossible to put in sewers in positions so that they may join together hereafter as part of a complete system, and so as to make the water running along sewers on a high level available for washing out sewers on a low level. I mean of course the districts not under high-water mark. Without such a plan and system of levels the arrangement of the sewers must be guess work.

Have you ever represented this opinion to the Commissioners?—Yes, repeatedly; both in Court, and to individual Commissioners out of Court. About two years ago, I wrote an article in the "Builder," in my own name, in which I urged that no more work should be done until the actual condition of the sewers was ascertained, and a scheme laid down for their entire improvement. This is an extract from that article.

"It should be distinctly understood that no more work should be commenced until the sizes and falls of all the sewers have been determined on, and re-arranged according to a regularly graduated scale; and I have no hesitation in saying, that until either this be set about and done, or they be entirely rebuilt, there are very many lines which will never be any other than elongated and filthy reservoirs or cesspools, the matter in which will be continually contaminating the atmosphere with its deleterious products. These great evils require immediate reparation, which should not be done piecemeal, but upon a well-organized system of arrangement; and if the matter be taken up, as I trust it will, the cost of putting the whole of the badly formed sewers into a state of comparative efficiency could be ascertained without great

* App No. 13.

difficulty." The paper containing that article was sent to the Court by the Editor of "The Builder."

What attention has been paid by the Commissioners to your representations?—None whatever, until very recently, when I was ordered to report as to the measures to be taken for obtaining a complete survey and map of the jurisdiction of the Commissioners.

Would you make no exception to the suspension of employment until a survey can be got?—Of course I make exceptions for cases of emergency. I apprehend that the first step would be to commence simultaneously on all the outlying or suburban districts, where buildings are in hand or likely to be commenced, and then complete the plans and levels first, so as to give the greatest facility to new works and prevent the workmen being thrown out of employment.

Is not this piecemeal mode of surveying, planning, and levelling, attended with much expense, loss of time, and inconvenience?—I feel sure that, were a competent staff of surveying officers employed to make a complete map of the metropolis, the expense in the end would not be near so great as the present piecemeal mode of proceeding. A considerable saving of time would result, and the work would be better and more accurately done, and consequently could be safely depended on.

Do you from your levels make longitudinal sections of the streets, showing the levels of the proposed improvement of the sewers?—Yes, after I have determined as to the best arrangement of the lines of sewers.

Are you satisfied that in your new arrangements of the sewers and the levels you determine to put them in at, you are designing the work correctly, and with a view to their future extension, and for the improvement of other districts?—No; I cannot say that I am quite satisfied of that. All piecemeal work, however careful one may be, is liable to lead to disappointment. When I begin the work of improvement in a street, I am induced, with a view to a complete arrangement of the sewers, to travel from that street to another, and so to another, until I go so far as to embrace an entire district, and even then I find it necessary to take in other districts as well. I know not where to stop, the drainage and the sewers generally being so very bad and dilapidated, and nearly the whole, in some way or another, requiring amendment or alteration. I often find it necessary to take up sewers that have been put in of late years. I do so rather than risk incompleteness. I should feel more safe and confident in being able to produce a perfect arrangement of the sewers had I to lay down an entirely new and complete scheme for the improvement of the drainage of the whole of a natural area or of the entire metropolis, than I should do by simply taking a small section of either; and my experience in laying down of plans for the re-arrangement and improvement of the sewers obliges me to say that the drainage will never be improved as it should be until a comprehensive scheme is put in hand similar to what I have described.

Mr. Beek,* the surveyor of the Tower Hamlets district, was

* App. No. 29.

questioned as to the state of the essential means of guidance for the systematic construction of works within that district.

With respect to a survey, have you levels of your whole district taken?—No; we have longitudinal sections of the sewers built within a few years past. Those were sections made before the work was carried out.

Suppose you wanted a block of houses drained in some part, how could you tell that it would join on with any future system of drainage?—All I could do is to take the situation of our sewer, and likewise the situation of property beyond it. By that I can ascertain the probability of its being carried further.

You drain to your nearest outfall in fact?—Yes; if I found there was a fall in the land one way or the other, I should take care that the sewer was taken to the lowest possible level.

Have you ever mooted the subject of getting a general survey to a fixed datum line to the Commissioners?—No.

Nor have they to you?—No.

It has not entered into the consideration of the Commissioners?—No; we have a very large plan.

When was that made?—In 1833.

You cannot tell what levels were taken?—No levels were taken.

You do not know how far it is to be trusted or not?—No.

In the Kent and Surrey district it appears that separate levellings are required for each separate piece of work, and that the general condition of the sewerage, whether as respects the actual state of the works, or the conceptions of its managers as to the means of amendment, is no better than is displayed in the testimony of the last witness, notwithstanding all the illustrations that have been publicly and authentically given upon the subject.

Perceiving the paramount and pressing importance of a general and complete survey and levelling, and considering it probable, that out of the various surveys in the several districts, some of them made apparently at considerable expense, there might be found trustworthy materials in aid of a general work, we requested Colonel Hall,* of the Royal Engineers, who has succeeded Colonel Colby in the direction of the Ordnance Survey to examine them, which he did. His report is in effect a condemnation as worthless of the whole of the materials shown to him in the several offices for any general survey. None of the plans are based upon points trigonometrically fixed.

In connexion with this subject of a general survey as a basis of systematic work, it remains to us to advert to the proposition already demonstrated in preceding reports, that the whole of one natural drainage area, comprehending at the least the lines of watershed to natural outfalls, should be under one and the same jurisdiction. We directed our inquiries to ascertain whether any effectual attempts had been made by voluntary co-operation (on

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App. No. 32.

which, however, the important interests of the public health should not be left dependent) to remedy the evils experienced from the separation of the districts. On this subject Mr. Roe,* the surveyor of the Holborn and Finsbury division, was asked—

Notwithstanding your existing materials, would it not be an economy to have a plan upon a large scale for this district, as well as for the whole of the metropolis?—Yes; I think it would be of great importance to have a plan on one large scale for the whole of the metropolis, and that it should be governed by one law.

(Mr. *Stable.*) In that I also cordially concur, as I consider it would be a matter of great importance.

Will you not require more outlets and main lines of drainage?—(Mr. *Roe*) Yes, I am preparing a report to show that more main lines will be required.

Under the existing state of things, will not two or more independent authorities have to concur, not only in the expediency of those lines, but two or more sets of independent officers have to superintend the execution?—Yes.

May not two or more independent authorities determine, if they so think fit, to have a different form of sewer for the discharge of the same run of water through the different districts?—Yes, they may.

Have you not had even recently different forms of sewers made for the same outfall?—Yes, we have.

Will you give the last example?—The last two were in Charlotte-street Bloomsbury, and in Museum-street. They were both for the relief of the Holborn district, extending from the Hampstead-road to George-street, Gower-street, and Bedford-square.

What were the differences of form in the same outfall?—In Charlotte-street, the Holborn and Finsbury being the egg-shaped sewer, with the small end downwards, the Westminster Commission brought up their outlet to ours in the egg-shaped form, only with the broad end downwards. In Museum-street the Westminster sewer was of the upright sides, and nearly a flat bottom, with spreading footings.

What was the difference of the expense of the two forms?—One form, I know, cost about 14*s.* per foot. I have been informed that the cost of the Westminster sewers was about 28*s.* per foot in Museum-street.

Had, then, the natural drainage area been under one jurisdiction, may it not be presumed that the same main line would have been carried throughout, of one form, and at one expense, and that expense a reduced one?—Certainly. I should never have thought of having different forms for the same outlet.

Irregular workings and public inconveniences are manifest from part of the outfalls to this same upper district, the Holborn and Finsbury district, being under the jurisdiction of the lower or intermediate district, the Tower Hamlets division; and the witnesses† from the Tower Hamlets in their evidence, admit that the public convenience would be promoted, if from that district an outfall were constructed through the lowest district, which is in

* App. No. 1. † App. No. 28. and No. 29.

the Poplar division, by which outfall they the upper, or intermediate district, would obtain a more rapid exit to the Thames; whilst it appears that the rate-payers in Poplar, this lowest district, have in their turn reason to complain of unequal charges arising from their paying for the outfalls benefiting houses and property above, which, from the ancient and capricious arrangement of the districts, apparently constituted for the surface drainage of separate pools, do not contribute in proportion to the supposed benefit derived from the general works of drainage.

Whilst such continues to be the state of the works and of the administrative divisions in the metropolis, we find little or no amendment in the inequalities of assessment, and the most unsatisfactory collections of the rates. In the Kent and Surrey district, indeed, the principle of the distribution of charges for permanent works, pointed out under preceding inquiries, has been introduced; but it has been misapprehended and misapplied to the extent of three-fourths or more, the equity of the adjustment amongst the contributors being apparently sacrificed to the supposed convenience of the officers, or the avoidance of their trouble. Mr. Drew,* the clerk, having stated that the Commissioners had the powers of distributing charges, was asked—

What are your means of doing so?—They exist under the present Act of Parliament. All sums above 10*l.* may be thrown over 20 years.

Take a case of a sum under 10*l.*, how may that be dealt with?—The Commission decides upon the course.

What may the Commissioners do?—They have said the payment shall not exceed 20*s.* a-year, so that if it is 5*l.* it will be spread over 5 years.

Supposing it to be a class of house inhabited by labouring people, or one of the fourth class of houses, where the payment would be 5*l.*, it would be required to be paid for in five years?—Yes.

Supposing a house to be held by a person who has only the remainder of a lease of five years, he would have to pay in those five years for that which would probably last during thirty?—Yes.

Would not the circumstance of his having to pay such a sum form in itself a very great obstruction to the application of drainage to cottages of that class?—I am sorry to say that the payment of any money by the owners of small houses very much retards any improvement.

Supposing that cost of 5*l.* to be spread over a period of 30 years, and to be repaid by annual instalments, it would amount to 5*s.* 11*d.* per annum principal and interest at 5 per cent. per annum. If, instead of requiring 1*l.* per annum, or 5*l.* in 5 years, it were only 5*s.* 11*d.* which was required, would not that be not only more correct in principle, but give an enormous facility to the drainage of that class of houses?—But I am afraid the public would lose a great deal of money in that way.

In what way?—In getting those small payments.

You would charge rates upon that small property?—Yes, but they are generally compounded for by the landlord.

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* App. No. 19.

Would he not compound for this 5*s.* 11*d.*?—He would have five years to pay it in according to the present plan.

Would not it be more equitable to him if he had 30?—It might be so.

Would not it facilitate the drainage of this class of houses by persons having short interests—a lessee, for instance, having only a term of five years?—Yes.

And so with all other classes of houses of that description?—Yes, but it would create a great deal of work to be done. There is an instance where the Commissioners are going compulsorily to arch—here (*producing the same*) is a plan of it; here is the name of every individual, the length of feet he has got to pay, some of the cases amounting only to 3*l.* or 4*l.*; and in this little account there are twenty or thirty debtor and creditor accounts to keep.

Would there be more difficulty than in levying every other species of rates?—It would be generally speaking, added to the rate.

And it would be a convenient consolidation to collect it with the poor's-rate, or with any other?—Yes.

We beg to guard ourselves from any supposition that we assume that any legal obligation attaches to the general or to the particular recommendations set forth in the official reports, or any other than the authority of the facts and reasonings themselves, whether of the witnesses or of the persons charged with such investigations. When, however, the causes of public evils were clearly traced to the construction and management of works under the direction of these district Commissions, and the principle and means of amendment, which might have been readily tested, were made plain and illustrated, and widely promulgated, it became obviously incumbent on such Commissions to modify their proceedings conformably to such improved principles.

Under some of the Commissions of Sewers, the law of sewers has been read as not comprehending house drainage, or that portion of the town drainage which is now understood by the term sewerage. It is highly probable that drainage of surface water solely was contemplated at the time of the passing of the statute, and the formation of the sewerage districts; but that the early usage and accustomed interpretation of sewerage was town drainage, in the most comprehensive sense, is shown in such passages as the following, from the life of Lord Guildford, the Lord Keeper of the Great Seal, temp. Chas. II. and Jas. II.; and at all events there is an implied duty in the administrators of the law who perceive its working to be defective or injurious, to represent those facts early and authentically.

His Lordship procured to be done another good work, which exceedingly improved the dwellings in all Chancery-lane, from Jackanapes-alley down to Fleet-street. He found in a house a small well in the cellar, into which all the drainage of the house was received, and when it was full a pump went to work to clear it into the open kennel of the street. But during this pumping the stench was intolerable, and

offended not only his Lordship, but all the houses in the street, and also passengers that passed to and fro in it. And other houses there which had any cellars were obnoxious to the same inconveniences. His Lordship proposed to them to join in the charge of making a drain or sewer all along the street, deep enough to discharge into the grand common sewer in Fleet-street. The inhabitants would not join, alleging danger to their houses, and other frivolous matters; and thereupon his Lordship applied to the Commissioners of Sewers, and obtained a decree, by virtue of which it was done whether they would or no, and the charge paid by a contribution levied upon them; and then they thanked his Lordship as for a singular good done them. Which is an instance showing that the common people will be averse to their own interest till it is forced upon them, and then be thankful for it.

We now beg leave to submit the summary of our conclusions in this our First Report.

Having consulted in relation to the rise and spread of cholera, the experience obtained in the most severely visited districts in the metropolis, and also the most authentic records of the experience in the principal towns in Great Britain and in Europe, we find, in relation to this disease:—

That amidst the town populations the cholera visits with most severity the same classes of persons and the same places, and is governed nearly by the same circumstances as typhus.

That it has been proved by experience that those circumstances are generally removable by proper sanitary arrangements, and that typhus is to a great extent preventible; and we have every reason to believe that the spread of cholera is preventible by the like means, namely, by general and combined sanitary arrangements.

That these arrangements, instead of being incidental and collateral to other measures, are paramount, and principal, and effective, not only against cholera, but also against other epidemics.

That when cholera first appeared in this country the general belief was that the disease spreads principally, if not entirely, by communication of the infected with the healthy, and that therefore the main security of nations, cities, and individuals, consists in the isolation of the infected from the uninfected—a doctrine which naturally led to the enforcement of rigorous quarantine regulations; the establishment of military and police cordons; the excitement of panic; and the neglect, and often the abandonment of the sick even by relations and friends.

That since opportunities have been obtained of a closer observation of the character of this disease, and of the mode in which it spreads through continents, nations, cities, towns, and families, facts have been ascertained which are incompatible with the foregoing view of its mode of dissemination, and of its prevention.

That the disease is not, as it was then generally supposed to be, contagious, and that the practical application of that doctrine did no good, but was fraught with much evil.

That when it previously visited this country it was believed that the most powerful predisposition to this disease is induced by improper or deficient food, and that, for this reason, its chief victims are found among the poor; but it is now universally admitted that a far more powerful predisponent is the habitual respiration of an impure atmosphere; that the highest degree of susceptibility is produced where both these conditions are combined, that is, where people live irregularly, or on unsuitable diet, and at the same time filthily; and that, in places in which a great degree of cleanliness is maintained, the poor as well as the rich enjoy exemption from this disease.

That on an examination of the actual state of the back streets, lanes, courts, and alleys of the metropolis, it is found that in general little or no improvement has taken place in their sanitary condition since the prevalence of cholera in 1832; and that were this disease again to break out in the present state of these localities, there is no reasonable ground to suppose that the pestilence would not spread as extensively and prove as fatal as on its former visitation.

In regard to this disease we fear that complete measures of prevention must be eventual on the combination of works, which must be the subject of further investigations; but in respect to the immediate and special measures available for its prevention, we find that such would be—measures of cleansing of whole lines of sewers, from their commencement, through the several districts to the outfalls; the cleansing of cesspools (wheresoever it may be effected in the sewers), and the removal of whatsoever may be removed in suspension in water in the various modes of flushing, by the use of additional and abundant supplies of water, and we find—

That it is expedient that a Commission for the entire drainage of the whole of the metropolis, should be appointed, with a special view to such measures, and with aid to carry them out.

With respect to measures of alleviation of cholera, we find—

That it is one of the peculiar characteristics of this disease, that it sets at defiance, to a great degree, the resources of medical art and science, as is too fully proved by the fact that, under the most favourable circumstances, of those whom it attacks there perish nearly two out of seven, and under the most unfavourable circumstances nine out of ten.

That still there can be no doubt that individuals are saved, who would otherwise perish, that are early placed under favourable circumstances and judicious medical treatment.

That although the removal to cholera hospitals, unless at a very early period of the attack, and unless the situation of the hospital happened to be highly favourable, was proved by experience to be injurious rather than beneficial; yet among the classes most subject to this disease, there must be individuals in a state of such utter destitution as to render some provision absolutely necessary.

That it is desirable that existing establishments for the reception

and treatment of the sick, be immediately inspected by officers especially conversant with warming, ventilation, and other structural arrangements, to advise on the alterations and adaptations necessary to afford effectual aid to the individuals who may require it.

That where there is at present adequate accommodation by proper hospitals for fever cases, such accommodation will in general suffice for cholera, fever not being prevalent when cholera is epidemic, and fever cases being in general more numerous than those of cholera.

On the inquiries we have made as to the administration of the law of sewers in the several districts in the metropolis since the year 1834, when the administrators of that law were examined by a Committee of the House of Commons: since the year 1842, when they were examined under the Sanitary Inquiry, and 1843 when they were investigated by the Commissioners of Inquiry into the means of Improving the Health of Towns; and on the best consideration we have been enabled to give to the descriptions of works which have subsequently been carried out by direction of the Courts of Commissioners of Sewers, to the mode in which they have exercised their existing powers, and to the measures for which they have obtained, or propose to obtain, the sanction of Parliament, we find—

That unnecessary expense and inconvenience to the public is consequent on the division of the natural drainage areas among several distinct authorities, and that it is impossible that improved works of systematic drainage can be carried out under arrangements that geographically divide the lines of watershed and the outfalls between separate and conflicting authorities.

That the works which the present district Commissions execute, and propose to execute, are uncertain, erroneous, and defective in their general principles of construction, injurious in their action, and unduly expensive.

That after the authentic expositions which have been given of the principles of construction and management of improved works, the extensions of sewers or drains, accumulative of decomposing refuse, are acts of injury to the public health, and of waste of the public money.

That the execution by the district Courts of Commissioners of large works of drainage or sewerage, without reference to any general plan or survey, involves great risk of erroneous and imperfect works and waste of the rates they are empowered to levy.

For the prevention of disease and the saving of health and life, by early carrying out efficient works of drainage, and diminishing the mass of atmospheric impurities, by which the public health is depressed; and, for the prevention of expenditure upon inefficient

works, we feel it our duty to recommend an immediate exercise of the powers of the Crown, and

That the several Commissions appointed under its authority, in the metropolis, be recalled with the least possible delay.

That the law of sewers, now administered by numerous persons in these separate districts, be confided to one body of Commissioners for the whole of the metropolis.

That to ensure executive dispatch, and obviate that weakening of responsibility which arises from its present division amongst large bodies, the Commissioners should be limited in number; and competent, through their known attention to sanitary improvement, to select and sustain the labours of paid officers and the execution of works in the attainment of this their proper object.

Though the practical consolidation which we submit as necessary, and within the power of the Crown—its rights not being, as we believe, barred by any of the local Acts—would be a great advance upon the existing state of things as a permanent arrangement, yet we now submit it as a measure of immediate urgency to abate epidemic disease, and to stay waste; at the same time we regard it as essentially preparatory to further alterations which we propose hereafter to submit for the consideration of Your Majesty.

Should the apprehension of the return of the pestilence prove unfounded, as we fervently hope it may, all measures preventive of that epidemic cannot fail to be successful against fever, and other large and fatal classes of disease. If that which may be done within the time, with every aid and exertion in carrying out such measures, be little, as compared with the magnitude of the evil, it can scarcely fail to repay the effort.

Concurrently with the immediate works of flushing and cleansing, which the paid officers may be enabled to carry out, we expect that the first work which a consolidated Commission must see the necessity of directing to be proceeded with would be the general survey by the officers of the Royal engineers, under the direction of the Board of Ordnance. Whatsoever may be the modifications of the authorities having charge of the public works for drainage and cleansing, or the ulterior measures which may be adopted, there can be no reasonable doubt of the execution of the survey being the measure of paramount and most pressing importance. Until the consolidation of the districts which we recommend is effected; until the work of the survey is proceeded with, and further inquiries and experiments based upon it are made, we do not see that it will be practicable to make satisfactory proximate estimates of the extent, and expense of the alterations and adaptations practicable in the old and erroneously constructed works, or the extent of new works which may be required to be done for the purposes in question. Such estimates would be desirable, in order to determine the modifications of the executive

agency for conducting the new works required. We apprehend that it is only by such a body as the one we recommend for the whole of the metropolis, that complete general results, deducible from a general survey, may be reasonably expected to be brought out for the future guidance of this branch of the administration.

We beg leave to represent the expediency of concentrating early the largest practicable force of the Ordnance Survey upon the metropolis. It appears that surveys have been made for Liverpool, Manchester, and the other towns in Lancashire and Yorkshire, as enumerated in the evidence of Colonel Hall.* If the survey of those depressed towns, and that important part of the kingdom had not been completed, we might have adduced evidence, of the expediency even, as regards that population, of completing the survey and plans for the metropolis, in the first instance. It has been generally found that the errors of the works of this class in the metropolis are literally copied and exaggerated in the provincial towns, where it is rare and accidental to meet with any improvements upon them. In the provincial towns, which had abundant sources of water supply within reach, the pernicious system of intermittent supplies have been copied from the metropolis, to the injury of trading companies, the deterioration of the supplies, and at double expense of works to the consumers. The metropolis presents, perhaps, the greatest variety of difficult conditions to be dealt with; upland districts and lowland marshes with outfalls below high-water mark, densely populated town districts and open suburban districts, with much important agricultural drainage to be considered and provided for in the general arrangement of the drainage of the natural areas. The early improvements of these works in the metropolis, cannot fail to be conducive to the extension of the like improvements in the provincial towns.

The south side of the river, of course, forms of itself a distinct drainage area, and might be the subject of a distinct jurisdiction, but we need not advert to all the considerations, amongst which is the saving to the rate-payers of the unnecessary expenses of separate establishment charges, which render it desirable that it should be brought under one and the same survey and course of systematic improvement, under the same administrative body. There are also engineering grounds for this proposed consolidation.

Though the natural drainage basin is the least extent of geographical area that can be included under one establishment or set of works with economy and efficiency, more than one basin or natural drainage area may be comprehended with public advantage within one jurisdiction. The eventual combination of works for the supply of water, with works for the application of refuse, and with works for sewerage, indicate the necessity of extending the administrative district beyond the drainage areas to comprehend these related works.

* App. No. 32.

It might be considered and objected that the details of management for so extensive a district, would be numerous beyond the powers of one Board to compass, and such would be the case, if the same modes of transacting business which are now in use in these district Courts were to be continued; if business which ought to be dispatched from day to day by paid, competent, and responsible officers giving their whole time and attention to the subject continues to be reserved and delayed, incurring the expensive attendance of architects and builders until Court days held at long intervals, when it is dispatched, unavoidably, *en masse*, by the honorary and irresponsible members who casually attend, and who dispose of it in the manner described in the evidence of Sir George Phillips* and of Mr. Hertslet,† the clerk to the Court of Sewers at Westminster. On analysing the business of these district Courts, meeting weekly, fortnightly, monthly, or quarterly, it appears that a large proportion of it arises from the very defects of their own plans and works, which under an amended system will disappear. Those who have paid attention to the dispatch of large amounts of varied business are aware that up to certain limits the larger the amount the more complete are the means of classifying and systematising it, the better the real dispatch of it. We shall have occasion to cite as an example, the consolidation under the Metropolitan Road Commission of the administration of the roads formerly administered by a number of local trusts, comprehending the suburban parishes in the metropolis. Under that Commission, the roads have been improved, the tolls and the debts reduced, and the business of 100 miles of road transacted satisfactorily, with less attendance and consumption of time on the part of the honorary members of the Board than was previously required by the defective dispatch of business, by any one of the numerous separate Boards under which important improvements were found to be impracticable. It may be averred, that the business of a Commission of Sewers for the whole of the metropolis may eventually be dispatched better, and more expeditiously than the business of one of the single Commissions.

On the Commissioners of Sewers on which we have felt it our duty to report as above, we find the names of his Grace the Duke of Wellington, of the First Lord of the Treasury, of the Lord Chancellor, the Lord Chief Justice, and of other noblemen and gentlemen of the highest position and talent in the country. As it must have been known that they could not attend to the duties of these Commissions, we submit that it is objectionable in principle, so to use such names, or to associate them before the public with business in which they can really have taken no part.

It has appeared to be our duty to state that we have had presented to us ground of exception against one class of appointments

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* App. No. 15. † App. No. 12.

to these Commissions, namely, that of surveyors, of architects in practice, of builders, traders, agents, and professional persons connected with building operations in their respective districts.

The more the investigation advances, the more is it apparent that the progressive improvement and proper execution of this class of public works, together with the appliances of hydraulic engineering, cannot be reasonably expected to be dealt with incidentally, or collaterally to ordinary occupation, or even to connected professional pursuits, but require a degree of special study which not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice.

In justification of this conclusion, and to show the evil of the perverted application of names of high general professional authority, we might adduce examples of the most defective works which have received their sanction.

All the improvements which the public have yet obtained in this branch of public works have been the result of the special and undivided practical attention of well qualified paid officers, and it appears to us that further improvement must be sought by the same means, and that one of the chief objects of future administrative arrangements must be to secure, protect, and encourage the zealous undivided attention and efficient labour of such officers.

The urgent causes for expediting this our First Report, have compelled us to restrict our investigations to the condition of the chief districts in which the powers of the Crown may be immediately exercised for the public protection, by revoking the Commissions and altering the geographical areas of their jurisdictions. We have therefore postponed similar investigations in the City of London, where the Commissioners of Sewers are appointed under an Act of Parliament by the Corporation, and have also the control of the paving and lighting. For the same reason we have deferred any inquiry into the means of improved water supplies, surface cleansing and paving, the assessment and collection of rates, and the other important topics of inquiry involved in our Commission.

All which we humbly certify to your Majesty.

(Signed) ROBERT GROSVENOR. (*L.S.*)
EDWIN CHADWICK. (*L.S.*)
T. SOUTHWOOD SMITH. (*L.S.*)
RICHARD OWEN. (*L.S.*)
RICHARD LAMBERT JONES. (*L.S.*)

Gwydyr House, Whitehall,
19th Nov., 1847.

MINUTES OF EVIDENCE.

No 1.

R. Bowie, Esq., Surgeon.

(First Part.)

Where were you practising at the time that the cholera broke out in the metropolis in 1832?—In Burr-street, East Smithfield.

That is close to the river-side; what description of places and population had you to attend to within your district?—I had to attend to persons of all descriptions; merchants, wharfingers, seamen, sea-captains, the dock officers, and the poor population in the neighbourhood, in lanes, courts, and alleys parallel to the river; and on the northside of the London Docks, including Rosemary-lane, and the courts and alleys adjacent.

What was the condition of the houses in the district inhabited by the labouring classes?—In general very bad; it was the practice to pump the water out of the cellars, which had got up into the houses by infiltration from the river, or more frequently by flowing in through the house-drains from the sewers when the tides forced back the water into the house. The stench from the water pumped out from the cellars was often intolerable; so much so, that I was accustomed to go out of the way to avoid it. The pumping took place late at night.

Were cesspools general?—Yes.

They percolated the substratum?—Of course.

And the river water, percolating through the substratum, carried with it the matter from these cesspools?—It would; besides the river itself there was very impure, in that locality large sewers emptying themselves into it at various places. The outlet of a very large one emitting most noxious effluvia was at one of the wharves nearly opposite the western extremity of Burr-street. The shipping, chiefly Scotch smacks, lay close to this outlet; on board of which vessels many cases of cholera occurred.

How were the labouring population situated as to crowding, ventilation, supplies of water, and cleanliness?—In all these respects wretchedly; the crowding was excessive, the ventilation bad, the rooms, furniture, and clothes dirty. The water supply was very insufficient; it was an intermittent supply from the water Company, distributed in courts, by stand-pipes, on intermittent days. The fatigue of fetching it was so great that it was only used for purposes deemed of absolute necessity, such as cooking; the population rarely bestowing much of it on their own clothes or persons. I remember it well, as a fact, that the water, from being kept so long, and absorbing the impurities of these places, often smelt very offensively.

What was the condition of the streets as to paving, cleansing, or scavengering?—The paving in the courts was a rough bolder paving, like the roadway or paving of the streets; but much neglected (as it is still in many places), with cavities filled, after rain, with decaying

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vegetable and animal matter, and stagnant or putrid water, the scavenger rarely visiting them.

To what extent were these places visited by epidemics?—Very frequently, and very severely. In 1828–9, I attended the district as the honorary surgeon to a Society, called the London Destitute Sick Society; and it fell to my own lot to attend there seventy-two cases of typhus, besides numerous cases of scarlet fever, many of them of a very malignant type.

Was the visitation of the cholera very severe in that neighbourhood?—Yes; the cholera first appeared there. I believe I had the first case, of which we had any knowledge, as having occurred in the metropolis. Disease then spread over that side of the river, including Limehouse, and the opposite side, Rotherhithe and Bermondsey.

Do you know the sanitary condition of the population on the opposite side of the river?—Yes, it is very bad; the land lying low, being very ill-drained, and abounding with foul ditches.

State the nature of the first cases which you had.—The first case was that of a seaman named Daniel Barber, mate of the "Felicity," of Limerick, which had come to London direct from that port, and had lain in the river three weeks prior to his being attacked. My brother, who was with me in practice, saw him about 10 o'clock on the night of the 7th of February, 1832. He sent for me, and I went on board about 11. The patient was then in a state of collapse, blue, cold, and pulseless, and suffering severely from spasms. He died about 4 o'clock.

What was the condition of the ship itself?—There was nothing very particular in her condition.

What, however, is the general sanitary condition of merchant ships?—The accommodation of the smaller class of ships, especially coasters, is very confined; they are filthy, unpleasant, and unwholesome. The men often sleeping, feeding, and cooking in the same place, which is very badly cleansed and ventilated. Frequently, moreover, considerable quantities of wet clothing are thrown down upon their chests, or boxes, or anywhere else they can place them. Fever is very frequent among the crews of these vessels, and very severe.

That is to say, fever occurring on board the ship?—Yes.

May not such circumstances give rise to the popular suppositions of fever or epidemics being imported by such vessels, which have arisen on the spot, on board, and with sufficient cause?—Undoubtedly. In the very instance of the "Felicity" it was given out that the cholera had been imported into the metropolis by that vessel. Now the neighbourhood where this case occurred was one of the dirtiest along the river. What were called the "bone-vessels," vessels employed to carry old bones for manure, usually lay there, and some of them lay there at that time. The smell was exceedingly sickening, and was perceptible at a great distance. Such was the recklessness of the crews of these vessels, that I have frequently seen them using the bones as fuel, and cooking their provisions with them; the most offensive smoke meantime penetrating into the houses along the shore. Putrid carcases of dogs, cats, and other inferior animals, likewise the refuse from the shipping in the neighbourhood, thrown into the river, or left on the muddy beach by the tide, were allowed to remain there, deteriorating

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the atmosphere, until removed by nature's scavengers. The whole of the coast extending from St. Catharine's Docks, the entire length of High-street, Wapping, was very bad, with the exception of a few houses at and near the entrance of the London Docks. And I know it to be a fact that the water for all domestic purposes was pumped into many of the houses from the parts of the river where these impurities abounded.

From the circumstances of seamen, though robust and young in life, living in such condition as you describe, would not you consider them to have a special susceptibility to such a state of atmospheric impurity?—Yes; but even at sea, and away from all ports, cholera has apparently broken out spontaneously.

Do you attribute that to the confined and unwholesome state of the ship itself, or that part of the ship in which the seamen take their meals and sleep?—Principally to that part of the ship where the seamen take their meals and sleep. But the whole of the internal part of a ship may be very unwholesome; according to the nature of the cargo, or where bilge-water is allowed to collect. Vessels containing putrid hides, or other animal matters in a state of incipient putrescence, particularly guano ships, I would say, are likely to be dangerous when cholera prevails epidemically.

Had you the next cases which occurred in your neighbourhood?—I believe I had; I am not quite certain, but think the second case was a seaman named Thomas Skowes, of the "Evander," of Aberdeen; he died likewise. The vessel lay off the Hermitage, the patient was visited by several medical gentlemen, amongst whom was the surgeon of the "Dover" cholera hospital-ship. Skowes exhibited one of the peculiar features of the disease—a strong likeness to Barber; on mentioning this to the surgeon of the "Dover," I remember his saying that he had himself observed, or had heard remarked, there was a kind of family likeness in all the cholera patients.

Will you describe the circumstances under which they arose?—The next, I believe, which I had was the mate of a Scotch vessel lying likewise at the Hermitage. He recovered. I rather think that his was the first recovery in London. He told me that he had got up early one morning and gone on deck; that the smell from the bone-vessels lying a-head was so bad that it made him feel sick, and that he had never been well since.

Was he in the blue stage?—He was blue, but not so blue as the first patient; he was more of a leaden colour.

Would it be conformable to your experience of the susceptibility of individuals to malaria, that seamen on board vessels from healthy ports, but lying for weeks in the vicinity of the bone-ships, and amidst the surrounding deleterious influences, would be more liable to be affected by such circumstances than the seamen on board the bone-ships themselves, accustomed to the foul atmosphere of such vessels, and, as it were, acclimated to them?—Yes, I believe they would be. I believe that those who are acclimated are less liable than those who are not.

What do you suppose to be the effect of the atmosphere of the bone-ships upon the health of the crews?—I should imagine that many of the weaker sort must die, or quit the vessels through ill health, and that only those of stronger constitution would remain and become acclimated to them.

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The Commissioners understand, that during the late unhealthy condition of the metropolis, whilst typhus was exceedingly prevalent in the houses occupied by the poorer classes in Glasshouse-yard, you have in the model lodging-house there, by cleanliness and ventilation, kept it free from that disease?—Yes.

Do you think that by the use of the like means cholera itself might be kept away?—I believe so. For I believe that cholera is governed by the same circumstances as typhus.

And influenced by the same set of ascertained preventives?—Yes.

Judging from personal experience, do you conceive that any system of quarantine, in respect of vessels from ports, the known seats of cholera, or that the strictest "cordon sanitaire," would have prevented the occurrence of such cases of cholera as came under your own notice and care?—I do not. Not a single nurse or attendant that I employed was attacked.

Have you any knowledge of the neighbourhoods through which the cholora spread from Wapping and Rotherhithe?—I believe the next cases occurred in the lower parts of the borough of Lambeth, then in the lower parts of Westminster, next along the Fleet Ditch, and thence into the city.

Have you any reason to believe that the disease was communicated during this progress from the contact of the sick with the healthy?—No.

Did any circumstances occur during your observation of the disease which led you to believe that it was so communicated?—None.

Will you state the chief circumstances which appeared to you to favour the spread and to increase the severity of the disease?—Impure air, and want of cleanliness; the circumstances which produce typhus fever will favour the production and spread of cholera in general, but probably in this case improper food and fear had a more immediate influence.

Do you think that such food, excesses, and depressing emotions, as you observed to favour the production and spread of cholera, would have been attended with these results in a pure air?—No. I do not; and the circumstance hereafter mentioned of the usual diet of the seamen of the Scotch shipping, will be found to corroborate this opinion.

When you mention bad food, do you mean insufficient food, or unsuitable food?—Unsuitable food.

You are probably aware, that in some prisons where the drainage, ventilation, and cleanliness have been good, they have been kept free from typhus and other epidemics, whilst the population of the districts surrounding have been ravaged by them. Thus, in the Glasgow prison, whilst a severe and fatal febrile epidemic left scarcely a house or a family without a case, not one case arose amongst the prisoners; that forty persons were committed to the prison suffering under the epidemic, and that not one case arose amongst the prisoners?—Yes; I am aware of such facts.

Now at Glasgow, the expense of the diet is stated to have been somewhere about 1*s.* 6*d.* per week; and at the Salford prison, where the expense of the diet was no higher, similar immunity from spontaneous fever was maintained?—Yes; I have heard that such was the case.

In the statements of cases of cholera, cases are frequently stated where the attack followed a hearty supper of fish or meat of some sort?

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—There was nothing more likely to produce such attacks, the mucous lining of the stomach and intestines, while the epidemic prevailed, being preternaturally irritable.

From such observations, does it not follow that it is rather to simple and wholesome, or suitable food, that regard should be had, than high and stimulating food?—Most assuredly. And I would add, that spirits, wine, and every stimulant of that description, on the commencement of an attack of cholera, by quickly exhausting excitability, did irreparable mischief. Abstinence, almost total abstinence, I always found highly essential, until convalescence had taken place. I have seen many patients whose deaths, I firmly believe, were the consequence of an over anxiety to give them nourishment. Toast and water in small quantities, and frequently repeated, seemed to me the best and safest beverage, and also, for a considerable time, sufficient nutriment; and, as progress was made to recovery, the addition of an equal quantity of milk, excepting with those who lived rather freely, was found beneficial. To show how readily the disease was reproduced after its most alarming symptoms had abated or even ceased, I subjoin a few instances:—

Beer reproduced vomiting, watery dejections, and spasms, which had abated.

Wine—vomiting, watery dejections, heat in the stomach, spasms in the legs.

Brandy and pepper—incesssant vomiting, water dejections, violent spasms, and great prostration.

Oysters—vomiting, watery dejections, and severe pain in the abdomen.

Ham—all the symptoms of the earlier stages of the complaint, after they had disappeared.

—Next in importance to cleanliness in preventing cholera, is the avoiding of unsuitable food, for, in almost every case that occurred in my practice, I imagined I could trace it to some article of diet likely to create gastric irritation. Among the Scotch shipping, I frequently found that in about 24 hours after taking broth composed of meat, barley, cabbage, turnips, &c., and drinking beer, an attack took place, and that diet of a similar nature very frequently preceded an attack ashore. On mentioning this to the proprietors of the wharves, the broth and beer were prohibited, and the cases of the disease became much less frequent. Acid, or ascescent nutriment, solid or fluid, I considered highly dangerous, and all rich food as being difficult of digestion. One patient died who had been drinking punch the day before. Three deaths, although not in my practice, took place from eating pickled salmon, and one from eating dough pudding. Several cases occurred too from taking Epsom salts. The trash eaten by children, seamen, and many of the poor, is, in my opinion, a prolific source of disease.

Cannot you now pronounce with tolerable certainty in what places you will not find cases of typhus?—I believe I could; I could also tell very well in what places I should find typhus.

In case cholera should re-appear, are these the places where you would expect to find it?—No doubt of it.

During the prevalence of cholera, did you observe much fever?—

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None at all, and but for the presence of that disease, London was never less unhealthy than at that time.

Then it is your opinion that cholera took the place of typhus, affecting the same class of persons, and being influenced by the same class of circumstances?—It is.

Supposing that you had it in your power to place the whole of the district of which you have been speaking in a sound sanitary condition, in respect to house and street drainage, &c.; cleansing and ample supplies of water, and ventilation, what do you believe would be the result, as preventing the appearance and spread of cholera?—I believe that if this were done for the whole district, and for all other districts in the metropolis, cholera would not appear at all, or if it did, it would appear only in a very mild form.

Do you think the class of persons whom you saw affected with cholera had it in their power to secure for themselves those external conditions of cleanliness which you regard as so highly important a means of precaution and prevention?—The majority certainly could not. However much the poor might have desired to increase the cleanliness of their houses, they had no control over the supply of water, and they had no means of procuring receptacles for holding it. Many of them, too, were quite unable from their large families, from weakness and disease, to clean their houses; neither had they any means of draining the surface of the streets, courts, and alleys in which they reside, or cleaning the privies and cesspools in the neighbourhood, or of escaping the poisonous emanations given off from them.

In case such a calamity were to happen as the return of the cholera, if the people saw that combined and systematic means were taken by public authority to make the places in which they live as clean and wholesome as the main streets and great thoroughfares of the town, and particularly to afford them a constant supply of water, not only sufficient for their domestic use, but also to keep the surface of their lanes, courts, and alleys clean, to wash away their filth, and to cleanse their privies and cesspools, do you think that such measures would give the poorer classes confidence, and prevent that fear and terror which you regard as powerful predisposing causes of the disease?—I think it would be attended with a highly beneficial effect. On the former visitation of cholera, they looked on what was attempted for their relief with suspicion and apprehension; and that especially was their feeling with regard to their plan of placing them in separate hospitals.

From the knowledge which the great intercourse you have had among the poorer classes must have given you of the circumstances which influence their minds and feelings, do you think that they would appreciate the value of those preventive measures, and that such measures would have a beneficial influence on the internal economy of their houses, and in promoting habits of internal and personal cleanliness?—I have no doubt of it. And that the result would be most beneficial in all these respects.

Then from what you have observed and know of the dispositions and intelligence of these classes, you do not coincide with the popular notion that they love dirt, and that they cannot be trained to habits of cleanliness?—I do not. I think this is a most erroneous opinion, and has been most completely refuted by the circumstances of the bathers,

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and washers, and ironers of clothes in Glasshouse-yard, as by the fact of there being such a cleansing and whitewashing of houses, rooms, and courts, in Rosemary-lane during 1828, when pails and brushes were lent to the poor, and a present made to them of whitewash, that to those formerly accustomed to some of the black dirty-looking places it seemed almost as if a snow-storm had taken place. And the same inclination for cleansing their apartments was again manifested last year.

A strong conviction has been expressed and stated in evidence by those who have paid attention to the subject, that there is almost as close a connexion between filth and crime as there is between filth and fever, do you coincide with this opinion?—I have long been of that opinion, and every day's experience proves to me that it is a correct one: physical degradation soon ends in moral debasement.

Then you think that that external and internal cleanliness which constitutes the main means of prevention against the origin and spread of epidemic diseases, must also precede any material improvement in the physical, moral, and religious condition of the people?—Decidedly.

What were the means adopted in your district to improve its cleanliness?—Cleaning the drains, and the surface of the streets.

Were any means taken to remove the filth?—Yes, but this was done very unskilfully, and under the influence of great alarm. Cesspools were emptied; drains and sewers opened and cleaned out. The contents of the drains and sewers, if not of the cesspools likewise, were accumulated on the streets. and left in small heaps, for the convenience of cartage, opposite houses where patients at the time were laid up with cholera. This matter was highly offensive when first placed on the surface, and produced, in some cases, an intolerable stench; so that I thought the very means taken to lessen the disease tended to increase the evil, the stench from these heaps being perceptible in the houses of patients labouring under cholera at that very time.

From what you relate, from the aggravation of the evil which you represent followed the unskilful attempts at cleansing on the former appearance of the cholera, may we conclude that preventive means for the future should be systematic and comprehensive?—Yes; and they should be adopted at once; and you may be quite certain that, if cholera do not come, the public will have the benefit of them in the prevention of typhus.

What were the public means of alleviation adopted?—Removing the sick to cholera hospitals.

What were the character of the hospitals that were provided?—They consisted of dwelling-houses, taken for the purpose of affording temporary accommodation; the one that came particularly under my notice was very badly ventilated, and situated in a bad locality; that is, close to the Hermitage, and near the bone-vessels already spoken of.

What was your impression as to the benefit derived from those temporary hospitals?—That they did no good, but much evil. The cases that were treated, as far as I had an opportunity of observing, at their own houses, however wretched those houses might be, did far better. For example, in the particular hospital to which I have just alluded, of those sick two only out of eleven recovered; whereas out of 21 or

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24 treated at their own houses only three died. The very fatigue of removal seemed to me to do much harm. I have known the mere circumstance of patients sitting upright in bed in their extremely feeble state, reproduce the worst symptoms of the disease. Some of the Commissioners, in the practice of their profession, must have observed a similar result in advanced stages, even of common fever. I saw one striking example of the advantage of non-removal. A captain of a large vessel lying near the West India Docks called upon me one morning. He stated that two or three of his seamen had been attacked with cholera, and sent to the cholera hospital-ship at Limehouse, where they had died. That another of his men, to the best of my recollection his mate, had been seized with the disease, and that all the crew had threatened to leave the ship if he died too. Under these circumstances he said he had been recommended to apply to me to advise him what to do. I at once told him I did not at all approve of cholera patients being subjected to the fatigue of removal. He then asked me if I would take charge of the sick man, which I agreed to do. Taking a man with me upon whom I could place dependance I went on board. The case was a severe one, quite as much so, it was said, as any of the others who had been removed. My patient recovered; the alarm ceased; all the seamen who had left the ship returned on board, and not another case of cholera occurred in that vessel. So great was the panic at the time, that the attendant I left on board told me there had been no one but himself and the patient in the ship for several hours.

—The following are the conclusions to which Mr. Greenhow, of Newcastle, who treats of the cholera at Gateshead and Sunderland, arrived:—

"Perhaps the following summary of the arguments by which the non-communicability of cholera from one person to another by means of contagion appears firmly established, may not be devoid either of interest or utility.

"1. That there has been no proof adduced of the disease having been brought to Sunderland by shipping. That, on the contrary, the suspected vessels have neither come from diseased ports, nor have they had cases of cholera on board.

"2. That there is the best reason for believing that cases of cholera had occurred in different parts of the country, and at some distance from the sea, before it made its appearance in Sunderland at all.

"3. That although cases have occasionally occurred having such proximity to each other, both as to time and place, as might lead to a suspicion of contagion, yet they would always admit of a different and more probable mode of interpretation, consistent with the broad fact, which is totally irreconcilable with contagion, that numerous cases have occurred simultaneously at distant points, where no communication could by possibility have taken place.

"4. That when several members of one family have been attacked, it has usually been either so precisely or nearly at the same point of time as to forbid the belief of one having communicated the disease to another. And that the true principle of the occurrence of such plurality of cases is to be found in the common existence of predisposing causes, natural or acquired, and a common exposure to the efficient cause of cholera.

"5. That in the hospitals at Newcastle and Gateshead, where, were there such an agent as contagion, it must have been present in its most concentrated form, no case has occurred of illness arising from attendance on the sick, either in the persons of the nurses, the resident apothecaries, or the attending or numerous succession of visiting members of the medical profession.

"6. That the notion of persons being infected by the dead bodies of cholera patients appears equally unfounded, since such suspected cases are referable to other causes, and those most exposed to contact with the dead, as medical men, in pursuing post-mortem examinations, have not, in any instance, suffered.

"7. That the principle of contagion is acknowledged to be unequal to the explana-

tion of the manner in which the disease extends itself, without the assistance of an epidemic condition of the atmosphere.

"8. That an atmospheric agency, of more or less intensity, and of greater or more confined extension, which visits different places in succession, generally leaving, partially or entirely, one place before it arrives at another whose distance is not very considerable, appears solely and fully equal to the production of the phenomena which attend the progress of this extraordinary disease.

"1. *The stage of the disease.*—If the first stage only has shown itself, the patient may be removed with comparative safety; if the stage of collapse have set in, and especially if in an intense form, the danger of removal must necessarily be very great, and ought not to be incurred unless the danger of remaining in his own house should be yet greater; this must depend upon,—2. How far the patient can be supplied with the necessary comforts of nursing, if permitted to remain at home. If his house be comfortable and well provided with proper supplies of blankets, &c., or if any deficiency in this respect can be readily supplied, and if his family are likely to prove attentive and efficient nurses, the idea of removing him to an hospital ought to be entirely abandoned; for without doubt his chance of recovery would be greatly diminished by such a step. If, however, from deficiency of accommodation, and the absence of comforts, and of proper nursing, his residence appears unfit for the efficient employment of the requisite remedial measures, more especially if the deficiency will not admit of being immediately supplied, then and then only can his removal to an hospital be considered advisable; and even then it becomes a choice of two evils, in which the relative force of each ought to be fully considered. If the hospital is distant and the weather unfavourable, the danger of removal must be imminent, and nothing but an extreme case of domestic discomfort can render it justifiable. Many cases, however, may doubtless arise wherein the propriety of removal is indisputable.

"On the whole it is well worthy the attention of Boards of Health and Committees appointed to visit the houses of the poor, to aim rather at supplying the proper comforts and nursing at home than to remove the sick to hospitals. If they are enabled to accomplish this with any degree of perfection, they will certainly contribute in a much greater degree to the preservation of life than by the best hospital arrangements that can be devised. It is an undoubted fact, that the relative mortality in hospitals has been greater than in private houses, and I apprehend it distinctly arises from the disturbance, fatigue, and exposure attendant on the removal of patients, and the consequent delay in the use of remedies."—*Extracted from Treatise on Cholera in Newcastle and Gateshead, by T. M. Greenhow, M.R.C.S., Newcastle.*

How far does your experience coincide with his?—It is in exact accordance with my own observation and experience.

He further describes the condition of the population whom the cholera chiefly attacked in that district. You will observe the influence which he attributes to habits of intemperance. How far does his opinion on this point coincide with your own?—

"It has been generally remarked, that wherever cholera has hitherto prevailed, it has principally attacked the broken down in constitution, the dissolute, the abject poor, those devoid of proper bodily comforts, whether in lodging, clothing, or diet, those enfeebled by age, and the inhabitants of low, dirty, crowded, and ill-ventilated situations, and with few exceptions such has been the case in Newcastle. These then must be considered as the general predisposing causes of an acquired physical nature; we may add to them exposure to great fatigue, damp, cold, or dietetic excess. A diligent inquiry would, I am satisfied, enable us to discover instances of all these circumstances having led more or less directly to the attack; but of the effect of the latter cause in particular, dietetic excess, the extraordinary irruption of the disease at Gateshead, in the midst of the Christmas feastings, offers a most remarkable example. It is true that Mr. Fife, of that place, has been led to doubt the effect of habits of intoxication in producing predisposition to cholera, as will be seen in his excellent communication on the subject, wherein he observes, that 'from the great proportion of orderly sober persons and children of all ages, among the patients, I cannot consider drunkenness a powerful predisposing cause, though for the sake of morality, it is well to favour the opinion.' But after all, this only proves that such habits are not the only predisposing causes. Innumerable instances might be brought forward, wherein the attack super

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vened either during the continuance of or immediately subsequent to, excessive indulgence in ardent spirits. Such was the case in two of the earliest instances that occurred in Newcastle, those of Eddy and Mills, and others have come under my own observation. Nor will it admit of a question, that their habitual use greatly diminishes the healthy tone of the stomach and bowels, and induce an irritable condition of their mucous lining."

—It is quite in accordance with what I have myself observed.

—Of the dangerous effects of seemingly very slight fatigue in cholera, the following are proofs:—

—Captain Swanson, master of a Scotch smack, lying near the Hermitage, was doing well. He got out of bed, remained up for several hours, nearly undressed, busily engaged with his books and papers, whilst so occupied he suddenly relapsed into the disease and never rallied. I believe he was about 70 years of age.

—Another patient, whose name is not recorded, was removed to a house in the neighbourhood, 48 hours after he had rallied. He relapsed, and suffered severely before he recovered.

—Andrew ——, the mate, who stated he had never been well after smelling the bone-ship, was doing well until removed to a house in Hermitage-street, 24 hours after he had rallied. He relapsed, and likewise suffered severely, so much so, that for a considerable time his life was despaired of.

—Captain Dickson, master of a Leith smack, at the expiration of 76 hours, after rallying, relapsed, and was for several hours in a state of collapse. The consecutive fever with him was very bad, assuming, in every respect, the most malignant form of typhus fever.

——— Ellis, a seaman, at the end of 48 hours, got out of bed, and experienced a relapse; got up again, and was attacked so severely, as to be obliged to remain in bed, dangerously ill, seven days.

—Captain Swain's boy, at the expiration of three days, reproduced collapse by getting out of bed. The names of these patients were all reported to the Central Board of Health, as also the history of many of their cases.

—In cases where perfect rest was observed, the patients recovered without experiencing any relapse.

—In an adjoining parish (Wapping), seven deaths are recorded, and two recoveries. I believe the majority, if not all, of the deaths took place in the hospital. The two recoveries were my patients. One, a poor girl, inhabiting, with her parents, a miserable hovel in a narrow lane immediately behind the south side of Wellclose-square; and the other, a seaman, in a small cabin on board of a ship.

—A patient, who was recovering in the Central Asylum for the Houseless Poor, was sent to the hospital and died. Another patient treated in the Asylum recovered.

—I could multiply such proofs, but, believing that a sufficiency has been given to justify my opinion of the impropriety of removing cholera patients, I will merely add, that when the disease first broke out wherever a thread of pulse was distinguishable at the wrist, with the exception of Barber, Skowes, and Swanson, my patients recovered. Whereas, in a cholera hospital, I have felt pulsation distinctly, have seen the patients to all appearance doing well, and yet they have died.

—I have seen a patient sent to the hospital ship in whom pulsation was

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distinguishable, and other favourable symptoms present, but next day brought intelligence of his death.

—Concerning the effects of fear, I may mention that I attended a gentleman who died during the second outbreak of cholera, who was in a state of great alarm during the attack, and for several days preceding it.

—I likewise attended a captain who recovered. He was the master of a Bridport trader, lying near the Hermitage. Whilst attending one of his boys, whose case was one of great severity, he used to look down from the deck into the cabin, and declare he would not go into it if all London were to be given to him for doing so. All his crew assisted in waiting upon the boy without suffering from the disease, while the captain, who had never gone near him, was attacked on shore, where I had to attend him.

—That the disease could not be very contagious the following facts will probably go far to establish :—

—On board of the vessel where the first case occurred, the captain, a boy, a man, two medical attendants, my brother and myself, were with him for hours in a close heated cabin, without being affected.

—On board of a smack, the captain, boy, men, medical attendants, three in number, were all in a heated cabin for hours, and escaped.

—On board of a sloop, the captain, crew, four medical attendants, were present in a small cabin for hours, without taking the disease. The patient was afterwards taken to a dwelling-house, where neither the nurse, nor any of the inmates, five or six in number, were attacked.

—On board of another ship where the man died, the captain, the mate, the crew, six medical attendants, were all crowded together in a small heated cabin ; likewise a gentleman, anxious to see a case of the disease, and three of the crew of the " Dover " cholera ship ; none of them became ill in consequence.

—In a wretched house, a girl, residing and sleeping with her brother, sister, and parents, an old woman, three medical attendants, and several visitors, all escaped.

—On board of a trader, the captain, crew, nurse, and three medical attendants, never caught the disease, nor did any of the family in the house to which the patient was sent.

—On board of a vessel, master, steward, crew, boys, visitors, and medical attendants, all remained well, as were the family to which the patient was taken.

—On board of a coaster, the captain, crew, family to which the patient was taken, and the medical attendants, all escaped.

—The family where a captain was taken to reside, the nurse, the medical attendants all remained well.

—On board of a vessel, the captain, the crew, nurse, and medical attendants all escaped.

—On board a very small vessel, the captain (patient the captain's wife) and two children, one an infant, sleeping, or rather lying, in the same bed with the patient, and suckled, all escaped, as did also the medical attendants and several visitors.

—On board of a similar vessel, (patient the captain's wife) the captain, his wife, and three children all slept in the same bed. One of the children, an infant, was suckled by the patient. There were

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several visitors and three medical attendants; all remained free from the disease.

—On board of a coaster, the crew and medical attendants escaped.

—On board of a smack, the captain, crew, medical attendants, and the family where the patient went to reside, remained well.

—In a cholera hospital, one man, in the agonies of death, was hung over and kissed by his weeping daughters; none of whom took the disease.

—I could bring forward other and numerous proofs of the disease being non-contagious were they deemed necessary.

—Another circumstance it might be worth while to mention. A second outbreak of cholera took place in June, when I found it more intractable than on its first appearance, especially with regard to the consecutive fever, for while I never lost a single patient in the spring whom I could get into that stage, several died, who, judging from former cases, I expected to do well.

—It is a curious fact, that the first and the last case of cholera I attended was at the Hermitage. The last was a captain of a vessel; and when I reported his case, an official notice was sent to me, that the Cholera Boards had ceased to exist, as cholera had ceased in London. That occurred, I think, in September, 1834.

(*Second Part.*)

Will you be so good as to describe the Model Lodging-house at Glasshouse-yard?—It is a large building consisting of three floors. The lower floor contain two wards; the middle floor one ward; the upper floor two wards, and two lodging-rooms, convertible when necessary into sick rooms. Attached to this building are a receiving office; two rooms inhabited by the clerk and matron; a reading, refreshment, or waiting-room; a convenient kitchen; good water-closets, and a large tank containing a good supply of water. The buildings altogether form an oblong square, leaving a considerable unoccupied open space.

What was the expense of constructing and fitting the buildings?—The house and part of the offices have formerly formed a portion of a glass manufactory, from which the street and yard where they are situated derive their names. They were in a most dilapidated and ruinous condition. Indeed it may be said that the greater part of the kitchen, reading-room, receiving office, and clerk's apartments had to be rebuilt; the water tank and water-closets to be wholly built; the yard levelled; large flues dug out of the building; wooden floors substituted for earthern ones, full of deep trenches and uneven projections. Water and gas laid on; old drains repaired and new ones formed; painting and glazing executed to a great extent; bed places, bedding, stoves, funnels, kitchen utensils, &c., procured; all of which was accomplished for a sum not exceeding 1000*l.*

Judging from experience, would you make any alterations were you to construct or fit up others?—Several trifling improvements might be effected, but I would not be inclined to depart far from the plans adopted in the first model lodging-house.

Describe the numbers, occupation, and the behaviour of the lodgers?

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—The number of lodgers nightly were :—

	Men.	Women.	Total.
January . .	1,242	..	1,242
February . .	1,448	376	1,824
March . . .	1,738	435	2,173
April . . .	2,487	592	3,079
May . . .	4,109	576	4,685
June . . .	3,285	439	3,724
July . . .	2,685	389	3,074
August . .	2,839	483	3,322
September .	3,550	319	3,869
Total .	23,383	3,609	26,992

With very few exceptions, indeed, the behaviour of the lodgers is quiet, orderly, and respectful. They seem perfectly aware that disorderly conduct will not be tolerated, having seen in the few instances necessary to be taken notice of, that the rules are not broken without reproof or dismissal, and that when crime is committed, they are not screened from punishment. I may here mention that there are seats set apart for them in a chapel of ease belonging to the church, which appears to afford a number of them gratification. As many as thirty or forty have gone there at a time and conducted themselves with propriety. On Sundays their favourite book seems the Bible, and I have frequently found them in their bed-places reading it, when they could have no expectation of endeavouring to gain favour by any ostentatious display. The library is tolerably well supplied with religious and instructive books and periodicals, and it is interesting to see with what anxiety they inquire for the new publications about the time they generally reach Glasshouse-yard. The books and periodicals are generously supplied by the gentlemen through whose means the experiment of the lodging-house has been made, and by donations from visitors who approve of the undertaking. I feel assured that the conduct of the lodgers is improving, and that many of them now look upon the establishment as a home. It is only of late their occupations have been inquired into.

—The first class lodgers are chiefly,—

Dock-labourers.
Coal-porters.
Cabinet-makers.
Carpenters.
Seamen.
Bakers.
Cheesemongers.

—The second class,—

Weavers.
Sailors.
Shoemakers.
Bricklayers.
Hawkers.

—Give a description and the dimensions of the various parts of the building.—The first class ward is on the lower floor, and contains 87 bed-places, 2 feet, and 2 feet 3 inches wide; the bottom of the bed-places 18 inches from the floor, division 3 feet high.

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—The ward itself is 43 feet long, 40 feet wide, and 12 feet high; it has 3 windows:—

One 5 feet 8 inches high, and 10 feet wide.
One 5 feet 8 inches high, and 5 feet wide.
One 5 feet 8 inches high, and 3 feet wide.
Door 10 feet high, and 5 feet wide.
Door, half glass half wood.
Ventilator of open canvas 43 feet long, 1 foot deep, and 18 inches wide.

—Second class ward is on the same floor. The sleeping places, like those of the first class ward, contains 53 sleeping places, is 26 feet long, 40 feet wide, and 12 feet high. Five windows:—

One 5 feet 8 inches high, and 7 feet wide.
Four 5 feet 8 inches high, and 10 feet 5 inches wide.
The door 10 feet high, and 3 feet wide; is one-half glass, and one-half wood.
Ventilator of open canvas 26 feet long, 18 inches wide, and 12 inches deep.

—Third class ward contains 72 fixed bed-places, similar to those in the first and second class wards, and 28 moveable bedsteads, to be filled with shifting divisions; is 70 feet long, 41 feet wide, and 10 feet high. Has 7 windows:—

Five 5 feet 7 inches high, and 10 feet 6 inches wide.
Two 5 feet 7 inches high, and 9 feet 3 inches wide.

—Has 7 ventilators of open canvas:—

Four 3 feet square.
Three 3 feet long, and 1 foot wide.
The door is 3 feet high, and 1 foot wide.

—Women's ward contains 4 room, 2 large and 2 small.
The large rooms 24 feet long, 30 feet wide, and 14 feet high.
The small rooms 13 feet long, 14 feet wide, and 14 feet high.
Four windows in each large room, and one in each small room; all the windows are of the same size, 3 feet 6 inches square.

—Reading and waiting room, 34 feet long, 15 feet wide, and 17 feet high.

Skylight 5 feet 6 inches long, and 4 feet 10 inches wide.
Door 6 feet high, and 4 feet wide.

—Kitchen 20 feet long, 11 feet wide, and 18 feet high.

The skylight 5 feet long, and 4 feet wide.
Door 6 feet high, and 3 feet wide.

—Yard 48 feet long, and 35 feet wide, with a post and gas-lamp in the centre.

—Water tank 13 feet 10 inches long, and 6 feet 3 inches wide. Water closets:—

Men's, 7 feet high, 4 feet wide, and 7 feet long.
Women's, 7 feet high, 4 feet wide, and 5 feet long.

What methods for ventilation are in use?—The upper panes are of perforated glass; the apertures small and numerous for the purpose of admitting air in such minute streams as to prevent unpleasant or dan-

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gerous cold draughts coming in contact with the persons of the lodgers; the frame of the upper part of the windows and the top of the doors are similarly perforated. An upper direction is given to the entrance of the air, by giving the panes an inclination outwards at the top and inward at the bottom, and by drilling the apertures obliquely in the wood. The panes have the advantage of admitting light, an object I deem of great importance in preserving health. In the middle of the ceiling in the lower wards extending the whole length of the building is a channel bottomed by coarse open canvas, 12 inches deep, 18 wide, communicating with the shaft of the chimney; under this channel passes an iron funnel conveying the smoke of a ship's hearth in the largest ward into the chimney in the lesser ward—where it receives another impetus for its expulsion from the heat given out by another ship's hearth. Heated vitiated air being specifically lighter than pure air, it is a necessary consequence that it will make its way into the channel in the ceiling, and be drawn out of it and up the chimney, with the smoke escaping from the fire-places. It is almost needless to add, that the entrance of the foul air into the channel in the ceiling will be expedited by the heat of the funnel conveying the smoke from the most distant fire-place.

Could you effect any improvement in the ventilation?—It could be increased if found insufficient as it is employed at present, but by opening all the doors and windows during the day in summer; as the building has never been overcrowded, there did not seem any necessity for making any alteration.

What advantage do you imagine is gained by having the beds in compartments?—I believe that as vitiated air is lighter than that which is pure, it will have a tendency to ascend when respired, without diffusing itself laterally so as to be capable of being inhaled by those sleeping near each other. But whilst I would prefer this plan for the prevention of disease, I would not recommend it where disease has really taken place, as it might have an injurious effect upon those whose duty it is to render assistance. I have never seen any bad effects result from attending fever patients in these bed-places; but when a case does occur where it is necessary to take it under my care, the patient is immediately taken to another part of the house, placed in an open bed, and the precaution used not to allow another bed containing a patient to be within a distance of several feet. Another advantage is gained in accordance with decency, the allowing the lodgers to dress and undress in comparative privacy.

What has been the result of the ventilation, as practised in the lodging-house?—The absence of unpleasant smells, the possession of an agreeable temperature, and an almost total exemption from febrile disease.

Have there been any cases of typhus?—A few.

Were they under such circumstances as that the disease might have been contracted elsewhere?—All of them; for they went out during the day, sometimes not returning until late at night, after being exposed to the inclemency of the weather, and no doubt spending a considerable portion of their time in places filled with air of a most deleterious character.

What is the state of health as compared with that of the adjacent

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population?—Whilst fever has been prevailing to a very great extent in Glasshouse-street and its adjacent courts and alleys, and a verdict of a coroner's jury has been given that disease and death have been the consequence of breathing impure air, there is not at present an individual under medical treatment in the building, nor has there been a single case of fever there for upwards of four months. The only deaths which ever occurred among the lodgers were two children, labouring under hydrocephalus internus when they were admitted, and an aged mutilated seaman, who had long been affected with hydrothorax and disease of the heart.

Judging from your present experience of the habits of the labouring population, do you believe it will be practicable, with available appliances, to put an end to typhus originating spontaneously in other dwellings?—I believe that it might be as completely put an end to in houses, villages, and towns, as the ague has been in many parts of the country where it usually prevailed. I have often heard, while in practice in Stirlingshire, Scotland, that in a certain district there ague prevailed every spring and autumn, but since the land had been well drained the disease seemed to have become extinct. I can only say on this point that during the five years I was actively engaged in that very district, I never saw a case of ague except one. The man told me he had been attacked with it in Lincolnshire.

May not this same conclusion be applicable to other diseases?—I have no doubt of it.

As you have examined the habitat of typhus, is it invariable that physical circumstances are found to account for the origin of the disease?—I believe that on all occasions, if diligently sought for, they might be found.

May it not be stated with confidence, as a general conclusion derived from your experience, that all offensive smells (the consequence of decomposing animal and vegetable matter) are eventually disease?—I have not the slightest doubt that in certain constitutions of the atmosphere there is nothing so likely to produce disease. I could bring forward several instances corroborating this opinion, but the following may perhaps suffice:—A young lady whom I attended during a long and severe attack of typhus, frequently told me she attributed her illness to a very disagreeable smell she encountered while passing through Whitechapel Market. Among the first cholera patients in London were the mate of a vessel lying off Hermitage, and the wife of the master of a small coasting vessel lying off Horsleydown. Both of them had the disease very severely. The mate told me that he had never been well after getting up one morning very early, and smelling something very offensive from a bone vessel lying a short distance from them. The master's wife said she had never felt right since she had "a sniff of bad yeast" from some casks on shore. Within a few days after experiencing those smells they were both attacked with cholera. I remember a house in Hermitage-street where I think three of its inhabitants died of cholera; the necessary had not been cleared for several years, and the smell which pervaded every room was dreadfully offensive. When cholera made its appearance, drains, sewers, and cesspools were opened which had long been neglected; and I have attended patients in houses where the smells arising from the contents of the drains and

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sewers, if not of the cesspools themselves, heaped on the streets for removal, were in all probability the cause of exciting the disease. In the end of the year 1830, and during 1831, typhus fever prevailed epidemically in various parts of the country, and also in London. It broke out, in the end of January or beginning of February, in the Eastern Asylum for the Houseless Poor, then situated in Globe-street, Wapping. In the course of a few days upwards of 40 of the inmates were laid prostrate on straw, and before the end of a month there were 65 cases under my care. What I have no doubt increased its rapid diffusion throughout the building was a cesspool, which at that time began to smell offensively; but that it originated the disease may be questioned, as several men had been admitted who had passed through fever in the Grampus hospital ship, and been discharged as convalescent. And there is another reason for having some doubt on that point; that the cesspool did not smell so offensively until after the fever broke out, which latter circumstance I attributed in a considerable degree to a greater quantity of water being used for the purpose of cleanliness. The same house had been used for several years as the Asylum without any outbreak of fever, but I strongly advised that it should never again be occupied for that purpose. The Eastern Asylum is now in Glasshouse-yard, East Smithfield. Just as my professional services were ceasing to be required, I was attacked by the disease myself; and I remember well, just a few days before I was taken ill, being called to visit a poor man residing in a miserable room in one of the courts of an alley in Rosemary-lane. He was almost in the last stage of typhus fever, and the room smelt most horribly, so much so that it almost made me sick. From that time I never felt well, until after I passed through fever. At the time I was attacked, however, my brother and my assistant were laid up with it in my own house. Both of them had been most assiduous in their attendance on the sick in Globe-street. It affords me great satisfaction to be able to state that only 1 man out of 63 treated in the Asylum died, and his was a case of relapse through imprudently going out during a very wet day while he was in a state of great debility. Prior to the occurring of fever in the Eastern Asylum, it was the practice to bed the inmates in straw, without any means of separation. When the disease did break out, the chairman and committee placed the whole establishment under my care, on which I caused an infirmary to be fitted up, provided with separate cribs, blankets, and sheets, and the sick supplied with clean cotton shirts. As they became convalescent the patients were removed into another ward, fitted up in a similar manner. This afforded me an opportunity of seeing the advantage of having separate sleeping places, both in increasing comfort and lessening the chance of the occurrence of disease; for it was no unusual event to witness the wards crowded to an alarming extent, in defiance of all my remonstrances to the contrary, a *full house* seeming as necessary for the satisfaction of the officers of the Asylum as a similar event would have been to any manager of a theatre. Besides, in wet evenings it often happened that those who had managed to keep themselves dry before coming into the ward had to lie down and be in contact with those whose clothes were saturated with rain and covered with mud. It was several years, however, before I could succeed in effecting my purpose, but at length I did so, and

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had the satisfaction to see it become one of the laws of the institution that each individual be provided with a separate crib and clean straw. There was yet another purpose in view, which likewise took me some time to attain, the substituting of waterproof mattrasses for the loose straw, used as bedding, a filthy and unwholesome article, as when it becomes heated and impregnated with the effluvia from human bodies and dirty clothing, it gives out a nauseating, offensive smell, vitiating the air of the apartment, and rendering it a fit agent for the production and spread of disease; besides which, it affords a harbour for the rapid engendering of vermin, and the communication of itch,* a disease at one time very common among the applicants, and costly to the charity. When the trial of a few waterproof beds, furnished with leather sheets, was made, the advantages of the plan were soon perceptible, and orders were given to have all the three asylums similarly fitted, since which the wards look cleaner, the inmates express themselves as more comfortable, the disagreeable smell was almost removed, and the great expense for the procuring and removal of the straw obviated; besides fever has become less frequent and much less fatal than before the new beds came into use. Since the baths and the washing and drying apparatus were added to the asylum, there is a still greater appearance of cleanliness and comfort, absence of offensive smells, and exemption from fever, so much so as to excite the surprise and secure the approbation of many of those who were opposed to the introduction of these improvements when first proposed.

Describe the drainage of the Model Lodging-house?—The drain is a 14-inch arched drain, with an iron bottom; it commences at the water-closets, and runs under the south end of the lower and smaller ward a distance of 100 feet. Several smaller drains open into it from adjacent houses, which are insufficient for carrying off all the soil and refuse, especially as they often get choked by old clothes thrown into the privies by the ragged casual lodgers who occupy the adjacent tenements, which are principally low common lodging-houses. It is therefore necessary to have a cesspool to receive these habiliments, which must accumulate in extraordinary quantities, as I saw nearly a cart-load which had been fished out of the drains leading into others of the lodging-houses. On one occasion the adjacent houses were flooded with foul fetid fluid, in consequence of an obstruction which it was alleged our alterations of the drain had occasioned; an allegation which was found to be wholly incorrect, when at our own expense the nuisance was removed. On inquiring whether such an obstruction had ever occurred before, we were informed that it had very frequently. The measures we have taken will now permit all the soil to be suspended in water, and carried away to the common sewer, all the water used in the Model Lodging-house flowing in that direction.

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* One of the impositions attempted to be practised by the applicants was simulating itch, those affected with that disease having sixpence and a ration of bread given to them and sent away. It happened one evening that while examining one of these cases I discovered some minute portions of a glittering dust on the skin surrounded by small inflamed specks discharging an ichorous fluid exactly like that of itch. I found the small particles were broken down straws, and that it was the irritation they occasioned that gave rise to the belief of the itch being so abundant as generally imagined. Wherever straw is used as bedding, I have no doubt similar mistakes will be made.

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Describe the drainage of the Eastern Asylum for the Houseless Poor?—The drain here is 18 inches diameter, and 120 feet long; the water runs into the water-closet from the cistern, and from the baths and washing-tubs into the common sewer in East Smithfield. It likewise is often choked with rags and old clothing, so that it is necessary also to have a receptacle from which they can be taken. The quantity of water sent down the drain suspends and carries away all offensive matter so effectually as to keep the building free from smell, although sometimes nearly 400 persons have been contained in it.

Describe the water-closets of the Asylum?—The first water-closet, for the men, is 6 feet high, 4 feet wide; the second, 6 feet high, 4 feet wide. Each closet is fitted with two seats, covered by flaps. When the flap is raised by means of a small chain, one end of which is attached to a valve in the cistern, and the other fixed to the flap, the valve is lifted sufficiently to allow a run of water to commence and continue during the whole of the time the flap is up; and when it falls, the flow of water does not cease immediately, as the portion between the closet and the tank has to find an outlet. The third water-closet, for the women, is 5 feet high, 3 feet wide. It is fitted in the same manner as that for the men, and terminates in it.

Have you not some of the dirtiest population in the country?—I think it would be difficult to find them worse than the majority are when they first apply for admission to the Asylum.

Judging from your experience, is there any warrant for the hypothesis or apprehension expressed in the city of London and other places, that the water-closet principle could not be economically applied in courts and alleys, and that cesspools might be discontinued by some sort of soil-pan apparatus, so that all refuse might at once be removed by suspension in water?—I think there are no just grounds for such hypothesis, or apprehension, as I am convinced that, by interposing gratings at particular places in the course of the drains to intercept bulky articles, there would be little difficulty in washing everything offensive away. To effect this object without a cesspool at all, I caused rods to be placed across the commencement of the drain in the Asylum, which for a long time prevented the necessity of opening the drain; and the improvement I purpose to effect in the drainage of the Model Lodging-house and the Asylum is to have similar bars established. While on this subject, I would also mention, that as the very poor are indifferent with regard to bad smells, unless watched they will frequently leave the flap open. To prevent this, the flaps are so hinged as to be higher at the back than front, or a piece of wood is made to project from the wall, whereby they fall down of themselves after being raised, and the flow of water from the cistern is shut off in time to prevent waste.

From your own observation, is disease lessened by attention to cleanliness in courts and alleys?—I have not the least doubt of it; for I have seen disease greatly lessened by getting the poor to become more cleanly in their dwellings and in the courts adjoining them.

Do you believe that an ample and convenient supply of water in rooms occupied by the labouring classes would have a sanitary effect?—I feel assured it would be one of the greatest improvements which

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could be effected; as, from the water being on for but a limited time in the day or week, I know that sooner than undergo the hardship of waiting for, and carrying it, in many instances it is dispensed with until the small stock kept for culinary purposes is exhausted or becomes perfectly unfit for use.

Describe the bathing and washing apparatus in Glasshouse-yard?—There is a small boiler of one-horse power for the purpose of generating steam. The steam passes from the boiler through a pipe running the whole length of the upper part of the boiler, giving off in its course branches terminating in tubs fitted with lids. These tubs can be used in the first instance for washing the clothes, and afterwards as boilers, by shutting down the lids. There are likewise three open tubs, one to each boiler, for the purpose of rinsing the clothes, after they are boiled, in cold water. A cold-water pipe runs alongside of the steam-pipe, and also branches off to various tubs. The main steam-pipe then dips under the floor, and is carried into an adjoining ward, where four double tubs of the same kind are fitted up and in constant use. It also supplies and heats two baths in that ward. On the right-hand side of the boiler the steam passes through a pipe into two baths near the boiler, and into two in another ward. A pipe leading from the upper part of the boiler terminates in a water-cask, placed at such a height as to ensure a pressure under that of the safety-valve: by this plan a useless escape of steam is prevented, and an additional safety-valve which can never set fast is given. By this device, too, there is always a large quantity of hot water ready for bathing or filling the boiler. To guard as far as possible against accidents, there is added a vacuum valve to prevent collapse of the boiler.

How many baths are there?—Six; two of wood, two of sheet iron, and two of brick, covered with cement.

Judging from experience, which of these baths do you find most useful?—The brick baths, as they are sooner heated, and retain the heat longer than either those of wood or iron.

What means are provided for drying the clothes?—There is an apparatus, the invention of Messrs. Davison and Symington, for drying, by sending a current of heated air through a chamber. This plan was intended in the first instance to be used for drying wood. Conceiving that it might be applied with great advantage to drying clothes, I proposed its being added to the plan I had formed of heating the baths and tubs by the direct introduction of steam. The suggestion was acted upon and is now at work in the new baths and washhouses, and proves exceedingly efficacious. I believe this to be a most valuable sanitary agent, as it not only dries and ventilates the clothes, but can be raised to such a temperature as to decompose or render innoxious offensive or unhealthy matters which may be lurking in them. On a wet evening, when the clothes of the inmates of the Eastern Asylum have been saturated with rain, the usual washing of clothes has been sometimes suspended, and drying only had recourse to. At these times the clothes were taken out of the heated chamber, feeling softer and smelling far less offensively than when washed in the way they are generally done among the poor.

What were the effects of the bathing and washing upon the inmates

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of the Houseless Poor Asylum?—As I have already mentioned, a very great improvement in personal appearance, the almost total disappearance of vermin and of itch, the removal of unpleasant smells, and the diminution of febrile disease. Indeed, I feel convinced that, had it not been for the bathing and the washing in the Asylum during the past season, fever of a very malignant character would have broken out and spread among the inmates; there being an extraordinary influx of Irish applicants, many of whom were labouring under that disease when they applied, or were taken ill so soon after admission, that it became necessary to take them under treatment, from the impossibility of getting them into hospitals.

What is the apparent effect on the health of the bathers and washers generally?—All of them speak in high terms of their good effects; and I have heard many of them say, that they are sure, if they could not have got their clothes washed, the fever would have been very bad among them; there is so much of it about.

How much filth is due to occupations, and how much to the soot and dirt of the ill-cleaned rooms, courts, &c.?—I believe that it is fully as much owing to the dirty state of their rooms, courts, and alleys, as to their occupations, as may be seen in the condition of the women and children.

If the streets were well scraped, washed, and cleansed, would there not be a considerable diminution of dirt on the skin, clothes, and furniture?—Most assuredly there would. In some of the arguments brought forward in favour of street cleansing, it is stated that the loss and damage done to goods and furniture had been very great.

Have the poor themselves observed the difference in amount of the lasting of clean, compared with dirty, linen?—I have often heard it remarked that, owing to the clothes "having the dirt so ingrained into them" in London, they were soon rubbed to pieces.

What is the comparison between the expense of washing required in London and one living in Manchester or Hull?—I cannot make the comparison; but I have often heard it said, that clothes kept clean as long again, especially linen, in the country as in London. And from what I have myself seen, I am sure this is no exaggeration.

Can any opinion be formed of the reduction of washing by the removal of the smoke nuisance?—I expect there would be nearly one-half; the difference in the dirt of the town and country being chiefly owing to the greater quantity of carbonaceous and other blackening matters contained in coal smoke.

What is the estimate of the amount of washing, and wear and tear of linen, from defective street cleansing, and amount of smoke?—From any inquiries I have been able to make, I find that the cost of washing and ironing for families in ordinary circumstances may be averaged at 20*l.* a-year at least; some paying 15*l.*, others 20*l.*, 30*l.*, 40*l.*, and larger sums.

What is the prime cost of a warm bath?—In Glasshouse-yard, 1*d.*

What is the prime cost of washing?—A sufficient supply of hot water and tubs can be furnished at 1*d.* for two hours' washing.

What would be the saving if the clothes were washed wholesale?—I should think at least one-half.

What return would make baths and washhouses self-supporting?—

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About 1*d.* for every two hours of washing, and, as before stated, 1*d.* for each bath.

Would filtering the water not be a great improvement?—It would; as, the purer the water is, the less chance there would be of its containing anything capable of producing soil or stain.

In irritation of the skin, what substitute may be used for soap?—I have generally found thin gruel an excellent substitute, and sometimes, especially where there are sores or wounds, nothing answers better for soap in shaving than good olive oil.

What soaps are least irritating?—This will depend greatly upon the condition of the skin. I have seen the common yellow soap destroy the cuticle of the hands of washerwomen, while the mottled soap produced no such effect; and I have known where a troublesome, and long-continued eruption on the face, was always relieved, and nearly removed, by the use of coarse yellow soap. I suspect that many of the perfumed soaps, owing to the essential oils they contain, must often increase irritation. I am told that it may be given as a general rule, that the longer common soaps are kept they will become the milder.

Will they have the greatest stimulating effect, during infancy, childhood, or adolescence?—During infancy and childhood. It is no unusual thing to be compelled to leave off using soap in the cutaneous eruptions of infancy and childhood, from the great irritation it excites. That it is capable of exciting considerable irritation is proved by the smarting it occasions when, by chance, it comes in contact with the surface of the eye, or when it gets up the nostrils.

Among what class are the habits of cleanliness most easily promoted?—Among the poor; for if encouraged they will eagerly avail themselves of opportunities of cleansing themselves, as is evidenced by the fact that 34,843 have bathed, &c., 38,445 washed and dried their clothes, and 11,296 ironed them during the second year of the free baths; and many hundreds have purified their dwellings by the gift of a little whitewash and the loan of pails and brushes. I have found that the young are more eager for bathing than those further advanced in life; and I have every reason to believe that the rising generation are acquiring a taste for bathing, sufficient to render it a necessary of life instead of one of the luxuries. Concerning the washing of clothes, I am of opinion that it might be accomplished without rubbing them in the usual manner, without beating them with machinery, and without any injurious chemical agent. An experiment which I purpose making this week will enable me to ascertain whether my conjecture be a correct one.

No. 2.

Robert Little Hooper, Esq., Surgeon.

No. 2. R.L. Hooper, Esq., Surgeon.

Where do you practise?—In the London-road, in the parish of St. George, Southwark, where I have been parish surgeon for nearly twenty years. I am assistant-surgeon to the Queen's Bench Prison; I have also a large private practice in the neighbourhood, which is necessarily chiefly amongst the labouring classes, the population not being a rich one.

You of course remember the visit of the cholera?—Yes, I was

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surgeon to the Cholera Hospital in St. George's Fields, which was the first establishment of the kind in London. There were 138 patients admitted into the hospital during the months of February and March, of which 117 died. They were not, however, taken there until they were in the last stage of the disease. The average of deaths amongst those attacked in the neighbourhood was about one in three.

That is to say, of those who did not go to the hospital? The parish of St. George was one of those which were the first and the most severely visited, was it not?—Yes, it was: I had under my own attendance upwards of 2,000 cases during the prevalence of the epidemic.

What was the condition of the persons and places which the cholera most severely visited?—The majority of those attacked were the occupants of Kent-street, the Mint, and other courts and alleys in the parish. They were filthy in their habits, living in confined and impure air; their habits were the worst possible; they were in a state of susceptibility to any disease which happens to be floating about in the atmosphere; there were many vagrants and mendicants inhabiting the low lodging-houses, where they sleep for a penny or two-pence the night; they were wretchedly destitute.

How were their habitations in respect to drainage?—Many of them had not even cesspools, the soil was oozing from a corner and through the pavement of the courts; where there were cesspools, they were in very bad condition, seldom or ever emptied.

How were they as to supplies of water?—Almost destitute of water.

In what condition were the pavements in and about the courts and residences?—The pavements were nearly all broken up. Within the dwellings, there was no boarding to the floors of many of the houses, the inmates slept on the earth, on a few shavings generally.

What is the present condition of the same district?—A little improved, but not much: in some courts it is now even in a worse state. I will mention, as an example, Three Tuns Court in White-street, in which there are about 15 houses and probably 150 inhabitants, principally Irish. There is but one privy, and that without covering; the fluid soil is running down the court in front of all the houses. They have no water but what they beg fram the neighbours. Several of the houses are entirely without windows or floors, that is, without boarding on the floors. The proprietor of the court is said to be in prison for debt. The people crowd in there because they pay no rent. There is no person responsible for them, and no law to enforce proper sanitary measures. The Court-Leet, the Commissioners, the Magistrates, and the Commissioners of the Borough Pavements, have been applied to, but there is no law to compel any one to put the place in a condition fitting for human habitation. I can, however, adduce examples of other courts, not quite in so bad a condition, but still deplorable, where the inhabitants do pay rents, and high rents, too, compared with the nature of the accommodation.

It is almost unnecessary to ask you whether these places are and have been the abodes of typhus?—Constantly; they are never free from it.

Suppose that cholera were again to visit this country, would you expect it in those places as before?—No doubt of it.

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Had you much typhus fever during the prevalence of cholera?—No, typhus certainly did not prevail as an epidemic during the prevalence of cholera.

Had you many cases in which those who were attacked with cholera, but did not die, fell into typhus?—A few, but not generally.

Do you think epidemic cholera took the place during this period of epidemic typhus?—It is certain that cholera attacked the same description of persons, and prevailed in the same localities as typhus, while few or no cases of typhus were observed when cholera was at its highest.

Have you any instance in your district in which improved drainage, supply of water, and ventilation, has been followed by a diminished susceptibility to epidemic diseases?—I am sorry to say that I know of no places in which any material improvement of any kind has taken place; in regard to draining, supply of water, and ventilation, the district remains in the same wretched state.

Have you any doubt that improvement in these modes of cleanliness would be followed by a corresponding diminution of fever cases?—I have no doubt of it.

Were these places properly drained, paved, cleansed, and supplied with water, and should cholera again reappear in the metropolis, would you expect to find any difference in the number and severity of your cholera cases?—I should expect a great diminution, both in the number and intensity of the cases.

Do you think the description of persons who now live in those places, and who would probably become the first victims of cholera, should it again visit the metropolis, would appreciate the value of these means of prevention?—I am persuaded the great majority of them would.

The persons who reside in the streets and courts in your district appear to be among those that live in a state of the greatest filth and wretchedness to be found in the metropolis. Do you think that even those persons would avail themselves of the means of greater cleanliness if they were afforded them?—I think they would to a very considerable extent. I think the fault is not in the people so much as in their want of means. These people can procure no water (even when it is to be got) without very great labour. The woman is always obliged to carry it up stairs; consequently she is very sparing in the use of it; and those stairs are common to all the families in the house, so that no one thinks it her duty to wash them. I have been often struck with the filthy state of the water in the rooms; even that for drinking and other domestic use has an offensive odour, from having absorbed the foul air of the room, though indeed, water for drinking or even washing the hands is seldom to be found; if I ask for it I have generally to wait till it is fetched. Then again, I often find a tub of exceedingly filthy water which has been used over and over again, on the landing place outside of the rooms, the odour from which is most offensive. It is also very common to find the clothes which have been washed in this filthy water drying in the room; the evaporation from these clothes I regard as most pernicious, and in the room in which the air is poisoned in this way there may be two or three children ill in bed, or perhaps the father or mother ill with typhus fever.

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So that in this district also, these poor people have the like difficulty in obtaining pure water and in getting rid of their foul water?—Yes, they have.

What were the means adopted as measures of alleviation during the prevalence of cholera in your district?—A local Board of Health was appointed, consisting of persons who had passed the office of churchwarden or overseer; the vestry clerk assisted them as the clerk to the Board, and the two parish surgeons, Mr. Evans and myself, undertook the medical duties. This Board engaged an isolated house, situated opposite Bethlehem, completely surrounded by a wall. The Board fitted up the hospital with beds and other necessaries for the reception of cholera patients. The vestry refused to supply funds for this hospital, which were at length obtained by an order of the Privy Council, that they should be paid out of the poor's-rates. Everything was paid for, except the services of the surgeons, which were most laborious and incessant. Being parish surgeons, we were told that, as we had contracted to attend all the poor for a certain salary, the breaking out of cholera in our parish was our misfortune, the Board "would have their bond."

Were the poorer classes willing or unwilling to avail themselves of the privilege of going into this hospital?—They were very unwilling to go, in consequence of the number of deaths that took place there; it obtained a bad reputation, and many positively refused to go. Still, the hospital was generally full, partly from those who were quite destitute of friends, and partly from those who were sent there by families that were afraid of contagion.

From what you saw of the effect of this cholera hospital, what was your impression as to its influence on the disease?—Little or no advantage was obtained in the cure of the disease, although every suggestion made by science at the time was put into operation there; and the poor had certainly many comforts and appliances which they could not obtain at their own homes. As I have already stated, the mortality was far greater in the hospital than in private dwellings; but then they seldom entered the hospital until they were in the last stage of the disease.

Did you observe any instances in which fear and terror seemed to have much effect in promoting an attack of the disease?—Yes; I saw several striking instances of it. Great nervous depression appeared to favour the production of the disease in a remarkable manner.

You have had many opportunities of becoming acquainted with the dispositions and habits of the poorer classes, what is your opinion as to the effect which the general adoption of the means of prevention compared with the adoption of the means of alleviation would have upon their minds?—I think the means of prevention, that is, the means of putting their localities and houses into a cleaner and more wholesome state, would have the best effect upon their minds, and that they would enter into these measures with great alacrity. Certainly they would do so if they understood that they were adopted with a view to prevent cholera or any other epidemic disease; whereas they had no faith in the cholera hospital, and entered it with the greatest reluctance. My colleague and myself, who were attached to this hospital, lost nearly all our practice at the time, for the poor said we killed them, and the better classes were afraid we should kill them by contagion.

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Is it your opinion, from what you observed of the progress of the disease, that cholera spread from contact of the sick with the healthy?—No. I believe it to be an atmospheric poison, aggravated by the filthy condition of the localities in which it most prevails.

Do you think the present state of the intelligence of the poorer classes is such as to enable them to understand and appreciate this truth?—Yes, I do.

What do you think would be the social and moral effect of this opinion becoming prevalent among them?—I think the effect would be, that they would readily assist in carrying out any measures suggested for their protection and safety against the disease. I daily see the pernicious effects of their belief in contagion. I see patients affected with typhus and other epidemic diseases neglected and even abandoned, sometimes by relatives and friends, and always by neighbours, from the apprehension that they shall themselves become the subjects of the disease. In reply to inquiries made to me, as to the nature of the disease with which their inmate or neighbour may be affected, I am always afraid to say it is a case of fever; for if I do the patient is sure to be abandoned.

Do you say sure to be abandoned?—A devoted friend may continue to assist and nurse at her own risk; but this is not common; it is an exception to the rule.

Have you read the evidence of Mr. Bowie? Will you state how far you coincide in opinion with him?—My experience is in consonance with his generally. From the Registrar-General's returns it appears that the attacks of epidemics in the districts fell as follows: in St. George's (judging from the year 1839)—

	Proportion per Cent. of Deaths from Epidemics to total Deaths.
Gentry; with whom are classed all professional persons and persons not in business . .	10
Tradesmen	15
Artizans	25
Persons undescribed	20

Are these such proportions as from their relative circumstances you would expect?—Yes, certainly. The proportions per cent. of deaths of children under 10 years of age to the total deaths were as follows:—

Gentry	22
Tradesmen	55
Artizans	65
Undescribed	21

Is this what you would expect of the relative effect in infantile life of the difference of the condition?—I should have expected that the deaths of the children of artizans would have borne a larger proportion than they appear to bear in the face of the returns. The average age of death amongst all classes, including children, appear to have stood thus in St. George's:—

Gentry	45
Tradesmen	30
Artizans	20

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The average age of all classes who died being, in your district, 23; whereas, in better-conditioned suburban districts in the metropolis, it appears to be as high as 34 and 36: are these results in coincidence with your own observations?—I think they are; but there are in operation in this district causes which affect all classes, rich and poor.

What is the condition of the district in respect to house and street drainage?—The houses are very badly drained; they have mostly cesspools, very few draining into any sewers; but the most depressing influence upon the health arises from the number of open sewers which surround and intersect the district; these ditches and sewers are sluggish, and evolve noxious gases. Typhus fever is always prevalent in the vicinity.

What is the condition of the covered sewers?—They emit very offensive effluvia. In the house in which I live we have experience of it. When the wind is in particular directions we have a severe experience of it.

Do you consider it of advantage, in the present state of the sewers, to open any communication with them?—I have been led to consider that point, and to doubt it very much; more particularly since the storm of August, 1846, when the water from the sewers was conducted from the drains into the houses, and burst through them. A number of houses were flooded with sewer water; mine was saturated throughout four feet deep; the walls have not yet got rid of the stench.

What was the condition of those houses which had no drains to join on with the sewers?—They were certainly better off; they had none of the sewer water.

No. 3.

Dr. *Murdoch*, of Rotherhithe.

No. 3. Dr. Murdoch.

How long have you practised in Rotherhithe?—Between 14 and 15 years.

Were you there at the time of the visitation of the cholera?—I was there only at the time of its close, in January, 1833, when there were only a few straggling cases, such as appear at the end of an epidemic. I had been previously 13 years in Paris. I had been two years as externe, or dresser, and four years as interne and house surgeon, in the large French hospitals. I was there during the dreadful attack of cholera in 1832.

Will you describe the present condition of your district in respect to disease?—There has been more fever than usual within the last six weeks.

What is the state of the locality where fever mostly prevails?—The houses are badly drained, badly supplied with water, and an open ditch receives the contents of privies. There is a block of houses where the privies hang over the ditch; the paths in the fronts of the houses are unpaved and filthy. The district of Rotherhithe is altogether excessively ill drained, intersected with ditches and stagnant water.

In what respect has its condition been altered since the cholera last visited it?—A few of the sewers have been arched over within the last few years, and some new sewers constructed. In some parts they have water laid on, which they had not before; but some of the dwellings are wretched hovels, as in the district of Kenning's-buildings and

No. 3. Dr. Murdoch.

Norfolk-place, in Swan-lane. In that district, in which typhus is always most prevalent when in the neighbourhood, one brother practitioner, Mr. Chandler, attended 90 cases of typhus and typhoid fever within 12 months.

Should cholera re-appear, in what places would you expect it?—I expect that it would follow the law of typhus and typhoid fever, and visit that neighbourhood, and others similarly situated, the first. Between Staple's-rents and Lucas-street there is a filthy ditch; there is one in Lower Rotherhithe-street, opposite the plying place called the Pageants; another between Thames-street and Russell-street, Lower Rotherhithe, and many others. Many of these places are below high-water mark, and the houses are subject to inundations from these sewers when the Thames overflows. The neighbourhood is always more unhealthy for a considerable time after such inundations, catarrhal and rheumatic affections prevailing.

You have read the evidence of Mr. Bowie with relation to the condition of the district on the opposite side of the river. How far is it parallel to that of Rotherhithe?—Rotherhithe is not so overcrowded; there is more unoccupied ground about it, and a greater degree of dilution of the miasma, and I should not expect the cholera to be so severe in Rotherhithe, except along the waterside. In the general conclusions stated by Mr. Bowie I agree. In Paris, the cholera followed the same law as typhus, visiting most severely the Cité, the Faubourg St. Marceau, and the crowded neighbourhood at the back of the Hôtel-de-Ville, or Town-hall, the most filthy and ill-ventilated districts. For several days the deaths were at the rate of from 1000 to 1100 per diem.

No. 4.

No. 4. M. F. Wagstaffe, Esq., Surgeon.

Matthew French Wagstaffe, Esq., Police, District, and Parochial Surgeon, Lambeth.

Where were you in practice when cholera prevailed in the metropolis in 1832?—In Southwark, Bermondsey, and Lambeth.

Did you see much of the disease?—Very much; and I observed its course along the edge of the river, and found that it prevailed principally in low marshy situations, in crowded, ill-ventilated courts and alleys.

What was the condition of the house and sewer drainage in the streets, courts, and alleys in which the disease principally prevailed?—The drainage was extremely bad; the privies were very often in the cellars; I have myself passed through two feet of water to get to the houses, being obliged to walk along planks, and the door-ways of the houses, at the time of high tide in Fore-street, Lambeth, being blocked up with boards and plaster, to prevent the water from getting into the dwellings. This state continues occasionally at the present time.

Are cesspools general in the district?—Yes, they are very general; and I have often seen the soil from these cesspools swimming about in the water.

Are the houses in these localities in general damp and dirty?—Yes, they are; and it is quite impossible for the inhabitants, under such circumstances, to keep them dry and clean.

No. 4. M. F. Wagstaffe, Esq., Surgeon.

Whenever typhus is prevalent in the metropolis, is it in these localities that you constantly find it?—Invariably, and common fever is very apt in these places to assume a typhoid type. This is the case at the present time with several cases now under my care. Scarlet fever, measles, and small-pox also are very apt to become malignant here. Under certain atmospheric conditions, for example, when I arose in the morning, and found the atmosphere warm and moist, I could always foretell that there would be an increase of malarian disease of some sort in these places, and that they would be more intense in degree; so that in this state of the atmosphere I always knew I should have more to do in these low, close, undrained, and crowded places.

Are there any places in your district in which fever is constantly present?—Yes, there are; several courts and streets in Lambeth-walk, also in some streets from Vauxhall-gardens, and in other places.

Is it in accordance with your observation and experience that the localities in which fever constantly prevails were those in which this particular epidemic, namely, cholera, chiefly raged?—They are the very same. I have at the present moment many cases of fever in the very places in which cholera was most prevalent. This autumn diarrhœa and dysentery have also been prevalent there, and some cases were so similar to Asiatic cholera, that I asked some of my professional brethren to go and see them: two of these cases were fatal. They had, in fact, all the characteristic symptoms—vomiting, diarrhœa, with rice-coloured evacuations, cramps, suppression of urine, the particular sunken countenance, giving the expression of age to the patient, with a livid and even blue colour.

Then you have no doubt that if cholera were again to re-appear in your district, these would be the places which it would first visit, and in which it would be most prevalent and fatal?—I have no doubt of it.

Has the condition of your district been materially improved since the last visitation of cholera?—Additional common sewers have been made, but in very few instances, indeed, have house-drains been made into them. Even large houses, in which the better classes live, have no drains into the sewers; they continue to have nothing but cess-pools; water-closets are very rare, even in the better class of houses, excepting in newly-built houses.

Then the streets, courts, and alleys in which the poor live are wholly unimproved?—They are not improved; indeed, being more crowded, they are even worse, and the quantity of decomposing animal and vegetable matter about them is greater. Near the river's edge, between Westminster and Vauxhall Bridges, there are several depôts or manufactories very unwholesome, such as bone-manure works, gas-works, and potteries, and it is a fact that the workpeople die at an early age.

Have you observed in houses communicating with the sewers any instances of noisome smells arising from their foul condition?—Yes, I have.

Is this common in the district?—I have very frequently noticed it.

Are not the houses frequently flooded with sewer-water, as well as subjected to poisonous smells?—Yes, they are.

In such cases, is not the communication of the house with the sewers

No. 4. M. F. Wagstaffe, Esq., Surgeon.

of very doubtful benefit?—In these cases it is certainly of doubtful benefit.

What, according to your observation and experience, were the effects of cholera hospitals?—By the congregation of great numbers together, I think they must have been injurious, and it is certain that the disease proved more fatal in those hospitals than in private houses, however poor.

Is not the unventilated and crowded condition of ships often sufficient to produce fever?—Yes; I have known several instances of the spontaneous generation of fever in ships; and in one case, which came under the observation of my father, small-pox broke out in a vessel which had not communicated or spoken with any other vessel for three weeks.

Is not the condition of ships very often quite as favourable to the generation and spread of fever and other epidemic diseases as the close, unventilated, and crowded abodes of the poor on shore?—Yes, decidedly so.

Were not the poor very unwilling to go into the cholera hospitals?—Very unwilling indeed.

If general and systematic measures of prevention were adopted, do you think the poorer classes would place greater confidence in them, and co-operate in carrying them out more readily than experience has shown they did with reference to the measures of alleviation which were proposed?—Yes, I think they would, most decidedly. If, for example, comprehensive and efficient means were taken to cleanse the surface of their streets and courts, to wash out their cesspools, to supply them with abundance of water for cleansing the interior of their houses, and for the immediate removal of all description of filth, I think they would have more confidence in measures of this kind than in anything which was formerly suggested or tried for their relief.

And do you think they would co-operate in promoting the success of such measures?—I feel very confident that they would.

What is the state of the paving in your district?—There has been some improvement; but a large portion of the district still remains in a very unsatisfactory and uncertain state.

Do you know whether there is any material improvement in the sewerage, drainage, and cleansing of Bermondsey since the last visitation of cholera?—More sewers have been made; but there still exist great numbers of uncovered sewers and ditches. There are great numbers of courts and alleys in which there are no drains, and fever of a typhoid character is existing in those places to a great extent at this present time; and I have seldom or never known Bermondsey without it.

Though there may be more sewers, if there is no greater flow of water through them, the population having considerably increased, are not those sewers mischievous rather than beneficial in consequence of containing a greater quantity of decomposing matter?—If the supply of water is not increased in proportion to the enlargement of the sewers, the sewers must act as extended cesspools.

From the Registrar-General's return, taking one year, the year 1839, it appears that the proportion per cent. of the deaths of children

No. 4.
F. M. Wagstaffe, Esq., Surgeon.

under 10 years of age to the total deaths in Lambeth of the children of each class of society, classing gentry as the persons following professions, or persons living in independent circumstances, were as follows:—

Gentry	31·2
Tradesmen	57·1
Artizans	60

Are these results conformable to your observation of the different sanitary condition of the several classes of society there?—They are; they are similar to a return which I made myself.

It appears that at Lambeth the average age of death of all who die is 24, whilst at Camberwell it is 34, and at Hackney 31; that in Lambeth the average age of all who die is of the first class 37, of the second 21,and of the third class, the artizans, 20; do these differences coincide with the differences of sanitary condition of the several classes?—I think they do.

It appears from the Registrar-General's return that the average age of death in Bermondsey is lower than in Lambeth, being 22 years for the whole population. This you would expect from the comparative sanitary condition of the population?—Yes, I should.

And so in respect to the proportion of attacks of epidemics to the total deaths which appear to have been in Bermondsey as follows:—

Gentry	0
Tradesmen . . .	12·8
Artizans	25

—Yes.

No. 5.

Thomas Robinson Leadam, Esq., Surgeon.

No. 5.
T. R. Leadam, Esq., Surgeon.

You are surgeon to the Poor Law Union of St. Olave's, Southwark, are you not?—Yes, I am.

How long have you practised in that neighbourhood?—Fifteen years. My practice is at present in every condition of society.

What part had you in meeting the visitation of the cholera?—The workhouse was parted off as a cholera hospital. I had partly charge of it, and of the out-door district.

Was that district very severely visited?—It was certainly one of the districts the most severely visited in the metropolis.

What were the descriptions of places and the classes of persons then most severely attacked?—It was chiefly in the filthy dens which we have about us, close courts and alleys; those inhabited by the Irish are the most filthy.

How far has the condition of those places been amended since then?—Very little.

What is the condition of those places in respect to the supply of water?—The houses are not supplied at all. Here and there there is a plug in the middle of the street or the middle of the turning, from which those fetch water who can.

What is the condition of the place in respect to house and street drainage?—Cesspools are general; the house drainage is excessively bad; we are surrounded by open ditches, frequently filled with black offensive matter, the water sometimes washing it away, sometimes not,

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and sometimes, on the occasions of high floods, running into the houses. The water used to flow up further, and wash better; but on one occasion it overflowed a great extent, and means were taken to confine it; and those means have diminished the run of water and the ditches are at times stagnant, although this has nothing to do with the flow of water in the sewers, the latter taking off the deep drainage, the former the superficial. The effluvia given off from the gully grates is very offensive indeed. I can speak now particularly of one before my own house. It really makes me sick to go out of my door at times. This effluvia is generally productive of disordered health; it induces a low nervous condition and chronic dyspepsia.

Was the cholera track and the typhus track in your district nearly identical?—With us it was so decidedly.

What are your anticipations as respects any future visitation?—As far as respects the *nidus* it will find, and in the sanitary condition of the population, I do not believe that, speaking generally, there has been the least improvement.

What improvements would you consider available for prevention?—In respect to the open ditches, arching them over and conducting a stream of water through them, so as to carry off the impurities; a better water supply to the houses; and the removal of cesspools and better paving, as well as scavenging for the courts; and the compelling the landlords to form proper communications from the houses with the sewers, so that some outlet may be made for offensive matters.

Have any applications, within your knowledge, been made to the Commissioners of Sewers for any remedy?—I do not remember at present any particular cases. I believe that Mr. Newman, who is the surveyor to the Commissioners of Sewers, has been applied to; but he states that nothing can be done to relieve the parish from the effluvia arising from the sewers up the gratings. Since this statement was made Mr. Newman has invented a trap, which is ordered to be applied in the district, but he fears that the effect will be to drive the effluvia along the drains into the dwelling-houses.

No. 6.

Wm. Simpson, Esq., Surgeon.

No. 6. W. Simpson. Esq., Surgeon.

You reside in High-street, Bloomsbury, and are a surgeon in general practice?—Yes; I am.

You are well acquainted with the neighbourhood of St. Giles, are you not?—Yes; I have been well acquainted with it since 1829.

Were you called on to attend cases there on the appearance of the cholera in 1832?—Yes; I was. I attended the first two cases which occurred in St. Giles's, at No 14, Buckeridge-street, both of which were females, and died. The cases became so numerous, and it was so difficult to get hot applications, and steady attention to orders, we were compelled to have an hospital erected in the stone-yard, now part of Bloomsbury-street.

Did the hospital seem to lessen the average number of deaths?—No; its being in the same locality, and subject to the same atmospheric influences, prevented that result, but it was much more convenient for

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two or three physicians, who after the heat of the battle and danger was over, reaped the credit.

What description of persons and in what localities were the chief attacks of cholera?—Precisely the same description of persons, and in the same localities, where typhus, influenza, and scarlatina assume the putrid type. The places most visited were Buckeridge-street, Bainbridge street, Lawrence-street, and Church-street. Not one of these streets had a sewer, and not a house in them had a drain. All had cellars inhabited, and every room occupied by different families. The filth and dirt before the doors was dreadful, and the stench overpowering.

What is the present condition of these localities?—All except Church-street, and part of Lawrence-street, have been pulled down and replaced by New Oxford-street. Church-street remains in the same state of horrible filth, indeed rather worse, from overcrowding consequent upon removal of other streets, the constant residence of typhus and every malignant disease that sweeps through the metropolis.

Have the late alterations improved the general health of the neighbourhood?—I should say yes, so far as we have now greater currents of pure air from above; but so long as these localities remain without sewers, and the present sewers remain as they are, I do not expect any permanent improvement.

Why so?—Because when the wind blows in certain directions, the stench is thrown back through the privies and water-closets, and the supply of water being limited, accumulations take place, particularly in the months of July and August, beneath the kitchens, which taint meat, and therefore taint also the blood of the living.

From what you state, the private houses of tradesmen and shopkeepers, &c., is not much better than those of Church-street?—I should say very little better, but the wholesome diet, clothing, and fuel, along with better ventilation, and more light, cause the diseases to assume a less malignant type, and therefore fewer die of typhus, &c., but more of pulmonary diseases and scrofulous affections; the number of children with deformed legs and spines is incredible, and all from the same causes.

Have no attempts been made to remedy these evils?—If you will allow me to state what happened to myself within the last three or four years, it will apply to nearly all my neighbours. About three years ago I went to the expense of about 15*l.* to have a sewer opened which runs beneath my kitchen; I was advised to have it lined with cement, and all the rat holes filled up, supposing that, the old mortar having fallen off, the stench penetrated up through the interstices. Little improvement took place. I then went to the office of the Commissioners of Sewers, in Greek-street, Soho, and inquired if they could do anything for this: they said no; but if I chose to go to the expense of 3*l.*, they would put a trap-door at the mouth of this branch sewer, where it empties itself into the main sewer; this, on consideration, I declined, as the drains from three or four other houses would still be running into mine, the *cause* would not be removed. The men at the office tried to console me, because Earl Spencer was situated the same as myself. He complained on the same day of the same kind of nuisance as I did, and they could not assist him.

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Did you ever learn whether Lord Spencer got anything done at his own expense?—I did not, but his Lordship, having the means of paying for large supplies of water, I dare say a trap would have been useful in his case, although not in mine.

Have you read Mr. Bowie's statement before us?—Yes; I have.

Do you agree with it?—I do. I have often heard of Mr. Bowie being a kind man to the poor, and I am now equally pleased to find he understands his profession so well. I found as much benefit from the toast-water he speaks of, with hot pure air and bottles of hot water to the feet and hands, as I did from anything else, and were the cholera again to occur, these, with calomel, would be my principal remedies.

What has been the effect of the removal of so many people from your neighbourhood?—The effect has been to lessen the population of my neighbourhood by about 5000 individuals, and therefore to improve it at the expense of other parts of London.

Where do you suppose these people have gone to?—Some to the streets leading to Drury-lane; some to Saffron-hill; some to St. Luke's; some to Whitechapel; but more to St. Marylebone and St. Pancras.

What has been the effect of their going to those places?—I find by the papers, that the vestries of St. Marylebone and St. Pancras dislike very much to be obliged to pay what Bloomsbury and St. Giles's vestries have done, without grumbling, all along. Places in these parishes, which where before bad enough, are now intolerable, from the number of poor who formerly lived in St. Giles's, and their friends who, during the last two years, have come from Ireland. I suppose it is the same in Clerkenwell and St. Luke's, but the reporters of the press do not take so deep an interest in their proceedings as in Marylebone and St. Pancras.

Have you still places in your neighbourhood as bad as Buckeridge-street and Bainbridge-street were?—Yes; I consider the courts between Crown-street and High-street, and Lascelles-court, beside the workhouses, as bad, if not worse.

Do the guardians and medical officers at the workhouse not see to Lascelles-court, at least?—No; typhus is never absent from them. Mr. Marshall, a plumber and glazier in Broad-street, has memorialized them repeatedly without their attending to his suggestions.

No. 7.

J. French, Esq., Surgeon.

No. 7. J. French, Esq., Surgeon.

You are the surgeon to the parish of St. James Westminster?—I am; and I have charge of the infirmary there. I am a general practitioner.

Were you surgeon to the parish at the time the cholera appeared there?—I was.

Did you attend to the disease specially?—I did; and I have written a book about it, in which I describe what I consider the best mode of treatment.

What number of patients had you in the cholera hospital at the time?—I think 50 during the three months. The Cholera hospital was only a receptacle for the most urgent cases. Four district surgeons besides

No. 7. J. French, Esq., Surgeon.

myself attended patients at their own dwellings; and these constituted by far the greater number of cases. My impression was, that the worst part of our parish was not so crowded as the corresponding part of St. Giles's and some other localities, and that much was done by the local authorities in the way of whitewashing and administering generally to the wants of the most destitute, which was calculated to render the visitation less severe.

Has the general condition of the dwellings of the working classes been improved since then in your parish?—Some few of the worst constituted dwellings have been improved; in many of them, Mr. Toynbee's ventilators have been introduced, which, I believe, is felt to be an improvement by the inhabitants of the rooms so ventilated; but, on the whole, the improvement has been very slow and very partial.

Have you read Mr. Bowie's evidence?—I have.

Do you concur generally with him?—I do. Where typhus has prevailed during this season, there I should expect to find a greater number of cases of cholera. I believe that cholera is no more contagious than typhus. I believe, however, that both are capable of propagation by contagion, though not to any extent under favourable hygienic circumstances.

You agree with Mr. Bowie, and other medical witnesses, in giving the preference and the advantage to the measures of prevention?—Undoubtedly: particularly when those measures are highly advantageous in themselves for all epidemics.

No. 8.

Edward Doubleday, Esq.

No. 8. E. Doubleday, Esq.

You act as medical officer to the workhouse of the union of St. Saviour's in the Borough, do you not?—Yes, I do.

You were examined some four years ago in relation to the sanitary condition of your district, were you not?—Yes, I was.

And you then described its sanitary condition in respect to sewerage and drainage as very bad?—Yes.

In what respect has it been amended?—In consequence of the public attention to questions of sanitary improvement, individuals have here and there drained particular houses or places; but the whole remains very much in the same state as before.

You were a practitioner in the district when it was visited by cholera, were you not?—Yes, I was; the visitation of the cholera in our district was very severe.

Will you describe the places and the classes which it visited?—In the parish of Christchurch and the neighbourhood of Broadwall, there are open sewers. At Brunswick-place there is another. In these neighbourhoods the cholera was unusually severe; in one row of houses, within two yards of the sewer, houses which are very miserable as regards size, ventilation, and means of cleanliness, the mortality was excessive; as many as five died in one house.

And that place remains without amendment?—Just the same; exactly in the same state. When certain atmospheric conditions prevail, and typhus arises, it is always found much more in these districts, and the result is more fatal.

If cholera should revisit the metropolis, what is your expectation in

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respect to these districts?—It would certainly be, that the cases would there be more numerous and fatal.

What is the bodily condition of the population resident upon them?—They are sickly and miserable, the children poor and dwindling.

How is the paving and cleansing of the courts and alleys attended to?—In my own, I think it fairly done; in others, abominably neglected,—the great defect of the district, however, is the state of the sewers and the house drains. When we visit the houses of the lower classes in these districts, we are met, or as the expression is, almost knocked down by offensive smells; on inquiring, we find that there is some house-drain stopped up, some cesspool deranged, or the cellar flooded. The lower offices of the houses in the neighbourhood of Holland-street and the water-side, are subject to periodical floodings, and that with very filthy water.

You have read the evidence of Mr. Bowie?—Yes, I have.

How far do you concur with him?—All that he states is quite consistent with my own experience.

From the Registrar-General's return, taking the year 1839, it appeared that the average age of death amongst the chief classes of society, including the deaths of children in St. Saviour's, was as follows:—

	Years.	Premature loss of Life as compared with Camberwell. Years.
Gentry	47	0
Tradesmen	25	13
Artizans	22	17
Persons undescribed	15	24

Does this mortality appear to represent the relative physical or sanitary condition of the dwellings?—No doubt it does.

The relative infantile mortality appears to be, from the Registrar-General's returns, as follows:—

	Proportion per Cent. of Deaths of Children to the Total Deaths of each Class.
Gentry	10
Tradesmen	48
Artizans	49
Undescribed	69

The deaths of adults above 21 years of age appeared to have been as follows:—

	Average Age of Death. Years.	Premature loss of Life as compared with the loss of Life at Camberwell. Years.
Gentry	52	10
Tradesmen	52	10
Artizans	45	17
Undescribed	51	11

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The proportion of deaths from epidemics appears to be as follows :—

	Per Cent. of Deaths from Epidemics to Total Deaths.
Gentry	10
Tradesmen	19
Artizans	18·7
Undescribed	22·7

Do not such proportions indicate the probable proportions of death from cholera, as well as from future epidemics, the condition of the several classes remaining the same?—Certainly it does. It appears that in the district of St. Saviour's the average age of death is the lowest in any part of the metropolis. I must attribute it chiefly to the open sewers and the general bad drainage of the place. In the neighbourhood of the Mint and Ewer-street, the condition of the population is certainly very bad. There not only the drainage, but the cleansing and scavenging is very bad; and nothing has been done to improve the defective conditions of the houses. The circumstances are such as to account for the mortality.

No. 9.

No. 9.
T. Taylor, Esq.

Thomas Taylor, Esq.

You are a medical gentleman residing in Bethnal Green?—I am.

Are you employed by the parish, or by the district, in any way?—I have one of the districts of the parish under my care.

What district is that?—No. 2 district.

Can you at all give the geographical position of it?—It is bounded on the eastern side by the Cambridge-road, upon the southern by Elizabeth-place, Collingwood-street, Wellington-street, North-street, West-street, part of Trent-street, up into Bethnal Green-road, Harts-lane; and on the northern side of the road, about on a line with Harts-lane.

What is the population of the district?—I should suppose it is about 17,000 or 18,000.

Of the poorest class?—A great many of them are very poor.

How long have you been acquainted with that district?—Since the year 1834.

Then you were not acquainted with the district when the cholera visited this country?—I was not.

Are you at all acquainted with the experience of the medical officer who had the charge of the district at that time?—I am afraid there is not any one of the medical men who attended during the time of the cholera who can be got at; Mr. Luff died from his labours during the cholera; and of Mr. Bryden I do not know what has become; I do not think he is to be found.

You cannot say what the districts were that were most severely visited by that disorder?—It was at the time I was a medical pupil; I visited, for the sake of seeing the disease, some of the districts where the cholera was prevalent, and I could point them out in the parish.

No. 9. T. Taylor, Esq.

From the information you have obtained, you would be able, you say, to point out the districts which were most severely visited?—Some few of them.

Do you find that those districts are the districts which are now most visited by fever?—I should say they were. I am not attending in those districts in which I saw the cases of cholera, but I am enabled to state that fever is prevalent in Virginia-row, where I saw several cases of cholera.

What is the state of your district generally, as to cleansing, the supply of water, and also as to the state of the houses themselves, in respect of cleanliness?—The cleansing is exceedingly deficient, caused in the first instance by a great want of water. The whole estate pretty nearly, till quite recently, was entirely without water.

What estate was that?—I believe it belonged to St. Thomas's Hospital. The property is in possession of Mr. Ridge at present. An Artesian well has recently been formed, and the want of water has been relieved; but for a long period they were without any water whatever.

Have any water companies their pipes laid down in the district?—The water company's pipes were in the district, but I believe there was some quarrel between the landlord and the company, and the water company, I believe, refused to let them have water.

Do you mean by the landlord, St. Thomas's Hospital, or the lessee?—The lessee, Mr. Ridge. In very many of the houses, in my district, the water is not supplied to them.

How long is it since this Artesian well has been sunk?—I think it has been got into operation within the last 12 months.

Can you state with respect to sewerage the state in which the district is?—Exceedingly deficient. Down the Bethnal Green-road, which is tolerably flat, on neither side is there any sewer that is three-quarters of a mile in extent.

Is that in the Tower Hamlet division of sewers?—Yes.

Do you know whether any complaints have been made respecting sewerage in that district?—I formed one of a deputation to them upon one occasion requesting that a sewer might be constructed. We were informed that if part of the money was subscribed they would then make the sewer. The doctrine that was held out by Colonel Gant, who was chairman at the time, was that the office of the Commission was not for the purpose of making sewers, but keeping in repair those that were already made.

How long ago is that?—That is some four years ago.

And it still remains without a sewer?—It does.

Are you aware whether the neighbourhood of that district is unhealthy?—There are very many diseases occur there that it appears to me would be remedied provided that the places were well drained.

Can you positively say that more disease occurs in that portion of Bethnal Green-road which is not sewered than in that which is?—I am hardly able to make that statement, inasmuch as no part of my district is well sewered.

Have you observed in any portion that is better sewered than another less fever prevails?—No doubt of it.

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Can you state that positively?—I think I can very safely.

Can you name a particular street?—I will take the Globe-road, a sewer was taken down there 10 years since, and the health of that district has materially improved since.

Does that sewer go into Whitechapel-road?—I think it does.

Do you attribute that improvement in health to the neighbourhood being less humid or to the filth being carried off?—To the filth being carried off from the surface. I should think the medical officer of the Green-street district would be able to speak to facts connected with disease and drainage. Green-street has recently, within the last two years, been drained by a sewer, and there, from the part being a dead level, the parties suffered very severely from the want of drainage.

You state that an Artesian well has been sunk in a portion of your district, are the houses supplied with pipes from that well?—Some of them are, some are not.

Are you aware whether many are?—I should suppose perhaps 40 houses may be supplied.

Are you aware at all whether any of the cesspools diminished in their fluid height in consequence of that Artesian well being sunk?—I should hardly suppose that to be the case, for in the construction of an Artesian well iron pipes are put down to prevent the surface drainage from entering the bore.

Has it drained any of the wells in the neighbourhood?—I think not; there are some gardens close upon the district, and no complaints of the water having failed in those wells have been made.

Are cesspools very common in your district?—Yes.

Where are they placed generally?—Very frequently close to houses.

Are they ever under the houses?—In some instances I could point out they are under the houses.

Do you know any instance where a bakehouse and cesspool are both under the house?—I do not.

Do you think there is any material improvement in the district since 1834, which was the period when you took it under your own charge, in the supply of water, cleansing, or sewerage?—There have been sewers constructed in some few parts, for instance, Globe-road, which I have mentioned, and a sewer was carried some time since down Lisbon-street; and the surface of those streets is in a very much better condition than it was before.

Generally speaking private houses do not communicate with sewers, do they?—They do not. I see an advertisement in the paper that the Tower Hamlets Commission are about to apply for increased powers. I think it is quite right that increased powers should be extended to them for the purpose of carrying on the sewerage; but I think it would be a duty on the part of the public to see that there was some protection for them also, that is to say, if parties in a district request that a sewer might be made, a petition being signed to that effect, the Commissioners of Sewers should be obliged to construct it.

If the Commissioners of Sewers are obliged to construct it who should pay for it?—The owners of the property, or long leaseholders, who would derive benefit. Even in poor districts there is considerable difficulty in managing it. It is utterly impossible, that persons who are earning from 10*s.* to 15*s.* a-week, who perhaps form the great bulk

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of the population in my district, could be called upon to pay any part of the sewers-rate.

Supposing the landlord paid it, would not it come upon them ultimately in the shape of increased rent?—I think the rents could hardly be increased beyond what they are.

Would not the supply of water carried into the house be actual economy of labour, and a saving even to the poorest weaver?—No question of it.

Supposing a constant supply of water could be carried into a house for a penny a-week, is there any poor weaver or labourer in Bethnal-green to whom it would not be a matter of economy?—It would be a matter of economy; but, under present circumstances, I do not think carrying water to them would be of much use, inasmuch as they have no means of getting rid of it.

Supposing it were practicable to carry away the refuse water again by a house-drain at another penny a-week, would not that be an economy of labour even to the poorest weaver?—There can be no question about it.

The inhabitants of the poorest tenement must make use of a privy or a cesspool?—Yes.

Supposing a water-closet apparatus or soil-pan could be put down at the rate of a penny a-week, would not that be economy over the existing charges?—I think so.

Supposing the front of the street could be swept or cleansed at a penny a-week, taking into account the expense of washing, would not that be economy to the poorest weaver who works in Spitalfields?—I think there can be no doubt about it.

Suppose the sanitary improvement in respect of those points could be carried out at 4*d.* a-week, that is to say, the price of a pot of porter, would that be too much even for the poorest to pay: and to the poorest, who must now pay in some shape, can it be other than an economy?—I think not. I think their increased health would give them greater energy to attend to their work.

The poorest man there contributes to sick clubs or benefit societies, probably?—Pretty generally, I should say.

Would not such a payment as 4*d.* a-week for those improvements so far reduce the chances of sickness, and extend the proportionate duration of life, that even as an insurance charge upon the family that payment would be worth while?—I think there can be no doubt about it.

Do not a great number at present pay more than that amount in the expenses of sickness?—In the loss of wages I think so, certainly; but the poor in the district are very badly off for medical attendance generally. They are not in a condition to pay a medical man, and there is considerable difficulty, which the poor complain of, in getting orders for attendance officially.

Are there dispensaries in the district?—There are; but the funds that come into the hands of the Bethnal Green Dispensary do not amount to more than 20*l.* or 30*l.* per annum. The great saving would be in their being in a condition to attend to their work continuously.

It appears from a statement, that of the deaths above 21 in your district as compared with the deaths in Greenwich or Camberwell, a work-

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ing man loses 11 years of his life. Do not you believe that those several things would have a value upon the duration of life, making it cheaper for him to pay for it?—No question of it.

It appears that the average age of your population is 22 years, whereas in Hackney it is 31, and in Camberwell it is 34. The duration of life among the gentry is 46; tradesmen, 24; artizans, 18. Do not you think the surrounding sanitary influences have a great deal to do with those various proportions?—Yes, certainly. The condition in which the poor man is placed from the want of every comfort of life about him will necessarily reduce the duration of his life.

Have you any gin-palaces in Bethnal Green?—Several.

Have you any notion of the expenditure in Bethnal Green in gin?—No.

Can you infer it from the sizes and magnificence of palaces?—I should think it is very considerable.

Supposing that expenditure upon gin-palaces were expended upon their own houses, would not it lead to a very considerable improvement in them and increase of comfort as well as economy?—No doubt about it.

Can there be said to be an absolute want of power to pay for water, while you have displayed before you in your streets such a power of spending upon gin?—I am quite willing to admit the tendency to spend money upon a luxury of that sort, as they consider it, when they would not spend it upon water.

Supposing they had very good water constantly supplied to them, would not that, to a certain extent, be an inducement to them to make use of it?—Yes.

Do not you think the condition of the localities in which a great many of the people in your district live, the uncleanliness of their houses, and the impossibility of keeping them clean without any drainage, or paving, or water, has a considerable influence in driving them to those gin-palaces?—I think there cannot be a doubt of it. There can be no question that they do go to public-houses because they are more comfortable there. I knew an instance of that some time ago. A man and his wife had left their home to go to a public-house, and they stopped there till three or four o'clock in the morning; they quarrelled, and the man struck the woman; she lost a largish quantity of blood, and the matter came under the notice of the police. They had avowedly gone from their own wretched home to the public-house in consequence of its superior accommodation.

(*The following paper was delivered in by the Witness.*)

TABLES showing the NUMBER of PERSONS SLEEPING in one ROOM, its dimensions, and the times when *death* would take place, provided there were no ventilation; those houses form courts and streets in a nearly direct line from the Bethnal Green to the Whitechapel-road, a distance of half a mile.

"In calculating these tables, the following data have been used, namely, that each respiration is 40 cubic inches (Menzies), the respirations 20 per minute (Haller), and that the existence of ·08ths of carbonic acid gas is destructive (Liebig).

"Parliament-court consists of 9 houses, each containing 2 rooms, and a small wash-house (30 square feet), and a yard, of about the same size, less the space occupied by the privy; the pressure of the water is so little that No. 9 is very badly supplied; No. 8 somewhat better, and the other houses tolerably well three times per week.

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No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1				2	31 37
2				9	7 1
3				4	15 49
4				2	31 37
5	7 8	10 6	9 7	9	7 1
6				4	15 49
7				3	21 5
8				5	12 39
9				empty.	

"A little court out of Parliament-court contains four houses; they have one privy in common in the open court; having no back premises, they obtain their water from a stand pipe three times a-week.

No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1				2	31 8
2	7 0	10 6	10 2	2	31 8
3				2	31 8
4				4	15 34

"Jubilee-place consists of eight houses, having no back premises; there are two privies in the open yard in front of the houses common to them; there is but one stand-pipe, from which water is obtained three times a-week. The houses Nos. 3 and 4 have a drain passing under the floor; they stink most abominably, and the paint (white lead) is blacked by its conversion into sulphuret of lead. This court is approached by a very narrow alley, and has no ventilation; it is a stagnant lake of air loaded with putridity.

No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1				6	9 27
2				1	56 42
3				3	18 54
4	6 9	10 5	9 10	3	18 54
5				9	6 18
6				7	8 6
7				6	9 27
8				8	7 6

"Little Collingwood-street is divided into two portions, one contains 20 houses, and the other 22, a little smaller than the former; four of the houses in the first division are wholly without water, and their inhabitants have to beg it of their neighbours, who, in supplying it, subject themselves to a penalty of, I believe, 5*l*. The first 10 houses are supplied by a stand-pipe, each householder having a key. This stand-pipe is the cause of much quarrelling for turns, and because it is frequently left running, and thereby annoys the person who lives in the house next it, frequently floating the floor; the other houses all have the water laid on.

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No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1				8	6 47
2				6	9 2
3				4	13 34
4				2	27 7
5 empty.				..	..
6				6	9 2
7				5	10 51
8				6	9 2
9				2	27 7
11	7 9	9 11	9 5	7	7 45
13				3	18 5
14				6	9 2
15				5	10 51
16				6	9 2
17				2	27 7
18				6	9 2
19				4	13 34
20				2	27 7
21				7	7 45
22				5	10 51

"Second part of Little Collingwood-street—

No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1 empty				..	..
2				5	9 45
3				5	9 45
4				6	8 7
5				3	16 14
5				10	4 52
7 empty				..	..
8				6	8 7
9				5	9 45
10				3	16 14
11	6 7	9 7	9 5	5	9 45
12 empty				..	..
13				6	8 7
14				5	9 45
15				5	9 45
16				8	6 5
17				7	6 58
18				4	12 11
19				7	6 58
20				7	6 58
21				9	5 25
22				6	8 7

"Foster-street is a tolerably open street—has a supply of water three times a-week, and a yard at the back of each house containing a privy; the rooms up-stairs are small, and, as will be seen in too many instances, excessively packed; it contains 24 houses.

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No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1				1	52 13
2				5	10 28
3				2	26 7
4				9	5 48
5				4	13 3
6				3	17 4
7				1	52 13
8				10	5 13
9				5	10 28
10				3	17 24
11				2	26 7
12	6 10	10 2	9 2	4	13 3
13				5	10 28
14				3	17 24
15				4	13 3
16				2	26 7
17				2	26 7
18				5	10 28
19				5	10 28
20				3	17 24
21				4	13 3
22				4	13 3
23				2	26 7
24*				5	10 28

"Elizabeth-place is a court containing 14 houses, the entrance is from the Cambridge-road, it is very narrow, and being an out-of-the-way place, is a receptacle for dust and disgusting refuse; the houses are in a most wretched condition, as are most of its inhabitants morally as well as physically; it is a harbour for the most degraded class of street-walkers.

No.	Height.	Length.	Breadth.	No. of Persons.	Death produced in
	Ft. in.	Ft. in.	Ft. in.		h. m.
1 empty				..	..
2 ,,				..	..
3				4	15 14
4 ,,				..	..
5 ,,				..	..
6 ,,				..	..
7	7 1	10 7	9 11	5	12 11
8				3	20 19
9 ,,				..	..
10				5	12 11
11				2	30 28
12				5	12 11
13				9	6 46
14				2	3 28

"In these tables no deduction has been made for the space occupied by furniture or the bodies of the inmates, which would tell very much in such cases as 6, Little Collingwood-street, 8, Foster-street, and 13, Elizabeth-place; how the parties are to lie without being super-imposed is to me a perfect puzzle, but to contemplate fever invading is most horrible."

* This last house has an extra room in it.

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J. Wright, Esq., M.D.

No. 10.

John Wright, Esq., M.D.

What is your public position?—I attend as general medical attendant to the poor of the united parishes of St. Margaret and St. John Westminster. I have practised as a general practitioner in the neighbourhood.

Were you connected with the parish at the time of the cholera?—My partner was, and I was actively engaged with him in attendance on the cholera patients.

Was the visitation of the cholera severe at that time?—Comparatively to the rest of the metropolis, it was severe.

What were the descriptions of places which the cholera attacked?—The low, ill-drained, ill-cleansed, and ill-ventilated places; the low courts and alleys in which a large proportion of the population live.

You have read Mr. Wilson's account of the condition of a portion of the parish: do you agree as to its general correctness?—Yes, I do.

When fever is prevalent in your neighbourhood, these are the places where you find it?—Yes, in the courts, and alleys, the low neighbourhoods; fever has of late been very severe there. I have given in the following account to our Board:—

"From the 29th September, 1846, to the 30th September, 1847, the number of out-door cases attended by order of the parochial authorities amount to no less than 2460, having steadily increased during the last three years from the previous annual average of 1000 to the present number; the increase of the past year over the preceding one is above 800, which I apprehend is principally to be attributed to the destitution resulting from the high price of provisions during the winter, and the prevalence of fever, in the first place apparently caused by the influx of destitute Irish; the number of cases of fever during that period have been upwards of 650."

Are not the crowding of the Irish into such places and their filthy habits quite sufficient of themselves to produce fever, whatever were their previous condition?—Yes, I am quite satisfied that it is so from my personal observation of them, they have no notion of ventilation; they have no care for personal cleanliness; they never think of water; they never care what they lie down upon; they huddle together and are utterly careless.

But what is the condition of the regular English or other population?—Still very bad; the lower parts of Westminster were formerly badly crowded, but they have been undoubtedly still more densely crowded, the low lodging-houses especially, by people driven in from St. Giles's and the other neighbourhoods pulled down to make clearances for the improvements.

It is of course in these neighbourhoods you will expect cholera?—Yes, or any other epidemic. Within the last four months I have had nearly 200 cases of measles, and now scarlet fever is prevalent. Whenever there is an epidemic we have it on a large scale.

From the Registrar-General's return it appeared that in the year 1839 the proportions per cent. of deaths in your parishes was—of professional persons 17 per cent., tradesmen 25 per cent., and artizans 25 per cent.; that the deaths of infants under ten years was—of the gentry 27 per cent., tradesmen 55 per cent., artizans 56 per cent.; in fact that more than one half of all born are swept away before the tenth year, and the average age of the whole is 25 years, or ten years less than a less unhealthy suburban district; the years of life being

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thus distributed—to professional persons, 42; to the tradesmen, 20; and to the artizan, 21; that is to say, man, woman, and child of the class. Do these proportions to your mind correspond with the relative sanitary conditions of the chief classes of the population?—Yes; and the loss of life amongst the artizan class would be greater if they were not more out a-field, and shorter residents than the tradesmen, who are almost always at home, and more exposed to these influences.

Regarding the state of the atmosphere in the neighbourhood of the seat of the deliberations of the Legislature, you would probably approve as wise the proposed arrangement for drawing the air for the ventilation of both Houses from a superior position?—Yes; I should think it well to get the air from a purer atmosphere.

Do you regard cholera as an epidemic, attacking the same classes, and influenced by similar circumstances as ordinary epidemic disease?—I do.

In your experience did it not attack the same subjects as typhus, and prove most severe and mortal at the same ages and in similar constitutions?—That is my decided opinion. I was so much struck with this similarity, on a careful examination of 100 cases of true Asiatic cholera, that I drew out a table with a view to illustrate the fact, which I published at the time.

What was the result of your observation as to the beneficial result of the cholera hospital?—We had a very efficient staff; that is, very efficient comparatively; we had the means of giving much greater attention to the cases than the poor could have received at their own houses; and I certainly think some degree of benefit was experienced by this alteration. I should, however, deprecate the removal of a person in cholera in the stage of collapse; and, indeed, unless in cases of extreme destitution, I think they would have a better chance of recovering if treated at their own houses.

Do you think instances of the abandonment of cholera patients by friends and neighbours was a common occurrence?—It was very common for friends and neighbours to desert the sick; they were afraid to go into the sick room, and this fear, and the consequent neglect of the sick by neighbours, and even occasionally by relatives, is no uncommon occurrence even in fever, especially among the Irish.

Did the poor willingly avail themselves of the benefit of the cholera hospital in your district?—They did not; they said they were going there to be slaughtered.

If they were to see systematic and efficient means adopted for improving the cleanliness of the localities and houses, do you think they would place more confidence in such measures as means of prevention, and would more willingly co-operate in securing their success?—I do. I believe the poor inhabitants in general would do anything in their power in carrying out such means of prevention.

Is not your poor-house kept free of typhus cases, except imported ones?—Yes; such cases as we have are generally cases brought in.

Have you not schools and well-regulated places which are kept free from typhus within the parish?—Yes, there are such places, of which I never hear of any cases of typhus.

May we not from such examples infer the practicability of keeping the dwellings of the labouring classes within your parish free in proportion to the application of similar means?—Yes, I have no doubt of it.

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TABLE I.—CHOLERA CASES in London and Vicinity, reported in 1832.

	Places.		Population.		Cases.		Deaths.		Recoveries.	
Metropolitan Registration Districts.	Bethnal Green			62,018		304		170		134
	Bermondsey			29,741		516		210		306
	Camberwell			28,231		217		107		110
	Clerkenwell			47,634		143		65		78
	George, St., Hanover Square			58,209		125		74		51
	George, St., in the East			38,505		224		123		101
	Giles, St.			52,907		628		280		348
	Greenwich	Deptford	19,795		93		55		38	
		Greenwich	24,553	62,009	94	243	54	149	40	94
		Woolwich	17,661		56		40		16	
	Hackney	Hackney	3,846		5		5		..	
		Stoke Newington	3,480	7,326	5	10	3	8	2	2
	Holborn			27,334		165		46		119
	Islington			37,316		60		39		21
	Kensington	Chelsea and Brompton	32,371		186		82		104	
		Fulham	7,317		24		8		16	
		Kensington	20,902	75,130	18	313	15	134	3	179
		Paddington	14,540		85		29		56	
	Lambeth			87,856		565		337		228
	London, City			55,798		614		359		255
	London, East and West		No return.							
	Luke, St., Middlesex			46,642		258		118		140
	Marylebone, St.			122,206		516		224		292
	Newington, Surrey			44,526		476		200		276
	Pancras, St.			103,548		186		111		75
	Poplar	Bromley	4,846		8		..		8	
		Poplar	16,849	25,066	179	208	101	107	78	101
		Stratford	3,371		21		6		15	
	Rotherhithe			12,875		21		19		2
	Shoreditch			68,564		107		57		50
	Southwark	Christchurch	13,705		85		35		50	
		St. George the Martyr								
		St. Olave's	77,796	91,501	2,160	2,245	856	891	1,304	1,354
		St. Saviour's								
	Stepney	Limehouse	15,695		188		83		105	
		Mile End	40,282		5		1		4	
		Ratcliffe	9,741	78,826	158	487	62	225	96	262
		Shadwell	9,544		108		55		53	
		Wapping	3,564		28		24		4	
	Strand	St. Mary-le-Strand	2,052		28		8		20	
		St. Paul, Covent Gard.	5,203	9,937	30	84	18	37	12	47
		Rolls Liberty	2,682		26		11		15	
	Westminster	St. James								
		Sts. Margaret & John		124,585		545		325		220
		St. Martin's								
	Whitechapel	Botolph without Aldgate	3,453		275		100		175	
		Spitalfields	17,949	52,848	196	922	97	470	99	452
		Tower and Liberty	713		30		10		20	
		Whitechapel	30,733		421		263		158	
	Total Metropolitan Districts			1,451,138		10,182		4,885		5,297
Not included in Metropolitan Districts, &c.	Bartholomew, St., the Great			2,923		9		6		3
	Brentford, Old and New			2,085		70		30		40
	Chiswick			4,994		21		18		3
	Highgate			2,172		6		2		4
	Afloat in River		Not known.			270		139		131
	Hospital, Greville Street					141		68		73
	Sundry Prisons					245		81		164
	Wandsworth and Clapham	Battersea	5,540		9		6		3	
		Clapham	9,958	26,188	27	76	17	46	10	30
		Putney	3,811		15		9		6	
		Wandsworth	6,879		25		14		11	
	Total Metropolis and Vicinity			1,489,500		11,020		5,275		5,745

Note.—The parishes and places from which returns of Cholera were obtained, have been arranged into the Registration Districts adopted by the Registrar-General, in order to facilitate comparisons with Fever cases, as shown by Table III. The places last-named above are excluded from the calculations, as not forming part of the Metropolitan Districts, or being otherwise defective in the returns.

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TABLE II.—DEATHS from TYPHUS in LONDON in each Week, and the Averages for each Quarter of the Years 1845, 1846, and part of 1847.

Weeks ending Saturday.	Deaths from Typhus.					
	1845		1846		1847*	
1st week	39		41		49	
2nd ,,	27		37		39	
3rd ,,	33		34		40	
4th ,,	23		35		28	
5th ,,	32		28		32	
6th ,,	24		37		28	
7th ,,	25	28	24	32	26	34
8th ,,	30		22		32	
9th ,,	18		27		41	
10th ,,	35		34		28	
11th ,,	21		29		32	
12th ,,	24		26		33	
13th ,,	31		36		34	
14th ,,	19		28		18	
15th ,,	26		33		43	
16th ,,	23		36		29	
17th ,,	23		23		41	
18th ,,	26		23		40	
19th ,,	22		15		34	
20th ,,	20	24	25	28	52	44
21st ,,	27		20		54	
22nd ,,	17		28		52	
23rd ,,	28		32		51	
24th ,,	29		38		44	
25th ,,	19		33		52	
26th ,,	29		30		58	
27th ,,	14		28		61	
28th ,,	18		28		52	
29th ,,	18		29		64	
30th ,,	29		36		57	
31st ,,	17		25		54	
32nd ,,	18		23		55	
33rd ,,	19	21	37	31	70	66
34th ,,	22		26		62	
35th ,,	22		37		74	
36th ,,	17		26		77	
37th ,,	23		40		81	
38th ,,	29		34		111	
39th ,,	27		34		77	
40th ,,	23		38		79	
41st ,,	19		41		79	
42nd ,,	22		45		93	80
43rd ,,	33		61		78	
44th ,,	28		55		73	
45th ,,	31		47		80	
46th ,,	31	27	48	48		
47th ,,	29		58			
48th ,,	32		42			
49th ,,	20		48			
50th ,,	28		59			
51st ,,	34		34			
52nd ,,	28		43			
Total	1301		1796			

Weekly average derived from Deaths of 1842–3–4–5 and 6, and corrected for increase of Population to middle of 1846 32

* The deaths in the district of Lewisham and sub-district of Hampstead added to metropolis for the first time in 1847.

TABLE III.—CHOLERA. No. 11

	Districts.	*Deaths from Fever in 1838 to Population.	†Cases of Attack of Cholera in 1832, to Population.	†Deaths from Cholera in 1832, to Population.	Proportion of Deaths to Cases of Attack of Cholera.	Average of each Group. Deaths from Fever in 1838.	Attacks of Cholera in 1832.	Deaths from Cholera in 1832.	Deaths to Attacks of Cholera.
		1 in	1 in	1 in	1 in				
Highest.	St. Saviour and St. Olave	160	45	114	2·5				
	Whitechapel	165	57	113	1·9				
	East and West London	206	..	..	..				
	Bermondsey	206	58	142	2·5				
	St. George-in-the-East	208	172	313	1·8				
	Holborn	227	166	594	3·6	1 in 237	1 in 116	1 in 253	1 in 2·1
	Bethnal Green	239	204	365	1·8				
	Shoreditch	256	641	1203	1·9				
	Westminster	260	229	384	1·7				
	St. Giles	261	84	189	2·2				
	St. Pancras	269	557	933	1·7				
	Stepney	288	162	171	2·2				
	Rotherhithe	302	613	678	1·1				
	Greenwich	304	255	417	1·6				
	St. George Southwark	321	36	91	2·5				
	St. Martin	352	228	385	1·7				
	Lambeth	396	155	261	1·7				
	Poplar	412	120	234	2·0				
	St. George Hanover Square	424	466	786	1·7				
	St. Luke	458	181	395	2·2				
	Strand	463	118	270	2·3				
	Clerkenwell	478	333	733	2·2				
Lowest.	Marylebone	479	237	546	2·3	1 in 494	1 in 183	1 in 358	1 in 1·9
	City of London	507	91	155	1·7				
	Islington	518	622	957	1·5				
	Kensington	522	240	561	2·3				
	Camberwell	638	130	264	2·0				
	Newington	688	94	223	2·4				
	St. James Westminster	781	229	385	1·7				
	Hackney	999	733	916	1·3				
	Average of Totals	319	142	296	2·0				

15 Districts in which Deaths from Fever in 1838 were

* Taken from the Second Annual Report of the Registrar-General, p. 201.

† From Returns of Cholera Cases made to the Privy Council Office.

Note.—No Returns of Cholera Cases appear to have been made to the Council Office from the East and West London Districts, and portions of other districts, comprising altogether a population of about 160,000.

No. 11.

TABLE IV.—CHOLERA.

PROPORTIONS of ATTACKS and DEATHS, of FEVER and CHOLERA, in 20 Metropolitan Districts.*

	Metropolitan Districts from which Returns of Fever were made in 1838.	Number of Paupers registered.	Number of Paupers attacked with Fever.	Proportion of Paupers attacked with Fever in 1838, to Total Number of Paupers.	Proportion of Cases of Attacks of Cholera, in 1832, to Population.†	Proportion of Deaths to Population.		Average of each Group.			
								Attacks of		Deaths from	
						In 1838, from Fever.‡	In 1832, from Cholera.†	Fever.	Cholera.	Fever.	Cholera.
				1 in	1 in	1 in	1 in				
Districts in which attacks of Fever amongst Pauper Population, in 1838, were—Highest.	St. George Southwark.	1,467	1,276	1·15	36	321	91				
	Whitechapel	5,856	2,405	2·4	57	165	113				
	Bethnal Green	3,632	1,209	3·0	204	239	365				
	Holborn	2,339	705	3·3	166	227	594				
	Lambeth	7,911	1,658	4·8	155	396	261	1 in	1 in	1 in	1 in
	Camberwell	1,158	238	4·9	130	638	264	3·4	85	263	185
	Rotherhithe	1,745	356	4·9	613	302	678				
	Bermondsey	3,000	593	5·0	58	206	142				
	Hackney	2,620	428	6·1	733	999	916				
	St. Saviour's	1,856	294	6·3	54	160	136				
	Stepney	8,596	1,348	6·4	162	288	171				
	Strand	1,692	231	7·3	118	463	270				
	St. Olave's	1,949	264	7·4	36	160	91				
	West Ham.	3,041	326	9·3	..	626	..				
	Kensington	6,114	573	10·7	240	522	561				
Lowest.	St. George-in-the-East	6,869	627	10·9	172	208	313	1 in	1 in	1 in	1 in
	Wandsworth and Clapham	2,553	234	10·9	345	573	569	9·5	157	324	326
	Poplar	6,039	520	11·6	120	412	234				
	Greenwich	6,607	522	12·7	255	304	417				
	St. Martin's	2,142	165	13·0	228	352	385				
	Total	77,186	13,972	5·5	110	291	234				

* Taken from the Fifth Annual Report of the Poor Law Commissioners, 8vo., p. 162.
† From Returns of Cholera Cases made to the Privy Council Office.
‡ From the Second Annual Report of the Registrar-General, 8vo., p. 201.

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Lewis Cooke Hertslet, Esq., Chief Clerk to the Court of Sewers for Westminster and part of Middlesex.

The Commissioners are desirous of ascertaining the extent of work for house, and street, and main drainage, which remains unaccomplished in your district. Have you any plans in the office on which you can rely for making an accurate return of the number of streets within the district which have sewers in them?—We have such plans; but our new surveyor informs me constantly of inaccuracies in them. Within the last few days he has told me of two courts where there are sewers, but which sewers are not laid down on the plan.

Have you sections of all the lines of sewers?—We have not a complete section of more than one or two of our main lines.

How many main lines have you?—About twenty, that is to say, in our active jurisdiction. But of the jurisdiction between Hampton and Fulham, we have neither plan nor section excepting of the shore line made many years ago.

Taking the shore line, what proportion does your active jurisdiction

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bear to your inactive jurisdiction?—The active jurisdiction is less than one-fourth. About 70 years ago, the Commissioners commenced proceedings beyond the Counters Creek Sewer, but a lawsuit stopped them.

What sections have you of the collateral lines of sewers?—We have sections only of some of the streets in which sewers have been rebuilt, and of some new sewers.

What proportions do the streets, courts, and alleys in your district in which the sewers have been rebuilt bear to the whole number of streets, &c.?—I do not know exactly the number of streets in our active jurisdiction, which contains about 20 parishes, but the proportion of rebuilt sewers must be very small. We have, however, done much lately, and have heavy works in hand.

Are your plans of the sewers in courts, alleys, and mews less in proportion to the number of courts, alleys, and mews than the proportion of plans to streets?—Very much less. There must be hundreds of courts and mews of which we have no plans and sections.

Have you a set of levels from any fixed datum line?—No, we have not. Our surveyor is trying to remedy the evil, so far as he can do so by taking plans of fractional portions of the district.

Of what proportion have you completed such plan?—Not one-twentieth part of the district is complete even of the active jurisdiction. Until lately I had heard and believed what has been so generally stated, that our plans were tolerably complete; but since I have been admitted to a more intimate acquaintance with the surveyor's department, I find that the case is as I have now stated it. There is a vast collection of books containing plans with very little practical information in them.

Of what description are these plans?—They are plans of all scales, sorts, and sizes. Very few of them bear any signature whatever, and have been made generally without reference to any fixed datum line. In most cases what is shown upon them is the old and not the present state of the sewerage.

How, in the absence of a proper general plan, and sections to a fixed datum line, can you proceed with any certainty that works laid down in separate places will fall in with a general system?—We cannot proceed with any certainty at all. The surveyor is daily deploring to me the want of such a plan; and, with a list of about 70 matters already referred to him for reports, and accumulating each court day, it is no wonder he should do so. We have urgently pressed upon the Commissioners at various times, in and out of court, the absolute necessity of such a plan; and the surveyor is at present engaged in obtaining information as to the cost of one, and other particulars.

What are these reports upon?—Principally upon complaints of inefficient drainage.

Do these complaints come from the poorer districts?—The greater part of them do not. The poor, being used to the want of drainage, and never having heard of the value of it till very recently, bear their lot most patiently, and seldom make any serious complaint, except perhaps to the collectors of the rates. The complainants are, for the most part, of another class; such as from Bryanstone-square, Montague-square, Norfolk-street, Park-lane, Upper Brook-street, and also with reference to some of the principal main lines being uncovered.

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Are you aware that it has been stated that there have been typhus fever cases in Bryanstone-square?—No; but I have heard of fever in Montague-square. In Bryanstone-square, there is a sewer on each side, but not sufficiently deep to drain the houses. Complaints have recently been made that the water does not freely flow from the drains, and that the gullies' gratings are excessively noxious. The sewers in Montague-square do not extend much above half the length of the square, and run northward. These were evidently sewers built without regard to any fixed datum line, and had reference only to what was believed to be the nearest and most ready outfall.

If you amend that drainage now, can you be sure that you will not have to undo it again before long?—Every care would be taken by our present surveyor, no doubt; but we can never act with confidence until a general survey is made.

Would it not be expedient for the public good to suspend all your important works for a year or some such period, to have the security of a general plan and sections?—I think the most urgent works only should be allowed to proceed, in any district, till a general plan of that district, at least, shall have been completed. I believe no means could be adopted more necessary or advantageous for the public service than to suspend all works of magnitude till the survey shall have been made. During the progress of the survey, in order to keep the workmen in employ, the house drainage (of which at present, we know nothing, but which by the recent local Act is placed under the control and supervision of the Court) might be examined, and brought into some state of preparation for the improved sewerage. The saving which would be effected by the survey would be immense. The existing volumes and rolls of plans, with the books and registers of depths, the lists of sewers, &c., &c., might all be thrown aside, and the facility of reference to an engraved plan and sections, corrected regularly, would be so great that the staff of officers required to refer to the present books and plans, to take disconnected levels, to prepare detached portions of plans from time to time, as is now done, and to make out fresh lists and registers of such detached portions, would be no longer needed. It must, however, be borne in mind that the additional charge of the internal drains of 60,000 tenements, and the control and superintendence of all new drains, which the new Act has thrown upon us, will necessitate a very large increase in the staff of inspectors, if it is to be efficiently carried into effect for the public service.

Would not the dangers, and the expense of these doings and undoings of works, and the loss of health and comfort, as well as of money, from bad works, be also saved?—They would.

Might not a very close approach be made to the cost of a complete system of sewerage and drainage, and street cleansing, on such a plan being completed?—A very close approximation might be attained to, and I should think it might be done as each level is completed.

Until such a survey be made, can any good estimates be reasonably expected?—It would be out of the question. If made they would totally mislead.

Would it not be desirable that such a survey should be superintended by officers of the highest practice, qualifications and standing?—There can be no doubt of it. The work would be done once for all, and it should be done in the best possible manner. That would be the truest

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economy. I believe also, that the cost of such survey on a scale of 60 inches to the mile is very much over-estimated, and in this I speak both from observation and experience.

Have you seen any of the large maps made under the superintendence of the Board of Ordnance?—Yes, and I have greatly admired them.

Should not the same system prevail throughout the metropolis?—Yes; I am decidedly of that opinion.

Will you furnish us with instances of the inconveniences arising from the division of districts?—They are numerous. 1st. There is the endangering of the rates, by their being laid open to legal objections. To take an instance close to the Sewers' Office: Tottenham Court-road is drained by one sewer, and yet one side is rated to the Westminster Commission and the opposite side to the Holborn Commission; consequently an objection may be taken that the rates are unequal, inasmuch as all the property drained is not included in them. 2ndly. One side is rated at sixpence every two or three years, while the other side generally pays rates at threepence twice in that period. Again, the want of uniformity in practice, both as to the form of sewers and as to the mode of charging frontage. To take the same instance: In Tottenham Court-road, the sewer has been entirely rebuilt within a few years, and yet one-half has upright sides, and nearly flat bottom, whilst the upper half is of the oval form. Moreover, in the same street or road, great dissatisfaction and confusion is caused by four different modes of charging frontage. On the Holborn side, a house having an original drain is charged 2*l.* for connecting with the sewer, and a house having no original drain is made to pay 4*l.* On the Westminster side, a house which had no old sewer in front is expected to pay 10*s.* per foot, according to frontage, for going into the new sewer; while a house which had a sewer, however small in front, has nothing to pay, even though it had no drain into the old sewer. Museum-street, Bow-street line at Bloomsbury-street, Regent-street, &c., are similarly situated in many respects. Much confusion is caused by Regent-street being abstracted by a special Act from the Westminster Commission. Indeed, till it is restored, the most obvious improvement of the drainage of that part of the town cannot be effected. The new Bow-street line of sewer from the Strand to New Oxford-street is so placed as to be quite useless as a main line to the Westminster Commission, and yet the cost of this sewer was wholly borne by the eastern division of the Westminster sewers, while the Holborn Commission for whose benefit it really turns out to have been built, paid no portion of the expense.

Do you know what is the state of the paving of Tottenham Court-road?—It is execrable. The southern end has within the last few years been improved, but if the whole street were to be repaved at once in the improved manner, the small district which would have to bear the burden would be most severely taxed. The Hampstead and Highgate omnibus and coach proprietors have told me that they have more damage done to their springs, &c., in Tottenham Court-road than in the whole of their journey.

It appears that in your's (the Westminster division of the drainage area of the metropolis) there are 25 separate Boards having charge of the paving of the streets?—Yes, about 25; there are also the Regent-street Commission and the Metropolitan Roads.

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What practical inconveniences do you find arise from the separation of the paving and cleansing of the streets from the works of the sewers, gully-shoots, and other means of surface draining?—Scarcely a day arrives without notices from some of the Paving Boards of sewers or gullies requiring alteration. The most frequent, though not the most important difficulty arises from the petty jealousies of the officers acting under the different authorities, and sometimes even the disagreements between the Boards themselves. In the next place the charges, which we have been long obliged to submit to, of 3*s.* per yard for the relaying of footway pavement, and 1*s.* 9*d.* for the carriage ways, throughout the district.

Are the regulations of these very numerous Boards such as to facilitate business?—I cannot say that they are so generally. In a recent instance a sewer contractor was called upon to deposit about 300*l.* before he broke ground.

What was the reason for this?—I heard no other than that it was the rule of the Paving Board.

Was this complied with?—Certainly not. We refused to comply, and gave directions to the contractor to proceed. He appeared alarmed, as the surveyor of pavements had threatened to fill in the trench as fast as it was opened, and to take the plant to the green-yard.

What was done upon this?—The contractor received written instructions to proceed, and was told to take with him a sufficient force of labourers to open the trenches. He took a strong force of men with him and the works proceeded.

Where was the scene of this proceeding?—Lower Brook-street Grosvenor-square, and neighbourhood. The surveyor of pavements lowered the demand for a deposit one-half, and ultimately, the Court of Sewers directed vouchers for 1*s.* 9*d.* per yard to be given, and deducted the amount from the contractor's bill.

Is this of frequent occurrence?—Not in that form; but another contractor was recently made to pay for nearly the entire width of a court at the rate of 3*s.* per yard, although not nearly so much of the paving had been taken up. In the Strand expensive pavement has just been put down, but the old, open, and wide sewer grates are allowed to remain, the surveyor of pavements there not approving of our new form of grate. I mention these as the most recent, though they are not perhaps the most important cases.

Do the parish officers afford assistance in carrying out the recent improvements adopted by your Commission?—I am sorry to say that, although there are some exceptions, the reverse is generally the case; not with myself personally, but with the surveyor.

Are not these collisions the natural consequence of the present state of things?—Manifestly; and they are not confined to conflicts with Paving Boards, but extend to water and gas companies. Thus, during the last few weeks, the contractor for a sewer in Marylebone was threatened by the officers of a water company to have the supply kept constantly on so as to run from every house-drain into the trench; and they actually threw in so much water as to endanger the work by washing out the sand. And notwithstanding the practice has been to require private companies to support their own pipes over an old public sewer, (though we give them the cost in a new line,) in this case,

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though our usual notice was served upon the company, they have thought fit to call upon *our* contractors to support *their* pipes.

Does not the present system of demanding payment at once for the works press very heavily and unequally upon property in the district?—No doubt it does.

Does not the plan of carrying on the works of one district, say district A., out of funds raised in districts B. and C., whilst districts B. and C. remain undrained, constitute one main motive for exertion to get districts drained first?—It does. The surveyor takes the matters up as early and as regularly as he can, but, it really is a mere scramble for precedency, and Commissioners in their respective neighbourhoods are frequently solicited to attend and press forward applications from particular districts.

What do you conceive would be the effect of diffusing the charge for permanent works over a period of years, and levying the expense by equal yearly instalments of principal and interest until the expense was defrayed, so that district A. instead of drawing its expenditure from districts B. and C. would draw it from some capitalists' fund and pay interest for the same until it was repaid?—The result would be that the burthen would be wonderfully lessened, and that the right parties would bear it, and bear it in more just proportions. For example, the surveyor has proposed a plan by which an opportunity is afforded of making the city of Westminster, that is the parishes of St. Margaret and St. John, probably the best instead of one of the worst drained districts of the Commission, by carrying up to the proposed Victoria-street a new outfall sewer 10 feet deeper than any of the sewers yet constructed, with a discharge below low-water mark, and many other collateral advantages; but to effect this, one-third of the usual rate of threepence in the pound over the largest district of the Commission will be immediately required. Now if this money was borrowed and spread over a series of 30 years, a payment of an average sum of about 300*l.* per annum (for principal and gradually decreasing interest), or less than fourpence per house, would do all that is required for this work, and future owners of property would bear their proportion of this improvement, from which they will derive equal advantage with the present landlords.

Would not this power, however, render it necessary to take great care as to the parties to whom it should be instrusted; as, if left unguarded, temptation for profuse expenditure might be afforded?—I should so imagine. We have, however, unlimited power to borrow money under our new Act of last Session.

It appears from a printed Report of Mr. Phillips, that even on the present improved system a sum of 20,000*l.* is required to drain a tract of land in Marylebone. Who will be the contributors to this drainage of Marylebone?—The parishes of St. Clements Danes, St. Mary-le-Strand, St. John Baptist, Savoy, St. Martin-in-the-Fields, St. Paul Covent Garden, part of St. Pancras and of St. Giles, and Bloomsbury, St. Ann, St. James, in addition to that part of the parish of Marylebone east of Regent-street and Portland-place.

The owners of the undrained property in courts and alleys in St. Clements Danes will then have to pay for the branch sewers, as well as the main sewers for draining Marylebone, their own remaining

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undrained?—Yes, until similar works are done in St. Clements, when St. Marylebone will be called upon to pay for them.

Within what time will they have to pay for the drainage of Marylebone?—As soon as possible; a rate is now in preparation for the purpose.

Within what time may they have drainage themselves out of the district funds?—Many years perhaps. It is quite uncertain.

Are there not many parts, of Westminster for instance, that have been rated for centuries, and yet have no house drainage?—No doubt there are; but it is only within 40 years that houses have been allowed to have sullage drainage at all.

But they have been rated?—Certainly. To the general rate.

Amounting sometimes to 1*s.* and 2*s.* in the pound?—Yes, formerly.

Do these places still pay rates?—Yes.

And they have as yet no efficient drainage?—I do not consider it efficient.

Supposing these works for Marylebone were paid for in 30 years, by equal annual instalments of principal and interest, what would be the annual instalment due from that part of the district which actually receives the benefit?—Including the gradually decreasing interest, it would be rather more than 1100*l.* at 5 per cent., I think.

That is for 3000 houses, as stated in the Report, between 7*s.* and 8*s.* per house annually?—Yes.

That is about 1¾*d.* per week?—Yes.

Do you not think that this might be much reduced; that is, that even your present plans may be much improved upon?—Yes; I am satisfied of it. Mr. Phillips, our surveyor, and myself have had much conversation lately upon this point, and I believe he thinks, as I do, that though much has been effected by his forms of sewers, &c., far more remains to be done; that is, provided we can get a sufficient supply of water, and control over it.

The adoption of this plan of spreading the payment over a period of years would then save great discontent and pressure in the district from undue preferences of particular places and property out of systematic course; and would enable the authorities, in case of emergency, to commence works in one district without so much prejudice to any other?—Of course it would.

Have you inspected the sewers yourself?—I have traversed withinside all the principal main lines from one end to the other; and I do not think that any work exceeding 100*l.* in value has been executed that I have not visited several times.

What has been the result of your observations as to the sizes of the sewers?—I have been perfectly at a loss to conceive why such immense sewers should be built to carry off such mere threads of drainage. I have often thought, and have so stated in Court, that the Commissioners generally, from viewing only the main lines, have a very false impression as to the sizes required. I have seen sewers 5 feet 6 inches high by 3 feet wide, being built where, even during heavy rain, a 3 or 4-inch pipe would evidently have carried off all the water.

Will you look at these reduced sizes? Do you think them, from your observation, large enough to carry off even storm water?—If

properly systematized from the outlet upwards, no one who has paid practical attention to the subject can doubt it.

Have you considered the building of all sewers by the public authorities, and what would be the advantages, if any?—I have; and I am convinced the result would be most advantageous to the public, certainly in economy, and I believe in construction also.

Will you give the particulars?—I have no doubt that if the works were all done by public contract a much cheaper form of sewer might, in very many cases, be permitted than could be intrusted to private builders and bricklayers. In a recent case a saving equal to the entire cost of the work has been effected in this manner; and I anticipate a similar economy in the next work to be advertised.

You have recently effected some economy in the forms of sewers; will you state particulars?—I would briefly state it thus, in round numbers:—

Former price of sewer per foot run	21*s.*
Cost of new forms in 9-inch work	14*s.*
Cost of ditto if built by public contract in 4-inch work	7*s.*

Besides the saving in the use of pipes for gully and house drains. It appears from our printed Returns that the average length of all the sewers built and rebuilt by the Westminster Commission, and also by private individuals within the Westminster district, for the last seven years, has been about seven miles per annum, which, calculated at the average price of the old form, would have cost at least 35,000*l.*; but, if taken at 12*s.* per foot, the average cost of our new forms, that will give about 23,000*l.*, saving about 12,000*l.* per annum. It further appears that a general rate of 1¾*d.* on our present rental would produce about 22,000*l.* Now under the old system the average of the rates levied in our Commission during the same period was rather more than twopence in the pound per annum, besides leaving the private builders to pay for between five and six miles of sewer per annum, built by themselves. If, therefore, our improvement of the old sewerage shall in future progress no faster than formerly, we may, in addition thereto, build, even in 9-inch work, all those sewers now constructed by private parties, with but very little increase of the present rates. And if the economy already effected by our recent alterations in the forms of sewers alone has been so great, surely the economy to be expected from the improvements, not only in the sewers, but in the house-drains also, under a systematic arrangement, would be such as to make sanitary improvement a far easier thing than it yet appears to be, even to the minds of practical persons. Another economy may be effected by a consolidation of the collections. If the sewers'-rates were collected by the poor rate collectors, the poundage of the poor-rate collections might be reduced in proportion as the amount to be collected was increased by the sewer's-rate, and the sum now paid by the Westminster Commission alone, of about 1000*l.* per annum, would at once be saved. 2ndly. As to the construction:—I foresee great improvement in that respect also, under an improved management, but I should prefer to leave the surveyor to speak to that point.

But, to return to the question as to sizes of sewers,—would you

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think it necessary to provide sewers large enough to carry off the waters of a storm which might occur once in 100 years?—It would be better if it could be so managed without any great increase of expense.

But the inconvenience and expense of the large sewers are constant?—Yes; and during the very remarkable storm of August, 1846, I remember that the principal damage was done, so far as we heard at the office, from the foul water forcing its way from the sewers up the untrapped drains, rather than from the storm water in the undrained districts. Indeed, I do not think the damage in those districts was greater than occurs in Westminster and Lambeth every excessively high tide. If the paving and sewerage were under one control, I feel sure that an excess of rain-water could be readily provided for upon the surface during storms.

Then the flooding you allude to was with sewer water?—Yes, it was.

A gentleman residing in Lodge Place, St. John's Wood, has stated that, in August, 1846, the basements of his own and other houses in that neighbourhood were filled with sewer-water 4 feet deep, and that they have only lately got rid of the annoyance; and, moreover, that the foundation of his house is giving way, in addition to the loss he then sustained by the destruction of bedding, cutlery, and picture frames; and that all this was occasioned by the want of proper sewerage?—I know that such was the case on that occasion in several places, especially in Pall Mall and St. John's Wood. The evil in the latter neighbourhood is attributable not only to the want of a proper main sewer, but also to the entire absence of branch sewers in several of the long roads thereabouts. The main sewer at this point has been built of a contracted form, to connect the larger portions above and below, for the purpose of passing over the canal, and in times of storm the sewer-water backs up and floods the houses adjacent for a long distance. Mr. Phillips has a plan prepared to remedy this evil, by carrying the main sewer under instead of over the canal, but the branch sewers will still remain to be built.

From your own experience and observation, do you believe that the metropolis might be economically comprehended in one district, and under one direction, for the several objects of sewerage and water supply and street paving, and without becoming too cumbersome?—I have well-considered this subject, and I see no difficulties which any man of business would not readily overcome; and I am convinced that by a reconstruction and consolidation of these matters, great advantage and security would be obtained by the public. (With regard to the water supply, I mean a supply adequate to all purposes of drainage and cleansing.) But till I can see a return of the cost of the Paving Boards, District Trusts, and similar bodies, I should not like to give a very definite answer as to the amount of saving. There are, in St. Pancras alone, from 15 to 20 Paving Boards, and nearly 1000 Commissioners, and one of these Boards, I know, spends about 1000*l.* a-year for management exclusive of works; the consequent waste in every way, from want of consolidation, must be enormous.

Will you state some of the practical difficulties of the present state of things in your own office?—To mention a case daily, almost hourly, occurring: A person desires to lay a drain from his house to the sewer. The first step is to apply at the Sewer's Office, when in most cases,

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except in very old districts, he is told that he must obtain the permission of the party who built the sewer; when this is done he calls again, pays for the opening, and is informed that he must attend the next meeting of the Court, causing a delay of from three days to two and sometimes three weeks. He has then to apply to one of the numerous Paving Boards to obtain leave to open the ground; and here, again, further delay must occur. So soon as he has obtained the leave of the owner of the sewer and of the Paving Board, he has to attend the Court of Sewers; and when the ground is opened, ready for the ring, &c., to be put into the sewer, he must again call, or send, to give notice at the Sewers' Office for the work to be done. If, in taking out the ground, his men should happen to damage a gas or water-pipe, after another puzzle as to which company or companies he is to apply, further delay and trouble must supervene. Even when there are no actual fees to pay, there is time lost; and as most persons employ a builder, or other agent, there is an actual disbursement rendered necessary. And this description of what should be so simple a matter as laying a drain, though sufficiently harrassing as it stands, is given upon a supposition that matters run smoothly on; that all parties, Sewers' Office, Sewers' Owner, Paving Board, and Water or Gas Company are all agreed and willing to co-operate; but when any hitch occurs, in any one instance, it is evident that a great discouragement, perhaps, to a poor man, an impassable barrier, is thrown in the way of so necessary an adjunct to health and comfort as laying a drain from one's dwelling into a sewer just in front of it. But, on the other hand, supposing a consolidation of all these matters to be effected, and that there were a central office where all these details could be settled at once and in half an hour; where, if any difficulty should arise, the chief officers of each department could, within a short period, be congregated into one room, if necessary, there would be an end to the delay and misconception occasioned by one Board corresponding with another, no waiting for the meeting of distant and sometimes contending bodies; and as the various regulations would all emanate from one source, there would be no dubious or conflicting by-laws to reconcile, but in one short interview the whole affair might be settled; and any unforeseen occurrence during the progress of the work might be met and rectified, because the same officer in each district would superintend all the practical branches of the various details before enumerated.

Whatever ultimate measures may be taken by the Government, do you not think that a general outline survey of the entire metropolis should be the first and indispensable step?—Yes, and as each district is finished, I see no reason why the details of the plan, and even some of the improvements might not at once be commenced and safely proceeded with. I verily believe that if the attention of the officers could be concentrated upon a given district at once, even during the progress of the survey of the other portions, a thorough change in the present state of things might, even with our present powers, be effected within a few months. Indeed, I feel assured, that in three or four months the wretchedly drained city of Westminster might be placed in such a state of fordwardness as not only vastly to improve the health of the population, but also permanently to increase the value of property. I name Westminster, because being a district below high-tide level, it is isolated,

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and improvements might be carried on there at once, without any fear that they would not fall in with the general plan when the large survey is finished.

But we understand you to say that the consolidation of the administrative machinery would be necessary to turn the general survey to account for the purposes of improvement?—From my experience, and after anxious consideration of the subject lately, I am thoroughly convinced that but little, comparately, will be effected for the public welfare till all these matters, so similar in themselves, are consolidated under one authority. As, however, this may be almost too much to anticipate for the public at once, I imagine that the most ready and most practicable step towards this end would be the consolidation of the various Commissions of sewers, and the immediate reduction into one system of their present varying regulations. Indeed, the full benefit of a general survey will scarcely be brought out until this step shall have been taken as a necessary preliminary to any valuable measure for the health of the metropolis. For instance, in the suggestions which I have just thrown out as to Westminster, if the Commissions were consolidated, the energies of Mr. Roe and Mr. Phillips might be brought to bear upon the same spot for a time, and I feel sure the results would be most satisfactory.

Do you agree with the evidence of Mr. Phillips, which you have just heard read?—I have carefully attended to it, and I have not discovered, upon practical points, the least difference in opinion between us. I most fully concur in all that he has said. Though I am painfully aware of the extreme delicacy of the position in which I stand, as an officer of the Court of Sewers for Westminster, I feel constrained to make some remarks upon the replies of Mr. Phillips to the questions with regard to the conduct of some of the Commissioners; and in corroboration of what he has said in that respect, I think I ought to mention that several of our best officers in the surveyor's department, who have since left, but whose names I can hand in if required, have made similar complaints. When examined before the Health of Towns Commission four years ago, I declined to answer questions of this nature, but I feel that I ought no longer to remain silent, lest the responsibility of further delay should, in any measure, rest with me. It will be perceived that what Mr. Phillips and myself have now said, has reference only to a section (though unhappily a large and very active one) of the Commissioners; and I feel bound to add that, since the addition made by Lord Chancellor Cottenham in 1837-8, the officers have had a weight removed from their shoulders under which they had long groaned; and if the Commissioners of Inquiry will permit me, I will take this opportunity of publicly thanking those gentlemen for their aid, not only in liberating the officers from a most paralyzing and demoralizing system, but also in effecting such great economy in the public works. The lists of divisions in the Court will point out their names: I cannot, however, omit to mention thus publicly the special services rendered by Mr. John Leslie, and the Hon. Frederick Byng. I am very desirous of mentioning the names of other gentlemen also, but as a selection might be considered invidious, I will only add that, as the chairmen have been mentioned, I

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think it is but justice to state that the gentleman who now generally occupies the chair (Captain Bague, R.N.) has taken precisely the opposite course to that of his predecessors, and has assisted, to the best of his ability, in forwarding the improvements and reforms which the officers have been able to bring forward since they have been allowed to present their own opinions without first submitting them to the chairman.

Do you consider architects, builders, agents, or persons in trade; or attorneys and conveyancers in practice, to be persons who can be considered qualified to act as "indifferent" (that is, impartial) Commissioners within the meaning of the Act?—Certainly not. A person having a delicate sense of public duty would scarcely like, if he had a previous knowledge of the fact, to accept an office in which he could not act in an unbiassed manner without frequently offending his employers and customers; and in which, if he could not be tempted unduly to make friends, he would be sure to make bitter enemies.

Is there not a clause in your recent Act prohibiting Commissioners from acting, when interested, under a heavy penalty?—There is a clause, but no penalty is attached to it.

How is it that the clause was so loosely worded? Who drew the clause?—The clause, as originally drawn, contained the penalty, but the Court of Sewers struck it out before it went to Parliament.

Is the effect of the clause apparent? Is it serviceable to protect the public?—I fear not. In a recent instance, when the chairman rebuked a Commissioner interested for voting, he said he should do as he pleased, there was no penalty.

Have you not those who are or have been bankrupt traders and outlaws remaining and acting on the Commission?—There are several who have been so; of their exact position, as to certificates, &c., I am uncertain.

Are there not persons on your Committee of Accounts who have been bankrupt?—Yes, there are.

How many does the Committee consist of?—Six.

Of whom how many have been bankrupt or insolvent?—Three, I believe; certainly two.

Have you not fair reason to infer, and that constantly, connexion, more or less direct, in the supply of goods or execution of works between trading and professional Commissioners which you have no means of proving judicially?—I regret to be obliged to say that, among a certain class of the Commissioners, private rather than public interest appears generally to be consulted.

Will you give a few instances?—The following is one:—Prices are sent into the surveyor by several parties; a Commissioner calls and inspects them; on the following day or so, notice is received from one of the parties who sent in the prices (on whose premises the Commissioner was seen after the inquiries at the office) stating that the price first sent in was an error, and substituting the price of the lowest tender. Again; I state in Court (as clerk) that a certain notice has not been received from a public Company, which, under their Act, they ought to have given. A Commissioner, being an officer of that public Company, leaves the Court, and in an hour afterwards the notice arrives. I could pass in review the meetings of the Court from time to time, and

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in the greater part of them I could cite something of that kind more or less palpable. I again repeat that I speak of a section of the Court only. Unhappily, however, those Commissioners who took the most active part in obtaining a fair hearing for the officers have not recently attended the Court, and things are gradually resuming their former state.

Would, however, any alteration in the present names vary your conclusions in respect to the consolidation of the Commissions?—Certainly not. The consolidation could not possibly be effectual without an alteration in the class of names.

Do the district surveyors interfere in those places where houses are being built, from the owners of which they will receive fees for superintendence?—Some of them in the new districts do very much.

Can you give any recent instances?—I will give one out of several which occurred about the same time:—A speculative builder, on a large scale, applies to the Court to provide him an outlet by rebuilding a sewer; the Court decides that he must build the sewer himself, as what he imagined to be a sewer is only a road drain. The builder accordingly presents a petition for leave to build a sewer about 900 feet in length at his own expense, which the Court grants: he, however, meets the district surveyor upon the stairs, who tells him that the Court has decided wrongly, advises him to return and withdraw his petition, and persuade the Court to build the sewer at the public expense, which was accordingly done at a cost of about 700*l*.

What is the average attendance of Commissioners at your meetings?—About 30.

Do the 30 Commissioners remain during the whole sitting of the Court?—Very rarely indeed; I may say never.

Do half that number?—No.

Do not some stop a few minutes only, just to put down their names as having attended?—Some few do so.

Not to mention names, will you look at this list of the division on Mr. Phillips' improved forms of sewers, and state what professions the several gentlemen voting have followed?—There were for the amended form 16; viz., one clerk in a public office, one tea-dealer, one builder, one stationer, two pastrycooks, one barrister, one silversmith, one attorney, two architects, one mason, one ironmonger, two tailors, and one pawnbroker. Against the new form there were five who voted; three architects, one attorney, and one ironmonger, making in all 21.

How many were summoned on so important a subject?—About 140.

And only 21 voted?—Yes.

How many architects and builders were summoned?—Between 30 and 40.

And only three voted for the amended form?—Only three.

You have had various complaints in respect to the administration of the sewers from parishes and from other local authorities, have you not?—Yes, we have; and of late much more frequently than heretofore. Except during the time of the cholera, and very recently, we have not had many complaints from the parish Boards.

Have any of those complaints been directed to the forms or the efficiency of the works, or the expense of them?—I do not remember a single instance.

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Nothing that marked any perception of the defects of the works generally?—Sometimes a complaint has been made that some local drainage was bad, but the complaint was always in general terms.

Were the complaints accompanied with any suggestions of improvements?—No; indeed, the Commissioners of Sewers have rather been the complainants against the local Boards. In one instance, under an improvement Act for the parish of Chelsea, obtained a year or two ago, some active steps have been taken. But, in general, the powers under local Acts for sewerage and drainage are allowed to lie entirely dormant. In the Tothill-fields' Trust some works have been done, but we have been compelled to call out a jury to amerce very poor tenants, principally washerwomen, as much as 30*l.* a-piece, in order to enforce the abatement of a nuisance, under the powers of the Tothill-fields' Act, on the property of the Dean and Chapter of Westminster. Where the Parochial Boards have the remedy in their own hands nothing has been done; even where they have power to call upon the Court of Sewers to repair and cleanse defective sewers, drains, and cesspools, and when, if not done forthwith, they may do the work themselves, and recover the amount from the Commissioners of Sewers. As instances of the mischievous effect of the division of authorities I will mention that we have been unable to induce the referees under the Building Act to compel a builder, brought before them by their own officer (the district surveyor), to drain more than one-half of his property, although there is a sewer into which it is "lawful and practicable" to drain within 100 feet of the whole of the property; and in Westminster a sewer cannot be built by a local trust in a direction which would give a far better fall than that which they propose, because the better line runs through a street just outside of their jurisdiction.

Have not the inconveniences of this disunion of the naturally-connected works of paving and drainage been early manifested?—They were discovered many years ago. Here is a copy of a petition for a Commission in or about 1770, which I met with at the Crown Office a few days back, when inquiring about our new Commission:—

"To the Right Hon. Henry Earl Bathurst, Lord High Chancellor of Great Britain, the Right Hon. the Lord Chief Justice of either Bench, and the Right Hon. the Lord Chancellor of the Duchy of Lancaster.

"The Humble Petition of the Right Hon. Granville Leveson, Earl Gower, the Right Hon. Lord George Sackville Germain, Sir Charles Whitworth, Knight, Owen Salisbury Brereton, John Plumptre, William Adair, Esquires, General Studholm Hodson, and Thomas Bullard, Esquire.

"Sheweth,

"That a Commission of Sewers for the Parishes of Hampton, Teddington, Twickenham, Isleworth, Hanwell, Brentford, Acton, Ealing, Hammersmith, Fulham, Kensington, and Chelsea, in the County of Middlesex, and to and within the City and Liberty of Westminster and precincts of the same, and so to Temple Bar, within the said County, and from thence to and within the Parishes of St. Giles-in-the-Fields, and St. George Bloomsbury, Pancras, Marylebone, Hampstead, Wilsden, and Paddington, and so to the river Thames in the County aforesaid, or in the borders or confines of the same, is now subsisting under the Great Seal of Great Britain, and another Commission of Sewers for the same places under the Seal of the Duchy of Lancaster, issued on account of some parts of the said limits lying within the Liberty of the said Duchy, both which Commissions bear date in December, 1768.

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"That the business of sewers has been managed by a few Commissioners, as several that are named in the said Commission are deceased and many others have not acted or qualified themselves to act.

"That the Commission is very ancient, and justly esteemed of the utmost importance as the property, health, and convenience of many thousands within the aforesaid limits depend upon the faithful and diligent execution of the trust reposed in the Commissioners.

"That the Commissioners of Pavement mentioned in the list annexed are of great fashion and property, and much interested in the expenditure of the money raised on account of the sewers.

"That the business of the two Commissions frequently interfere with each other, insomuch that the City of London have applied to Parliament and obtained an Act to unite them, from which great convenience has arisen.

"That the Commissioners of Pavement meet weekly, and will thereby be enabled to give the most speedy relief where matters of complaint may arise; and at their meetings they pay their own expenses.

"Your petitioners, therefore, pray that your Lordships will be pleased to grant your warrant for new Commissions of Sewers for the limits aforesaid, one under the Great Seal of Great Britain, and the other under the Seal of the Duchy of Lancaster, directed to the persons named in the list annexed, or such of them or such others as your Lordships shall be pleased to appoint.

"And your petitioners will ever pray."

[*Here follow the Signatures as above.*]

What are the "wages" allotted under Act 23rd of Henry the Eighth to the substantial and "indifferent" men named as Commissioners?—Four shillings for each day they take pains in the execution of the Commission.

You have stated that the gentlemen who attended your Court for the purpose of arresting what appears to have been waste, and in order to promote economy and efficiency, have slackened in their attendance. Do you consider the work itself of a nature to interest or to engage continuous weekly attendance and exertions?—Certainly not. The subject in itself has few attractions; indeed to this I trace the Commissioners' anxiety for the continuance of the dinners. On dinner days, as we call them, the attendances are more numerous and continuous, and of quite a different complexion.

Have the attendances of the architects, builders, and practising attorneys diminished?—No; I think the reverse.

Does the dinner-party consist of that class of Commissioners?—They compose the majority of it; without them it would soon expire.

Presuming the entire respectability of the tradesmen and professional men above described, can you say that any one of them had paid such special attention to the subject of the sewerage, and the connected questions of hydraulics, that if you were the owner of buildings, and had to expend your own money in works of drainage, you would apply to any of them for advice, or would intrust to them your own money for the purpose?—The pertinacious resistance offered by a certain class of architects to the recent improvements, and the extraordinary objections taken by some of them, astonished me, and convinced me that drainage is a subject to which they have not attended. In 1844 the question was referred to several architects standing high in their pro-

fession, and taking a prominent part at our Court; and though they appear to have felt the necessity of a reduction of the size of sewers, they proposed a considerable addition to the cost per foot run, in order to have a granite bottom. They strongly recommended a sewer calculated to cost, at their lowest estimate, 16*s.* 4*d.* per foot run,—exclusive of the digging, which would be about one-third more. Mr. Cumberlege, Mr. Charles Mayhew, and Mr. Pownall, however, assisted very materially in breaking up the old order of things, and in carrying through the new plans; but they seldom attend at present.

In the Report of the Committee of the House of Commons on the Sewerage of the Metropolis, 1834, there is the following passage given on the 24th of March:—

"*Select Committee of the House of Commons on Metropolis Sewers*, 1834.

"EXTRACT from the Evidence of Mr. *James Walker*, Surveyor to the Poplar Commission.

"Do you conceive that the works of the Commissioners at present are well executed?—I know of no public works, and I have been employed by a great many public Boards and companies, and I know at present no public concern of which the works are better done, and in which the public interest is better consulted, than that part of London where I now live, viz., the Westminster district.

"There is the utmost possible security for the public for the performance of all contracts for those works?—Yes, as far as I know. The chairman of the Commission was an architect, and is a magistrate of the county, and he devotes his whole time and attention to the management of the Westminster sewers, and I think very, very much to the benefit of the public; the works are done in the very best possible manner.

"You approve of their plans, and the general management of their works?—The particular plan of the great work is my own and my partner's; but as regards the management, I must say, in that work nothing in the mode of contracting could be more open and consistent with the public good than that was; the work is now a little above Vauxhall-bridge to speak for itself. When the French engineers, sent over by their Government, were in this country last year, nothing seemed to attract their attention more than the sewage of London, the idea at present being to drain Paris; but their ideas of the proposed drainage never extended to more than taking away the surface drainage, and they seemed astonished when I told them that the water from our lowest cellars drains into those great sewers.

"Did they go over the sewers of London?—Partly; they made a plan of the work I have alluded to, at the outlet of King's Scholars' Pond Sewer, and all that they could see they took. I recommended them to apply to that which I considered the very best authority, the Westminster Commissioners, to see the way in which the work was done; but when applied to as a professional man for my ideas as to draining Paris, I refused to give any opinion without having plans and sections of the streets.

"You have been employed upon more than one Commission?—Three in London; but as a civil engineer I have been employed in many different parts of the country.

"With reference to the works executed under the Westminster Commission, they are not only good in design, but exceedingly durable in construction?—Very much so.

"And the very best materials employed?—Yes."

Is this Mr. Walker the engineer who was President of the Institute of the Civil Engineers?—No doubt it is.

Yet the set of works and the form of sewers as then in use, and the set of works then carried out, was the set which has since been demonstrated to be erroneous in science, and has been superseded as inefficient

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and wasteful?—Yes. The Court of Sewers for Westminster have so declared, having found it necessary totally to change their form of sewers since that period. And if the special work to which Mr. Walker refers be the King's Scholars' Pond Sewer, though I scarcely like to dispute such an authority, I must say that we differ here most essentially; and I think I could convince Mr. Walker that he relied too much upon the architect of whom he speaks, if I were to have a quarter of an hour's quiet conversation with him, with the plan of the entire district, and the Reports of Mr. Rennie and Mr. Tredgold in 1807, before us.

Have new sewers been built under the Houses of Parliament?—Yes, in 1838-9, I think.

Have applications been recently made to your office in respect to them?—Yes.

Will you produce any correspondence which has passed respectin them?—I will.

Copy of Letter sent to Mr. Barry by Surveyor.

"*Sewers' Office, No.* 1, *Greek-street, Soho-square,*

"Sir, *October 20th*, 1846.

"In consequence of your complaint to me that the deposit in the sewer in Abingdon-street formed an obstruction to the discharge of the sewage from the sewer which communicates therewith from the New Houses of Parliament, I went into them on Thursday last for the purpose of examining them, and now beg to report to you the result of my examination.

"There are two flaps placed across the sewer from the New Houses of Parliament, one of which is made of slate, and is fixed close to its junction with the sewer in Abingdon-street, and the other is made of wood, and is fixed about 60 feet backwards from it. These flaps are very heavy and clumsy, and are badly constructed for allowing the water and sewage to run off freely. This sewer is on the same level as the one in Abingdon-street, and its bottom for a few feet outside each flap is sunk about 9 inches, so as to allow the flaps to close the sewer; consequently, the water and deposit outside, by pressing against them, prevents the sewage inside, until it accumulates to a great extent, from forcing them open.

"From the bad construction, therefore, of these flaps, as well as the improper form and levels of these sewers themselves the sewage is being constantly pent back, and the sewer under the New Houses of Parliament forms, as it were, an elongated cesspool, the great evil of which must eventually be very obnoxious and injurious. Both sewers now contain a large accumulation of soil, and from their present arrangement and construction, I do not see how this can be otherwise or ever obviated unless a systematic plan of flushing be adopted, which will cause constant attention and great expense. But had the sewer along Abingdon-street, as also that communicating therewith, running under the New Houses of Parliament, been properly formed in the first place, they would have kept themselves clean without the assistance of flushing.

"In consequence of these defects, I am of opinion that the main drainage of the New Houses of Parliament should be entirely re-arranged, and diverted from its present course.

"Should you feel disposed to perfect the same, for which there are ample facilities at hand, I shall be most happy to afford you any assistance in my power relative thereto.

"I am, Sir,

"Your most obedient servant,

"*To Charles Barry, Esq. &c. &c.*

"(Signed) John Phillips, *Surveyor*,"

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What size and sorts of house drains do architects commonly recommend for insertion?—The Building Act requires a 9-inch drain as a minimum, under the advice of architects of course.

From your own observation and experience, and judging by such examples, if you were the owner of property which required an extensive outlay, would you, if you were unaware of the possession of any special knowledge by them, intrust the outlay of your own money, even to a court or assemblage composed entirely of architects, any more than to an assemblage of tradesmen in the present ordinary state of professional knowledge and of common interests in the amounts expended?—From the experience I have had in the Westminster Court of Sewers, I should prefer to consult clear-headed non-professional men rather than architects engaged in the ornamental and fine arts department of their profession, and mainly because such men would be less prejudiced, and have less to unlearn. The increase of expense proposed by architects for the sake of having granite bottoms to all sewers; and the varied professions and trades of those Commissioners who were in favour of the improved forms of sewers, while the architects were in opposition, will illustrate my meaning.

For the successful prosecution of such works, then, special attention and practice and skill, with a responsibility and an interest in the attainment of the ends in the most economical way, are necessary?—They are the main requisites, doubtless. Without them, here, as in other things, we seldom get beyond mediocrity.

At the time of the passing of the Act, in the reign of Henry VIII., 4*s*. per diem would be equivalent to about 24*s*. per diem of our money. The following list will show you what were the salaries of some of the judges and Crown officers at the latter end of the reign of Henry VIII., and if you multiply each sum by six, it will give you the equivalent in our money:—

	Per Annum. £.	*s.*	*d.*
Chief Justice of the King's Bench . . .	154	0	0
Do. Common Pleas . .	130	0	0
Do. Chief Baron . . .	133	0	0
Puisne Judges	100	0	0
Chancellor of the Exchequer . . .	26	13	4
Chamberlain of the Exchequer . . .	52	3	4
Chamberlain of King's Household . . .	20	0	0
The French Secretary	40	0	0
Chief Surgeon	26	13	4
Under Clerk of Parliament	5	0	0
Solicitor-General	10	0	0
Constable of the Tower	100	0	0

From such a payment is it not clear that a high standard of position was intended to be established to ensure the impartiality or "indifference" requisite for the exercise of such functions?—Yes; and remembering what tradesmen then were, it is quite clear that they were not intended. I have, indeed, heard as an office tradition, that formerly the business of our Commission was transacted in the Court of Queen's Bench, that the Chief Justice occupied the chair, a few Commissioners only surrounding him. I should scarcely think a multiplication by six

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sufficient; I imagine that eight or nine times the amount would be nearer the present value

You spoke just now of your Committee of Accounts. Does it work well?—I had anticipated very beneficial results from the appointment of a Committee who would go into the accounts, but the attendances have been so bad, that I scarcely know what to say. We have summoned the Committee 14 or 15 times this year, and only five times have we had a quorum of three.

To what do you attribute this?—I cannot be sure of the motive.

Are they entitled to the 4*s.* on that as on other Committees?—No; they are not.

Have you seen the Parliamentary Paper, No. 686, of last Session, containing Mr. Leslie's charges against the Westminster Commission, and the reply of the Court, together with Mr. Leslie's rejoinder?—I have.

Do you consider that the points of objection made by Mr. Leslie were met by the reply of the Court?—I do not think that they were fairly met. You speak of it as the reply of the Court, but I have never so considered it. The Court, upon receipt of the letter from the Secretary of State, referred Mr. Leslie's pamphlet to a Committee, who nominated Alderman Johnson, chairman; the alderman prepared a Report, but having in the interim become Lord Mayor, the duties of his station prevented his completing it. The late chairman of the Court drew up the reply. The following resolution of the Committee, given at page 48, will explain the affair:—

> "Resolved unanimously, That the Committee have read with deep attention the condensed Report prepared by the chairman of the Committee, the Lord Mayor, so far as it embraces the subject; but inasmuch as it is incomplete, and as it is important for the Committee to draw its labours immediately to a close, and feeling, also, that the nature of the pamphlet under review requires a more detailed reply than that contemplated in the Lord Mayor's Report, deem it prudent to adopt the full Report drawn up and already generally approved by the Committee, and that the same, with Appendices, be submitted at an early meeting of the Court."

But surely the Court approved it?—No; a Court was summoned, and the Report and Minutes of the Committee were read. An order was made to send a copy to the Secretary of State and to each Commissioner, and thanks were voted to the Committee, and congratulations to the Lord Mayor; but the document was not put for the approval of the Court. Only 35 Commissioners were present during the whole meeting.

Was it not an omission on the part of the chairman not to put the Report of the Committee for approval of the Court? Who was in the chair?—The same Commissioner who drew up the Report.

In the official return, at page 49, the attendance of the Commissioners forming the Committee appear as follows:—

	Attendances.
Thos. L. Donaldson	222
Edward Willoughby	164
Wm. Hawkes	144
Fred. Crace	91
John White	89
Henry Harrison	51
John Johnson	39

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Do you know how it happened that the gentleman who had least attended to the business was chosen to be chairman of the Committee? —I do not.

It appears that Alderman Johnson was not in the Commission till 1839, while some of the Committee were nominated in 1806; do you know why, as the Committee complain that the charges were old, the junior Commissioner was appointed chairman?—No. The fact is, that the worthy alderman had very little to do with it.

Will you state your own impression as to the correctness of Mr. Leslie's facts and conclusions in his pamphlet and in his rejoinder?—His facts in both cases are quite unimpeachable. Of course his inferences are open to question.

There are, however, two or three prominent statements, and charges founded upon them; for instance,—

As to the self nomination of the Court.
As to the intricacy of the surveyors' accounts.
As to the heavy excess of the cost above the estimates in many cases.
As to a series of suspicious circumstances on each occasion of obtaining contracts.
As to unfair measurements of depths.
As to the better management in the works of the Holborn and Finsbury Commission.

On these several points we should be glad to know whether you coincide in opinion with the reply of the Committee?—Upon the face of the documents, which were prepared under the direction of the Committee, and which are most of them appended by Mr. Leslie to his rejoinder, I could not have come to the conclusion the Committee came to in those cases. The Committee evidently felt what my opinion was; indeed, I made no secret of it, and the Report was not even copied in my office, but by a law stationer, employed by one of the Committee.

The Committee, we perceive, take no notice whatever of the charges made by Mr. Leslie before the Health of Towns Commission. Will you state your opinion as to his correctness on a few of the matters brought forward by him; for instance,—

The employment formerly of Commissioners as contractors for works.
The strange proceedings as regards the purchase of the Court-house in Greek-street.
The increase allowed to parties after they had obtained contracts.
The statements connected with the diversion of the Ranelagh sewer at Bayswater, and the subsequent failure of those works.
The alleged mistake as to quantities which gave the contract to the wrong parties.

—I believe Mr. Leslie's statements to be quite consistent with the facts. I should add, however, that the error as to the bricks appears to me to have been a clerical error.

Are the additional statements made in Mr. Leslie's rejoinder respecting the proceedings attendant upon the purchase of the Westminster Court-house correct?—They are.

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Is the document at p. 26, amounting to an anticipatory record of the proceedings of a meeting of the Court, at which nearly 25,000*l.* were ordered to be spent, without notice, at one time and place, really in the handwriting of a Commissioner?—It is.

Are the further statements of Mr. Leslie, as to the circumstances connected with the contracts, correct?—I believe them to be so.

Can it be that the documents prepared for the Committee with respect to the quantities for the contracts of 1836 prove the reverse, or nearly so, of what they state in their reply?—I think so. But the papers, added to Mr. Leslie's rejoinder (at pages 29 and 54), will speak for themselves.

Are the statements as to improper measurements correct also?—That is my belief.

Was a passage in Mr. White's paper suppressed as stated?—It was; with his consent.

It has been stated that formerly the names of the juries used to be forwarded from the Court to the sheriff. Can this be so?—The practice has long been discontinued; but such was the case formerly, no doubt.

Were not the names of the tradesmen of the Court in those lists, and are not the names of some gentlemen who are now in the Commission to be found in them?—I believe so. Of course this was before I had anything to do with the Commission.

In Mr. Leslie's rejoinder he accuses a Commissioner of making the surveyors state what was untrue, in their report as to a property upon which he was employed as architect, if not personally interested in it. Is that so?—Yes. I have no doubt of it. The alteration in the Report, so as to abstain from referring to that Commissioner, is very palpable.

It appears that that sewer cost the public 487*l.* 16*s.* 8*d.*, exclusive of paving. What would a sewer of Mr. Phillips' improved form for courts be built for?—About 50*l.* for the sewer; and I am sure such extras would not be thought of now.

Was the chairman in the habit of altering the surveyor's reports?—Yes; he was.

Did not the officer remonstrate?—He had been accustomed to it for so many years that he thought nothing of it; but I pointed out to him the impropriety of recommending what he did not approve, and he at length summoned up resolution to omit sending his reports to the chairman.

What was the result?—The chairman obtained an order at the next Court that both the clerk and surveyor should submit all reports to him in future. But the order was not regular, as no notice was given of it.

Have you anything to add to your examination?—Throughout my examination I have given the first instances which memory has suggested; and should it be thought that I have expressed myself strongly, I can only say, that if I have said much, I have very much more to add if needful. One expression in the commencemant of the second part of my examination may require explanation. I have spoken of a "demoralising system" under which the office laboured; now, Mr. Leslie has proved that the two chief surveyors were induced,

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under the influence of a Commissioner, to state what was not true; and Mr. Phillips has shown, that under the fear of some one, the clerks of the works habitually attested what was not the fact. To this I will add one single circumstance which will, I think, establish the point:—A short time since it was found that a large district had been described on the plans as being in one division, whereas it was in another, and had of course been rated accordingly. When this was clearly ascertained, I spoke to the officer who had laid down the line of demarkation, when he said he knew that it was so, but a late chairman had so ordered; "Then," said I, "you have, for many years, and on oath, misled the presentment juries." He replied, "Yes, but there was an order of Court for it."

Have you read the evidence of Sir George Phillips?—I have.

He complains of the way in which he has been treated by the Court of Sewers for Westminster?—He does; but under the existing regulations he has been treated better than 99 out of every 100 cases that come before the Court. He has had an outfall brought up for him, and is expected to carry on the sewer himself.

But it will not be altogether for his own benefit, will it?—Certainly not.

How does it happen, that so many persons were in waiting?—There were on that day, I remember, some tenders opened earlier than usual, and some parties in attendance from Drury-lane, but a great part were petitioners for sewers and drains no doubt.

Why is it necessary to require petitioners for ordinary works to attend?—In my opinion, it is quite unnecessary. Other Commissions do not require it, and it has always been a very fruitful source of complaint against our Commission. I have long tried to get it altered, and in July last, at a special meeting summoned to consider the steps to be taken under our new Act, I drew the attention of the Court to the fact that we had by public advertisements warned all builders that they were liable to an indefinite penalty, if they proceeded till their buildings were properly drained, and I suggested that the same powers should be intrusted to the surveyor of the Westminster Commission as were exercised by the officers of other Commissions, as to granting leave for ordinary sewers and drains. The solicitor gave it as his opinion, that some such regulation was absolutely necessary, and the Court were pleased to vote, by a majority of 1 to 13, as follows:—

"*Ordered*,—That, in order to prevent inconvenience to the public, the clerk and the surveyor be conjointly empowered to grant permission to proceed with the necessary works to such persons as shall present applications in the usual form for sewers and drains, and who will bind themselves to abide by the printed regulations of the Court with regard thereto; a list of the applications so granted being presented at the next meeting of the Court."

But the same Commissioner, who was in the minority of 1, succeeded at a subsequent Court in getting the order rescinded. You will perceive that the order was very carefully worded to guard against any abuse of power; as originally drawn, it referred to the surveyor only, but the clerk was associated with him by the Court. Its repeal has caused

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much dissatisfaction, as the public are greatly annoyed at being made to attend the Court and necessarily lose much time, merely to have their names called, and to be told their petitions are granted. If this plan had been adopted years ago, a painful case which I had recently to report, of an officer receiving money for a sewer, and keeping it for several years, could scarcely have occurred, the public would have been spared much loss of time, and the Court would have escaped very much ill will on the part of builders.

Out of the whole 50 cases who appear to have been in attendance on the day mentioned, what proportion do you consider need have attended under a proper arrangement of business, in which the greatest proportion would be dispatched by competent and really responsible officers, that is to say by paid officers?—The Court-room and the adjoining room were full of applicants when Sir George Phillips came; I do not know the precise object of the whole of them; but except as to the decision on the tenders, scarcely one need have been present. There were some parties summoned for irregularities in drainage, which under proper regulations would not have occurred.

Is this instance a fair specimen of the current business of a Court day?—It is, of a heavy day; we only got through about half the business, and had a remanet paper for another Court day.

Would not many of the parties not only have weeks to wait to obtain the consent of the Court, but would have to come long distances to attend?—Our office being at the extreme eastern end of the district, and the building operations being principally at the north-western and other extremities, the petitioners must in most cases have come considerable distances. The cases of several who were not in attendance stood over until the next Court.

What would be the charges of architects or builders, or other agents per diem for attendance?—I do not know what their charges are. Architects or respectable builders, however, would not, I should think, charge less than a guinea for the time lost in attending, and in going to and fro and getting a petition passed.

They have to attend several times at the office?—Yes.

Supposing then that the time of each of the 50 persons were worth 10*s.* the day on the average, it would appear that time to the valne of some 25*l.* for the Court day was consumed needlessly?—No doubt it is so.

How many Court days have you in the year?—Twenty-five ordinary Courts, and about as many extraordinary Courts.

Do you think 1200*l.* per annum would be a fair estimate of the waste of the public time in the mode described?—Taking into consideration the preliminary calls at our office, and upon the owners of the sewers and the Paving Boards, that must surely be an estimate greatly below the truth,

Under a system of management in which the interests of the public were consulted, and time properly economised, would it not be a good arrangement to have branch offices at which information might be given, and sanctions expressed by competent officers as to settled points?—I have constantly mentioned the necessity of a branch office at Kensington or Knightsbridge; and the public time, there can be no doubt, might be largely economised in that way. But if the works

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were conducted on a general system, for house and court as well as main drainage, the causes of complaint and this grievous loss of time would be removed. The origin of the applications and the causes of the complaints being removed, the public would have nothing to come to the office for.

In the case of the drainage of this mews, complained of by Sir George Phillips, it is stated that the expense would be 200*l.*; that expense, it is to be presumed, is on the present improved system?—Yes, I believe it is; but that is his builder's estimate.

On practicable arrangements, comprehending more efficient drainage, for what do you consider the works might be executed?—The surveyor and myself believe that the works might be executed on system, and in an improved manner with glazed circular drains, for less than one-half the present amount—considerably less; even, however, on the present system, if the sewer were executed by the Commission, instead of the private builder, it might be executed for much less than the sum stated. Every builder cannot be expected to have plant for sewer work.

We understand that under some of the Courts of Sewers the surveyors are paid by a commission upon the sums expended for works?—I believe that is the case.

Has not the reduction of the price of sewers in your Commission been very considerable lately; in some cases even to three-fourths or four-fifths?—Yes.

Then if your surveyor had been paid in that way he would have proposed the reduction of his own income in the same proportion as the works were reduced, for example, from 400*l.* or 500*l.* a-year to 100*l.*?—No doubt. The greater the economy effected, the less the income that would accrue to the surveyor.

At the time of the appearance of the cholera in 1832, were there any complaints as to the state of the sewerage?—There were complaints—principally from the Central Board of Health.

Those complaints probably related to the defective drainage of particular districts where cholera was prevalent?—Yes; more particularly Westminster and Chelsea, I think.

In what respects have the condition of those districts been altered?—Some two or three lines of sewers have been built; but very few houses are connected with them. The old drains are as bad as ever, and the system of pumping the sullage water into the gutters at night still continues, especially round Buckingham Palace. There are many in Dartmouth-street, Westminster, and near Buckingham Palace, who pump out their sewage-water at night into the streets; indeed I am told that the basement stories of some of the houses are worse than useless.

Are cesspools prevalent in your district?—The public are scarcely aware of the fact, that many of the very best portions of the West End are literally honeycombed with cesspools. Many houses have from three to six or seven under them. In some *porous* neighbourhoods the practice is still, when one cesspool is full, to arch it over and dig another, to avoid the expense and trouble of removing the soil. It is extremely difficult to persuade builders that they are not necessary

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adjuncts to drainage; and no wonder, as it is only recently that I have been able to do away with something of the kind at our office in Greek street, which was at times extremely offensive.

Then, on the whole, there has, in those districts, been very little change?—Very little; as a glance at our map of Westminster and Chelsea will testify, where we find street after street without any public drainage whatever.

You are conversant with the system of flushing in use in the Holborn and Finsbury division, where they flush 100 miles of sewers regularly: to what extent is the same system carried out in the Westminster division?—Probably two miles of covered sewer.

What is the length of sewer within your district?—About 200 miles; but a large proportion of the sewers in our district ought to cleanse themselves without flushing or mechanical means.

Do they do so?—Scarcely any of those built before last year do so thoroughly, except the main lines, which have a good flow of water through them.

The Hon. Frederick Byng, in a pamphlet which he published in relation to the sanitary condition of his own parish, St. James, Westminster, states that there are constantly 2,500,000 cubic feet of decomposing refuse retained in the sewers and drains. Do you believe the statement to be correct?—I do. I know that before he published the pamphlet he consulted our surveyor as to its accuracy on these points.

Do you believe that if the evil were dealt with systematically, by the application of water, this refuse might be removed, without occasioning that extensive development of the noxious gases that is incident to the common modes of the removal of the refuse by hand labour and cartage?—I see several modes in which, chiefly by the application of water, the refuse might be removed speedily, comparatively innocuously, and more cheaply.

Do you not consider these sewers in which the decomposing matter remains as noxious as cesspools?—Yes; I see no difference between them and cesspools, except their shape and position, and the depth of the decomposing matter within them; indeed the exposed surface is greater, and the annoyance is more public.

The Commissioners requested you to make some inquiries as to the prices charged by private builders for laying drains into the sewers. Have you done so?—I have taken from the books the first cases that occurred in the neighbourhood of our office; and out of a considerable number I have only been able to obtain the following, in consequence of the way in which the drains have been mixed up by the builders with other charges:—

Oxford-street .	17*l.* for drain from house to sewer.
Ditto	about 10*l.* for ditto.
Ditto	about 15*l.* for ditto.
Ditto	10*l.* to 12*l.* for ditto.
Drury-lane . .	22*l.* for 2 drains, ditto.
Ditto	9*l.* 7*s.* 3*d.* for 1 ditto, ditto.
Ditto	16*l.* to bricklayer, and 1*l.* 1*s.* paid at the office, besides frontage for the sewer at 10*s.* per ft.
Mount-street . .	23*l.* 10*s.* for drain to sewer.

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Warwick-street . 25*l.* for drain from sewer through house exclusive of office charges.

Tottenham Court-road . . . . 16*l.* 1*s.* for 1 drain from house to sewer.
Ditto . . . . 16*l.* 16*s.* for 1 ditto, ditto.
Ditto . . . . 13*l.* for 1 ditto, ditto.

Do you know at what rate the contractors of the Sewers' Office charge for their private drains? — The charges have always been extremely high; but the following prices charged in Berwick-street, where the sewer has just been rebuilt, show some improvement in that respect though, they are still much too high, viz.:—

Berwick-street . 3*l.* 17*s.* for pipe from house to sewer.
Ditto . . . . 3*l.* 17*s.* ditto (besides time of owner).
Ditto . . . . 2*l.* 15*s.* ditto.
Ditto . . . . 4*l.* 10*s.* ditto.
Ditto . . . . 4*l.* ditto.

Formerly, these matters never came into my department, but recently I have advised several parties not to pay above half the sum demanded.

Have you made any inquiries as to the advantages derived from the sewers when rebuilt?—I have taken one case where the sewer was rebuilt 10 years ago, and one quite recent case in the same neighbourhood. The replies have been very conflicting indeed. In many cases an evident fear of incurring additional expense prevented a full and explicit statement. There were great complaints of smell in some cases, when the back-door was shut and when the house was closed at night; and generally it would seem that very much remained to be done, the old drains at the back being left as they were before the sewers were rebuilt; the new system had however a decided advantage. In once instance, about four years ago, it appears that, in Wardour-street, a man whilst cleaning out a drain was taken suddenly ill and died in three hours, and that the medical man attributed it to the noxious effects of the work he was engaged in.

Do you not consider that it is most wasteful to go on driving sewers without provision for the house drainage?—It must be so. If earthenware pipes, instead of the brick and mortar drains recommended by architects, had been put in during the progress of the works in Drury-lane and Tottenham Court-road, &c., under a proper system, the prices above-mentioned would, I believe, have been half-crowns, and in some cases even shillings, intsead of pounds.

You are acquainted with the action of the several local Acts which have been obtained for the government of the Commissioners of Sewers. Taking into account the probable visitation of the cholera, and the expediency of the earliest preparation of preventive measures of cleansing under the laws of sewers, will you state the comparative advantages of one general Commission, under which the powers of the local Acts shall be suspended; or of an issue of new Commissions for the several districts directed to the same persons, in order to

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obtain uniformity of action?—I think the object might be best attained by the issue of a general Commission, (extending in Middlesex from the Colne westward to the Lea eastward; and in Surrey, from the Ravensbourne eastward to the Mole westward), in which general Commission should be recited the bounds of the present Commissions one after another. This step might involve the supercession of the several local Acts, but it is a question whether, in the event of the arrival of the cholera, they might not rather be an hindrance than an advantage. They would, of course, prevent uniformity of action, an object of so vast importance, and the Acts of last Session contain many clauses, for which at present there is no adequate preparation. Up to this time the Tower Hamlets' Commission has been worked entirely under the powers of the 23d Henry VIII., c. 5, and that Act is so admirably drawn, that I believe, if its powers were confided to a few public-spirited, disinterested, common-sense men, and were taken together with the Nuisances Prevention Act, 9th and 10th Vict., c. 96, almost all could be accomplished which the local Acts give power to do. If the powers of the local Acts remained intact, and could be wielded in their several localities by one general Commission, the present system of levying rates in each district, and to which the population have become accustomed, might be continued; but if they should cease, then the plan pursued in the Tower Hamlets, under the 23d Henry VIII., must become general, at least on the north side of the Thames. On the Surrey side, another general Act, 3d and 4th Wm. IV., would apply as at present. A very considerable portion of the time of the gentlemen selected to work such a Commision would be consumed, no doubt; but a judicious arrangement of Committees, somewhat according to the present plan of the Holborn and Finsbury Commission, (if the Act of Henry will allow it,) would put a stop to much of the present debating-society character of the Courts of Sewers; and, if accompanied by a few clear and intelligible bye-laws, leaving some discretion to the paid officers, the time, both of the Commissioners to be appointed, and of the public generally, might be most materially saved; and in a case of great public emergency, such as has been imagined, immense advantages doubtless would arise from the combined and energetic action which could be brought to bear unfettered on any given point of the metropolis.

How many names accompanied the petition of your Court sent in to the Chancellor, asking for a new Commission?—184.

How many of them had never attended the Court during the whole period of the Commission?—48 had not even taken the oath of office.

Will you look at this list of acting Commissioners, which you have sent in to us as requested, and will you state how many of the Commissioners whose names have been sent in to the Chancellor for reinsertion in the Commission, have not attended during the past seven years?—7.

How many have not attended above 14 times?—54.

Then out of the 184 names sent in, 102, or considerably more than half, have not attended more than 14 times, or twice a year, and more than one-fourth have not attended at all?—That is so.

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And your meetings are about three or four times each month?—Yes.

You have probably had little short of 300 meetings in that period then; how many have attended 100 times?—30.

Will you state their professions or trades?—Magistrates, 3; architects, 7; attorneys, 4; surgeon, 1; tradesmen, 15.

Some have attended, it seems, above 200 times; will you state their calling?—Only 9 have attended 200 times, namely,—magistrate, 1; architects, 3; attorney, 1; tradesmen, 4.

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Mr. *John Phillips*, C.E., Chief Surveyor to the Westminster Court of Sewers.

You have heard read Mr. Hertslet's evidence. Is it consistent with your own observation and experience?—I agree most cordially with all that he has said.

Will you state shortly the nature of the improvements which you have proposed? When were you appointed to your present office?—In March, 1846. For two years previously I had been clerk of the works on the several districts.

On what works had you been previously engaged?—On a great variety of public engineering and private building works.

Had you ever been employed on sewer works?—No; excepting that many years ago I once worked as a bricklayer, in the building of a sewer.

Were you brought up to the profession of a surveyor?—No; I went to work, when I was eight years old, as a bricklayer. I never had the slightest education. The little I do know I have taught myself, and that, too, under a succession of trying difficulties. Some few months ago, the members of the Institution of Civil Engineers did me the honour to elect me an Associate of that Institution.

Had you heard, when you were first engaged on these sewer-works, of censures pronounced on the works of the Westminster Sewers' Commission?—Not a word.

In what state did you find the works?—A reference to the "Book of Informations," kept at the Sewers' Office, will show continued entries by me of complaints of improper modes of executing the work; and, considering the uses of sewers, it appeared to me that their form, mode of arrangement, and construction were far different from what a knowledge of their purposes and of the sciences of statics and hydraulics would dictate. I thought, and often said, that the science of sewerage in this Commission was a century behind the present age; and I was greatly surprised that such sewers should be built, seeing that there were many eminent architects, &c., in the Commission.

Will you give instances of the manner of building them?—The nearly flat bottoms of the sewers, built by private builders, were almost invariably put in without any mortar or cement. The effect of this appeared to me to be that large proportions of the foul drainage, instead of being conducted to the outfalls, and so carrying off the soil, passed through the open joints of the bottoms, and saturated the ground

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beneath with the sewage water. The materials sometimes, as also the work generally, were indifferent. The form of sewer then in use was nearly flat-bottomed with upright side walls.

And spreading footings, was it not?—Yes, it was.

Have you passed through a great extent of the sewers?—Yes; from time to time I have passed through very many miles of them, both old and new.

In what condition did you find the old sewers?—I found that the whole of them had flat bottoms and upright side-walls, with semicircular crowns. The old sewers are generally about 3 feet wide, and their height varies from 3 feet to 6 feet. The bricks, and the greater part of the mortar, of which they had been built, were of very inferior quality. These sewers are from this cause mostly in a ruinous condition. They have been repeatedly cleansed at an enormous aggregate expenditure. The cleansing of old sewers, and also of new ones, that have a tendency to choke up, appears to me to be only perpetuating a monstrous evil. I apprehend that steps should rather have been taken under a combined, systematic, and uniform plan of arrangement and levels, to have rebuilt, or otherwise improved them, instead of removing the soil, and so creating voids to be afterwards again and again filled up. Enough money, I should say, has been wasted in this way, and in patching them up, to have rebuilt the greater part of them. The sewers of modern construction, that is to say, those which have been put in during the last 40 years, have slighly curved inverts.

The old sewers are of course situated in the older districts of the Commission?—Yes, they are.

In what state did you find the new or more modern sewers, as regards their stability?—I found that in very many places, the side walls had bulged in.

Expensive sewers of this form have been altogether forced in, have they not?—Yes.

Where?—In the Harrow-road, by Westbourne-green, at Notting-hill, and other places. The ground in which they had been erected being a slippery clay, and such a form of sewer being least calculated to resist side pressure.

Do you concur with the late Mr. Butler Williams in his explanations of the defects of this form of sewer?—Yes; I do most fully.

Is not the comparative expense of this upright-sided sewer one-third greater than that of a sewer of the same capacity but of the egg-shape?—Yes.

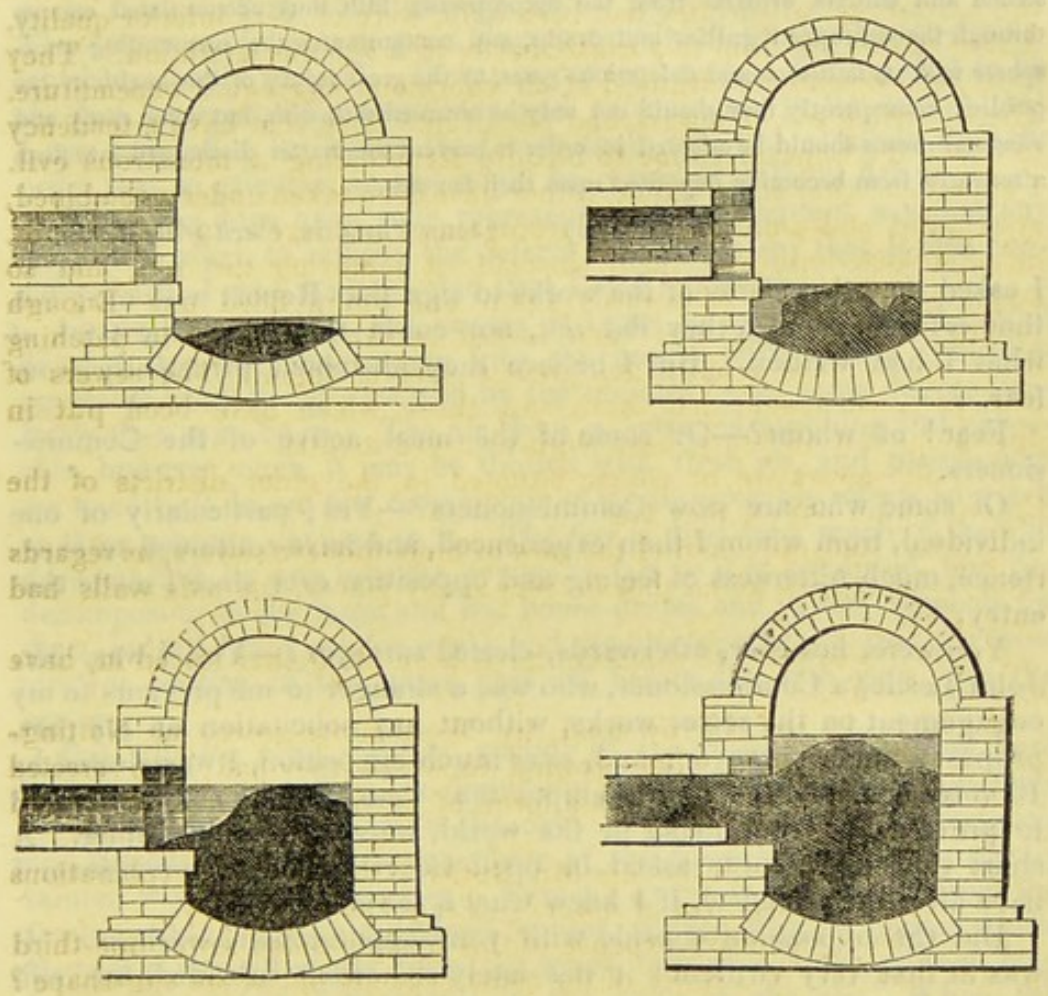
In other words, three streets of the same length might have been sewered at the same expense that two were under this mode of construction?—Yes; and with the same fall less deposits would have accumulated.

In what state did you find the sewers in regard to cleansing?—I had observed, in passing through them, that a large number of them had a tendency to choke up, inasmuch as not only was the flatness of the bottom unfavourable to the free flow, but there was the escape of drainage from passing through the open joints of the bottoms, as I have described. I will presently submit a copy of a Report made by me at the time I was clerk of the works. That Report relates only to the

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district on which I was then engaged. The remaining districts were in precisely the same, or I may say a worse state, as the sewers I referred to were many of them comparatively new.

How do you know that the state of the other districts were as bad or worse?—Because I had previously been into the sewers. After the Report was read, the Court ordered me to furnish particulars, when I delivered in a list of about 130 streets in my district only; and, with that list, sketches of the manner in which the refuse had accumulated. I submit a copy of the sketch with the addition of the position of the house-drains.



It had previously been a matter of routine for years, as can be seen by reference to the "Book of Informations," that the clerks of the works had entered monthly, that they had inspected the whole of the sewers in their respective districts, and had found no matters on which to report other than had been inserted in that book. I had followed the usual course for several months, but as I proceeded with my inspections of the sewers I began to perceive that I was signing my name to a deliberate falsehood. I, therefore, on the 3rd of October, 1845, wrote the following entry in the "Book of Informations:"—

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"*Sewers' Office for Westminster, &c. No.* 1, *Greek-street, Soho-square, 3rd October,* 1845.

"In obedience to the order of Court (as expressed in Bye-law No. 60), namely, 'that each clerk of the works do endeavour to obtain every information on the state of the sewers within the district placed under his superintendence,' and 'that in the course of every month he inspect the whole of his district and report his having so done, together with his remarks and observations in the Book of Informations, in addition to such entries as have been usually made therein;' therefore I beg most respectfully to state that there are a vast number of sewers under my superintendence that are similar to elongated cesspools; that is, they retain nearly all the sewage matter that is discharged into them, instead of affording efficient means for speedily carrying it off; and the stench and effluvia evolved from the decomposing filth thus accumulated escapes through the untrapped gullies and drains, and contaminates the surrounding atmosphere with its nauseous and deleterious gases, to the great injury of the health of the public; consequently they should not only be cleansed forthwith, but some ready and effectual means should be adopted in order to prevent the matter discharged into them afterwards from becoming deposited upon their bottoms."

(Signed) "JOHN PHILLIPS, *Clerk of the Works.*"

I asked the other clerks of the works to sign that Report with me; but they refused, though they did not, nor could they, deny the truth of what I had written. But I believe they abstained principally from fear.

Fear! of whom?—Of some of the most active of the Commissioners.

Of some who are now Commissioners?—Yes; particularly of one individual, from whom I then experienced, and have continued to experience, much bitterness of feeling and opposition ever since I made that entry.

You were, however, afterwards, elected surveyor?—Yes, I was. Mr. John Leslie, a Commissioner, who was a stranger to me previous to my engagement on the sewer works, without any solicitation on my part, proposed me as surveyor; and, after much opposition, I was elected by 19 votes against 17. The attempts that were made to crush me, and to prevent me from rising in the world, were extremely galling. A short time since I was asked in open Court by the Commissioner I have already alluded to, if I knew what a sewer was.

Did the opposition subside with your appointment?—Oh, no. It was at first very virulent; it has lately somewhat subsided, but still there is a wearing opposition under which it is extremely difficult for an officer to act who really wishes to remedy the existing evils; at least, under a body where the parties for and against improvement are so close that a majority giving cordial support can but seldom be relied upon. I have several times expressed to the chief clerk my disposition to resign my appointment, but he has always endeavoured to give me confidence in the public support to improvements, and of living in hopes of seeing better days, as it was impossible that the present state of things could last but for a short time.

Have you, in passing along the sewers, ascertained which way the currents of air were flowing, either into or out of the sewers?—In going

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along the sewers, I have been always anxious to ascertain that fact. The light which I had in my hand I have placed immediately by the side of and into the house-drains, and I found almost invariably the flare carried into the mouths of the drains, so that there must have been direct currents from the sewers through the house-drains, and so into and through the houses themselves. I rarely met with any instances where there was not a current from the sewer into the house-drain, and also from the sewer through a large number of the gully drains into the streets. Of course some gullies have a down draught.

Then it is to be presumed that your experience justifies the general description given of the existing sewers in the Sanitary Report of 1842, as retorts with necks carried into the houses for the conveyance of the gases there?—Yes, unfortunately, such I have found to be the case. The sewers are in a very great degree ventilated by the house-drains, which are badly trapped. It was in consequence of finding that to be the fact, by repeated observations and experiments in the sewers, that I was induced to lay before the Court their real and absolute state, in order that so grievous an evil might be remedied without delay.

What was done upon your representations?—I cannot say that any steps were taken to remedy the defects; but I can say that it was considered that I was too bold, and that I said too much.

Are not the gases in the sewers at times in such a state of partial dilution that they may escape into the houses without any very disagreeable smell being observed by the inmates?—In some degree probably that may be so. The air from a sewer is anything but agreeable, however much it may be diluted with fresh air, and people who are used to it do not feel or complain of its disagreeable effects so much as those who are not used to it. The fact is, that very much of the filth does not find its way into the sewers as fast as it is produced, but lies decomposing in the large and flat house-drains and in the cesspools for days, indeed I may say for weeks and months together, so that the most virulent portion of the gases pass off before the filth gets into the sewers.

But still the most virulent portion of the gases of which you have spoken, in escaping from the drains and cesspools, infect the atmosphere of the houses?—Yes, that is the case. Wherever there are cesspools and defective drains, the atmosphere of the houses is being constantly tainted with deleterious gases. Persons going in a morning from the fresh air into defectively-drained houses, or into drained houses where there is a current of air from the sewer into the house, cannot help feeling something disagreeable in the state of the air. When the houses are closed for the night, the indrafts of foul air from the sewers, drains, and cesspools increase, and in this atmosphere people sleep, inhaling disease and death.

Are the chief clerk and yourself on good terms?—Yes; we have always been so. In mere matters of detail we have thought differently. I never let personal feelings for any one interfere with my public duty. But with regard to Mr. Hertslet, he is a gentleman for whom I entertain the highest respect; and I think the public very fortunate in having such a straight-forward, able, and efficient officer, as, from daily experience of nearly four years, I have ever found him to be.

From the return of attendances at the Court, and of the occupations

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of the Commissioners, it appears that the numbers attending consist of non-professional persons, and of professional persons and tradesmen; the professional being architects and attorneys, and the trading persons builders and traders connected with building works. Which class of Commissioners have been most strongly supporters of improvement?—Certainly not the architects, nor the attorneys connected with them. In saying that, I wish of course to make exceptions. Among large bodies there will always be found those who think and act for themselves without being biassed by the acts and opinions of others.

In what way do you find the Commissioners of the class you speak of interfere?—In the first place, in the ordinary daily business, by personal solicitations to go out of the usual course to serve particular friends who are in trade or otherwise connected. Thus I have received notes from Commissioners, asking me to oblige them by employing persons; and these notes bear, of course, but a small proportion to the number of verbal solicitations. The persons recommended may be very proper persons; but supposing they are not so, and they are refused, it is natural to expect displeasure from those Commissioners. Then again, one is exposed to requests in respect to works in which Commissioners or their friends are directly or indirectly engaged. The requests may appear harmless, but taking the whole together, they have a tendency to prevent the officers doing their duty discreetly. Clerks of the works have expressed to me the same sentiments. I wish to declare, as a public officer, that as the Commission is now constituted, I and the other officers have found it, and do still find it, impossible that we should do our duty as we ought to do.

Do you find the class of Commissioners connected with building operations in the district favourable to economical works?—Decidedly the contrary. When I propose works of improvements which would save expense, I know from what side opposition will come.

What improvements have you proposed—but state in the first place what you consider to be the best form for a sewer?—I beg leave to state my reasons for recommending the egg-shaped form of sewer: solidity of execution in construction, economy of materials and labour, combined with strength to bear the lateral and vertical pressures of the ground, and efficieney in affording the best channel for quickly conveying away the sewage, are the essential requisites for a sewer. The circle affords the most capacious area of all plane figures having the same circumference, and conversely its circumference is less than any other figure of the same capacity. It, therefore, supplies the greatest capacity for receiving the water, with the smallest frictional surface. and the least consumption of materials. As regards strength: when the pressure from the ground around a circle is the same, it is equally distributed throughout the entire thickness composing the arch; for, as the extradosal length is greater than the intradosal length, the arch is necessarily made up of a series of wedges all pointing to the centre of the circle; hence the circular form prevents the earth outside of it from forcing it in, and from disturbing it, provided the pressure be equal, while upright walls in the same circumstances would most probably be unable to withstand the pressure. The removal of sewage and prevention of deposit of matter in sewers are entirely dependent on the quantity and velocity of the water running through them. In order, therefore, to keep them well washed

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out and cleansed, the utmost scouring force should be imparted to the streams. A semi-circular, or a still narrower and deeper-curved channel of a semi-elliptical or catenarian form, concentrates the flow on a small area of friction, heaps it up, and so increases its velocity, and makes it more powerful in lifting, holding in suspension, and carrying away all matters which may find their way into the sewers, than a wide and flat channel. A sewer, therefore, having an arched crown, curved side walls, and a narrow and deeply-curved bottom, which, combined together, give the shape of an egg with the small end placed downwards, is, in my opinion, the best and most efficient form for all branch sewers. It would appear however from what has been stated, that the circle, from having a more capacious area and less rubbing surface than any other figure, is the best shape for *all* sewers. But this is not the case; for although the surface of contact of the egg-shaped sewer is somewhat greater than a circle of the same area, yet by contracting the channel and so raising the height of the stream, the ratio of velocity and consequent *power to scour* is increased thereby, as will be evident on experiment being made. It is the prerogative of the egg-shaped sewer, therefore, to combine in its form, capacity, economy, strength, and efficiency. It is also the best form for house-drains. As however the principal main lines have always a good flow of water in them, I would make them circular.

What is the shape of the sewers now in use by your Court?—The egg-shape with the narrow end placed downward. I beg to submit this drawing, showing the forms and other details as proposed by me.

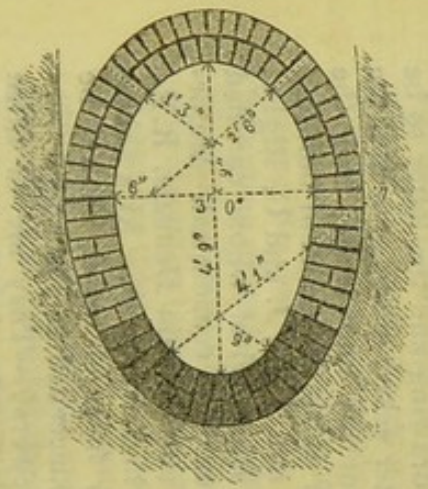
See pp. 170, 171.

When did these sewers come into operation by your Court?—About two years ago.

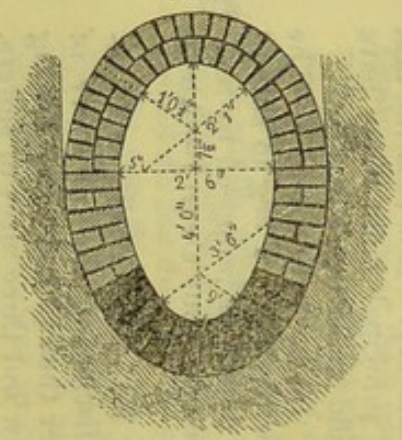
By whom were they introduced?—By Mr. John Leslie, a Commissioner. At that time the Court was discussing the propriety of making some alteration in the form of sewer then in use; and having given the subject much consideration, I drew out three sizes of sewers, all of the egg-shape, with the small end down, differing in some respects, though similar in principle, to those introduced by Mr. Roe, the surveyor to the Holborn and Finsbury Commission, and I sent the drawing, accompanied by a respectful letter, to the Court for consideration. The then chairman, however, would not receive any proposal for improvements from a person in the position of a clerk of the works, as I then was, and he ordered the drawing and the letter to be handed back to me. Mr. Leslie shortly after asked me to give him the drawing, which I did. He then, without my knowledge, had the drawing lithographed, and sent copies of it to the eminent building firms of Messrs. Thomas Cubitt, Grissell and Peto, J. and C. Rigby, William Herbert, Elger and Kelk, and H. Biers, all of whom certified that the proposed forms were durable, efficient, and economical. Major-General Pasley highly approved of them; and Captain Denison, R.E., stated that they were the best forms he had ever seen. At a subsequent Court Mr. Leslie proposed that my form of sewer should be adopted, which, after severe struggles, he succeeded in carrying.

Of what sizes and thicknesses are your sewers?—They are of three sizes, viz., No. 1, 3 ft. wide by 4 ft. 9 in. high; No. 2, 2 ft. 6 in. wide by 4 ft. high; and No. 3, 2 ft. wide by 3 ft. 3 in. high, all in the clear. The thickness of each is one brick, or 9 inches.

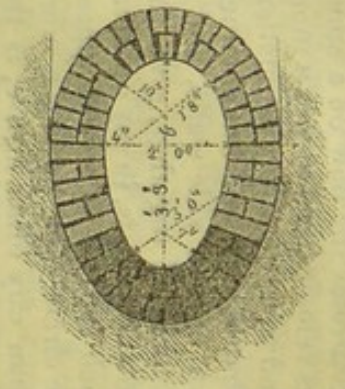
No. 1.



No. 2.

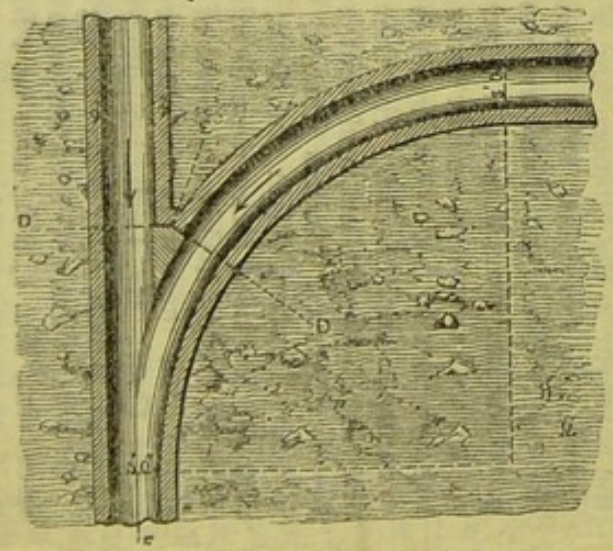


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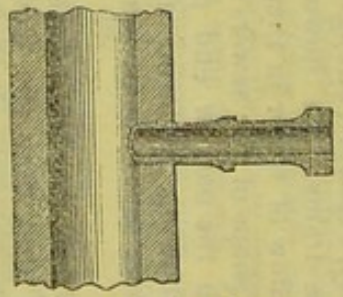


The darker portions of the Inverts to be worked in Cement.

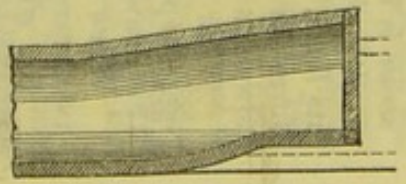
Fig. 1.



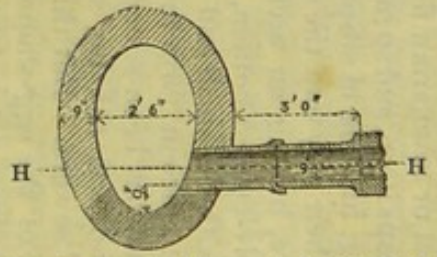
Plan showing the mode of forming the junction of a side sewer with a leading one.



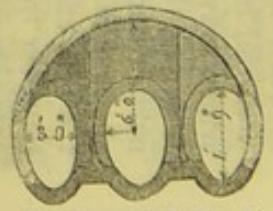
Plan of drain and sewer through H H.



Section on E E, Fig. 1.



Section showing the mode of connecting drain with sewer.

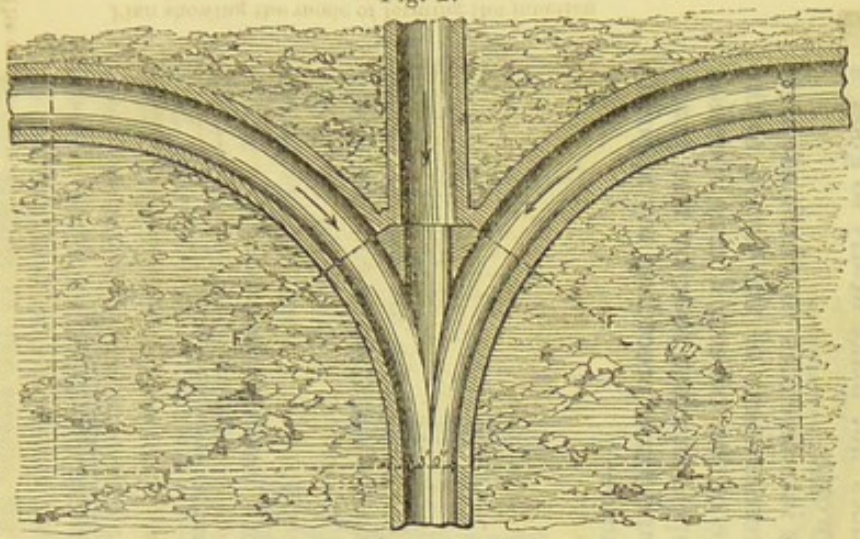


Section on F F, Fig. 2.

* The curves must in all cases be struck with a radius as long as the localities will allow.

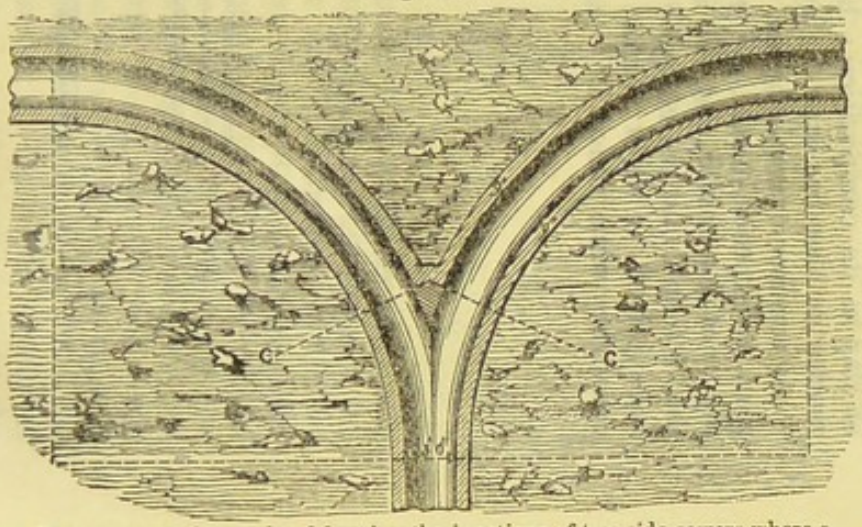
The curves must in all cases be struck with a radius as long as the localities will allow.

Fig. 2.

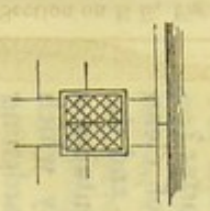


Plan showing the mode of forming the junctions of two side sewers with a leading one.

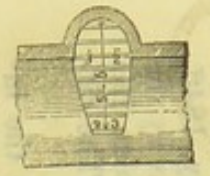
Fig. 3.



Plan showing the mode of forming the junctions of two side sewers where a straight one terminates.



Plan at top of flaps and footway.



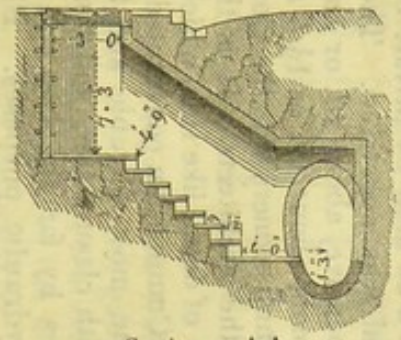
Section on B B.



Section on C C.

The number of steps determinable by the depth of the sewer and its distance from the footway.

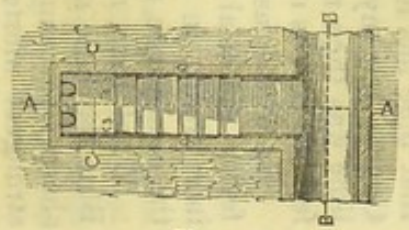
Side Entrance.



Section on A A.



Section on D D, Fig. 1 ; and C C, Fig. 3.



Plan.

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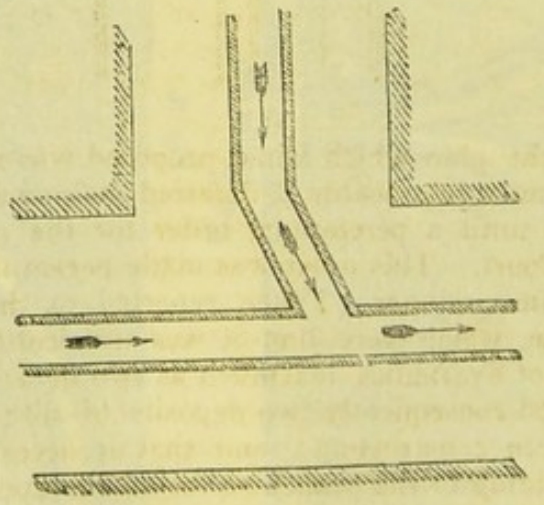
What materials do you use in their construction?—The best hard well-burnt stock bricks, blue lias and Dorking limes, Roman cement, and clean sharp Thames sand. Blue lias lime is used by the Court, and Dorking lime by private builders.

Why should there be any difference in this respect? Is the blue lias lime more expensive?—There certainly ought not to be any difference, in my opinion. If blue lias lime mortar be the best and most proper mortar to be used in the building of sewers by the Court, then of course private builders should use it also. Here I wish to present an example of the sort of interference to which I have been subjected in the execution of work. I proposed to the Court, in May, 1846, that blue lias lime should be used by private builders as well as by the Court; but my proposal was negatived. The price of the blue lias lime was then more expensive, about 2*d.* or 3*d.* per bushel. The difference now is not so much, about 1*d.* or 1½*d.* a bushel.

By what class of Commissioners was the Court led to adopt the inferior material?—By the architects. It is the liability to vexatious interference in matters of detail like this which causes a great deal of the annoyance under a Commission constituted as the present is.

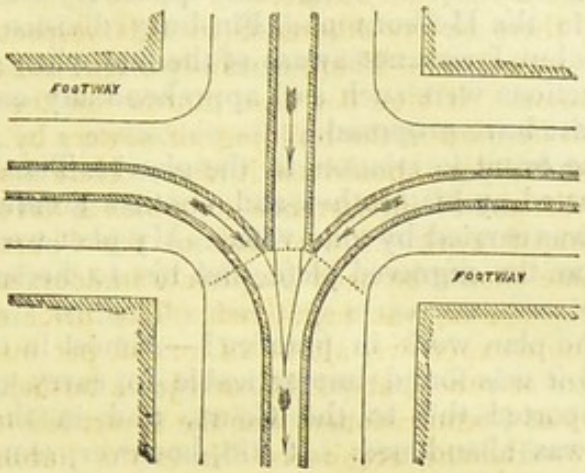
What lime makes the most durable and the strongest mortar?—Blue lias lime mixed with clean water, and twice its measure of clean sharp river sand, makes by far the best and most durable, and the strongest mortar for hydraulic purposes. Blue lias lime contains a large proportion of clay in combination with it. It is the clay which imparts to the mortar the peculiar property of setting and hardening under water. What is called Dorking lime has a much less proportion of clay in its composition; hence it does not make nearly so good a mortar as blue lias lime for hydraulic works.

As another example of the vexatious interferences to which any new plan is exposed under the existing constitution of the Court, to the injury of the public and the annoyance of the officer, I may mention that I found that the old sewers had, up to the last four or five years, been joined at right angles. For some time preceding my appointment they were joined by "cants" thus:—

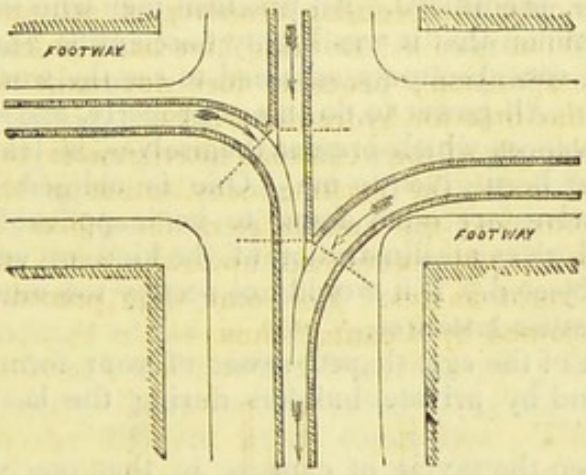


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The plan I proposed, where two branch sewers fell into the main, was of curved junctions, as shown by this sketch :—



The advantages I anticipated would follow from the use of this plan were simplicity and economy in execution, gain in the force and freedom of the sweep of waters, and the prevention of deposit. My plan was objected to by a former chairman of the Court, who proposed the following as an amendment, and carried it :—



Knowing that the plan which I had proposed was really the cheapest, strongest, and most practicable, I deferred making any alteration in the engraved plate until a peremptory order for the purpose should be issued by the Court. This order was made peremptory at the instance of the same Commissioner. I then reported to the Court the objections to his plan, which were, that it was unscientific; contrary to the first principles of hydraulics, inasmuch as two deflections of the stream were caused, and consequently two deposits of silt; that it was weak and expensive in construction; and that it necessitated, in narrow streets, the building of the branch sewer on the upper side of the street to the left, and on the lower side of the street to the right, instead of in the middle of the streets, its natural and proper position. At the same time I handed into the Court a letter which I had received from

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Mr. Roe, the surveyor of the Holborn and Finsbury sewers, supporting my view of the case.

Had not such mode of forming two opposite junctions been previously in use in the Holborn and Finsbury divisions of sewers?—Yes, they had; but I was not aware of the fact when I proposed the plan. The junctions were such as I apprehend any engineer of ordinary ability must have proposed.

What was the event in relation to the plan?—The late chairman's plan was supported by his brother and another architect and district surveyor, and was carried by one vote. My plan was ordered to be obliterated from the engraved plate, and his to be substituted in its place.

How does the plan work in practice?—Almost in the first instance which occurred it was found impracticable to carry out the plan as altered. I reported this to the Court, and in that instance the amended plan was abandoned. It still, however, remains a standing order.

What is the comparative expense incurred by the plan?—In one instance where the amended plan has been adopted, in Wells-street, Marylebone, the contractor informed me that it has cost him 84*l.*, whereas, had my plan been used instead, he told me that it would have cost him only 49*l.* I should think, however, the average increased expense to the public would be about 40 per cent., and the effect, according to all experience, prejudicial. All practical men who saw the work, expressed their opinion that it was highly unscientific and prejudicial. I must say that I was absolutely ashamed to see the work being done in such a manner. All power to do things properly, and according to the several circumstances which present themselves, is taken from me, or rather has never been given to me. One is obliged to act by rules which in themselves are often found to be inapplicable. The case I have just stated gives an illustration of the kind of vexation to which I have been subjected. If it would not occupy too much time I could bring forward other instances.

What length of the egg-shaped sewer of your form has been built by the Court and by private builders during the last year?—41,657 feet.

What has been the saving of expense in that one year?—At least 13,000*l.* As an instance of the saving of expense in the building of sewers of my form, I may state that a private builder has very recently built in our district 6000 feet of second-class sewer at 10*s.* 6*d.* per foot-run, and 1500 feet of third-class sewer at 8*s.* 10*d.* per foot-run, which, together, amount to 3812*l.* 10*s.* The cost of the two lengths, that is 7500 feet, if built of the old second-sized form, with upright sides, would have been about 15*s.* per foot, or, for the entire length, 5625*l.*; so that to this person alone a saving has been effected of 1812*l.* 10*s.*, and he has a complete system of sewerage on his estate which he would not have had on the old system.

What class of Commissioners opposed the adoption of your improved form?—Mostly architects and professional persons connected with building matters.

What objects may architects and tradesmen serve by maintaining

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uneconomical works?—If I may say so, without intending the least disrespect to individuals, I should say that the architect is connected with and dependent upon the builder, just in the same way as amongst the inferior members of the medical profession, the physician is dependent upon the apothecary who supplies medicines and recommends physicians.

Can a person, in a profession so connected as an architect in private practice (a practice habituated to emoluments dependent on the extent of expenditure), or persons in trade as builders; or as suppliers of materials connected with architects or with contractors, be fairly accepted as indifferent and substantial persons, or as impartial and substantial persons, within the meaning of the law of sewers?—I should think not.

From your statement it appears that a considerable saving of expense has already been effected in the building of sewers, and that the working has been greatly improved. Are you confident that you have arrived at the limits of reduction in respect to the size and economy of sewers?—By no means. I have given this subject much consideration, and I am convinced, that if control be obtainable over a proper supply of water, the present mode of constructing sewers might be wholly superseded by the adoption of a far more efficient and economical system. Even with the improvements that have been already made in their form, arrangement, and construction, very many of the sewers built for some time past are not perfect through not having a proper supply of water. Indeed it is utterly hopeless to expect that house-drains and sewers can keep themselves, or be kep clean, and in perfect condition, without having, at the same time, control over a supply of water. In passing through the sewers, deposit appeared to me to be the necessary consequences of one or all of the following causes—namely, too little fall; inefficiency in the supply of water, or deficiency in the force of the currents; too large a capacity of the sewers, or the improper form of their bottoms, they being flat and wide; abrupt angles which produced eddies in the currents; and heavy substances which had either been thrown or had found their way into the sewers. In dry weather nearly all the water running along the sewers is due to the supply from the different water companies. The quantity due from springs or land drainage is very little. With drains and sewers the whole filth of a town is dependent for its removal on the supply of water. If that supply be deficient, or fall short of its proper quantity, and so of the necessary power to lift and carry away the filth, it must of course deposit and accumulate in the drains and sewers. A proportional supply and force of water is therefore essentially necessary to ensure its entire removal. A considerable proportion of the supply is lost in various ways for cleansing and scouring purposes. The more abundant the supply and the better the drains and sewers are proportioned thereto as to size, form, and fall, the more rapid will be the removal of the filth, and the less liability will there be to deposit. Indeed, I feel sure that by a systematic arrangement of the house-drains and the sewers, and application of a proper quantity of water, no deposit will take place. For the short collateral branches of the sewers in streets, courts, &c., the smaller they are (provided they be large

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enough to receive and carry off storm waters in addition to the ordinary run), the less chance will there be for them to choke up. In the course of my experience I have examined hundreds of drains, and I have always found small drains and sewers which had a moderate fall, and anything like a good supply of water, quite clean and perfect in that respect. I anticipate, indeed I confidently entertain an opinion, that with a combination of the water supply and a tubular system of sewerage and house-drainage, the whole of the annoyance now experienced by the public from defective drains and sewers may be made to cease. The greater part of the duties of the officers of sewers is taken up by attending to complaints of the stoppage of drains and sewers, and in superintending the removal of the soil. Now, with such a system of sewerage and house-drainage as I recommend, nearly the whole of the duties in this respect will cease. I apprehend that it would be far better for a staff of officers to be constantly engaged in making examinations in order to prevent filth from depositing and accumulating, than to wait for it to collect, and so annoy the public with its noxious emanations, perhaps for weeks and months, before complaint is made and steps are taken to remove the evil. The public, who pay rates for paving, sewerage, water, and lighting, have a right to expect that their health and comfort are cared for, that the money is expended frugally, and that both the works and the management are carried on in a scientific and systematic manner. To this end, therefore, I am of opinion that the supply of water and of gas, the sewerage, and the paving, of the entire metropolis, should be under the direction and control of one administrative Board of Health, and that the metropolis should then be divided into districts, with a proper staff of officers on each district, which officers should receive their instructions from, and be responsible to, that body; and that one rate should be levied for the whole of these purposes on the entire property of the metropolis. I have no hesitation in saying that a saving would thus be effected greatly exceeding one-half of the present expenditure. This plan is a comprehensive one certainly; but I see no practical difficulty in the way of its realization, and of its being conducted with harmony, economy, and efficiency.

Have you seen sewers keep themselves clean, where constant currents have been running in them?—Yes, I have. I am of opinion, that if constant currents of water be carried through the drains and sewers, though the currents may be small, yet provided they be constant and concentrated on very narrow and smooth bottoms, they will keep the sewers clean. Where the supply is intermittent, the matter discharged from the house-drains, meeting with no current, accumulates. Hence it is necessary to have the sewers large enough for men to pass through them with tackle, shovels, wheel-barrows, and pails, to remove these accumulations, which the intermittent supply of water is not strong enough to remove. In order to prevent deposit in drains and sewers, there must be a certain degree of velocity and force given to each current, so as to produce agitation equal to, or rather greater than the *vis inertiæ*, or weight, mass, figure, and superficies, of the sand, silt, mud, and other substances, to be lifted, and kept always moving, or united and incorporated with the running water, added to the friction of the

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bottom and sides of the channel. The chance of any sewer keeping itself clean is dependent on four things,—namely, its capacity, its form, its fall, and the quantity and force of the water running through it. It is only from observation and experience, and the application of rules deduced therefrom, to the proportioning the capacity, the form, and the fall, as also the quantity and force of water requisite to prevent deposit, that we can hope to arrive at perfection in sewerage. From observation and experiment, I find that it requires a constant velocity of current to be running through the sewers equal to about 2½ feet per second, or 1¾ mile per hour, to prevent the soil from depositing within them.

Have you made use of flushing in the cleansing of the sewers in your district?—Yes, I have partially. I have ordered the lighter and more fluid portion of the soil to be eluted and washed away in the streams, and the heavier matter, such as stones, rubbish, sand, &c., to be lifted to the surface and carted away. I knew that if these substances were washed away in the sewers in the western division, they would deposit along the channel of the main sewer between Buckingham Palace and the river, and there have to be lifted or cast out.

Would you think it necessary to make use of flushing for a tubular system of sewerage with constant supplies of water?—I should be obliged to do so only in places where I could not get sufficient fall for the currents to keep the sewers clean. In such situations the sewers would require to be made somewhat larger than where they keep themselves clean, as the flow would be more sluggish.

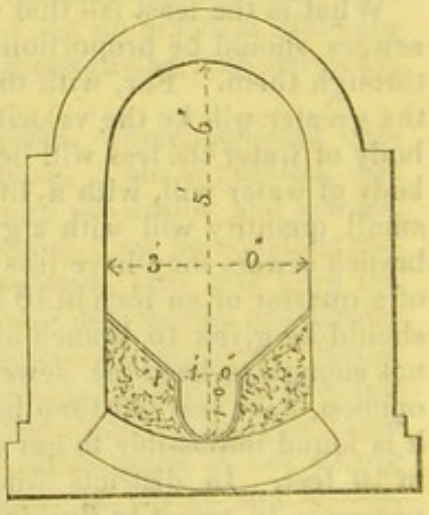
Have you paid attention to the flow of water in the sewers?—Yes, I have. There is less water running in the sewers on Sundays than on other days of the week; and most on Saturdays. The height of the flow every day goes on increasing from an early hour in the morning until about noon, when it is highest; it then gradually subsides to its lowest level. The period of the greatest flow every day is between 11 A. M. and 1 P. M.

What is the least fall that should be given to a sewer?—The fall of sewers should be proportioned to the quantity of water that is to pass through them. For, with the same fall, the greater the body of water the greater will be the velocity and scour; and conversely, the less the body of water the less will be the velocity and scour. Again, a large body of water will, with a little fall, run with the same velocity as a small quantity will with a great fall. Hence the recipient of many branch sewers may have less fall than the branches themselves. A fall of a quarter of an inch in 10 feet has been considered the least fall that should be given to branch and summit-level sewers; but this fall is not enough to keep the sewers clean. No such sewers should, in my opinion, have less fall than half an inch in 10 feet. In some districts it is found impossible to get even so much fall as a quarter of an inch in 10 feet. In districts where proper fall cannot be obtained, it is necessary to resort to flushing to keep the sewers free of deposit and clean. When a main stream receives a branch stream, the united body of water causes the height of the main stream to increase, consequently the surface rises somewhat higher than the surface of the divided streams; hence the water flows back, producing deposits of heavy substances about the junctions, which deposits draw back and impede the

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flow of the two streams. Now, in order to remedy this evil, the bottom of the main sewer, immediately below the junctions, should be made some inches deeper than the bottoms above the junctions. By this mode of forming the bottoms, the surface of the main and branch streams will have a uniform inclination, and the acceleration of this fall will prevent regurgitation and deposit, and the united streams will flow onwards with increased speed. In order to determine the depths below the junctions, it is necessary to calculate what height the body of water falling from the branches will increase the stream in the main. The capacity of the united stream is very much less than the sum of the capacities of the divided streams, and the velocity in the former is considerably greater than in either of the latter. The ratio of increase of velocity follows the ratio of decrease of capacity. It follows, therefore, that a gradually accelerating velocity takes place immediately below the confluence of the sewers throughout the ramified system, from their sources to their outfalls, and such I have found to be the case.

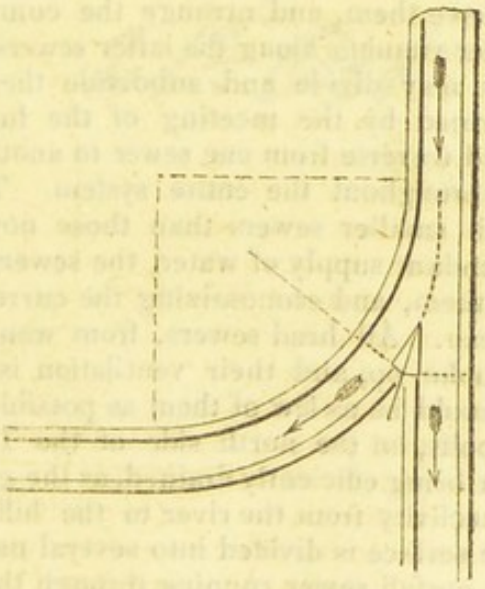
What size of ordinary or constant current—that is to say, a current independent of rain, would suffice to keep cleansed an ordinary-sized sewer?—I take my data from practical experience and observation rather than from theory or calculation. In passing through the sewers, I have observed that the currents of water running through very many of the branch and collateral sewers were mere dribbles, and that from being diffused over a large flat surface, they were not of sufficient strength to remove the soil. Looking at these currents, and comparing them with the extraordinary sizes of the sewers, I should say such currents might be passed through pipes, varying from 3 to 9 inches in diameter. In a large number of the sewers, the currents have cut narrow and deep channels through the soil, and by so doing, it appeared to me that nature was endeavouring to correct the faults of art. I think it would be desirable to take a lesson from nature in this respect, and form the bottoms of all the sewers which have a tendency to choke up, in accordance with the following sketch. It has sometimes been the practice to cut similar channels through the soil for the drainage to run through, and they have acted for a time very well indeed, so well as to give me entire confidence in the working of narrow and reduced sizes of sewers. I propose to bed channel-tiles, of various diameters, along the bottoms of the sewers, and fill-in behind them with concrete. I am satisfied that if the currents could be doubled in quantity, concontrated on smaller-sized channels, similar in form to the annexed sketch, and kept regularly in action, most of the sewers would keep themselves clean by this means. Egg-shaped sewers, varying in capacity according to the area, the number of houses to be drained, and the quantity of water to be discharged, from 9 inches wide by 1 foot 3 inches high, to 1 foot 6 inches wide by 2 feet 6 inches high, would suffice for sewers on summit levels, and also for branch or collateral sewers which had to receive the



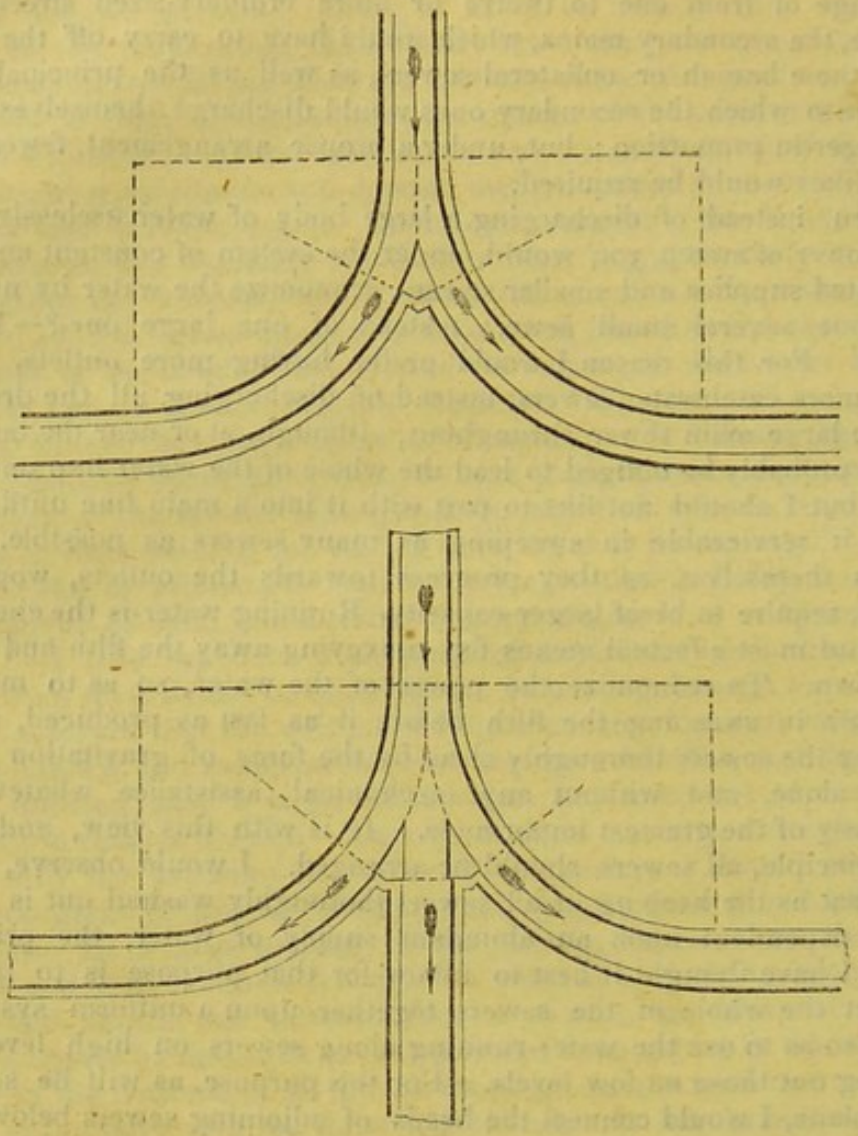
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drainage of from one to twelve or more ordinary-sized streets. Of course, the secondary mains, which would have to carry off the water from these branch or collateral sewers, as well as the principal main lines into which the secondary ones would discharge themselves, must be larger in proportion; but, under a proper arrangement, fewer principal lines would be required.

Then, instead of discharging a large body of water uselessly, as to any power of sweep, you would, under the system of constant and concentrated supplies and smaller sewers, economize the water by using it to scour several small sewers instead of one large one?—Yes, I would. For this reason I would prefer having more outlets, or, at least, more catchwater sewers, instead of discharging all the drainage by one large main sewer throughout, although, at or near the outlet, I might probably be obliged to lead the whole of the water into one main line; but I should not like to part with it into a main line until I had made it serviceable in sweeping as many sewers as possible. The sewers themselves, as they progress towards the outlets, would, of course, require to be of larger capacity. Running water is the cheapest, best, and most effectual means for conveying away the filth and refuse of a town. To economize the power of the water, so as to make it available in sweeping the filth before it as fast as produced, and in keeping the sewers thoroughly clean by the force of gravitation of the water alone, and without any mechanical assistance whatever, is obviously of the greatest importance. It is with this view, and upon this principle, all sewers should be arranged. I would observe, therefore, that as the keeping of all sewers thoroughly washed out is necessarily dependent upon an abundant supply of water, the principle which I have thought it best to follow for that purpose is to tie and connect the whole of the sewers together upon a uniform system of levels, so as to use the water running along sewers on high levels for washing out those on low levels. For this purpose, as will be seen by these plans, I would connect the heads of adjoining sewers below with



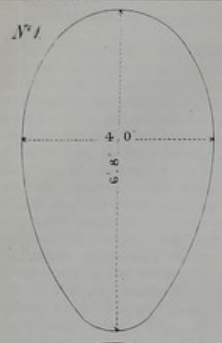
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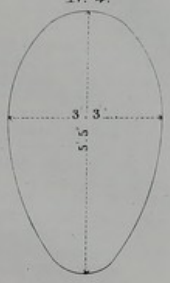


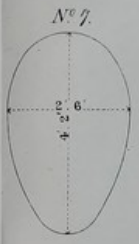
the superior sewers above them, and arrange the connexions so that, as the currents of water running along the latter sewers arrive opposite the connexions, they may divide and subdivide themselves by the ridges or groynes formed by the meeting of the inverts. By this means the water would traverse from one sewer to another, and so keep up a perpetual flow throughout the entire system. There can be no doubt, that with much smaller sewers than those now in use, and a more regular and abundant supply of water, the sewers would, by this system of arranging them, and economizing the currents, keep themselves thoroughly clean. All head sewers, from want of backwater have a tendency to choke up, and their ventilation is also very bad, consequently there should be as few of them as possible. The general surface of the metropolis, on the north side of the Thames, is most admirably situated for being efficiently drained, as the ground continues to rise with an easy acclivity from the river to the hills some miles to the northward. The surface is divided into several natural areas, each of which has its main outfall sewer running through the lowest level of the valley, and discharging into the Thames, and into these main or valley sewers the whole of the sewers on the sides of the declivities dis-

Graduated Series of Outlines of Sewers
for a District in which the Supply of Water and the Drainage
are under the same Authority.

(Thicknesses dependant upon Material and Strata.)

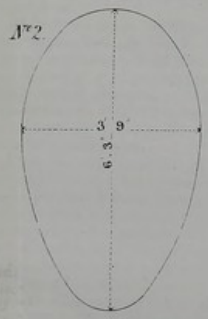


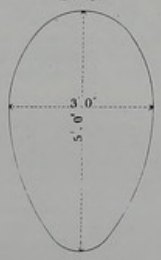








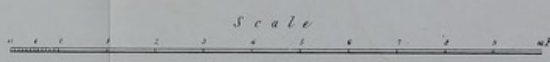




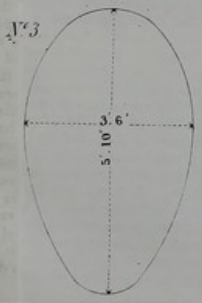


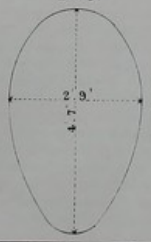






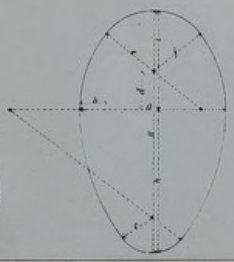
John Phillips
21st Oct: 1847.











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charge themselves. This mode of drainage is a very objectionable one, and should never be resorted to if it be possible to avoid it. The declivities of all natural areas are generally in two directions, namely, transversely towards the valley line, and longitudinally towards the outfall. Now, if attention be paid to the levels, and the sewers on the sides of the declivities be judiciously arranged, a perpetual circulation of water may be kept flowing throughout the whole of them from the sewer on the summit at the head of the natural area to the outfall in the river; that is to say, a system of collateral or concentric sewers should rise one above another from the valley line to the ridge or water-shed line of the district; each collateral sewer skirting the entire area, and discharging itself into the river by a separate outlet, or in the manner previously referred to. It will be seen that, when the sewers running transversely are connected at their upper and lower ends on the same levels with those running longitudinally, a facility is afforded for the drainage to circulate from the highest sewer to the one immediately below, from this to the one next lowest, and so on throughout.

Would you make the sizes of all your sewers large enough for a man to pass through them?—I should be obliged to do so under the present regulations of an intermittent supply of water; but if I had the control of a proper supply of water, as well as of the sewers, I could reduce the sizes of the sewers very considerably, because I should then be able to arrange them in combination with the water, so as to keep up a continuous current throughout them, and so keep them in proper action.

Then for the present brick sewers you would substitute tubular sewers?—For the branch sewers I would substitute small egg-shaped pipes, provided I could have a control over a supply of water. I beg leave to hand in these sections (*see* annexed plate), showing graduated forms of branch secondary and principal main lines of sewers, which I would make use of for the drainage of a district in which the sewers and the water supply were under one and the same authority.

What would be the economy of the system of the smaller collateral sewers?—The cost of the first class upright-sided sewer three or four years ago in the Westminster Commission was about 22*s.* 6*d.* per foot run. It has already been reduced more than one-third by the use of my forms, and ordinarily costs about 14*s.* 2*d.* per foot run; but I am sure that it could be again reduced to more than one-half of the present cost, namely, to 7*s.* per foot run as the average cost of the larger class of branch sewers, including every expense; and the smaller ones would, of course, be proportionably cheaper still, namely, to 6*s.* 4*d.*, 5*s.* 7*d.*, 5*s.* 3*d.*, 4*s.* 6*d.*, and 4*s.* per foot run. Indeed, after much opposition, I have succeeded in inducing the Court to build nearly half a mile of sewer at Kensington, 2 feet 3 inches wide by 3 feet 9 inches high in the clear, and half-brick thick, at an average depth of nearly 15 feet, for a fraction under 7*s.* per foot run, including all expenses; and I should be much gratified if the Commissioners present would do me the favour to inspect the works, which are now in hand. I could not, however, recommend the Court to allow private builders to execute sewers of half brick in thickness. If these low prices are to be generally adopted, the building of all sewers must be by public contract, and the

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work executed under the immediate direction and control of the Commissioners. Much caution is required in the building of sewers in a clayey soil; otherwise, from the treacherous character of this ground,—its liability to expand and slip,—the sewers may be forced in. The thickness of a sewer should be proportioned to the nature of the ground and the pressure it has to bear; but its stability is very much dependent on the goodness of the workmanship. A half-brick sewer, under ordinary circumstances, will, if executed well and soundly, the joints made thin, and the sewer worked true to the curve, be quite strong enough, and would be found to answer every required purpose. The equilibration may be altogether destroyed by a want of uniformity in the working of the curve. The greatest pressure of the ground acts laterally from the sides downwards. Much of this pressure may be prevented by leaving in the trench, from the surface downwards, short lengths of earth, say of 10 to 20 feet, and about 50 to 80 feet apart, to be tunnelled through for the sewer to pass. These benchings, as they are termed, will keep the sides of the trench from sinking and slipping, and so from pressing against the sides of the sewer.

Why would you not entrust the building of these half-brick sewers to private builders?—Because they execute their work generally in a very careless manner, as they know that when the sewers are once finished the care of them lies with the Commissioners, and any subsequent reparation falls upon the public, so that they are not interested either in the good quality or stability of their work.

Taking the case you have mentioned of the half-brick sewer at 7*s.* per foot run at Kensington, will not the first effect of the adoption of a tubular or pipe system of sewerage, with smooth glazed surfaces, be to diminish the friction, perhaps even one-third, and so to increase the flow?—The smoother the surface the less will be the friction, and, consequently, the greater will be the velocity and discharge; and the friction in a glazed pipe must be considerably less than in a brick drain, as commonly built. I am not prepared to say that the friction would be diminished so much as one-third; I think not so much. The smoothest glass pipes throw off transverse motions, which greatly impede the flow. There is a difference in the flow of pure clean water and of sewage water; the latter moves more sluggishly. This is caused by its being *thicker* and more viscid, from having matter chemically combined and mechanically suspended in it.

Supposing, then, that you have no increase of run of water, would you not, with a tubular system of sewerage, be enabled to reduce the sizes of drains and sewers perhaps to nearly one-third, taking into account the effect of increased velocity?—As the velocity increases, so does the transverse section of the area occupied by the stream decrease. This is a natural law, observable in all moving streams, for we see that in a moving mass of water the discharge is the same, whatever form and size the channel may assume, the velocity being greater where the channel is narrow and deep, and less where it is wide, flat, and irregular; but the exact ratio of decrease of area, from decrease of friction and increase of flow, can only be determined by actual experiment, and by taking into account all the attendant circumstances which influence and govern the motion of the stream.

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It is, of course, important for the whole subject of drainage and sewerage that experiments should be made at once before going further into the arrangement and construction of drains and sewers?—It is of the utmost importance that it should be so. It is a subject which I have long wished to take up, but have not had time to go thoroughly into. Notwithstanding all the experiments that have been made by mathematicians, and the data and formulæ which they have deduced therefrom, we have not at the present time sufficient information from which to plan and work with confidence and accuracy in regard to sewerage. The facts that have come under my observation and experience show that theoretical writers on hydrodynamics are, in some degree, in error in supposing that the velocities and discharges of streams vary directly as the greater or less extent of the frictional surfaces in contact with them. There can be no doubt, however, that the ratio of velocity and discharge is much dependent on the greater or less extent of the surface of contact; but, from what I have observed in the sewers, the effect of the variation of velocity and discharge is not wholly caused by friction. The impeding influence of the bottom and sides of the channel to the motion of *large* bodies of water, is very little indeed, and I think the velocity does not depend directly on the extent of rubbing surface, as compared with the volume of water. In proportion as the quantity of water increases at each confluence, from the source to the outlet, so does the velocity increase. And I think it will be found, on experiment being made, that the ratio of increase of velocity is not wholly governed by the extent of frictional surface. This is a point well worth ascertaining. *The sole cause of the pressure and motion of a stream is the inclination of its surface, or the force of gravity.* If there be a body of water, whose motion has become uniform in any river or water-course, whatever form and width the channel may be of, it is evident that there must be equal discharges at every section in equal periods of time, or else the stream could not go on; and the velocity will vary inversely as the area of each section. Those whose have experimented on this subject state, that the depth will be the same at every part of the stream, and the inclination of the surface will be equal to or parallel with the inclination of the bed. The quantity of water running through any number of dissimilar sections, a, b, c, &c., with the velocity v, in any given time, is manifestly equal, for $a \times v = b \times v = c \times v$, or the quantity passing through each section is constant, therefore the height of the stream being parallel with the bed, it is obvious that, in proportion as the area at any part increases, the velocity through each section decreases in inverse proportion. In our district we have sewers of the egg shape with the narrow end down, with the broad end down, and with the nearly flat bottom, sometimes all three of them joining on to the end of each other. Now, I have repeatedly observed that, with the same body of water and the same inclination, the height of the stream was parallel with the channel, and the velocity in the first form was much more rapid, and the deposit considerably less than in the second form, and still more so than in the last form. Those who say that the segmental and semicircular bottomed sewers are best, reason upon the supposition that all

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the sewers are always either full or three parts full of running water, when the fact is, that the streams, in 19-20ths of them at any time, are mere dribbles. Hence the error in providing for an occurrence that never happens, and so making the bottoms broad and capacious, whereby the slight flow becomes spread over a large surface, and deposit ensues. I speak of the streams in sewers, and not of water ponded up in them in low districts.

How soon do you think experiments might be made, and rules laid down from them, to determine the questions approximately for practical purposes?—It would mainly depend on the persons making experiments, and on the mode in which the experiments were conducted, but I have no doubt that, with exclusive attention to the subject, sufficiently practical data might be established in a few weeks.

Have you gauged the depth of the water flowing in the sewers?—Yes, I have done so on numerous occasions. I beg to submit these sections. The first figure shows the depth of the ordinary flow in the upright-sided first-class sewer in High-street, St. Giles's, draining about 90 acres of urban or covered town district, and of the greatest height of the flow during very violent storms; the second figure shows the ordinary and the storm flow in the same form of second-class branch and summit-level sewers, draining from one to three moderate-sized streets; the third figure shows the same quantities of water draining from the large surface concentrated in the present first-class sewer; and the fourth figure, the same quantities draining from the small area of surface concentrated in the second-class sewer now in use. It will be seen that in the case of the main branch sewers, draining large areas of town district, they are nearly double the size that they need be; and in the case of the sewers draining from one to three streets, they are at least seven and ten times larger than is absolutely required. I should state, that the average fall of the first-named sewers so draining is equal to half an inch in 10 feet.

Fig. 1.

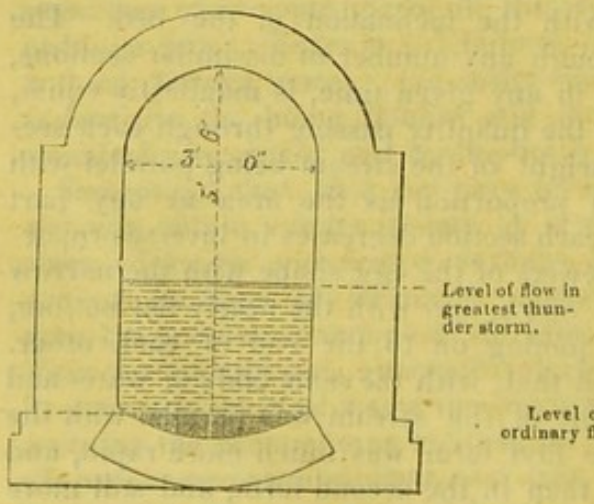
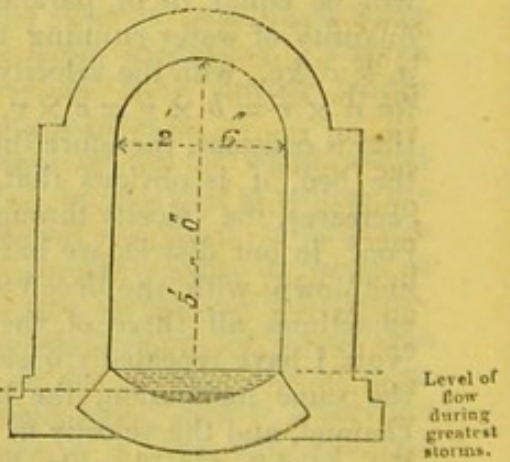
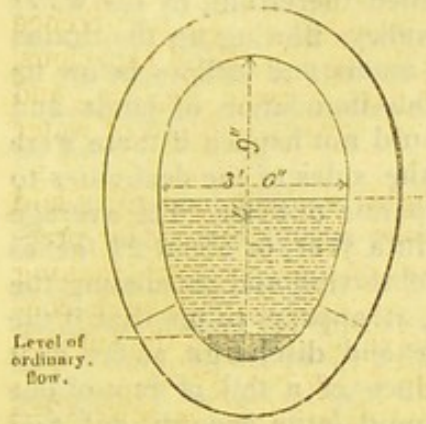


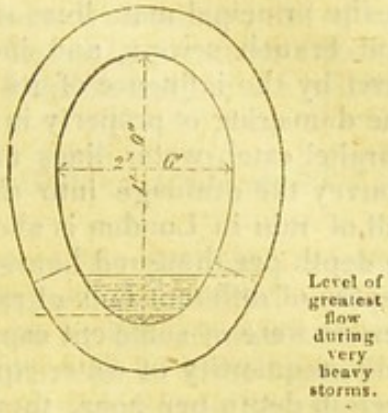
Fig. 2.



Main Sewer of the egg shape.
Fig. 3.



Collateral Sewer of the egg shape.
Fig. 4.



Have you at all considered the capacities of sewers necessary for draining different areas of ground?—Yes, I have given the subject much attention. If the consideration of the sizes of sewers was confined solely to the carrying off the water supplied by the several water companies, then I apprehend that pipes somewhat larger in size than the supply-pipes themselves would suffice; but provision has to be made for receiving and conveying away the waters of heavy rains. In London continuous heavy falls of rain are not of long duration, lasting seldom more than from one to four hours. About one-fifth of the quantity that falls is absorbed partly by the dryness of the surface of the roofs, the paving, and the ground, and partly by the porosity of the ground itself. A farther proportion is also prevented from flowing to the drains and sewers at all by hollows in the surface, and again re-ascends into the atmosphere as vapour. There is also a small quantity that enters into the composition of animal and vegetable bodies. Then there is the resistance the flow experiences from the friction of the entire surface, being accelerated or detained in proportion as the surface is more or less inclined. To provide for the discharge of a fall of rain of two inches in depth has been considered by Mr. Hawksley, C.E., the extreme datum upon which to proportion the capacities of town sewers generally. Now I believe that, practically, the sizes in his table, although they may appear theoretically correct, are (excepting for the smallest sizes) too large for sewers in London. It is extremely violent rains alone that produce a depth of two inches per hour, and such rains occur only once in four or five years, if so much. I am of opinion that it is unnecessary to proportion the sizes of the sewers to meet an extraordinary occurrence that may probably happen only once in so many years. My reason for not fearing any serious damage from an excess of rain at remote intervals being provided for in surface channels, excepting, perhaps, in situations peculiarly liable to inundation (for instance, at the foot of a long or steep declivity, or where the waters may, from any cause, be suddenly congregated at one focus) is, that I have observed, that in towns entirely destitute of underground drains, no such inconvenience is felt as would justify the formation of enormously large sewers, or the expenditure of large sums of money to provide against it. In August, 1846, a most extraordinary fall of rain occurred in London. The storm lasted nearly two hours, and from the

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best information I have been able to obtain, the depth of rain amounted to about four inches. Much damage resulted therefrom, by the water in the principal main lines situate in the valleys flowing up the drains and branch sewers, and inundating the rooms and cellars below its level by the influence of its pressure. The inundation of lands and the damaging of property in the valleys could not happen if there were parallel catch-water lines of sewers on the sides of the declivities to convey the drainage into the river by separate outlets. The average fall of rain in London is about 22 inches in a year, or about $2\frac{1}{2}$ inches in depth per thousand hours. Now after observing and calculating the depths of different falls of rain in London, it appears to me that if the sewers were of sufficient capacity to receive and discharge, as fast as it falls, a quantity of water equal to the produce of a fall of rain of one inch in depth per hour, they would be found large enough, and that more particularly if they were built on the intercepting or catch-water principle, and so as to communicate with each other, and all be filled with running water at the same time. The steps to be taken to proportion the capacities of sewers to receive and convey away the waters of heavy rains should, I think, be as follow, although I fully admit our present knowledge of the subject to be very elementary:—To ascertain the number of superficial yards or acres to be drained by each sewer separately; progressing in a uniform gradation from the entire natural area to be drained by the largest outfall sewer, to the small tract of land to be drained by the least sewer on the summit. Taking the hourly fall of rain, therefore, upon one acre at one inch in depth, we must provide for the discharge of a quantity of water $(\frac{43560}{12}) = 3630$ cubic feet per hour, or one cubic foot nearly per acre per second. Then taking into account the loss from absorption, the detention from friction, and otherwise, that quantity might be reduced to four-fifths of a cubic foot, but as the carrying off the waste water of the entire of London must be provided for at the same time, one cubic foot may, I think, be considered as the datum upon which to calculate the capacities of sewers sufficient for conveying away that quantity of water per second multiplied by the number of acres to be drained. The quantity of rain-water draining from an acre of ground in one second of time may be determined by first ascertaining the exact area of surface drained by some large main sewer; and, secondly, during the time of the storm, the quantity of water passing through the sewer in one second; then the number of cubic feet of water discharged, divided by the number of acres drained, will give the number of cubic feet of rain draining from the surface of each acre per second.

The velocity of the stream may be ascertained, if the section be uniform in any considerable portion of its length, by *timing* the *distance* a light floating body would pass over in a given time, as for instance, in one second. Let d be the distance described in t seconds, and v the velocity at the surface of the current, then $\frac{d}{t} = v$ the velocity. Thus if a floating substance be thrown into the stream, and it be carried over a space of 200 feet, or 2400 inches in 60 seconds, the velocity at the surface will be $(\frac{2400}{60}) = 40$ inches per second, or 3·33 feet. But the velocity is greatest at the surface in the middle of the stream, and least at the sides and bottom; and the *mean* velocity of the vertical section

is equal to half the sum of the surface and bottom velocities. Then, according to Du Buat, to find the bottom velocity, subtract 1·03 from the square root of the surface velocity, expressed in inches, the square of the remainder is the bottom velocity. Let m be the mean velocity, v the velocity at the surface as before, and b the velocity at the bottom, we have

$b = (\sqrt{v} - 1{\cdot}03)^2 = (\sqrt{40} - 1{\cdot}03)^2 = (6{\cdot}32 - 1{\cdot}03)^2 = 5{\cdot}29^2 =$ 27·98 inches the bottom velocity; and

$m = \frac{1}{2}(v + b) = \frac{1}{2}(40 + 27{\cdot}98) = 33{\cdot}99$ inches the mean velocity. Brünings makes the mean velocity $m = \frac{9}{10}$ths v the superficial velocity; and Prony makes $m = 0{\cdot}82\ v$, or $m = \frac{4}{5}$ths v; but all who have experimented on this subject differ in the results. Then if the transverse area of the vertical section of the stream at this part be ascertained, and multiplied by the mean velocity, the product will be the number of cubic feet of water discharged per second through the section.

The most accurate method, however, of ascertaining the quantity of water discharged in a second is by gauging the height of the flow passing through a thin rectangular opening, in a dam or waste board fixed across the outlet. The top of the dam must be raised as high as possible in order that the force of the running stream may be expended in the reservoir formed by the dam before it arrives at the opening. The edges of the opening should be made sharp; for this purpose I cut a perfectly rectangular hole, 12 inches wide by 18 inches high, in a plate of thin sheet iron, and file the edges quite sharp; I then fasten this frame inside the aperture made in the boarded dam, which aperture should be bevelled externally. The longitudinal surface of the stream as it issues through the opening takes the curve of a parabola, whose area is equal to two-thirds of its circumscribing rectangle; so that *the number of cubic feet of water discharged in a second over a wasteboard may be found, by taking two-thirds of the product of the square root of the height of the stream multiplied by* 5·1 (*the co-efficient of the velocity for contraction*), *and this product by the transverse area of the stream at the opening.* Call h the height from the lip of the opening to the surface of the water, equal to 1½ feet, w the width of the opening, equal to 1 foot, q the quantity of water discharged per second, the co-efficient for contraction being 5·1, we have

$$q = \tfrac{2}{3}\ (\sqrt{h} \times 5{\cdot}1) \times h\ w$$

$= \frac{2}{3}\ (\sqrt{1{\cdot}5} \times 5{\cdot}1) \times 1{\cdot}5 \times 1{\cdot}0 = \frac{2}{3}\ (1{\cdot}22 \times 5{\cdot}1) \times 1{\cdot}5 \times 1{\cdot}0$
$= 4{\cdot}148 \times 1{\cdot}5 \times 1{\cdot}0 = 6{\cdot}222$ cubic feet of water discharged in a second, or 373·32 cubic feet in a minute.

The following formula may also be used for calculating the discharge over a wasteboard:—

$$q = \sqrt{h^3} \times 11\tfrac{1}{2} \times w, \text{ or in words,}$$

multiply the square root of the cube of the depth (*all the dimensions being in inches*) *by* 11½, *and by the length of the wasteboard, the product will be the cubic inches of water discharged per second.*

It is supposed that the discharge by either of the foregoing formula is from a perfectly stagnant reservoir; should, however, the water

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reach the opening with any velocity, the area of the section must be multiplied by the mean velocity of the stream.

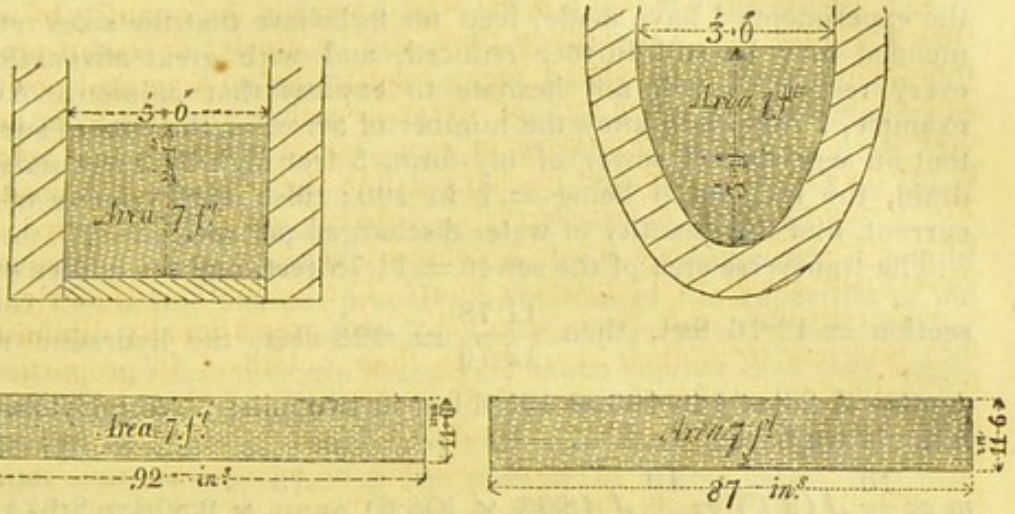
The area of surface that a sewer will drain, and the quantity of water that it will discharge in a given time, will be greater or less in proportion as the channel is inclined from a horizontal to a vertical position. The ordinary or common run of water in each sewer, due from house drainage alone, and irrespective of rain, should have sufficient velocity to prevent the usual matter discharged into the sewer from depositing. For this purpose it is necessary, as I have previously observed, that there should be in each sewer a constant velocity of current equal to $2\frac{1}{2}$ feet per second, or $1\frac{3}{4}$ mile per hour. The inclinations of all rivulets, brooks, streams, and rivers gradually and proportionally diminish as they progress from their sources to their outfalls. In proportion as the inclinations diminish so does the quantity of water increase. If the inclinations were the same throughout, the velocity of the united stream at each confluence would increase in nearly the same ratio as its quantity, or equal to the sum of the previous velocities of the recipient and the feeder, and thus would the velocity ultimately become so very impetuous as to tear up and sweep away the materials of its bed, and cause destruction along its banks. If the force of the waters of the river Rhone were not absorbed by the operation of some constant retardation in its course, the stream would have shot into the Bay of Marseilles with the tremendous velocity of 240 feet in a second, or 164 miles every hour; and even if the river Thames met with no system of impediments in its course, the stream would have rushed into the sea with a velocity of 80 feet per second, or $54\frac{1}{2}$ miles in an hour. The result, however, of the operations of nature is a compensation for the increased body of water by a diminution of the inclination of the bed, and so an economizing of the force of the gradually accumulating current. The inclinations of the sewers of a natural district should be made to diminish from their heads to their outfalls in a corresponding ratio of progression, so that as the body of water is increased at each confluence, one and the same velocity and force of current may be kept up throughout the whole of them.

All calculations respecting the flow of water in rivers and open water-courses are based on the proposition that *the mean velocity is uniform when the resistance arising from the friction of the channel is equal to the accelerating force which gives it motion.* The authors on this subject state that the resistance for any given quantity of water in motion will vary *directly* as the extent of the border in contact with the stream, and *inversely* as the transverse area occupied by the stream.

Calling the area a, and the border e, $\frac{a}{e} = d$, the hydraulic mean depth.

Then, by taking the bottoms of two sewers of the same width, but of different forms, and having equal transverse areas, the amount of friction in each bottom will be directly as the bases, and inversely as the heights, of the rectangular parallelograms obtained by $\frac{a}{e}$, viz., the friction in the square bottom will be $= 92$, and in the elliptical bottom it will be $= 87$, and inversely as the hydraulic mean depth, in the

former = 110, and in the latter = 116. Hence the superiority of a deeply curved to a square channel for the bottom of a sewer.



According to Eytelwein, *the mean velocity in a second of any river or watercourse flowing through a straight and uniform channel is equal to* $\frac{10}{11}$*ths of a mean proportional between the hydraulic mean depth and the fall in two English miles.* From this simple theorem may be deduced the velocity of the current from the fall, and the fall from the velocity, as also of the different areas of surface which a sewer, having the same capacity but with varying inclinations, will effectually drain. The formula from which the foregoing rule is deduced is as follows:—

$$m = \frac{10}{11}\sqrt{(df)}$$

in which d is the hydraulic mean depth as before, and f *the fall in two miles.* Sir John Leslie's formula for computing the velocity of a stream is also very simple. Let the slope be the nth part of the distance, and d the hydraulic mean depth; then $100\sqrt{\frac{d}{n}}$ will express the resulting velocity in feet per second. Hence if the declivity were one part in ten thousand, the velocity would be as the square root of the hydraulic mean depth ($\sqrt{d}$). Let f denote the fall *in feet each mile,* and the formula will change into

$$m = \frac{100}{\sqrt{5280}}\sqrt{(df)} = \frac{11}{18}\sqrt{(df)}.$$

Hence the mean velocity, reckoning in miles per hour, is expressed by

$$m = \frac{11}{18}\cdot\frac{15}{22}\sqrt{(df)} = \frac{15}{16}\sqrt{(df)}.$$

He states that this result is quite conformable to actual observation. From this formula we deduce the following rule:—*Multiply the hydraulic mean depth of a stream by the declivity in a mile, both in feet, and extract the square root of the product; the result, diminished by* $\frac{1}{16}$*th part, will be the mean velocity of a stream in miles per hour.* Now the above are the very best data which, after much anxious search and many inquiries, I have been able to collect, and it may appear to

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be an act of presumption to question them; but these are all, or most of them, theoretical, or have reference only to the natural and not to the artificial discharge of waters; but as my observation of facts, and the experiments I have made, lead me to believe that the sizes recommended may be still further reduced, and with great advantage in every respect, I will not hesitate to express that opinion. As an example, I require to know the number of acres, or the area of surface, that an egg-shaped sewer of my form, 5 feet high by 3 feet wide will drain, the inclination being = 1 in 100; also the velocity of the current, and the quantity of water discharged per second.

The transverse area of the sewer = 11·78 feet, and the border of the section = 12·76 feet, then $\frac{11\cdot78}{12\cdot76} = \cdot923$ feet, the hydraulic mean depth. A fall of 1 in 100 = 105·6 feet in two miles; ∴ by Eytelwein's formula we have

$$m = \frac{10}{11}\sqrt{(df)} = \frac{10}{11}\sqrt{(\cdot923 \times 105\cdot6)} = \frac{10}{11} \times 9\cdot872 = 8\cdot974 \text{ feet},$$

the mean velocity in a second; and by Leslie's formula,

$$m = \frac{15}{16}\sqrt{(df)} = \frac{15}{16}\sqrt{(\cdot923 \times 52\cdot8)} = \frac{15}{16} \times 6\cdot98 = 6\cdot494$$

miles per hour; and in feet per second

$$= \frac{6\cdot494 \times 5280}{60 \times 60}\ 9\cdot52,$$

Putting c = the number of cubic feet of water discharging per second, and s = the number of acres or area of surface draining by the sewer, we have $a\ m = c, = s$, or, by the latter formula, 11·78 × 9·52 = 112·14 cubic feet of water discharging per second, and also 112·14 acres draining, because (as we have already deduced) there is one cubic foot of rain draining from each acre of ground per second. Now, in practice, I find many instances of sewers with the same capacity and fall, and offering a much greater frictional surface, yet discharging, year after year, the concentrated drainage of a very much larger area of surface, and such sewers being never more than half full of running water; in fact, absurdly large as practice demonstrates the present sewers to be, these theories would make them larger. I have sometimes found the velocity and discharge of water through sewers much greater than the foregoing formulæ would give. I have no hesitation in saying that a sewer 5 feet high by 3 feet wide, with a fall of 1·20 inch in 10 feet, or 1 in 100, will effectually drain 200 acres of town area.

You have recently built in your district a main sewer along Berwick-street and Wells-street, Marylebone, for the drainage of All Souls' district?—Yes.

What is the transverse area of that sewer, its rate of inclination, and the number of acres draining into it?—The transverse area is 11¼ feet, the fall is 2½ inches in 100 feet, or 1 in 480, and the number of acres is about 130.

Are you quite sure that the sewer you have put in is of sufficient capacity for draining that area?—I am confident of it; indeed, I am not sure that it is not too large. Referring to Mr. Hawksley's Table, I

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find that a sewer of rather larger capacity, with the same fall, will drain only 33¼ acres; and according to the same table, it appears that the sewer should be 7 feet diameter, or 3½ times larger than the one built. I have plans prepared for re-building 2650 feet of the King's Scholars' Pond main sewer along Park-road, Regent's-park. I propose that the size of the sewer should be 6¼ feet diameter, the fall being 2½ inches in 100 feet, or 1 in 480, and the number of acres of town area to drain into it being about 500. Calculating from Mr. Hawksley's formulæ, I find, however, that the sewer should be about 14 feet diameter, or 5 times the capacity I propose it should be.

—According to the theories that have been promulgated, it would appear that nature has not properly proportioned the capacities of the beds of rivers to the area of surface and the quantity of water draining into them, and that they are hence very much smaller than they ought to be. But, on the contrary, we know that the economy of nature moderates all violence, and that it ever aims at an equilibrium. The greatest error in proportioning the sizes of the sewers arises from supposing so large a quantity of water as two inches in depth per hour flows into them from the surface, and also in supposing that the velocity is proportional to the extent of surface in contact with the stream. Art should aim at aiding and assisting nature. A perfect equality of action and reaction, and of proportion in the forms and capacities of a graduated system of sewers should be established in accordance with the progressive increase of the quantity and velocity of water flowing into them from the sources to the outfalls. Something like an approximation to accuracy in this respect may be arrived at by ascertaining the ratio between the capacities of rivers and the areas of surface draining into them. It is from viewing the discrepancies between the results of theories and formulæ which are laid down for our guide, and of what we actually know from practical experience, that makes me think it extremely desirable to commence at once an extensive range of experiments in the present sewers before going farther, in order to determine practical data and formulæ to work from.

It would appear that two, or even three districts of equal extent might be drained at the expense at which one now is, and that too very much more efficiently?—Yes, certainly.

Of course with the constant supply of water, and constant dilution of matters which decompose rapidly on exposure to the air, the emanations would be greatly reduced?—Yes; inasmuch as there would be less access of air and no time for the matters to decompose.

Under such a system, and with a constant supply of water, do you not think it would be practicable to remove all *fæces* from a town almost before they can have had time to decompose?—Most decidedly. The entire filth, in my opinion, would be carried off nearly as fast as produced.

Have you not observed that in a thunder-storm, in some of the town districts, there has been, during the first part of the shower, an increase of smell from the gully-shoots, and after the smell a remarkable freshness, or diminution of the ordinary smell in the atmosphere? Now, with a constant supply of water acting through smaller sewers, do you not believe that such occasional freshness of the atmosphere might be made constant?—In the ill-drained districts there is a heavy

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haziness about the atmosphere, as, for example, the lower and more densely populated part of the city of Westminster, and in many other ill-drained districts with which I am acquainted. I have always expressed my conviction that this evil may be remedied by a perfect system of house and street drainage; and, with the exception of the smoke and gas nuisances, such districts be rendered nearly as healthy as a suburban district. Now, as regards the city of Westminster, the greater part of the surface of which is below high-tide level, it is the worst-drained district which I know, yet it is capable of being drained almost as well as any other in London, and that, too, as regards the keeping of the sewers cleansed, without any supply of pipe-water. It is useless, however, to hope that the sewers of this low and flat district can keep themselves clean. It is absolutely essential, therefore, that a complete system of flushing should be adopted for that district. The river Thames is close at hand, and as much clean water as may be required for flushing can be obtained from that source alone. The construction of a main outfall sewer for the district and separate drainage of this district is a subject of the first consideration. Until this is done the interior drainage cannot be laid out so as to form a connected and efficient system. The drainage of the natural area by the King's Scholars' Pond main sewer, which, running along the lowest line of the valley and so descending from the high land into and through this low flat of land to the Thames, might have been all very well while the general surface was open fields, but as this surface became covered with streets and houses, the waters were gradually loaded more and more with filth and heavy matter constantly depositing along this low flat, and so the channel along this part is rendered wholly unfit for the new order of things. During the last 150 years this sewer through the low ground has been a perpetual source of trouble and expense from the overflowing of its banks and the constant choking up of its channel. The total sum of money that has been squandered on it must be enormous, at least 100,000*l.* has been expended on it during the present century; and even now it is expedient to intercept the upland waters by a catch-water sewer to be carried along the base of the high ground. A good and perfect outfall is the first object of consideration, especially through a low flat of land. It is quite impossible to preserve such an outfall if the natural drainage be prevented from passing off as it descends, and the channel be deprived of the scouring action of the tidal waters by sluices or flood-gates at the outlet, and they should never be permitted excepting for a district entirely below high-water mark. Indeed, experience proves that the bed of an outfall should be carried some feet under low-water level, the channel straightened, and the mouth left open for the free admission and discharge of the tidal and sewage waters. By carrying the outfalls of the sewers somewhat below the level of the lowest ebb, the constant flux and reflux of the tides will always keep the matters saturated, detached, and suspended, and so they will pass off. If there were no obstruction at the outlet of this sewer, the pressure of the downfall water would, at all times of the tide, and even if the sewer were full of tidal water, force its way outwards; and upon the receding of each tide the natural velocity and scour of both the tidal and sewage waters together would help to clean out and to sweep away the deposits, and so keep the channel clear and

open. It is my decided opinion that much advantage would result from the removal of the flood-gates which now obstruct the outlet.

But were you to do this, would not the lower floors and the low land under the level of high tide be in danger of inundation?—No, as I would take every precaution to prevent that by placing proper self-acting valves at the vents of all the drains and sewers discharging into it within the reach of the highest tide. Having maturely considered this subject, I am convinced that it would be a great improvement to the drainage; but even this is as nothing compared to the plan which I hope to see carried out for the entire and complete improvement of the drainage of the city of Westminster.

In what way do you propose to improve the drainage of the city of Westminster?—I have already said that the greater part of the surface of the city of Westminster is below high-tide level. The area of surface which I have more particularly in view, is bounded by the King's Scholars' Pond sewer to the west, by the River Thames to the east, and by the south side of St. James's Park and Whitehall to the north, and consists of about 700 acres of ground covered with streets, and a vast number of courts and blind alleys most densely populated. The ground from Charing Cross, Pall Mall, and the Green Park, rises very considerably to the northward. Nearly the whole of the drainage of the large and populous parishes of St. Marylebone, of St. George Hanover-square, of a portion of St. John Hampstead, and of the greater part of St. James Westminster, is conveyed away by the King's Scholars' Pond main sewer, which has its source at Hampstead, and, running through these parishes and this low flat of land, discharges itself into the Thames near Vauxhall Bridge. While the river-water is above its outlet, that is, during the space of five hours and six minutes in every twelve hours, the drainage is locked in. This sewer, therefore, may be considered the grand cesspool of the before-named parishes. Science on the one hand, public health and economy on the other, as also the great and beneficial use to which it might be applied, point out the necessity of diverting this sewer, by carrying it along the brow of the high land, so as to deliver the drainage quickly into the Thames at all hours of the tide, and thus intercept the upland drainage, and prevent it from flowing down upon the low land. Where an embanked district is under high-tide level, but little fall can be given to the sewers, and the drainage is obliged to be pent in them for several hours of each tide. The sewers of a low district require a far different treatment for keeping them cleansed than the sewers of a high district, where a good fall can be given to them, and the drainage can be constantly discharged. In the former case, from the stagnation of the drainage, while the tide is above the outlets of the sewers, deposit takes place; while in the latter case constant flow prevents deposit. The drainage of high lands should therefore be kept entirely separate from all lands below high-water mark. There are conditions which it is essential to observe in the arrangement of the drainage of some particular districts. The purification of the Thames water is a subject of the first consideration; to effect which an intercepting sewer must be made near to, and parallel with, the river, to deliver itself some distance below the town. It is quite practicable to carry out such a plan. After having diverted the King's Scholars' Pond sewer, I would convert that part of it be-

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tween Buckingham Palace and the river, about 7000 feet long and nearly 20 feet wide, into a grand reservoir of clean Thames water, instead of a reservoir of filth as at present. Its bottom along this part is from 5 to 8 feet above low-water mark. By making all the sewers between this reservoir and the river up to Whitehall communicate with each other and with the reservoir, upon a complete and uniform system of levels, keeping the outlets down to or near low-water level, there would be a fall throughout the entire system of sewers from the reservoir to the outlets; and, by allowing the tide to fill the reservoir when required, a body of water could be retained within it until the time of low tide; and upon the penstocks at the heads of all the sewers which communicate with the reservoir being lifted, the immense body of water would immediately flow down throughout the whole of the sewers with sufficient force to sweep away any deposit and accumulation that might be in them, and thus the entire sewerage of the city of Westminster would be kept in perfect condition. This operation might be repeated as often as desired; but once or twice a-week I should think would be sufficient for the purpose. In lieu, therefore, of the present miserable and defective drainage of this district, where filth abounds in almost every street, court, and alley, polluting earth and air around for a considerable distance, it is practicable to construct a judiciously arranged plan of drainage, whereby a profuse body of water may be made to flow—twice a-day if necessary—through the sewers, so as to sweep and carry all the filth and refuse before it.

Have you calculated the quantity of water that you could let run through the sewers from this reservoir?—Yes. Upwards of 500,000 cubic feet at one time.

Are there many streets and courts in Westminster without sewers?—There are a very great many that have never had any under-ground drainage whatever, but such as they have is effected by the surface drains. These places are at times so extremely filthy and offensive as to render them quite unfit for the habitation of human beings. Most of the existing sewers are very old and dilapidated and require rebuilding. But I should be sorry to do anything towards the improvement of the drainage of this district, other than providing a main outfall sewer, until a complete and systematic arrangement of the sewers had been laid down, and the level of each sewer previously determined, not only with reference to itself, but to all of them, and so as to form a uniform and connected system in accordance with some such plan as I have just now described. It is far better to take a little time to arrange as to the directions, currents, and levels at which the sewers should be put in than to put them in hap-hazard as hitherto. In the latter case it is most probable that when they come to be extended into other streets they will be found improperly placed both as to directions and levels.

How long would it take you to complete the plan?—If I were to devote the whole of my time to the subject, I think I could complete it in about seven or eight weeks. The utmost accuracy would be required in taking the levels.

Have you made any calculation of the probable expense of completing the whole of the plan you purpose?—I have made a rough calculation. It is difficult to say what the expense would be in the

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absence of detailed plans, sections, and specifications. I should say, however, that after the expenditure of about 5000*l.* for the outfall sewer, and about the same sum to be contributed by the Westminster Improvement Commissioners, to remodel the entire sewerage of the city of Westminster, so as to have a good, complete, and efficient sewer in every street, court, and alley, would cost about 20,000*l.* This sum is of course irrespective of the diversion of the King's Scholars' Pond sewer, which is a matter requiring most deliberate consideration, both as to the cost and as to the district to bear the burden of it.

Is this sum based on your present mode of building sewers?—No. It is founded upon plans much cheaper, and equally if not more efficient. I have a plan in preparation upon this subject, and propose to take the earliest opportunity which the immense pressure of business will allow of submitting the matter to the Court of Sewers. The preliminary report respecting the outfall sewer has already been laid before the Commissioners.

What form of sewer do you propose to make use of for this low and flat district?—The egg-shape form, with the narrow end down, of course. My object would be to prevent deposit by economizing the water, so that it may keep the sewers clean without, if possible, the aid of manual labour and flushing.

But must not the sewers act as reservoirs while the tide is above the outlets?—Some few of them must be so arranged, and such sewers should be sufficiently capacious to hold the drainage that may run off the surface, while the discharge is prevented by the tide being above the outlets. These reservoir sewers I would make circular, and all the others, the branch sewers, egg-shaped, for this simple reason, that the soil and the water are thus collected together in a narrow area, and the flow is quickened thereby. I know it is the practice to put in enormously large sewers in low flat districts bordering on the Thames to act as reservoirs, while the drainage is pent in by the tide. And I also know that it is the opinion of many persons who have given the subject consideration, that the large end of the egg-shaped sewers should be put downwards in such districts; but having myself not only given this question much consideration as well, but having repeatedly been in the sewers at all times of the tide, when there was rain and when there was the common run from house-drainage, I have seen sufficient to prove the fallacy of such opinions, and to warrant me in departing from the usual practice, and to pay more attention to the formation of the bottom of the sewer, that it may in the circumstances keep itself as clean as possible, rather than to put in reservoir sewers or extended cesspools, which will require the constant attendance of workmen to lift out or flush away the deposit. At the present time, with all that can be required to prove most incontestably the absurdities that have been followed in these respects, yet the same worse than waste and useless system is still carried on, and that too with renewed vigour.

But do not all the sewers become completely filled with the sewage while the tide is up?—All the outlets of the low level are perfectly flapped, so that little or, I may say, no water passes into them from the tide. It is very seldom in fine weather that even the principal outlet sewers, in the lowest parts of Westminster, are more than half filled. Where then, I would ask, is the water to come from to completely fill

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all the branch sewers? It is only the waste water due from the supply to the houses that accumulates in the sewers (excepting when rain is falling), and that quantity does not fill one-twentieth of the whole capacity of the sewers put together. The entire substratum of the ground in which the sewers are based is of a sandy nature, and very much of the drainage passes through the bottoms of the defective house-drains and the sewers, and thus it soaks away through the sand into the water-bearing strata beneath.

What size sewer would you put in?—For the branches in the streets I would vary the sizes, but the largest would be 2 feet 3 inches wide by 3 feet 9 inches high, and would cost about 6*s.* 8*d.* per foot run. The outfall sewer I propose to be 5 feet 6 inches in diameter. I intend it should be put in level with low water of spring tide, or about 18 feet under Trinity datum, and carried under the side bed of the river to discharge under low-water mark. Here is a complete set of working plans and sections which I have prepared for the entire work (*exhibiting the same*).

Where is the outlet to be? and what line do you propose it should take?—I propose that the outlet should be at Richmond-terrace, and the route thence along Parliament-street, across Parliament-square, and along the Broad Sanctuary to Tothill-street, thence along the proposed Victoria-street to Shaftesbury-terrace, Vauxhall Bridge-road.

What length of sewer do you imagine would be required to carry out all you propose to do in Westminster?—I cannot say until I have made a particular examination of the present sewers, and ascertained by levels whether any of them could be made available either by lowering their bottoms or reversing the currents; but about 12 miles altogether, I should think, would be required, or 63,000 feet.

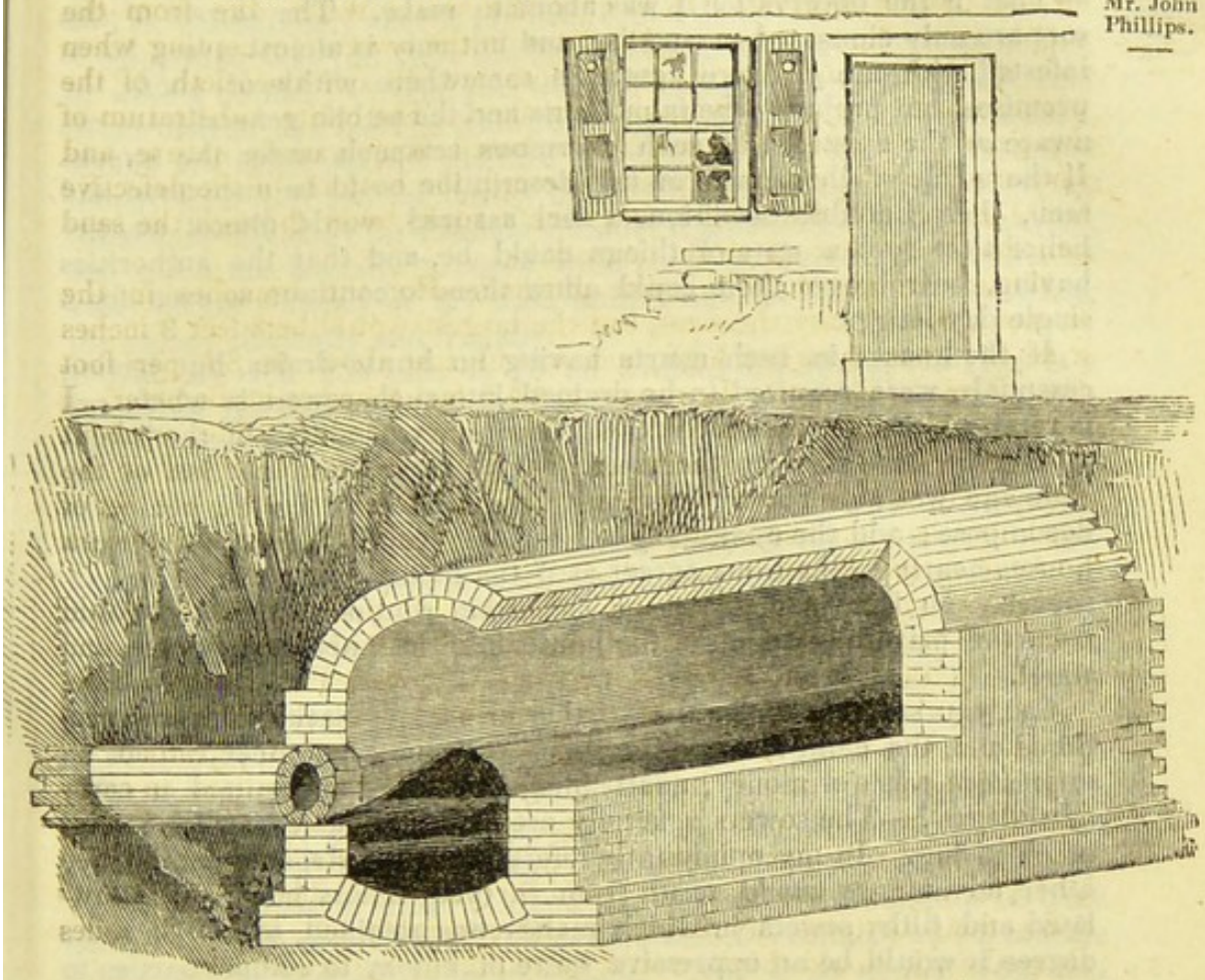
But would you think it necessary to complete the diversion of the King's Scholars' Pond sewer before carrying out your proposed plan for the entire improvement of the sewerage of Westminster?—By no means. That may be done at any subsequent period. I should, however, prefer having clean Thames water for flushing than sewage water, which contains a large amount of matter in suspension.

Public attention was recently attracted to the case of the death of a poor man who had been suffocated in the privy of an ill-drained court in Long Acre. You made an examination of the drainage of that court, did you not?—Yes, I did.

In what state did you find the drainage?—On examining the drainage of this court, Langley-court, I found that the houses on the east side of the court drained backwards into an old drain or sewer, constructed probably when the houses were built. This was a small sewer, 18 inches wide by 2 feet high, and had a good fall. The water running through it was sufficient to keep this small sewer nearly clean. I found that another sewer had been built in the court, under the authority of the Westminster Commission of Sewers. This sewer was one of the ordinary sewers, 5 feet 6 inches high by 3 feet wide, and contained an average depth of three feet of soil. This, though an imperfect instance, was an instance of the effect of a run of water in a small sewer, and of the common operation of a large sewer without a constant and sufficient supply of water. I hand in a section of the sewer, showing the condition in which I found it.

Sewer constructed in Langley Court, Long Acre.

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Does this exhibit the common size of a sewer formerly used for courts, and their condition?—Yes.

According to your experience, can you state what form or size would have been sufficient for the drainage of this court?—



The form and size are shown by this sketch, and the sewer and drain are drawn to the same scale.

Are you quite sure that even this small sewer is not too large?—There are 16 houses in the court, and in my opinion, a 6-inch tubular drain properly constructed would carry off all the drainage as fast as produced.

Supposing each house to be 15 feet frontage, what would the cost of the large sewer be per house?—About 7*l.* 10*s.* per house for one side of the sewer.

How much would the reduced size be?—About 1*l.* 12*s.* 6*d.* per house, being a difference of 5*l.* 17*s.* 6*d.*

What would be the difference of cost for the whole court?—99*l.*

That is to say, nearly six times greater for the sewer which acts as an extended cesspool than for the efficient drain?—Yes.

And this is not a singular instance as to the cost of court sewers?—It is not. In fact it is in consequence of these sewers being so enormously large and expensive that I believe there are so few courts drained

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This large sewer then was nothing more than an extended cesspool?—That is the observation I was about to make. The sewers of this sort are only elongated cesspools; and not only is almost every house infested with one or more cesspools somewhere within or about the premises, but probably the inhabitants and the public generally are not aware of the existence of such enormous cesspools under the streets. If the whole of the sewers of this description could be uncovered and seen, their horrible condition, I feel assured, would almost stagger belief that such a state of things could be, and that the authorities having control over them could allow them to continue so even for a single day longer.

If the houses in such courts having no house-drains, but having cesspools, were required to be drained into such sewers in which soil is retained, are you confident that the sanitary condition of the houses would be benefited by the work?—The more fluid portion of the drainage would certainly flow away, and the solid be left behind to decompose; and the noxious gases evolved would certainly infect the houses nearly to the same extent as if the houses had no drains whatsoever. In fact, in many cases, the drain would merely be turned from the private cesspool in the house into the public cesspool in the street.

Can you say that under the existing or any regulations proposed by the Court, the compulsory exercise of such powers would not be an oppressive waste of money, unattended with adequate sanitary or other advantages?—The sewers generally are extremely defective from want of cleansing. In my opinion, therefore, no very adequate sanitary or other advantages would result from carrying drains into badly-ventilated and filthy sewers in which matter was retained, so that in some degree it would be an oppressive waste of money to compel parties to lay drains into such sewers. It is almost impossible to have perfect house-drainage where the sewerage is imperfect, and *vice versâ*. It is absolutely essential that there should be the same power and control over the formation, and after management of the house-drains, as there are over the sewers. A defect in the one produces a defect in the other.

Are you not aware that some neighbourhoods are at times afflicted with more noxious effluvia from the sewers than if there were no sewers whatsoever?—I have no doubt that that is the case; but the evil admits of remedy in various ways, and amongst others, by the constant supply of water and constant circulation of it throughout the sewers. I have found that the atmosphere of districts contiguous to the outlets of the sewers was liable to be affected with effluvia when the wind happened to blow up the sewers, but the remedy for this evil would be to carry all the outlets under the side beds of the river to discharge into the main stream below low-water level. The air along the shores of the river would thus be much purified, inasmuch as there would be considerably less or no deposit, and no formation of filthy mud-banks for myriads of worms to revel in as at present.

Until proper and constant supplies of water are obtained for the cleansing of sewers, it would follow from your evidence, that going on with the system of large sewers constructed on the intermittent supply of water, and for men to go through them, is going on upon a system

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of at least double expenditure, often of very doubtful sanitary benefit? —Yes, undoubtedly that is my firm conviction.

Supposing that you were the owner of the district you superintend, or were a builder; or that you were an agent, or had the management of the district, and had the control, as agent, of the rate-payers' money, should you think yourself justified in going on with any expenditure of money until you had the means of altering the system, and applying the money efficiently?—I should consider it an absolute waste of money, and could not honestly proceed with such an expenditure either of other people's money or my own, until I had the means of expending the money efficiently and frugally.

How are you now able to go on without any survey?—That is a subject of the first and greatest importance; and I am confident that until a complete survey of the metropolis is made, showing every street, every court, every alley, and every house, with a system of levels, referable to a fixed datum line, (say Trinity high-water mark, which is the datum I use in all sections, showing the sewers,) it is impossible to put in sewers in positions so that they may join together hereafter as part of a complete system, and so as to make the water running along sewers on a high level available for washing out sewers on a low level. I mean of course the districts not under high-water mark. Without such a plan and system of levels the arrangement of the sewers must be guess work.

Have you ever represented this opinion to the Commissioners?—Yes, repeatedly; both in Court, and to individual Commissioners out of Court. About two years ago, I wrote an article in the "Builder," in my own name, in which I urged that no more work should be done until the actual condition of the sewers was ascertained, and a scheme laid down for their entire improvement. This is an extract from that article:—

"*September*, 1845.

"There are two modes which present themselves to my mind as being the best adapted for the purpose of keeping the sewers free from deposits and accumulations of matter.

"The first is the well known process of damming up the water flowing down the sewer, until it accumulates to a considerable height, and then suddenly letting it off, the impetus and force of the descending stream carrying away with it all the substances discharged into the sewer, and with which it comes in contact. This method of cleansing the sewers is now, and has been for some time, in successful operation in the Holborn and Finsbury Commission of Sewers, and is found to be, as I understand, and which I am satisfied, must be the case, from the great power and scouring action of the water thus obtained, not only a more effectual, but also a much cheaper way of removing and carrying off the deposited matter, than the ordinary dirty and antiquated method of raising it to the carriage ways, and then carting it away, with all its attendant annoyances.

"Now the old sewers, and very many of the new ones also, cannot by any possibility, keep themselves clean and free from deposits with the present quantity of water which is discharged into them, in consequence of their extremely large sizes, the injudicious form of their bottoms, and inadequate falls, as before referred to, for when one of them is cleansed, the matter which is immediately afterwards discharged into it becomes deposited upon the bed (its wide expanded border causing the liquid mass to spread) and the sewer again becomes in a short time wholly inefficient for the purpose of removing and carrying off the soil. The matter again accumulates until the private drains are choked up, when the soil has again to be lifted to the carriage ways, and this process of cleansing and re-cleansing must ever be continued so long as this form of sewer exists, and remains unimproved. From the filthy condition in which very many of the sewers now are, the means which have been proved to be highly efficacious for the purpose of

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keeping them clean, ought not, I think, to be longer delayed; and I feel assured, that were the authorities fully acquainted with the condition of the sewers under their jurisdiction, there being whole districts where sewers are more or less choked with decomposed matter, not another day should be lost without taking advantage of so simple and ready a method of improvement.

"It must, however, be admitted, that the method of flushing the sewers is only an expedient to be resorted to when the sewers cannot be kept clean by the simple means of proper construction and efficient fall; I would, therefore, beg to suggest another distinct method of proceeding, which, in the end, will prevent the matter discharged into the sewers from becoming deposited upon their channels. I propose that all the secondary or collateral sewers, those which branch out of the main lines, as also those which communicate with, and discharge their contents into, these secondary lines, should be strictly examined and properly surveyed; the relative levels throughout each of these collateral districts should also be carefully taken and laid down, with a view to an improvement of their falls.

"It should be distinctly understood that no more work should be commenced until the sizes and falls of all the sewers have been determined on, and re-arranged according to a regularly graduated scale, and I have no hesitation in saying, that until either this be set about and done, or they be entirely rebuilt, there are very many lines which will never be any other than elongated and filthy reservoirs or cesspools, the matter in which will be continually contaminating the atmosphere with its deleterious products. These great evils require immediate reparation, which should not be done piecemeal, but upon a well organized system of arrangement; and if the matter be taken up, as I trust it will, the cost of putting the whole of the badly formed sewers into a state of comparative efficiency could be ascertained without great difficulty."

The paper containing that article, was sent to the Court by the editor of "The Builder."

What attention has been paid by the Commissioners to your representations?—None whatever until very recently, when I was ordered to report as to the measures to be taken for obtaining a complete survey and map of the jurisdiction of the Commissioners.

Would you make no exception to the suspension of employment until a survey can be got?—Of course I make exceptions for cases of emergency. I apprehend that the first step would be to commence simultaneously on all the outlying or suburban districts, where buildings are in hand or likely to be commenced, and then complete the plans and levels first, so as to give the greatest facility to new works, and prevent the workmen being thrown out of employment.

If such a force as that of the Board of Ordnance were directed to this work, and they were to take the levels, and the outlines only the streets, leaving the details to be filled in afterwards, would these outlines and levels suffice for an emergency, and might they not be done quickly?—Yes, and that very quickly; and drainage works might then go on with safety.

You would, perhaps, ultimately contour the map?—Yes, one for reference; but for the working map I should not think it necessary.

What work could be proceeded with in the town districts?—Cases might arise where it would be desirable to do something, but I apprehend that no increased mischief would arise from stopping for a few months our works in the town districts. But going on with works in towns without the plans, is going on wasting money even if we had no prospect of being able to reduce the size and the expense of sewers so considerably as the public have a right to expect will be done. I am perfectly confident that the expense is now most wasteful, and the inefficiency most deplorable.

Have you a map of your jurisdiction sufficiently correct for you to

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work from?—No. I have found the plans in the office so very diffuse and incorrect, and arranged so very irregularly, as to be of little or no use whatever. Consequently I seldom refer to them now for information, fearing that they may mislead me. I find it impossible to proceed a single step with safety and confidence without a complete survey and plan of the locality requiring to be improved.

To what scale do you plot your new plans?—To a scale of 1 inch to 88 feet, or 60 inches to a mile. I have made use of a variety of scales; but I have found and consider that scale sufficiently large for all practical purposes connected with the arrangement of the sewers. The gas and water-pipes, the house-drains, and many other things, might also be laid down upon it without causing the least embarrassment. After the plan is made, I take the levels of the surface of the streets, &c., and show by figures at their intersections, and at other places, their altitudes above a fixed datum line, namely, Trinity high-water mark.

Is not this piecemeal mode of surveying, planning, and levelling, attended with much expense, loss of time, and inconvenience?—I feel sure that, were a competent staff of surveying officers employed to make a complete map of the metropolis, the expense in the end would not be near so great as the present piecemeal mode of proceeding. A considerable saving of time would result, and the work would be better and more accurately done, and consequently could be safely depended on.

Do you from your levels make longitudinal sections of the streets, showing the levels of the proposed improvement of the sewers?—Yes, after I have determined as to the best arrangement of the lines of sewers.

Are you satisfied that in your new arrangements of the sewers and the levels you determine to put them in at, you are designing the work correctly, and with a view to their future extension, and for the improvement of other districts?—No; I cannot say that I am quite satisfied of that. All piecemeal work, however careful one may be, is liable to lead to disappointment. When I begin the work of improvement in a street, I am induced, with a view to a complete arrangement of the sewers, to travel from that street to another, and so to another, until I go so far as to embrace an entire district, and even then I find it necessary to take in other districts as well. I know not where to stop, the drainage and the sewers generally being so very bad and dilapidated, and nearly the whole, in some way or another, requiring amendment or alteration. I often find it necessary to take up sewers that have been put in of late years. I do so rather than risk incompleteness. I should feel more safe and confident in being able to produce a perfect arrangement of the sewers had I to lay down an entirely new and complete scheme for the improvement of the drainage of the whole of a natural area or of the entire metropolis, than I should do by simply taking a small section of either; and my experience in the laying down of plans for the re-arrangement and improvement of the sewers obliges me to say that the drainage will never be improved as it should be until a comprehensive scheme is put in hand similar to what I have described.

How would you proceed to lay out the drainage of an undrained town district?—In the first place I would make a correct plan of that

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district, and then take the levels and contour the plan. After this was done I should, commencing at the outlets, proceed to lay down on the plan the arrangement of the lines of sewers so that they should all communicate with each other upon a uniform system of levels, and in the manner I have before described. Having determined their arrangement, the next step would be to make complete working sections of all the sewers, showing their depths and inclinations with reference to a fixed datum line. The capacities and thicknesses I would then regulate (after providing for their extension to other districts and for carrying off the back waters of the natural area) progressively from their heads to their outfalls, and according to the number of houses, quantity of water, and area to be drained by each sewer, allowing them to be of sufficient capacity for receiving and conveying away rain and storm waters.

Supposing a general outline survey to be made, what portion of it might be done, and on what scale, so as to facilitate the early and the safe prosecution of the works within your district?—If I had an accurate outline plan to a scale of 60 inches to a mile, simply of the streets themselves, without reference to any details whatever of the houses, together with the levels shown at each intersection of the streets, having reference to a fixed point, say Trinity datum, I could easily arrange the directions, depths, and inclinations of the sewers with perfect accuracy in a very short time.

Supposing you could not get a survey made by the Ordnance Department in sufficient time, what means would you adopt to obtain a sufficient plan by which to work from safely?—I would commence by laying down a base line, and triangulate the streets and roads, trigonometrically, and then fill in the triangles.

What force and within what time might this be done according to your view?—The triangulation cannot be done by a separation of districts, as the whole of the points and angles must blend and fit together to be accurate, so that this portion of it must be done first, and upon its completion the roads, streets, and courts within the various triangles, could be begun upon simultaneously and filled in in a short time. To execute this survey accurately, would require the undivided attention of several surveyors experienced in this particular kind of work, with a staff of assistants under them; and the plan might be completed, if carried on with spirit, in something like from six to eight months.

You have said that you have passed through very many miles of the sewers, and that you had found them, more or less, in bad condition as to cleansing. Do you know in what state the house-drains are? Did you examine them?—Yes, I did. They are execrably bad. It would seem from their form, arrangement, and construction, that they had been built expressly for retaining matter, rather than carrying it away. The sewers are miserably bad, but, bad as they are, most of the house-drains are far worse. More than two-thirds of the existing house-drains in old localities require to be periodically broken into to clear out the soil. It was formerly the practice to build all house-drains with flat paved bottoms, upright sides, the tops being covered with flat stones or pieces of wood. The drains of almost every house built previous to the commencement of the present century are of this description. A worse form of drain it is not possible

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to conceive. I have seen hundreds of them of all sizes, varying from 9 inches square to 18 inches wide, by 2 feet 6 inches high. I am of opinion, that not one-half of the entire filth produced in the metropolis finds its way into the sewers, but is retained in the cesspools and drains in and about the houses, where it lies decomposing, giving off noxious effluvia and poisonous sulphuretted hydrogen and other gases, which constantly infect the atmosphere of such houses from bottom to top, and which, of course, the inhabitants are as constantly breathing. In thousands of cases, I have no doubt, fevers and a large clase of diseases result from this cause. Of what use is it for the benevolent physician to be striving to succour his poor helpless suffering patients, while the very foundation of the evil is allowed to continue, and so baffle all his exertions. His labour to alleviate the sufferer, and eradicate disease, is, as it were, like a ball which is forced to rise on an inclined plane, whence it continually falls back again to receive new impulsions. It is like the labour of Sisyphus. There are hundreds, I may say thousands, of houses in this metropolis which have no drainage whatever, and the greater part of them having stinking overflowing cesspools. And there are also hundreds of streets, courts, and alleys that have no sewers; and how the drainage and filth is conveyed away, and how the poor miserable inhabitants live in such places it is hard to tell. In pursuance of my duties, from time to time I have visited very many places where filth of all kinds was lying scattered about the rooms, vaults, cellars, areas, and yards, so thick and so deep, that it was hardly possible to move for it. I have also seen in such places human beings living and sleeping in sunk rooms, with filth from overflowing cesspools exuding through and running down the walls and over the floors. It is utterly hopeless to expect to meet with either civilization, benevolence, religion, or virtue, in any shape, where so much filth and wretchedness abounds. The effects of the stench, effluvia, and poisonous gases constantly evolving from these foul accumulations, were apparent in the haggard, wan, and swarthy countenances and enfeebled limbs of the poor creatures whom I found residing over and amongst these dens of pollution and wretchedness. I should be ashamed to keep pigs in so much filth as I have seen human beings living amongst. Places similar to those I have described are existing at the present time in numerous parts of the metropolis. And here, if I may be allowed, I would beg, indeed I would implore, the Commission of Inqiury, if they have not already seen them, to accompany me to some of these places, and to devise and adopt, without delay, some ready means, and recommend the Legislature at once to make laws for the removal and suppression of so much evil—an evil, too, whereby the cleanly and the innocent are made to suffer nearly equally with those who may be called the dirty and the guilty; for wherever the natural laws in respect of cleanliness are neglected, there the seeds of infectious diseases are generated, which will spread into other districts where cleanliness is observed, and so will attack and afflict those who have had no hand in bringing the visitation upon themselves. To allow such a state of things to exist is a blot upon this scientific and enlightened age—an age, too, teeming with so much wealth, refinement, and benevolence. Morality, and the whole economy of domestic existence, is outraged and deranged by so much suffering

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and misery. Let not, therefore, the morality, the health, and the comfort of thousands of our fellow-creatures in this metropolis be in the hands of those who care not about these things, but let good and wholesome laws be enacted to compel houses to be kept in a cleanly and healthy condition.

What sized sewer would suffice for the drainage of an ordinary sized court or alley?—I would make use of an egg-shaped pipe sewer, of the form and size shown by this section, with a tank, and an apparatus for flushing at the head of it. The sewer represented is the least sized that I should think it safe to use.



What sized sewers do you now actually use for the drainage of courts and alleys?—A sewer of the egg shape, with a very narrow bottom, 2 feet 9 inches high, by 1 foot 6 inches wide, and half a brick in thickness, costing about 5*s*. per foot run, has been introduced by me; whereas, formerly, a sewer was used for courts costing about five times that sum. This small sewer is unnecessarily large.

What sized sewer has it hitherto been the practice to use in narrow courts, alleys, and short streets?—A sewer 5 feet high by 2 feet 6 inches wide, which is of sufficient capacity to drain 500 ordinary courts or streets.

Were those enormous sewers directed by the Commissioners who were architects?—Yes; the forms were originally laid down by a former chairman.

What would be the price of a sewer for a court or alley of the size you propose?—The pipe itself would cost about 20*d*. per foot, but the removal of the earth and the paving, and the making good, would increase the expense to about 3*s*. per foot.

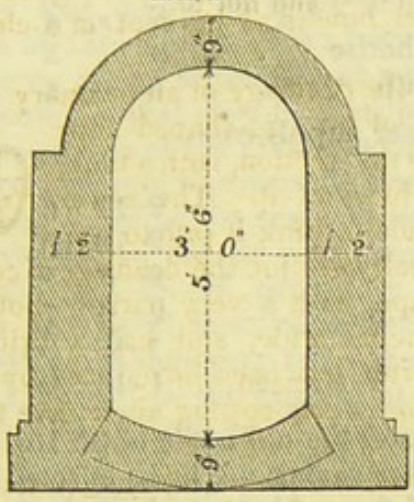
But do not the present Paving Boards charge 3*s*. a-yard for making good the footway pavement, and 1*s*. 9*d*. a-yard for the carriage-way paving? Do you include those charges in the 3*s*.?—No; in my answer I presume a consolidation of jurisdictions, and that the building of the sewer and the paving are under one and the same body, as, in fact, they ought to be. The present charges are, in my opinion, very exorbitant.

Will you contrast the expense of the general drainage of streets, courts, and alleys, with the expense at which an improved drainage might be carried out?—I have already stated that the cost of a first-class sewer of the upright-sided form was about 22*s*. 6*d*. per foot run, that the present first-class egg-shaped form ordinarily costs about 14*s*. 2*d*. per foot run, and that I think the expense, under an entirely different system, with constant supplies of water to keep the sewers clean, might still be further reduced to about 7*s*. per foot run for the larger class of branch sewers, and to about 6*s*. 4*d*., 5*s*. 7*d*., 5*s*. 3*d*., 4*s*. 6*d*., and 4*s*. per foot run for the smaller ones. The annexed sketches show the past, present, and future forms and sizes.

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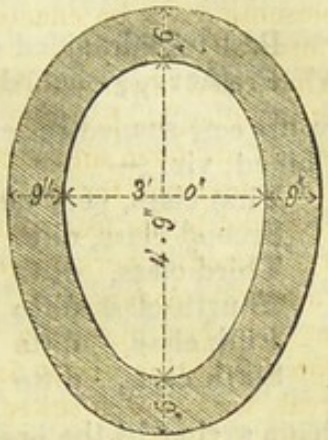
Past Form, First Size.

Cost 22*s.* 6*d.* per foot run.
Area, 15·5 ft.



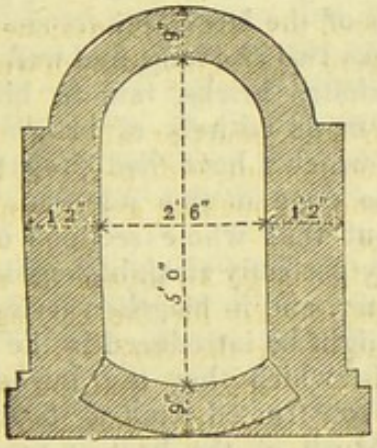
Present Form, First Size.

Cost 14*s.* 2*d.* per foot run.
Area, 11·2 ft.



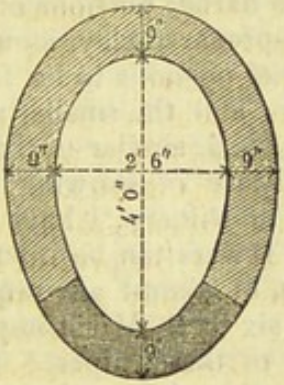
Past Form, Second Size.

Cost 19*s.* per foot run.



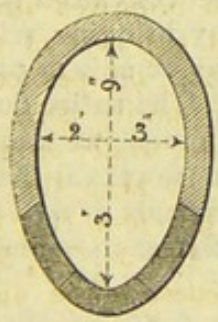
Present Form, Second Size.

Cost 12*s.* per foot run.
Area, 7·85 ft.

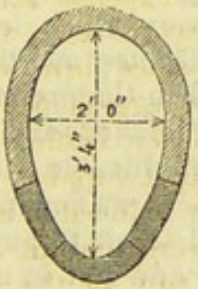


Future Forms and Sizes, with regulated supply of Water.

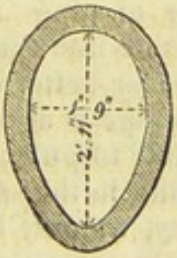
First class, 7*s.* per foot run.
Area, 6·6 ft.



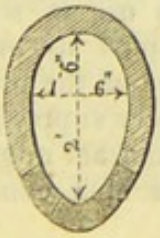
Second Class, 6*s.* 4*d.* per foot run.
Area, 5·2 ft.



Third class, 5*s.* 7*d.* per foot run.
Area, 4 ft.



Fourth class,
5*s.* 3*d.* per foot run.
Area, 2·9 ft.



Fifth class,
4*s.* 6*d.* per foot run.
Area, 2 ft.



Sixth class,
4*s.* per foot run.
Area, 1·3 ft.



Seventh Class,
3*s.* per foot run.
Area, ·736 ft.



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Taking a house of 17 feet frontage, the cost for one side of the sewer would be as follows; viz.—

	£.	*s.*	*d.*
Past upright-sided sewer, per house . .	9	11	3
Present egg-shaped sewer, ditto . .	6	0	5
Future egg-shaped sewers, with water supply combined, viz.:—			
First class, per house	2	19	6
Second class, ditto	2	13	10
Third class, ditto	2	7	5
Fourth class, ditto	2	4	7
Fifth class, ditto	1	18	3
Sixth class, ditto	1	14	0

So that a saving by the present mode over the old mode of 3*l.* 10*s.* 10*d.* per house is effected, and that a further saving might be effected over the present mode of construction of from 3*l.* 0*s.* 11*d.* to 4*l.* 6*s.* 5*d.* per house, and with far better sewers, which would be kept constantly clean, and which would scarcely or never get out of order. I propose that the darker portions of the bottoms of the larger sewers should be of well-prepared clay, moulded in blocks two feet long, and well burnt; the upper portions to be formed of radiated bricks, laid in blue lias mortar; and the smaller sewers to be made entirely of brown stoneware glazed, similar to this specimen, which I have had prepared for the purpose of showing what can be done in this material. With proper machinery, I have no doubt but that whole sections of egg-shaped sewers can be made in pottery perfectly straight, regular, and smooth, of almost any required diameter, and in lengths varying from two to six feet. Much improvement might be introduced in the manufacture of these pipes. The kilns in which they are burned also require to be differently arranged and constructed, both as to the economy of storage room and of heat. Much of the heat at present is wasted; the furnaces should be improved. Chemical analyses would point out to us the ready means of composing a cheap and durable clay, suitable for the making of these pipes. I feel convinced that the expense of pipes may be very much lessened, by bringing scientific knowledge into their manufacture, and that we may be able to produce pipes of far better quality than the present pipes. The entire question of sewerage is as yet in its infancy, and, in my opinion, we may hope ultimately to put in miles of durable and efficient sewers at the same price, and in the same time, as we now put in thousands of feet. That is to say, we may be able, I think, to put in five feet at the same cost and in the same time as we now put in one foot.

You have been requested to take the case of a court or alley, and estimate the expense of draining it upon the old plan of drainage, which has been carried out in the Westminster Commission of Sewers until within the last two or three years, and now in use in several other districts in the metropolis, and generally adopted by private builders; next to contrast this expense with the expense of the present plan of drainage, without any combination with the water supply; and then to make an estimate of the expense at which a contract might be probably obtained for the execution and maintenance of a complete

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house and street drainage of the same court and alley, in the most efficient and economical manner, draining the houses from behind, where that might be done, and would save breaking through the fronts of the houses. You were requested to estimate the expense of laying on water, at the rate at which it is done on the constant supply for houses of that class for Preston, and estimate the expense of a soil-pan apparatus of the same description as that described to have been in use at Ashton to supersede cesspools. Have you done so?—Yes.

What would be the expense per house of the house and street drainage recently in use in your own district, and now in use in several others?—14*l.* 2*s.* 6*d.* per house for the past system. The assumed prices at which I have calculated the quantities, I think, will be considered by builders very fair prices.

What would be the expense at the present improved system as it is called?—8*l.* 0*s.* 6*d.* per house. The prices are about the same as those at which I estimated the expense of the drainage of one of the districts in Marylebone.

What do you estimate the expense of drainage on the improved system which we contemplate, and the improved supplies of water?—2*l.* 8*s.* 9*d.* for each house, that is simply for the sewer and the drain. The expense of laying on the water would, I apprehend, be about 5*s.* per house in each instance, which is the rate of expense at Preston.

You think that 2*l.* 8*s.* 9*d.* per house will be a fair estimate for the expense of the complete drainage of a court?—Yes; taking one house with another, and contingencies, I have not the least doubt it could be done for 2*l.* 10*s.* per house. On a large contract, I should not hesitate to keep the whole drainage in a thorough condition for the term of 20 years, on a small per centage upon this estimate. Taking one court with another, I believe that the expense of taking up and relaying pavements, cutting through and underpinning walls, might be taken on an average for about 5*s.* per house extra.

This last estimate then is for drainage along the backs of the houses, and so avoiding carrying the drains through the fronts of the houses; yet in cases where it were found impracticable to drain along the back, what would be the additional expense of draining them in the front?—About 30*s.* per house.

Would not the drainage be better carried off at the back?—Yes, it would, if the whole were always under the authority and control of the Commissioners of Sewers; inasmuch as the force of the water would be concentrated into one drain, instead of into several drains.

What size drain would you put down at the back?—I would vary the size from a 9-inch at the lower end to a 4-inch at the upper end.

On the plan of repayment of principal and interest then in 30 years, these drainage works might be accomplished for a rate of 3*s.* 3*d.* per house, per annum, or less than 1*d.* per week?—Yes. After much consideration, I am satisfied that the complete drainage of courts can be accomplished for that sum.

You are aware that a constant supply of filtered water is provided to each house, in some districts, and on a larger scale than in the metropolis, for 1*d.* per week?—Yes, I am aware of it.

What would be the fair expense of emptying and filling up cesspools, and substituting an efficient soil-pan apparatus?—About 2*l.* per house.

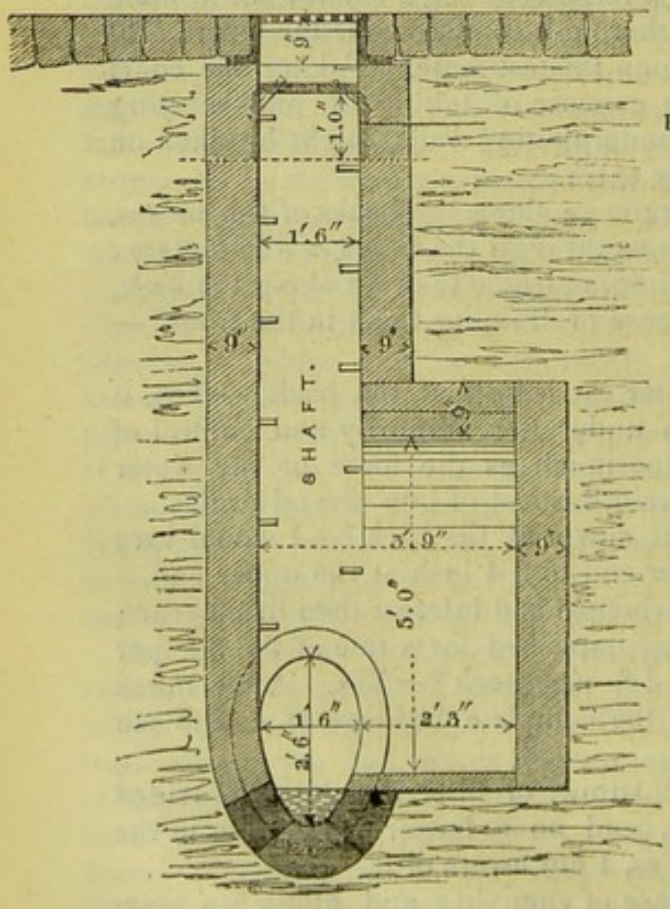
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This then would add another halfpenny per week to the charge; but supersede the present charge of properly cleansing the cesspool?—Yes.

From these estimates it appears that in superseding the old expensive mode which cost 14*l.* per house, or about 4*d.* per week if extended over a period of years, it is quite practicable for 1*d.* per week to afford complete drainage; for another penny per week to add a constant supply of water; and, in fact, although it will require about one halfpenny per week more to get rid of the existing cesspools and other defects, the whole may be accomplished for about half the cost of the bad house drainage alone under the old system?—Yes; the expenses of dilapidation and cleansing form a serious expense, which would be saved with the pipe system of drainage, and a proper and constant supply of water.

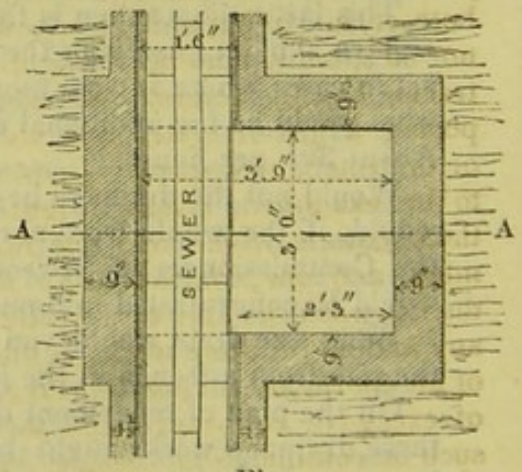
Would you build side entrances to a tubular system of sewers?—In some situations I would do so; but I believe their use, in some degree, might be superseded. Means of access to the sewers, so as to be able to get at and remove accidental obstructions, would readily suggest themselves. A shaft, having a strong moveable grating on top, could be built over the sewer, with ladder-irons built in the angles, to admit a man to go down and up, with a recess at the bottom on one side to give room. This shaft may be also made to serve as a ventilator.

Plan and Section of Shaft.



Section on A A.

Half plan top of shaft.



Plan.

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From your experience, it appears that the public may expect quite as large a reduction in the expense of town drainage as by attention to the forms and capacities of pipes for the discharge of water from land drainage, where the one-inch tubular drain has extensively superseded the flat-bottomed and upright-sided drain with circular top, so closely resembling the old form of sewer recently in use in the Westminster Commission?—Yes, it is so.

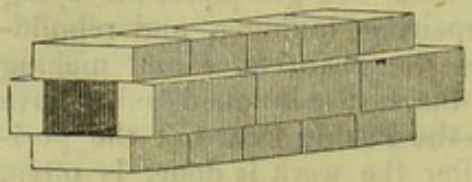
What appears to you to be the evils resulting from the paving, the sewerage, the supply of water, and the gas being divided?—The laying down, examining, and repairing of the water and gas pipes, the laying of private drains, and the cleansing, repairing, building, and rebuilding of the sewers, necessarily involves the disturbance and making good of the paving. After either of the last-mentioned bodies have opened the ground, the officer informs the Paving Board of the positions and extent of the hole, which, after the work is done, is often, notwithstanding the vigilance of the officers, filled in again without being properly rammed down, and the stones are laid or thrown in very carelessly. Each body cares very little about the property of the other; and, in consequence of the filling in of the ground being done badly, the paviors have to throw it out again, in order to prepare a sufficiently good foundation for the stones.

The filling in then and the paving has to be done twice over?—Yes; the 1*s.* 9*d.* per yard is supposed to cover the twice relaying, and sometimes it is laid three and four times over, the work is done so carelessly; the laying of the pipes of one Company very often interferes with the pipes of another Company; and the sewers and drains have to be cut about, altered, and removed likewise. These things are frequently attended with much expense and inconvenience. Sometimes the stones lie scattered about the streets for several days, and accidents ensue in consequence. The inhabitants and the passengers are necessarily put to much inconvenience and trouble by this separation of jurisdictions. I have repeatedly found that the execution of the work, both of the paving and of a sewer, was not nearly so sound and good, nor so speedily done as it might have been, had one body and one contractor had the control and execution of the entire work. Now, supposing a gas or water pipe were required to be laid down, repaired, or protected, or a private drain to be put into the sewer, or the sewer to be examined, cleansed, repaired, built, or rebuilt, if the whole of these matters were under one Board and a uniform system of management, and one contractor for the whole, one intelligent officer on a district would be able to pay attention to, and make arrangements for, any and all of these works at the same time; and thus would a saving of an enormous amount of time, labour, and expense, and prevention of excessive annoyance and inconvenience to the public result from such a consolidation, besides ensuring that the work would be done far better. As it is, confusion and wasteful expenditure of money are the result. Economy, public convenience, and efficiency, therefore, as regards the paving, the sewerage, and the supply of water and of gas, point out the absolute necessity of combining the whole of these things under the uniform control of one body and set of officers. Until this is done, I am confident that the sanitary condition of the metropolis cannot be made what it ought to be, and what the public have a right to demand.

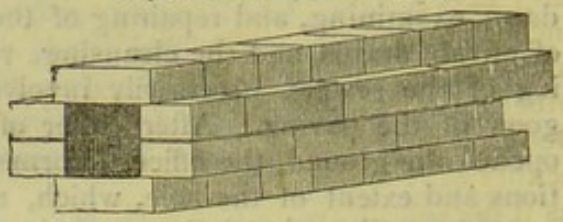
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What description and size of drains are now used for the drainage of houses?—Flat-bottomed square box and barrel drains of brick, and bad bricks too, the lower halves of the drains almost invariably put in without any mortar or cement whatever. The bottom bricks, up to the springing of the crowns of circular drains, are mostly bedded in sand, or fine dirt, or rubbish. I beg to submit these sections, showing the mode of constructing the drains I have just described.

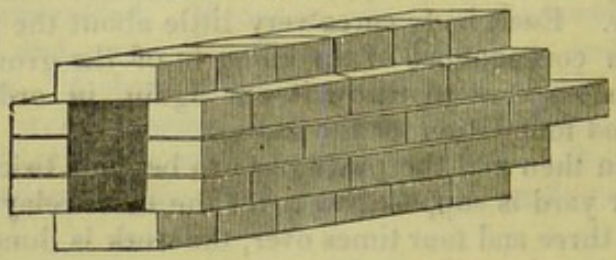
6*d*. per foot run, exclusive of digging.



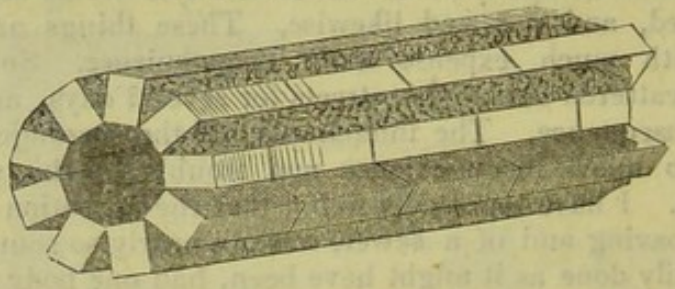
9*d*. per foot run, exclusive of digging.



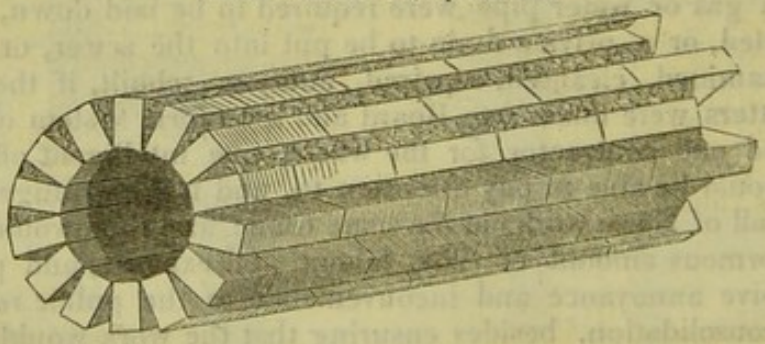
11*d*. per foot run, exclusive of digging.



9 inches diameter—1*s*. 4*d*. per foot run.



12 inches diameter—1*s*. 7*d*. per foot run.



(Bottom joints without mortar or cement.)

Would not a speculating builder blame his workmen for waste should they put mortar into the lower joints of a brick drain?—I have heard very many of them do so.

But do not brick-drains of this description very soon get out of order?—Yes, so much so as never to get in order again; as most of

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them are constantly choking up, and as constantly requiring cleansing; to which must be added, the excessive annoyance as well as danger to health of the inhabitants. I have frequently found the foundations of houses saturated with sewage water, in consequence of the defective state of the drains of this description. The junctions of brick-drains are almost always formed at right angles. The admission of one stream into another should be by a uniform curve line.

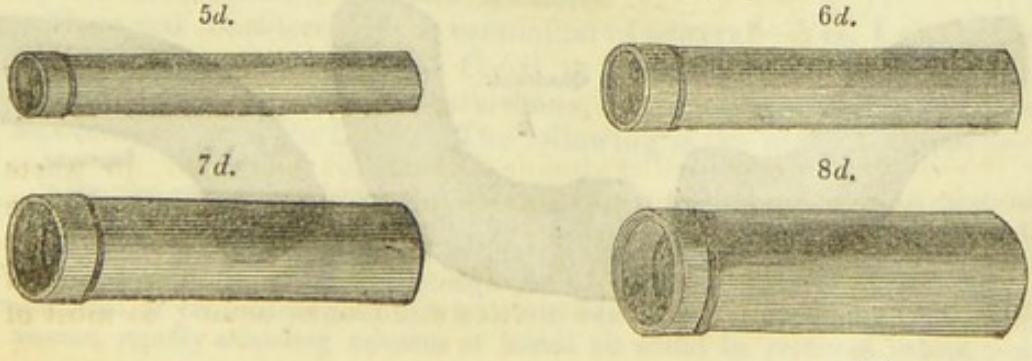
Have you seen tubular drains in operation?—Yes, I have; and they keep remarkably clean. I recollect seeing tubular drains of three inches or so in diameter, that had been in use for a number of years, and finding them as clean as when they were first put down; while other large brick drains close by, from houses of the same size and description, were choking up with filth. The fat from kitchens and sculleries is not liable to condense and collect in small glazed drains as it does in large brick drains, as the smoothness of the surface and the retention of heat, and the greater power of the water, would prevent it from sticking to the bottom and sides.

For common brick drains, then, you would substitute glazed stone-ware pipes?—Yes, of course. With much smaller tubular drains than the brick drains now in use, the hydraulic pressure and force of the water, from being concentrated, are very much increased, and so it acts with more effect in carrying the filth with it. The resistance from friction, too, of the surfaces of glazed stone-ware tubular drains is considerably less than from a brick drain. The flow, therefore, is much quickened; and as an ordinary sized vessel, such as a pail, would completely fill a small pipe with water, much force would thus be brought to bear, which can never be attainable with a larger pipe, one-half of which is, in most cases, filled with air.

Should not all house-drains be trapped to prevent a current of air passing through them?—Yes; it is absolutely necessary to do so according to the present arrangement and construction of drains and of sewers, without proper and concentrated supplies of water to keep them thoroughly washed out. But, under a complete system of drainage and sewerage, combined with constant and well regulated supplies of water, I should think it unnecessary, except in special cases, to trap drains at all, inasmuch as there would be no decomposition of matter within them, and consequently no foul emanations would be evolved.

What form and sizes of drains would you propose to use for the drainage of houses in lieu of the present brick drains?—Glazed stone-ware tubular drains, of 3, 4, 5, and 6 inches in diameter, and in 24-inch lengths, as shown by these sketches.

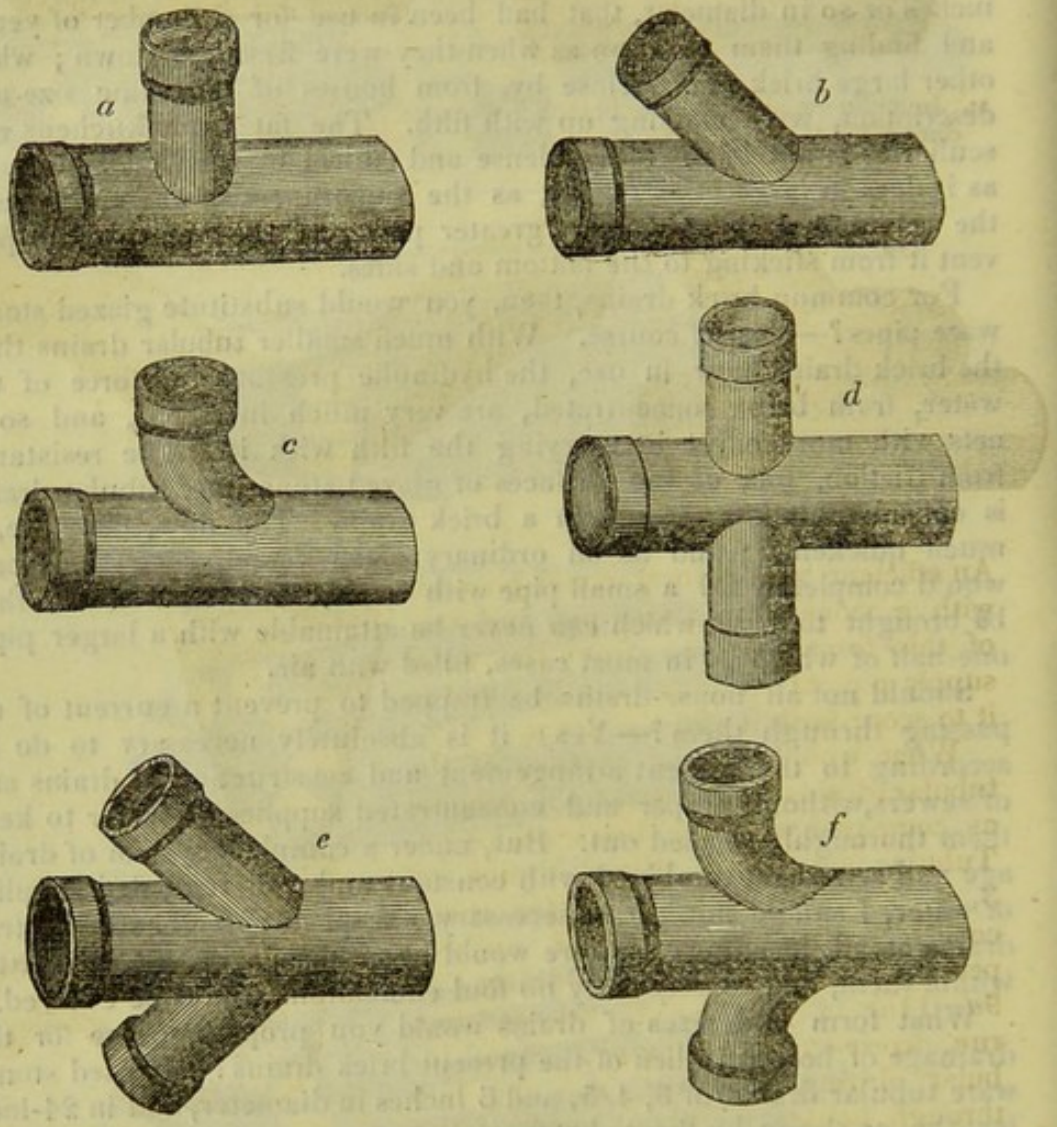
Cost per foot run, irrespective of digging.



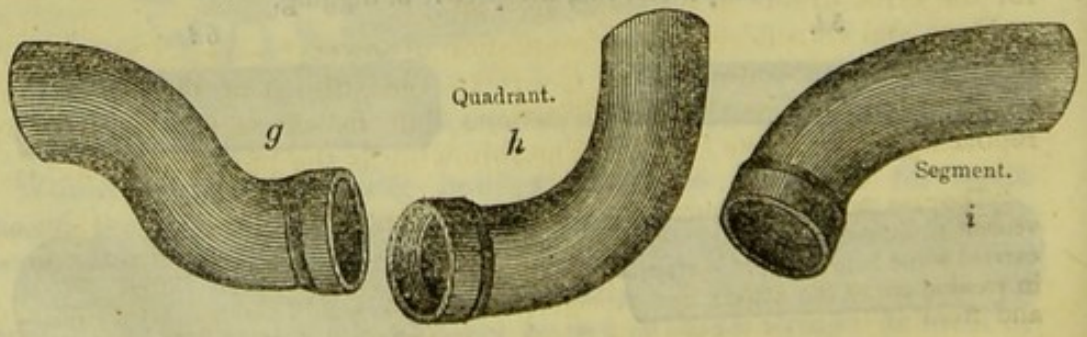
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In what way would you form the junctions of tubular drains with each other, and also with the sewers?—By beds, and canted and curved junctions, as shown by these sketches. By a combination of the straight tubes and the junctions the most efficient drainage can be formed. The junctions with the straight tubes can be made of any required diameter.

a, b, c, d, e, f. Single and double square, oblique, and curved junctions for introducing branch drains into main ones.

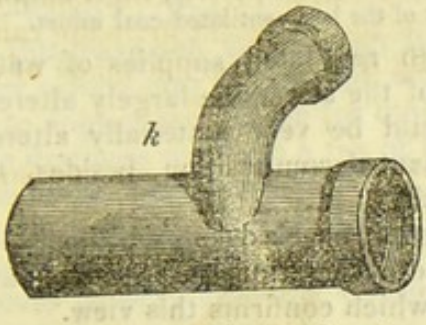


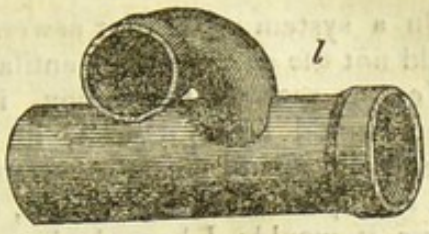
g, h, i. Curves for changing the direction of drains.



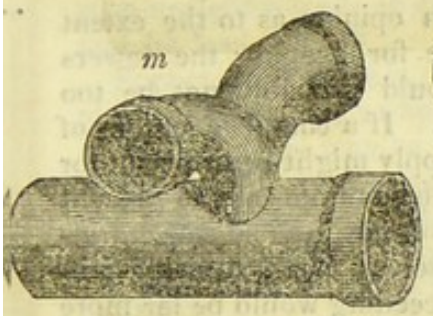
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k, l. Junctions for introducing perpendicular drains into the sides, as well as of branch drains into the top of horizontal ones.

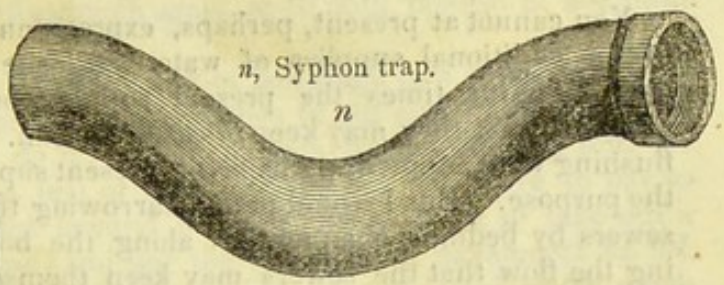


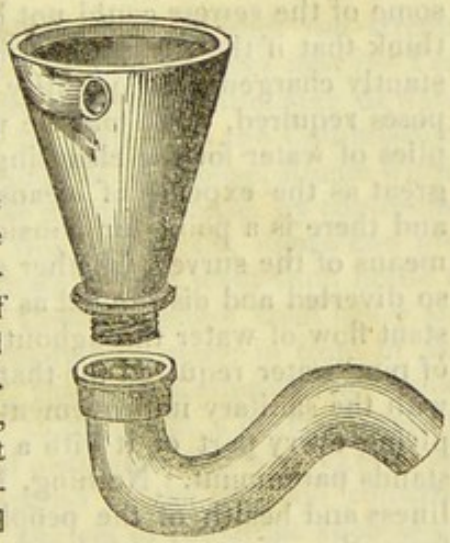


m. Junction for admitting two branch drains into the top of a main one.



n, Syphon trap.





An efficient water-closet could be made with a stone-ware glazed pan and trap of this form. A pipe from the water supply pipe of the house can be fitted to it to scour both it and the drain.

What would be the expense of the tubular drains of the sizes you propose as compared with the brick drains?—Tubular stone-ware glazed drains, of 3, 4, 5, and 6 inches diameter, would cost respectively, 5*d.*, 6*d.*, 7*d.*, and 8*d.* per foot run, and the brick drains 6*d.*, 9*d.*, 11*d.*, 1*s.* 4*d.*, and 1*s.* 7*d.* per foot run, irrespective of digging. Small tubular drains, however, can be laid through houses for about one-half the expense of brick drains; that is, according to the prices as charged for the brick drains in builders' accounts.

Have you considered of the ventilation of sewers?—Yes, I attempted to awaken the attention of the Court to the subject of the ventilation of sewers in my report on Marylebone, but it was struck out of that report by order of the Court. The following is the part struck out:—

"The plan consists in placing and distributing over the sewers, and in the most convenient situations, a number of distinct and separate downcast and upcast shafts, to be carried some height above the surface, with a furnace in each of the latter. The air, in passing out of the sewers, and through the furnaces, would become highly rarified, and freed of the noxious gases with which it was charged in the sewers, and in this manner, rapidly ascending columns of heated air would be produced, whose place

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would be immediately filled up with a supply of cold fresh air from the surface through the downcast shafts, and as it passes along the sewers, the deleterious exhalations would be carried to the furnaces, there to be consumed, and the air purified, before ascending into the atmosphere, in a similar manner to that of the best ventilated coal mines."

On a system of tubular sewers, with regulated supplies of water, would not the case for the ventilation of the sewers be largely altered?—Yes, as regards ventilation, it would be very materially altered. There would be no deposit, no stagnant decomposition, besides, the water itself, would create a current of air.

A supply of cold water would, moreover, check decomposition?—Of course it would; I have had scattered observations of sewage water mixing with clean cold running water which confirms this view.

Under such a system would not the pressure of the gases on valves and traps be greatly diminished?—Yes, I believe it would. This, however, is unimportant.

You cannot at present, perhaps, express an opinion as to the extent of the additional supplies of water requisite for keeping the sewers clean?—Nine times the present supply would probably not be too much, so that they may keep *themselves* clean. If a complete system of flushing were adopted, perhaps the present supply might be sufficient for the purpose. But I would prefer narrowing the bottoms of the present sewers by bedding channel tiles along the bottoms, and so concentrating the flow that the sewers may keep themselves clean, to using mechanical means at all, as such a course of proceeding would be far more economical in the end; although, at the same time, I am sure that some of the sewers could not be kept clean without flushing. I should think that if the present supply was doubled, and the pipes kept constantly charged, that quantity would be found sufficient for all the purposes required. We may be very sure that expense of additional supplies of water for the cleansing of drains and sewers would not be so great as the expense of cleansing them by hand labour and cartage; and there is a point for consideration, which might be ascertained by means of the survey, whether some of the upland streams might not be so diverted and distributed as to be made available for keeping a constant flow of water throughout the sewers, and diminishing the quantity of pipe-water required for that purpose. Of all the questions connected with the sanitary improvement of the metropolis, I believe that of supplying every part of it with a never-ceasing flow of pure spring water stands paramount. Nothing, I think, would tend to increase the cleanliness and health of the people so much as constantly pouring down from the more elevated parts of the metropolis copious and clear streams of pure water, so as to have a perpetual supply to every house, and a perpetual flow through every drain and sewer. In proportion as the supply is more or less abundant, so is general cleanliness and health affected accordingly.

You have given in to the Court of Sewers a plan for the drainage of the depressed district of All Souls in the parish of Marylebone, what is your estimate of the expense of draining that district?—About 20,000*l.*; that is for an entire re-construction of the sewers. The area of this district is equal to about 130 acres.

But still it is for a construction of sewers on the intermittent system of supply, and with sewers sufficiently large for men to pass through them?—Yes.

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What number of houses are there in that district?—About 3000 houses.

That is to say, the cost of rebuilding the sewers will be nearly 7*l.* per house?—Yes.

But inasmuch as upon an improved plan of sewers, the expense of new sewers may be reduced more than one-half, to proceed at present is to subject each house (or other districts who derive no benefit from the drainage work) to a tax of 3*l.* 10*s.* per house for a drainage which would be less efficient?—Yes, that is so; and moreover, the house drainage of the district is very bad, almost every house having a cess-pool; and the saving on the house drainage on an improved plan would be as great as the saving from an improved sewerage with the constant supply of water.

What would the expense of the reconstruction of the sewers in the district of All Souls have been under the old system of building sewers with upright sides?—Full as much again, or 40,000*l.* instead of 20,000*l.*, and far less efficient.

Suppose that there is now some sort of sewerage in a street, court, or alley, and that the owner of a house wishes to put down a house drain, at what expense may he do it?—Ten shillings for the opening into the sewer, and the first three feet of drain. That he will have to pay to the Commissioners. But beyond this, he would have to take out a licence to open the ground, and pay the surveyor of pavements 1*s.* 9*d.* per yard for as much of the carriage way, and 3*s.* per yard for as much of the foot way as he removed, and he might perhaps remove three yards of both.

Are not the new sewers now generally driven through the streets, leaving the inhabitants to provide house drains as they may?—Yes, such has hitherto been the case; but the recent Westminster Sewers' Act, 10th and 11th of Victoria, chapter 70, empowers the Commissioners of Sewers to order the owner or occupier of any house, situate within 100 feet of a sewer, to drain such house at his expense, by continuing such sewer up to and along the entire frontage of the house and premises; and by constructing a covered drain to lead from such house to such sewer, in such manner as the said Commissioners shall order and direct; and also, when there shall already be a sewer in front of any house, adapted to the drainage thereof, then the Commissioners shall order and direct the owner or occupier to construct a covered drain to lead thereto and connect therewith; and also, under certain regulations, to contribute a just sum towards the expense of the original construction of the sewer; and upon refusal or neglect to construct such sewer and drain, the said Commissioners are empowered to construct the same, and to recover the expenses by distress under their own hands. The Commissioners of Sewers are also empowered by this Act, wherever and whenever it shall appear to them to be necessary to do so, to stop up every street, road, court, place, &c., where no sewer previously existed, and to build sewers along the same, and the cost of making such sewers shall be borne (according to regulations) by the several owners of the lands and tenements abutting on the streets or ways under which the sewers are made. After the completion of the sewers so built, the Commissioners can call upon and enforce the owners to lay drains from the houses into the sewers; but it is doubtful, should the Commission-

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ers do this part of the work, whether they can charge the cost thereof upon the owners or occupiers, or include it in the amount payable for the sewer.

Is notice given to the inhabitants?—Yes, we have done so recently in our district.

But is it not the practice that the house drains are put in by private builders or by the contractors?—Yes, we have exercised no control as to who shall do the work.

At what expense are they usually put in?—I have known the charges to be most exorbitant; and when referred to, have advised the inhabitants not to pay them.

What has been the usual charge?—Various, from 4*s*. to 8*s*. a-foot.

What might have been the charge per foot if the house drainage had been included under the same contract as the sewer?—From 2*s*. and upwards, and perhaps as far as 4*s*.; but generally one-half what is now charged.

And under a proper system that half, distributed over a period of years, would greatly reduce the obstacles to drainage?—Yes.

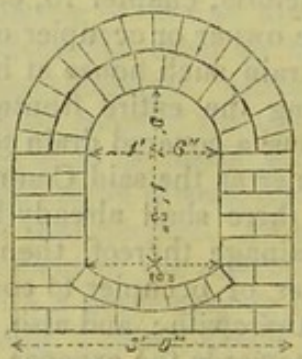
Under whose direction are the drains for conveying away the surface water of the streets put in, cleansed, and repaired?—Under the direction of the Court of Sewers.

Of what material, and in what manner, do you construct them?—The following order of Court was confirmed in 1839, and is still in force:—

"*Regulations for Gully Drains adjoining Arched Sewers.*

"That the following be the form of gully and road drains.

Transverse Section.

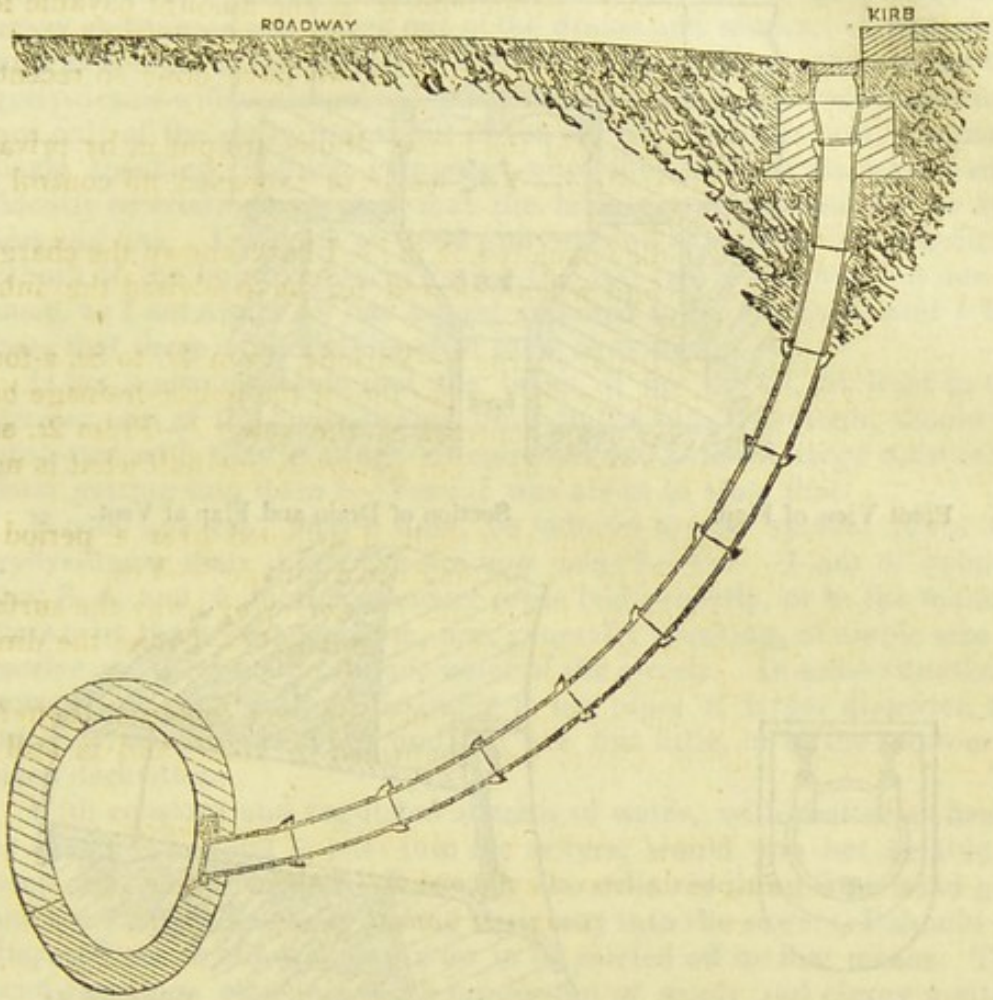


"That whenever a new gully shall be constructed, the bottom of the same be sloped with stone, rising at the back two-thirds the width of the gully; and that whenever an old gully shall be opened for cleansing or repairing, the bottom of which may not be so sloped, the said bottom be taken up and relaid in the manner above described."

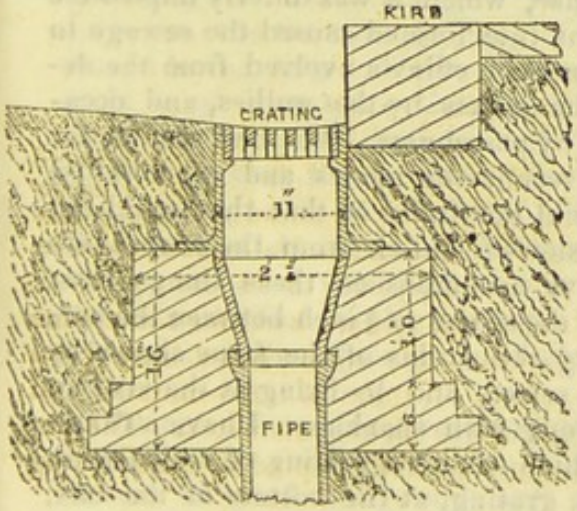
Sixteen-inch barrel drains, half-brick thick, were used for some time previous to March, 1846, as an experiment; since then I have been allowed, also as an experiment, to construct them of terro-metallic and glazed stone-ware pipes of 6 inches and 9 inches diameter. The annexed plans and sections shew the mode I have adopted in constructing them.

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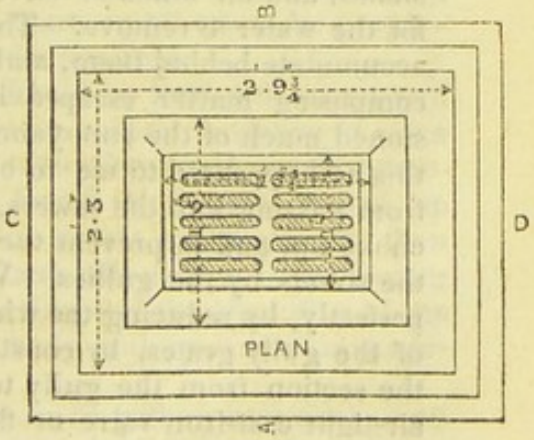
Section of Gully Drain from Grating to Sewer.



Transverse Section of Gully and Grating on A, B.

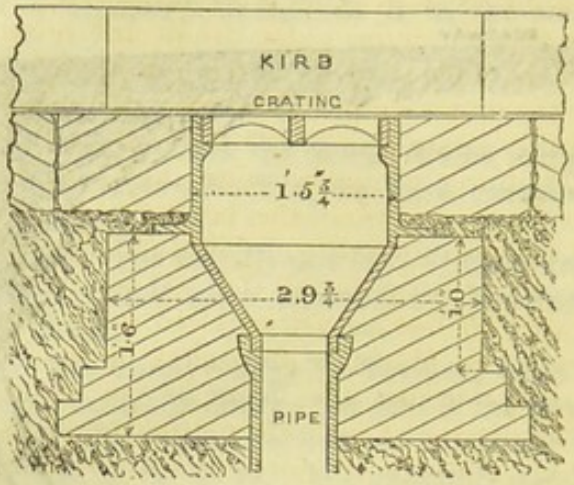


Plan of Gully and Grating

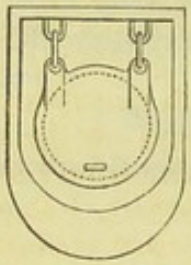


No. 13.
Mr. John Phillips.

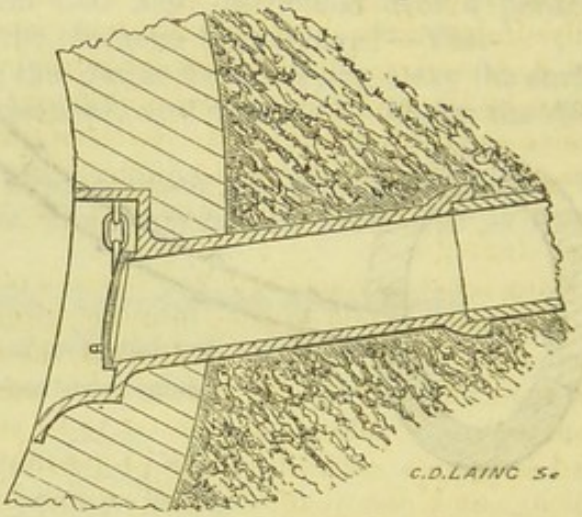
Longitudinal Section of Gully and Grating on C. D.



Front View of Flap.



Section of Drain and Flap at Vent.



I was led to recommend the adoption of this mode of construction from the following causes:—In passing through the sewers I found lying opposite the vents of a large number of the gully drains heaps of stones, and all kinds of street refuse, which it was utterly impossible for the water to remove. The dams thus formed caused the sewage to accumulate behind them, and the noxious effluvia evolved from the decomposing matter escaped into the streets by the gullies, and occasioned much of the annoyance felt by passengers. The best remedy for this evil appeared to me to be to prevent the stones and street refuse from passing into the sewers, to build the drains so that they could not choke up, and to prevent the emission of foul air from the sewers into the streets by the gullies. We have accomplished these things most perfectly, by reducing the width of the spaces to ¾ inch between the bars of the gully grates, by constructing the drains of the form shown by the section from the gully to the sewer, and by fixing at the vent an air-tight cast-iron valve or flap, hung with shackles. I have a drawing here (*exhibiting the same*), which shows a grating of trellis-work or cullender placed under the top grating, at the bottom of the box, for the purpose of catching small stones and rubbish that may pass between the bars of the grate above, and so to prevent them from falling into and choking up the sewers. I have not, as yet, made use of the

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lower grating, but probably I should be induced to do so in connection with a tubular system of sewers, as it is important to keep large and heavy substances and refuse out of the drains and sewers. I may state that, as a proof of the efficacy of the foregoing mode of constructing the gully-drains with the improved grate, the labour and expense of cleaning, not only of the gully-drains but of the sewers as well, is now, comparatively speaking, nothing compared what they used to be, and I confidently entertain an opinion that the labour and expense will be still less and less. Upwards of 2000 gully-drains have either been built or rebuilt of the improved form during the last two years, and not one of them, as I am aware of, has as yet required to be cleansed, and I believe that there is no likelihood of their choking up.

Is not it also desirable that the inlets, if not to all, at least to the greater part of the house-drains, built on the tubular system, should be protected with fixed gratings or cullenders to prevent large substances from getting into them?—Yes; I was about to state that.

Would not you, after a time, be induced to use smaller pipes for gully-drains than those you are now using?—Yes. I am of opinion that 3, 4, and 5 inches diameter pipes laid properly, or in the manner shown by the previous section, are, generally speaking, of ample size to receive and carry off the surface water of the streets. In some situations, however, it may be found desirable to use pipes of larger diameter, for instance, where the depth and fall are but little, or at the bottom of steep declivities.

With constant and regulated streams of water, with matter as heavy as road grit or sand to pass into the sewers, would you not be able to keep the sewers clean?—Knowing the evils resulting from road grit and road refuse generally finding their way into the sewers, I should be disposed not to allow such matter to be carried off by that means. The road scrapings contain a large proportion of sandy and clayey matter, which, combined together, and allowed to deposit, forms an almost irremovable conglomerate at the bottoms of the sewers, and which no flush of water will remove of itself. But, if the streams were strong, large, and constant, I should then see no objection to such mode of removing the road scrapings. To prevent such matter from depositing, however, the force of the body of water must, in all cases, be proportioned to the weight of the substances to be removed.

It is of importance that the streets should be kept well swept and clean?—I must say that although there is an evident tendency in some districts to keep the streets well swept, in other districts they are shamefully neglected in this respect. I have found the sewers choked up more in districts where the sweeping of the streets was neglected, than where attention was paid to them. There will always be conflicting causes and effects in the sewerage, the paving and the cleansing of the streets, until the whole be put under one body and system of management.

Do not you receive complaints that the small gully-grates choke up?—Yes, we do. My answer to the complainants is this, "Keep your streets in good order and well swept of the filth and refuse lying scattered about them, then the gully-grates would not choke up. I have greatly improved the working of the sewers by reducing the apertures leading to them, and I am not going to undo what I have done,

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merely to suit your neglect and antiquated notions of street cleansing, by allowing the refuse to pass into the gullies and the sewers there to accumulate until they become entirely choked up, when at last it has to be removed by a very expensive and inconvenient process. You have many able-bodied youths and men in your workhouses. Now, give a few of the well-disposed of them a few hours relaxation from being stewed up in close rooms, oakum picking every day, by sending them with trucks, brooms, shovels, and other instruments to sweep the streets, pick up the refuse, and clear the spaces between the bars of the gully-gratings."

Have you any observations to make to this Commission?—I have only this to state, that all I have said, and all I have done, has been solely for the public good. I may, in the course of my examination, have made use of expressions that may be considered harsh towards individual Commissioners and to the Court itself, but I can honestly say that I am not, nor have I been, actuated by any vindictive and improper feelings towards any one. To remedy the many glaring and grievous evils which existed, was worth the attempt on my part. It has always been my endeavour to bear the opposition, the bitter taunts, the sarcasms, and the insult, if I may so term it, which have been heaped upon me by some of the Commissioners, in consequence of so doing, with forbearance and good will. It is, however, extremely wearing and harassing to bear with it. I have been only four years in the employ of the Court, and although now a young man, I feel that my spirits and strength are much weakened, I feel at least 10 years older than when I entered its service. It is my firm intention, should the construction of the Court be continued as it now is, to resign my appointment. I have long felt that I was injuring myself in staying with them. It is utterly impossible for any right-minded man having a strict regard for himself and family, and the public service, to continue with a body so totally incompetent to manage the great and important works committed to their care and control. The system is radically wrong and rotten to the core, it is eating into the vitals of the population, and it is not to be expected that men who have been the means of making it so will now turn round and act energetically, in order to correct and remedy, or rather break up, what they have been so long doing badly. It is their forte, as is apparent every day, to meet every proposition for improvement, if not with direct and determined opposition, at least with all manner of frivolous and vexatious interferences. They look upon sanitary improvement as a whim, and an ephemera. Looking to their own interest only, and with every comfort in their own homes, they little know, and care less for, the privations of the poor. There is disease and danger lurking at every man's door, and who knows how soon the destroyer may come. Unfortunately, the visitation falls on those who are least able to bear the burden; the poor are the principal sufferers in consequenee of the neglect of the rich. Avert the danger while yet there is time. Root up the present demoralizing system, and establish another and a better system on a firm and equitable basis.

No. 14.

Captain Bague, R. N.

No. 14.
Capt. Bague.

You act occasionally as chairman of the Westminster Court of Sewers?—I have been in the habit of attending the Court from, I should say, the first moment I came into the Commission, and I scarcely or ever have missed a meeting. Latterly, when Mr. Donaldson and Mr. Willoughby gave up the chairmanship, from my constant attendance, and perhaps knowing a little of the routine of the business, as I came into the Court the Commissioners who were then present thought proper to do me the honour, if I may say so, of electing me chairman for the day. I believe that occurred on the 17th of February, 1846, and for the last year I have never missed a meeting in giving my attendance as chairman. I may also say that, from time to time, the Commissioners have been satisfied with the manner in which I have carried on the business of the Court, and also have been pleased to express their approbation of the way in which I have conducted the business.

Have you read the printed copies of the examinations taken here, which the Commissioners requested you might have an opportunity of reading?—I have.

Do you wish to present to the Commissioners any observations in relation to them?—No, I do not; I think what I have read is a very well drawn-up statement, both on the part of the clerk and on the part of the surveyor. I think, generally speaking, it is a manly straightforward piece of evidence which I think does them great honour and great credit.

So far as facts may come within your own knowledge, there is no point upon which you feel inclined, from your own observation, to give any contradiction to the evidence which they have given upon oath?—I should say not. I have been a very close observer of the conduct of the Commissioners of Sewers. Gentlemen present must be aware that, looking to them as a large body of men collected together, and in a great measure connected with each other, it would be a hard matter to say anything more than the clerk and surveyor have said,

It was stated that you had, upon one occasion, or some occasions, reproved Commissioners for taking part in relation to works in which they had a direct trading or personal interest?—There is one section in the Act of Parliament that my attention was particularly drawn to; and I distinctly told the Commissioner referred to, that, before he entered upon the question, he must observe that he was a party interested in that question; and I begged he would not for a moment enter into the discussion, or give his vote, when the time arrived. On the first occasion he retired; but, on the second occasion, in a rather flippant way he said, Oh, as to that, he did not care about what the chairman said; there was no fine against him for voting on the question; and that he should, in fact, do as he pleased.

Mr. Phillips has complained of his works and his propositions being dealt with, with some degree of temper, as if arising from rival schemes or rival interests, and that he has had interruptions which an officer intending to promote economy or submit improvements, tending to save public money and to increase the efficiency of the works, ought not to have met with. So far as you have observed, do you think him entitled fairly to make such a complaint?—I could not say honestly and

No. 14. Capt. Bague.

fairly that anything has come out at the Court to warrant my answering that question in the affirmative as to rival schemes; but I am quite aware that obstructions are thrown in his way. It would not be right, perhaps, in me to mention any Commissioner's name in this matter; but I know he has had a great deal to contend with. Mr. Leslie, one of the Commissioners, brought him under the notice of the Court, and recommended him very strongly, being, I believe, quite unacquainted with Mr. Phillips, except that he was cognizant of his ability as a person quite adequate to undertake the surveyorship of the Commission. If I may be allowed to speak of him, though in his presence, and to mete out the praise to him, which this being a public question is no more than he deserves, as far as I have observed his conduct and his attention to his duties, I can honestly and safely say that I do not think, though there may be his equal, there is his superior in the station he is moving in. I am quite aware that the evidence which Mr. Phillips and our clerk have given, may cause pain to some of the Commissioners; but as I observed before, I think both the clerk and the surveyor have given their evidence in such a straightforward way that there can only be one opinion upon the subject of it, namely, that it will be for the public good and for the benefit of the public service.

No. 15.

Sir *George Phillips*, Bart., M.P.

No. 15. Sir George Phillips.

The Commissioners understand that you are able to give them some evidence in regard to the difficulties experienced by an owner of property in obtaining sufficient drainage for his house. Will you have the kindness to state the particulars of the case to which you refer?—I am the owner of a range of stables in Farm-street Mews, over which there is a dwelling-house. The stables were taken on a building lease by a stable-keeper. I came into possession of them two years ago. I found that there was a great want of ventilation, and particularly that there was no drainage to carry off the contents of the stable. There were two privies, and all the filth from the house and the stables also.

In a cesspool?—Yes; I believe there were two or three cesspools. I saw that they were in a very filthy state, and I ordered my builder immediately to put a proper drain to the house to carry off the refuse. He wrote me word that this was done, but as soon as I came to London I was told by the Surveyor of Pavements in St. George's Hanover-square, that the parish would bring an action against me if I did not remove this drain which my builder had made into the only place into which it could discharge itself, an open gutter which goes down the mews. Upon this I asked him where I was to put it; as the premises were in really an unhealthy state before this drain was made. He said—very properly, do doubt, upon his part,—that he was not to tell me what I was to do, but what I was not to do; that I must not put this drain into the open gutter. I applied to know whether the Commissioners would give a drain through the whole of the mews, which was very necessary, but they declined doing so, I think, unless everybody in the mews would agree to pay their share of the drain. I said that I could only answer for myself; in consequence nothing was done. I was

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anxious to get a proper drain, and I applied to my next door neighbour, who has a very large range of livery stables, and he told me that he should be very glad to co-operate with me, and bear his share of the expense, if the drain were made. Upon which I said that I would undertake to do it if he would co-operate, he owning really the most extensive premises there. I was just upon the point of having the drain commenced by my own builder, when the livery-stable keeper said that he found it was much more expensive than he expected, and he declined performing his promise. So that I am left in this situation: I must drain for the whole neighbourhood, or else the Commissioners ought to make the drain themselves, and force every owner of premises in the mews (which I believe they have the power of doing under the new Act) to contribute their quota towards the expenses of the drain. This they refuse to do. They will not make the drain themselves, compelling those to pay who ought to pay. I say, "I will do it myself, if you will perform your part, and force my neighbours to pay me their share." That they say they will not do. The third alternative was, I said, "If they will not pay for the drain themselves, I am willing to make a common surface drain large enough to carry off all the filth from my premises at my own expense." That, also, they say they will not permit. I am threatened with an action, and the only thing that I, as an individual, can do, the Commissioners say they will not allow me to do.

What is the total expense?—I believe it will be somewhere near 200*l.*

For draining what distance?—I should think a couple of hundred yards; my own premises being a very small part of that 200*l.*

How many occupations would that drain serve for?—The main party who would benefit by it is this owner of the stables. He has a large house, and stables, I should think, of from 50 to 100 stalls, besides two or three houses, which are let, over the front of the stables.

Supposing the Commissioners had power to make the drain, and distribute the expense by a yearly payment over 30 years, then, of course, you would have found very little difficulty in inducing your neighbours to contribute?—I doubt whether any inducement would operate upon them, except it was backed by the force of law. If a man promises to pay, and then when the work is about to be done, comes and tells me he retracts his promise, I have no very great hope of his paying anything unless compelled.

His promise was that he would pay immediately a share of a work which was to last for the use of tenants in future time?—Yes.

Did the Commissioners assign any reason for not acceding to your request?—I could not see them to-day. I went at the usual time of their sitting; I believe between 11 and 12. I sent in my name, and the reply was that they would see me in my turn. I said, "How soon will that turn come?" They said, "We can tell you nothing about that; there are about 50 names before you." I asked them when the next Board-day was. They said, "A fortnight hence." I thought it was a very extraordinary circumstance that they should meet only once a fortnight, when they had upwards of 50 people waiting to see them. This is an account of the way in which my builder was treated, contained in a letter to myself:—

No. 15.
Sir George Phillips.

"*London, October 2nd*, 1847.

"Sir,—I beg to inform you, that yesterday, being a Court-day at the office of the Commissioners of Sewers, I attended both in the morning and afternoon. I first saw the surveyor, and explained the case to him. He desired I would prepare a written application to submit to the Board, which I did (I have enclosed you a copy of the same). When before the Commissioners, I urged upon them the necessity of taking this case into consideration, and begged they would themselves construct the sewer, as they had the power by the new Act to oblige each person whose premises fronted the same to pay their share of the expense, or to charge it to the district; whereas, if you built it, it would be considered a private sewer; and requested them to inform me how you were to act to prevent an indictment for a nuisance when not allowed a drainage. They treated the application with the greatest indifference, refused to build the sewer, and when I pressed the chairman for a direct answer to your application, he said you must abide by the Act of Parliament, which was, in reality, no answer at all. Allow me to observe that it was distressing to witness the manner in which various applications were treated by the Commissioners, some similar to your own case, and others much worse; they treated them with the greatest contempt, throwing them aside like waste paper, and one of the body said he wished 'members of Parliament would pass an Act to prevent persons sending them petitions.' I have looked carefully over the new Act relating to sewers, and find everything has been done that is possible to enable the Commissioners to cause all nuisances to be removed, and to afford to every one a proper drainage; but such Acts are useless when the persons are not competent to carry out the same.

"I have the honour to be, Sir,
"Your obedient servant,
"Thomas Watts."

—The following is the communication which my builder, at my desire, made to the Commissioners:—

"2, *South-street, Grosvenor-square,*
October 1st, 1847.

"Gentlemen,—I beg to inform you, that I am instructed by G. R. Phillips, Esq., M.P., No. 12, Hill-street, who has a stable building in Farm-street Mews, to renew his application made to you about six months back to form a sewer down the said mews, or to allow him to make a drain from his stables to the nearest existing sewer. Allow me to remind you that he has only a surface drainage either from the stables or water-closet, and has received a notice of indictment from the parish if this nuisance is not immediately put a stop to. I beg to state that, should you consider it expedient to construct a sewer instead of allowing Mr. Phillips to form a drain, he is willing to pay the expense of the sewer the extreme length of his frontage. Trusting, under these circumstances, you will not allow any further delay to take place,

"I have the honour to be, Gentlemen,
"Your obedient servant,
"Thomas Watts."

Is there any common sewer near this drain?—At each end of the mews there is a very good sewer, and it is only making one main sewer through the mews, and that would completely drain the whole place.

Were your neighbours leaseholders or tenants-at-will, or what was the nature of their occupation?—I should think the stable-keeper must have a long building lease, as he has been laying out a great deal upon the premises.

Persons would have to contribute in different degrees of interest, probably?—One side of the mews consist of the rear of the houses in Hill-street. I think there is only one of those that requires a drainage. From my own house in Hill-street the drain goes into the sewer in Hill-street. If something be not done, my only course will be to restore the old cesspools, which I should be very unwilling to do.

What is the length of the drain required?—I think it must be about 200 yards.

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Sir George Phillips.

Annual instalments of 14*l.* or 15*l.*, if distributed over the whole parties interested, would fall comparatively lightly, and be little or no object?—I should think so. I am sure it ought to do so.

The only reason why you could not get co-operation was the expense?—Yes.

And that expense to be immediately paid?—Yes, of course.

No. 16.

Mr. *G. Wilson.*

No. 16.
Mr. G. Wilson.

You were the secretary of the Board of Health for the parish of St. Margaret and St. John, Westminster, at the time of the cholera?—Yes, I was honorary secretary.

Did you visit the district at the time?—Yes, I did.

You know the present condition of the labouring population of the parish?—Yes, I do.

In respect to drainage and sewage-water, supply, and the means of cleansing, how far do you consider that it is altered?—With respect to the greater proportion of the parish, I believe it is exactly as it was; from Palace-street down York-street and Tothill-street, with the streets branching out right and left therefrom, there was, and there is, nothing but a surface drainage. The basements of the houses lie several feet below that surface drainage, and in order to get rid of the offensive liquids, the inhabitants of the houses pump it from the basements into the streets. In many cases, the pumps draw up the matter from the cesspools into the street. In Palace-street they pump up the soil into the street, and there it lies until the godsend of a shower clears it away. We feel for the people, because they cannot inhabit the basement-floors unless they do this. But this is the condition of a street close to the Palace, and of occupants of a property which belongs to the Crown.

Are other parts of Westminster in an equally bad condition?—I own some houses in Dartmouth-street, and my tenants are obliged to do the same. I think many parts of the district would be uninhabitable, but that there is a substratum of gravel through which the offensive liquids percolate.

What is the condition of the wells in Westminster?—Really it would be well not to think about that, or we should deteriorate the property of the district.

Have there not been any new sewers made there?—Yes, in some parts of the parishes, but they have been productive of very little benefit.

Do they emit offensive smells?—Yes, and it has been a frequent question with the Paving Board, whether they should be trapped, as the exhalations from them are often very offensive. These sewers, since their formation, have been very little used, from the fact that the poor property is not able to pay the sum demanded for permission to enter them.

Has the parish paid sewer-rates?—Yes, for centuries, but has derived very little benefit therefrom.

No. 17.

No. 17. D. H. Stable, Esq., and John Roe, Esq.

David Henry Stable, Esq., Clerk to the Holborn and Finsbury Division of Sewers, and *John Roe*, Esq., Surveyor.

What is the state of your surveys in the Holborn and Finsbury division of sewers?—(*Mr. Stable.*) Since the issuing of the present Commission in 1837, we have been constantly at work amending our old plans and making new ones. The Surveyor began, during the last year, a compiled plan of two districts, showing thereon all the main lines and the collateral branches, also all the courts and alleys. This general plan has been engraved and distributed.

(*To Mr. Roe.*) From what materials was this plan compiled?—From materials found in the office with corrections where new buildings had been constructed.

On what scale has this been prepared?—Ten chains to the inch.

How were the old plans made up?—(*Mr. Stable.*) By actual survey of Captain Ogle, architect and surveyor, compiled 27 years ago. When my colleague, Mr. Lush, and myself were appointed joint clerks in 1812, the Commissioners possessed no office in which to transact the business of the Commission, nor were there any books, plans, or records, except Minute-books of the Court, a few presentments of juries, and rate-books; soon after our appointment, upon our representation to the Commissioners of the serious inconvenience the public was sustaining for want of an established place of business, an office was taken in Hatton-garden, where daily attendance has ever since been given to receive applications and complaints, and thereby enabling the officers of the Commission to conduct its affairs with order and regularity. Previously to this time the meetings of the Commissions were held at the sessions-house and sometimes at a tavern, and the business conducted at the private office of the clerk.

(*To Mr. Roe.*) Has there not since then been considerable alterations in the surface in respect to the levels?—Yes, there have in various localities been considerable alterations in the surface.

Do you consider this general plan sufficient to go on with?—No, not the general plan; the scale is certainly too small, for a working plan: it serves at present as a plan of reference for the Commissioners at their meetings.

Have you cross sections of the main line and branches of your sewers?—Yes, we have cross sections of all the main lines, and of all the known branches. In the older districts we are finding occasionally sewers and drains not laid down in the office plans.

What is the state of your present plans in relation to courts and alleys?—In the district plans which are prepared to a larger scale than the general plan, and which relate to the proportion of the district which is rated, all the courts and alleys, and the divisions of the houses, are shown.

Are the drains or sewers of the courts and alleys laid down?—All the known sewers or drains are.

Is there not much that is unknown?—Yes, there is; I am, however, proceeding with an inquiry as to the state of the courts and alleys within my districts.

No. 17. D. H. Stable, Esq., and John Roe, Esq.

Notwithstanding your existing materials, would it not be an economy to have a plan upon a large scale for this district, as well as for the whole of the metropolis?—Yes; I think it would be of great importance to have a plan on one large scale for the whole of the metropolis, and that it should be governed by one law.

(*Mr. Stable.*) In that I also cordially concur, as I consider it would be a matter of great importance.

Will you not require more outlets and main lines of drainage?—(*Mr. Roe.*) Yes, I am preparing a report to show that more main lines will be required.

Under the existing state of things, will not two or more independent authorities have to concur, not only in the expediency of those lines, but two or more sets of independent officers have to superintend the execution?—Yes.

May not two or more independent authorities determine, if they so think fit, to have a different form of sewer for the discharge of the same run of water through the different districts?—Yes, they may.

Have you not had even recently different forms of sewers made for the same outfall?—Yes, we have.

Will you give the last example?—The last two were in Charlotte-street, Bloomsbury, and in Museum-street. They were both for the relief of the Holborn district, extending from the Hampstead-road to George-street, Gower-street, and Bedford-square.

What were the differences of form in the same outfall?—In Charlotte-street, the Holborn and Finsbury being the egg-shaped sewer, with the small end downwards, the Westminster Commission brought up their outlet to ours in the egg-shape form, only with the broad end downwards. In Museum-street, the Westminster sewer was of the upright sides, and nearly a flat bottom, with spreading footings.

What was the difference of the expense of the two forms?—One form, I know, cost about 14*s.* per foot. I have been informed that the cost of the Westminster sewers was about 28*s.* per foot in Museum-street.

Had, then, the natural drainage area been under one jurisdiction, may it not be presumed that the same main line would have been carried throughout, of one form, and at one expense, and that expense a reduced one?—Certainly. I should never have thought of having different forms for the same outlet.

Are not the gully-shoots, in an engineering point of view, essential parts of the machinery for drainage?—Yes.

(*To Mr. Stable.*) Have not a large proportion of the parishes within the Holborn and Finsbury division the right to direct the insertion of gully-shoots in any number they please?—Yes, the parochial Paving Boards generally possess that power.

(*To Mr. Roe.*) According to all engineering principles, ought not the inclination of the surface, and the paving of the surface of the street, to be considered, for the discharge of surface-water and filth, and governed in conjunction with the other arrangements for drainage?—Yes, undoubtedly. I certainly consider that the City of London has derived great advantage from the paving, and other parts of the same machinery, being under one management.

Besides the engineering discrepancies, in what other shape do inconveniences arise from the separation of the management?—We hear of

No. 17. D. H. Stable, Esq., and John Roe, Esq.

them chiefly in the shape of constant complaints from the contractors. They send in estimates for the building of the sewers, including the reinstatement of the pavements. On the Commissioners advertising for building sewers, the contractor sends in a tender for the construction of the sewers for a sum which includes the opening and reinstatement of the pavement. The Commissioners of Pavements have the power, which they exclusively exercise, of reinstating the pavement; and this power they retain tenaciously. After the completion of the contract, the contractors very generally complain of the exorbitant charges they have had to pay for the reinstatement of the paving, and put strong cases for an additional allowance. A new contractor has guessed at what would be the charge from what would be reasonable; some have thought it would be a mere trifle, but have been deprived of their profits by these exactions. This has been a peculiar grievance with our general workmen, who contract for the building and the repair of sewers during three years. They have contracted, as a general price, for 1*s.* 6*d.* per superficial yard, but they have been subjected to charges which have amounted to three times that sum.

If this were under one control, at what expense to the public might it be executed?—Certainly at 9*d.* per yard at the maximum; that is to say, at half the expense which, in ordinary cases, the Commissioners now pay the contractors.

But at that half expense, would not the work be much better executed?—Certainly much better, much quicker, and with less of that inconvenience to the public in the obstruction to thoroughfares which is now such a grievance in the metropolis.

What are the motives to the ineffectual pavement?—To the parish contractors every repavement is a source of emolument.

It appears that in this one subdivision of the drainage area of the metropolis, there are 34 parish Boards or Trusts, or sub-districts, having the independent powers described. In passing through two or more districts with one line of sewer, do you find wide differences in the charges?—Yes; in sewers passing through three parishes, one charged 1*s.* per yard, another 1*s.* 6*d.*, and the third 2*s.* 3*d.*, all in one line of road, and for one description of road.

What are the works you have at present in hand?—The building of sewers in Mansfield-place, Kentish-town, and in Providence-place, Kentish-town; in Bunhill-row and Lambs'-buildings, St. Luke's, Middlesex, and in Lamb-court, Clerkenwell-green; constructing gully-holes in St. Paul's-road, Camden-town, in Albert-street and King's-road, St. Pancras; and in Bagnigge Wells-road, Clerkenwell; and forming a junction between sewers in Plumber-place, Clerkenwell.

What works have you under consideration?—A new extension line of sewer for the drainage of Holloway, in Islington parish; the rebuilding of a dilapidated sewer in Bloomsbury-square; and the forming an outlet for sewers built by individuals near the City-road.

What may be the probable expense of the works you have under consideration?—12,254*l.*; besides which a very large sum of money will be required for the drainage of courts and alleys not yet ascertained, and applications have been made for the extension of sewers to effect a proper drainage for the north part of Kentish-town and Hampstead.

(*To Mr. Stable.*) Since it appears from the Surveyors' well-con-

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sidered reports, that the control and application of the supply of water will admit of extensive reductions of the sizes of sewers and drains, and a reduction of the expense of sewers to more than one-half, do you think it warrantable to go on whilst there is any reasonable prospect of obtaining such a reduction, putting the public to a double expense for a less efficient system of drainage?—Were the Commissioners of the Holborn and Finsbury Sewers aware of such improvements being under consideration, I have no doubt they would suspend all such works as are not of immediate necessity. The Commissioners themselves had intended to apply to Parliament for extended powers.

But did they propose to go for powers to obtain control over additional supplies of water?—No, they had not the least idea of it.

Admitting, as you do, the advantages of a general survey, do you believe that there would be any disadvantage to the public in the delay of the works within your district for such a survey?—I consider not, except such as are of absolute necessity.

From your experience and observation of this department of public administration, do you not consider that it would be of advantage to have a consolidated Commission for the whole district of the metropolis?—I consider it would be of great public advantage if a superintending general Board were appointed to frame uniform regulations for the management of the sewers and pavements of the metropolis.

Would not even a provisional Commission of Sewers for a consolidated district, comprehending the whole area of the metropolis, be of advantage (if not absolutely necessary, in respect to other districts of the metropolis at the least, if not of your own), to secure for the public, early, the full advantage of the survey of the whole district, and to prepare for further consolidations?—Yes, as far as general regulations extend.

Having experienced the collisions with the separate pavement authorities in carrying out sewerage works, have you formed any opinion as to the expediency of consolidating the works of paving with the works of sewerage and drainage?—Having seen how well the union of the management of the paving and drainage of the City of London has worked, I have no doubt that an extension of the same system would be of advantage to the public.

Would you still apply that conclusion to the case of a consolidation of the whole of the metropolis under one sewage district?—Yes.

Out of what fund will the new sewerage works for Bloomsbury be paid for?—Out of the general fund belonging to the Holborn division.

Then the rate-payers of Camden-town will be paying for the branch as well as the main drainage of the district below them?—Certainly; this shows the defect of the present state of the law; and on this subject I beg to refer to the printed copy of a Report made to the Court of Holborn and Finsbury Sewers on the 30th April last, in reference to the bill then pending in the House of Commons on the Health of Towns, which I beg to hand in.

Would it not be of advantage to distribute the charges for branch drains over periods of years coincident with the benefits experienced?—Certainly.

Will not this be also absolutely necessary in respect to the house-drainage?—Yes, if it is intended that house-drainage is to be supplied

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by the Commissioners instead of as at present being effected by the owners or occupiers of the individual houses to be drained.

From your experience and observations in these Commissions, do you consider that any man who is an architect or builder in practice or in trade, or in professions connected with them, can properly be held to come within the original meaning of the Statute of Sewers, as a substantial and indifferent person, to exercise functions in the control of public works, or the drainage of houses or lands?—I think that any tradesman is below the grade intended by the Statute of Sewers.

What do you pay for collections?—In the more opulent parts of the district 6*d.* in the pound, and 9*d.* in the poorer, the difficulty of collection being greater, and the assessments on individuals smaller in amount in the latter than the former portions of the division.

Do you not consider that a consolidation of collections would be advantageous to the public?—Yes, provided the sewers-rate formed a part of the poor-rate collection in the same manner as the police-rate.

Have you reason to believe that it would be of public advantage that the whole of the sewers should be constructed on contracts on behalf of the public, and none allowed to be constructed by private builders or owners?—Yes, more particularly as a means of preventing builders evading the regulations established for constructing sewers and drains.

Various objections have been made to the proceedings of the Court of Sewers from parochial or other local bodies: what has been the nature of those objections from parochial vestries?—I would put in a copy memorial of the Paving Board of St. Giles and St. George Bloomsbury.

Have there been received at any times from these bodies suggestions of improvements, either as to the works, or well-considered and approved suggestions of amendments in the administration of them? Have there, in fact, been received from the parishes any clear or well-considered statements of the evils arising from defective house-drainage or sewerage?—No suggestions have been received from any parochial or local boards as to improvements in the construction of sewers, the efficiency of house-drainage, or as to the general administration of the sewers laws in the Holborn and Finsbury Divisions.

In what intervals of time are your collections of sewers'-rates made?—Generally from one to two years.

Have you any persons on your Commission who are bankrupts, or outlaws, or insolvents?—One of those named in the existing Commission has been outlawed, and another is known to be in insolvent circumstances.

To the Right Hon. Henry Brougham and Vaux, of Brougham, in the County of Westmoreland, Lord High Chancellor of Great Britain.

The Memorial of the Committee for Paving, Cleansing, and Lighting the parishes of St. Giles-in-the-Fields and St. George Bloomsbury.

SHOWETH—

That your Memorialists, under and by virtue of an Act of Parliament passed in the 59th year of the reign of His Majesty King George the Third, intituled,

The Statement of the Commissioners of Sewers for Holborn and Finsbury Divisions, relating to the matters referred to in the annexed Memorial.

SHOWETH—

That the Commissioners of Sewers for Holborn and Finsbury Divisions extends from the centre of Tottenham Court-road on the west, embraces the several pa-

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"An Act for better Paving, Cleansing, "and Lighting the parishes of St. Giles-in-"the-Fields and St. George Bloomsbury, "in the county of Middlesex, and for "vesting the sole management thereof in "the Vestrymen of the said parishes and "a Committee of the Inhabitants thereof," have been appointed a Committee for effecting the several purposes in the said Act mentioned.

That part of the above-mentioned parishes is within the district of the Commissioners of Sewers for the City and Liberty of Westminster, but the greater part, namely, about two-thirds, is within the district of the Commissioners of Sewers for Holborn and Finsbury Divisions.

That in the Commission of Sewers for the city and liberty of Westminster twelve of the inhabitants of these parishes are nominated thereto, whereas the Commission for the Holborn and Finsbury Divisions, whose district in the parishes is of so much larger extent, contains (it is believed) only two of the inhabitants among the many persons exercising jurisdiction, and raising and levying so large a sum upon an average of 7000*l.* annually in the said parishes.

That from the smaller number of Commissioners resident in these parishes, in the said Holborn and Finsbury division of rishes of St. Pancras, the county part of St. Andrew Holborn, St. George the Martyr, the Liberty of the Rolls, about two-thirds of the united parishes of St. Giles and St. George Bloomsbury, the parishes of St. John and St. James Clerkenwell, St. Mary Islington, St. Luke, the liberty of Glass-house yard, part of St. Sepulchre, the liberty of Norton Falgate, St. Leonard Shoreditch, and Stoke Newington, in the county of Middlesex.

That the present number of Commissioners in the Holborn and Finsbury Divisions amount to 173, and for that portion of the united parishes of St. Giles and St. George Bloomsbury, which is within this Commission, there are nineteen resident Commissioners (their names and residence are herewith annexed), being a greater proportion of resident Commissioners than in any other parish in the Commission; and out of that number those to whose names an asterisk is affixed are on a standing Committee, and without whose order in writing no work is performed, and for which applications are constantly making at the office of the Commissioners, No 7, Hatton-garden, where daily attendance is given for receiving petitions for sewers, complaints of stoppages, &c. &c.

That the amount collected under this Commission within the said parishes, upon an annual average of the last nine years, does not exceed the sum of 1036*l.*, upon a rate of sixpence in the pound upon the assessment upon the poor-rate. The sewer-rate is not made every year, but as the works to be executed require, and such rate has been found sufficient for three years, with the exception of the rate made in 1831, which, in consequence of the prevalence of the cholera, occasioned a much larger expenditure, and lasted two years; the dates of the rates so made, and the amount collected in the district of the Committee for paving St. Giles and St. George Bloomsbury, are as follows:—

		£.	s.	d.
That in 1825	produced	2901	8	6
,, 1828	,,	2719	14	9
,, 1831	,,	2779	14	6
,, 1833	,,	*926	11	6

That in the Commission issued in June, 1830, the names of the noblemen and gentlemen submitted to the Lord Chancellor

* Being the supposed amount upon an average of three years.

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sewers, your Memorialists are desirous of being more adequately represented, by having a small number of the owners or proprietors of houses and lands within their respective parishes added to the Commission for the Holborn and Finsbury Divisions.

That your Memorialists, previous to making this application to your Lordship, applied to His Majesty's justices and Commissioners of Sewers for the Holborn and Finsbury Divisions, to be furnished with a list of the Commissioners, in order that they might interest those resident in these parishes to watch the large receipt levied within their jurisdiction, in reference to the small sum expended in the cleansing and repairing of old, or the constructing of new sewers within the said parishes of St. Giles-in-the-Fields and St. George Bloomsbury, but which list was refused to be furnished by the said Commissioners.

That your Memorialists respectfully request your Lordship will be pleased to cause the undermentioned gentlemen, inhabitants of those parishes, to be added to the Commission of Sewers for Holborn and Finsbury Divisions, namely:—William Henry Savage, of No. 68, Gower-street, Bedford-square; Captain Hardy, of No. 8, Tavistock-street, Bedford-square; William Matthew Thiselton, No. 59, Great Russell-street, Bloomsbury; Mr. Edward Bullock, No. 211, High Holborn, Auctioneer; Mr. Nicholas Winsland, Duke-street, Bloomsbury, Builder; Mr. Thomas Leverton Donaldson, No. 7, Hart-street, Bloomsbury, Architect.

Your Memorialists therefore humbly pray, upon the grounds herein stated, that your Lordship will be pleased to appoint the several gentlemen, inhabitants of these parishes above named, to the Commission of Sewers for the Holborn and Finsbury Divisions, if it shall seem meet to your Lordship.

By order of the Committee,

R. and R. F. Finnis, *Clerks*,
Hart-street, Bloomsbury-square.

for his approbation to be inserted in the Commission, consisted of the principal freeholders and leaseholders of the respective parishes, from whom a Committee of fifteen Commissioners are appointed by the Court of Sewers to superintend the works carrying on; and had the Commissioners entertained an opinion that a larger number of persons would render this Commission more efficient in operation, or more beneficial to the several parishes, they would not have omitted to solicit his Lordship to have increased the number.

That there are no printed lists of the Commissioners, but the names of all the Commissioners who attend are called over at the General Courts, which are held quarterly, and are open to the public, being Courts of Record. The annual statement of the expenditure for 1832, requested in this application, was sent to Messrs. Finnis, Clerks to the Paving Committee.

Accounts showing the receipts and expenditure are annually printed and sent to the vestry clerks of the respective parishes, and may also be had by every rate-payer upon the payment of one shilling. That the expenditure in the cleansing and repairing of old, or the constructing of new sewers within the district of the Committee for paving the said parishes of St. Giles-in-the-Fields and St. George Bloomsbury, upon an annual average of the last nine years, amounts to upwards of 900*l*.

By order of the Commissioners,

Stable and Lush, *Clerks.*

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Mr. *John Roe.*

(*Second Part.*)

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Have you carried on any set of practical observations as to the flow of sewers of different sizes and capacities, under different circumstances?—Yes, I have. Ever since I have been in the service of the Commissioners of Sewers for the Holborn and Finsbury Divisions, I have carried on observations as to the velocities of water in the river Fleet sewer. Subsequently I have, at Mr. Chadwick's suggestion, extended the observations to branch and collateral sewers of different descriptions.

Can you furnish the result of these observations, or tables founded upon them?—I have begun to form tables, which I hope to live to complete.

What area is drained by the river Fleet?—About 4400 acres; of which 1888 acres are covered or town area, and 2512 acres uncovered, or rural area.

What is the capacity of the river Fleet sewer, and what its inclination?—The sewer is 12 feet high and 12 feet wide, with a superficial area of 120 feet in the largest part in the Holborn and Finsbury Divisions; but the capacity of the whole line varies generally according to the quantity of surface drained by each portion; with regard to its inclination, it varies from 1 inch in 100 feet to 1 inch in 2 feet, whilst some portions are on a level.

What is the sum of the capacities of all the sewers that fall into it?—About 550 feet.

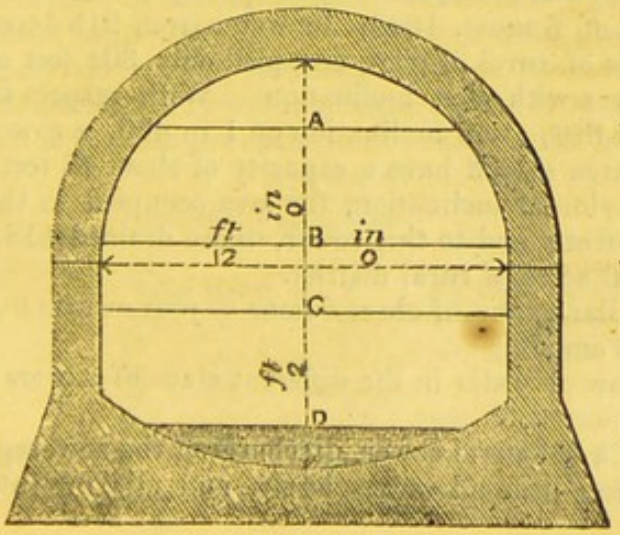
What is their number?—Sixty, that are called sewers.

Then the capacity of the main would be as about 1 to 4 of the capacity of the sewers, of which it is the general outlet?—Yes.

Can you furnish an approximation to the average inclination of the sewers which fall into the Fleet?—In most instances they vary; some of them are a quarter of an inch in 10 feet, others are 3 inches in 10 feet.

Suppose that every house within the district had a drain of 9-inch diameter, what proportion would the sum of the capacities of the house-drains bear to the sum of the capacities of all the sewers?—About 16 to 1.

And to the capacity of the main outfall?—About 75 to 1.



Thunder storm, August 1, 1846. Area occupied, 106 feet.

Thunder storm, July, 1844. Area occupied, 79 feet.

Extraordinary thaw, after fall of snow, 1841. Area occupied, 54 feet.

Level of ordinary flow.

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On the occasion of the greatest storm which you have known to have occurred, what was the condition of the main outfall?—There were 106 feet of the area of the larger sewer filled by water which fell during the thunder-storm on August 1, 1846; during which storm the fall of rain in one hour was double in quantity to any former fall that I have noticed in London. The foregoing section (p. 233) exhibits the portions of the capacity of the same sewer occupied on those occasions named, and are the greatest I have observed.

In the thunder-storm of last year, some damage was committed by the flood in the neighbourhood of the Fleet sewer. How was this occasioned, and what was the extent of the mischief?—No damage occurred to the covered part of the sewer between Back-hill, Clerkenwell, and Grafton-place, Kentish-town, but houses were flooded along parts of the line. Some houses which stood on the banks of the open part below Back-hill were washed down in consequence of the old arched sewer over a portion of the Fleet, a little below Round-court, which having only an area of 66 feet, and as the flood of August 1, 1846, occupied an area of 106 feet in the new sewer above Round-court, the waters could not pass off quick enough, hence they accumulated, and flooded Round-court so much as to cause the houses to fall into the open part of the Fleet.

At what period has any similar damage been previously sustained?—I am not aware of any damage to a similar extent; but much flooding of property formerly took place above and about Battle-bridge. The sewer has, however, been enlarged and lowered thereabouts, and except on this occasion such property has not since been flooded.

Engineers and theoretical writers have set forth various formulæ as to the flow of water; and in the Second Report of the Health of Towns' Commission there are some Tables by Mr. Hawksley on the capacity of sewers required for various areas of drainage: how do you find those Tables to agree with your actual measure?—Taking the Table No. 1, I find that the size recommended for sewers to drain certain portions of land are larger than the actual requirements; for instance, the quantity of acres that a cylindrical sewer, 48 inches in diameter, is, by the table, allowed to drain, when the inclination is 1 in 240, is 47; whereas, in practice, it is found that such a sewer, with that inclination, drains more than 100 acres of town area, at a similar fall of rain to that on which the table is formed. Again, a sewer, with a similar inclination, to drain 129 acres of town area, should (by the table) be of the capacity of about 28 feet; but in the great storm of August, 1846, the water from 215 acres of town area, and 1785 acres of rural district, occupied only 30½ feet of the superficial area of a sewer with that inclination. With respect to larger sizes, the table shows that, at an inclination of 1 in 480, a sewer to drain 329 acres of town area should have a capacity of about 78 feet; whereas, in a sewer with a similar inclination, the area occupied in the storm of 1844 was only 79 feet; and to this sewer, there drained 1181 acres of town area, and 2656 acres of rural district.

Are you aware of any similar extent of observations to your own on the flow of water in sewers?—I am not.

Have you observed the flow of water in the different sizes of sewers?—Yes, I have.

Will you take the case of a collateral sewer, discharging the sewerage of a street of which the houses have all water-closets, and all run into

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the sewer: can you give the proportionate flow in such a sewer at different parts of the day?—Near midnight, 32 cubic feet of water passed in 2 hours and 16 minutes. At noon the same quantity passed in half an hour. On a water day, whilst the water was passing from the main to the houses, 32 cubic feet passed along the sewer in 1 minute and 16 seconds.

What would be the amount of rain-fall from the area covered by those houses, and the spaces occupied as streets, passages, &c.?—In a street of 924 feet in length, containing 93 houses, on an area of 6 acres, 1 rood, 8 poles, a fall of rain, 2 inches in depth, upon the street, houses, and gardens, would produce 346 cubic feet of water passing per minute in the sewer.

What size of outfall would be needful for that?—The size required would vary with the inclination of the sewer. At the inclination of 1 in 480 the capacity required for that fall of rain would be 2·44 feet.

Have you ascertained the consumption of water in those houses?—The total quantity averages 75 gallons per day to each house; but deducting the quantity which runs to waste on water day, the consumption for household purposes appears to be about 50 gallons per house.

What would be the area required for that?—About one-sixth of a superficial foot for the whole of the houses, at the time of the greatest flow.

In a lowland district would there be much due to land springs?—There would be something due to land springs. In one sewer which passes through such a district, I have noticed a land spring which furnishes a continual flow of water to the sewer, varying in depth from 1 inch to 3 inches.

Have you observed the discharge of water from uncovered land?—Yes; I have.

Will you describe it?—Having taken the levels, and measured off the portion of meadow-land, about 82 acres, as shown in the diagram now produced, I caused the invert part of a sewer to be formed at the point marked with the letter A, that being the only outlet from this surface. Observations of the run of water and depth of rain were continued for five months. From all the particulars that were collected, the greatest amount that was found to reach the invert, from a fall of rain of half an inch in the hour, averaged 3 cubic feet per acre per minute at the period of the greatest flow; that period was generally from three-quarters to one hour after the heaviest portion of the rain had fallen.

Have you any table that would show what quantity of constant flow would keep the different classes of your present sewers clear of deposit at certain rates of inclination. Can you furnish a table exhibiting this calculation?—It will take some time to form such a table; but I will give you now some few instances of sewers that have never required flushing.

Class of Sewers.	Inclination. Inches.	Average depth of common run of water. Inches.	Remarks.
1	8½ in 100 ft.	3	A little hard deposit until rain fell, which requires to be loosened by the labourers.
2	9½ „	3	
2	15 „	2	No gully into this.
2	30 „	1	
2	20 „	2	
1	12 „	4½	A little hard deposit from the roads, loosened by the men.

Give an instance of a sewer that has been kept clear by a small supply

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of water?—It is difficult to point out any sewer that may be strictly said to have been kept clear by a small quantity of water. For, whilst the rains have access by the gully grates, it is impossible to say correctly what is due to the constant stream, and what is due to occasional flooding by rain. Some sewers have deposit accumulated in dry weather, which has been washed away in a storm. In others, neither the constant run of water nor the occasional rains remove the deposit. Hence, in upwards of a hundred miles in length in these divisions, the deposits have been removed and kept down by flushing.

Does it not follow that such sewers must be too large, or of erroneous construction?—Some are too large; others have no inclination, and some have flat bottoms; but the want of inclination, and a flow of water, are the greatest causes of deposit requiring flushing away.

Deduct for evaporation and percolation, what sized stream would convey away a 2-inch fall of rain in the district drained by the Fleet, at the usual fall of large rivers?—Supposing a river to run at the rate of three miles per hour, the stream would be about 65 feet in width by 10 feet in depth.

Was not much water likely to have been carried away by other streams than the Fleet?—The water that runs from the surface named, as drained by the Fleet, has no other outlet than that sewer.

According to calculation, was most of what was due to the rain fall, except what might have been accounted for by evaporation and percolation throughout the soil, carried away by the Fleet?—The whole, with those exceptions, was so carried away.

Have you been able to ascertain the difference between the actual fall and the quantity carried away by the sewer?—In the tables, which are in progress, I intend to give all the information on this part of the subject that I have been able to collect.

Allowing for the increase of velocity by the junction of streams under the circumstances you have ascertained by experiment in relation to the flow of water in the river Fleet, what relation in size, so far as any existing data will allow you to judge, ought the sum of the branch sewers to bear to the main outfall, and the sum of space of the house drains bear to the branch drains?—The mean velocity of the stream in the main line increases after the junction of each stream that flows from the collateral sewers, but no one specific proportion as to the size of branch sewers can be given to suit all situations. There are few localities where the same inclination can be given to all the sewers; hence, the proportions of the sum of the capacities of the branch sewers to the main sewers will always vary according to the advantages or disadvantages of the levels for drainage. If the main sewer have but little fall, and the collateral sewers have a quick descent, its capacity must be greater in proportion to the sum of the capacity of the collaterals than if the latter had a sluggish current and the main line a quick descent.

There were, at the time of the census, 270,000 houses in the metropolis. If each were to have a 9-inch drain at the least, as provided in the Building Act at the instance of architects, what must be the sectional area of the river or the stream of water requisite to keep them all full and flowing?—A stream 1132 feet in width by 105 feet in depth.

What proportion does this bear to the Thames?—Probably about three times as large.

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As cold water checks decomposition, would not the effect of a tubular system of drainage, and a regulated supply of water, be greatly to prevent any emanations whatsoever?—If a sufficient quantity of water was passed constantly through the sewers, no noxious effluvia would arise. Such is the case at Eton, where 16,000 cubic feet of water passes through the main sewer every hour in summer, and considerably more in the winter reason.

Would not a less supply of water, with a constant flow, suffice to keep it clear of deposit?—A less quantity would suffice to keep the sewer clear from ordinary deposit; but as, from necessity, these sewers have no inclination, deposit from the macadamised roads is loosened and flushed away periodically.

Would not a proportionate quantity in a smaller sewer suffice to keep it clear?—With a suitable inclination, a less quantity would suffice to keep such small sewers clear.

With a regulated flow of water to keep the drains in action, within what time would all matter received into the sewers in your district be discharged from it?—At the inclination which many sewers are of necessity placed, no constant run of water will suffice to keep them free from deposit. The deposit which comes into the sewers from the macadamised roads, and some other sources, is of that heavy and tenacious description, that it requires in some sewers a flushing-gate moving on wheels to concentrate the force of the water to one point; and the deposit has to be loosened before the water, with this additional force, can wash it away. If a sewer had a proper inclination, and a sufficient supply of water, no deposit would remain in it; but at the inclination that can at present be obtained for a large proportion of these sewers, deposit will accumulate unless prevented by flushing.

What additional quantities of water do you consider might be requisite for the proper action of a tubular system of drainage?—No additional water is required in the Holborn and Finsbury Divisions for flushing the 100 miles of sewers so kept clear. As regards the flow of water through tubular glazed pipes, I find that the velocity at the same depth of water is one-third more than in brick-made drains having the same inclination; and although at present the largest size of these is only 15 inches diameter, yet this size might be used to great advantage in similar situations to where a larger class of drains or sewers was formerly used. The following are some of the results of experiments made with glazed pipes:—

TABLE of COMPARATIVE TIME of RUN of WATER through BRICK DRAINS and GLAZED PIPES.

Inclination.	Depth of Water.	Time through Glazed Pipes.	Time through Brick Drain.
	Inches.		
Level	5	38	50
2 inches in 50 feet	4½	16½	25
2¾ ditto	5½	19	27
1¼ ditto	3	18	26
½ ditto	3½	25	36
3¼ ditto	4	15	22
1¾ ditto	6	13½	21½

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The experiments were made in the following manner—first, the velocity in each sewer was taken for a length of 50 feet; then 50 feet in length of glazed pipes were laid on the bottom of the sewer, at the same place, to secure the same inclination as the sewer; the water was then allowed to pass through the pipes at the same depth as it had been in the sewer, and the velocity ascertained. The results were as above stated.

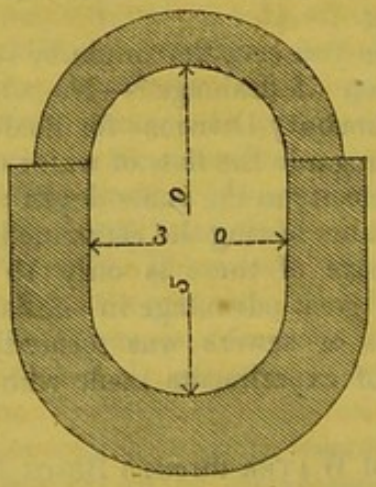
When you have had flushing going on, have you not observed that air is drawn into the sewers and carried down with the water?—Yes; I have often observed it.

With a system of tubular sewers and drains, and a regulated supply of water, and a quicker flow, must not analogous effects be produced, and instead of gases being given out from the sewers, air be carried in?—At the letting off a flush of water, there is a rush of fresh air into the sewers from the gratings, sufficient, in some cases, to blow out a candle. I have noticed that a current of air accompanies every flow of water, and where the depth of water is greatest, there the current of air is most considerable, the inclination being the same.

Will you give us cross sections of the sizes which you would propose for tubular sewers and drains, as deduced from the actual flow of water under a system of regulated supply; and also sections of the egg-shaped sewers, and the sewers formerly in use, and the house-drains now in use, as well as those you would propose, with the relative prices of these several descripton of works?

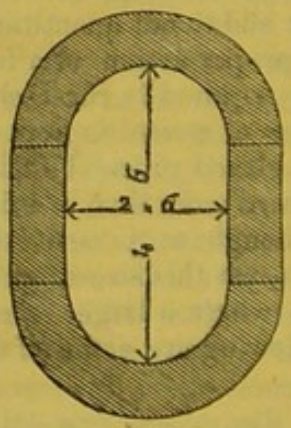
Transverse Sections of Sewers as originally constructed, with man holes for cleansing.

1st Class.



Cost per foot, 21*s.*, including Pavements.

2nd Class.



Cost, 15*s.*

House Drains.

1st Class.



Cost 3*s.*

2nd Class.



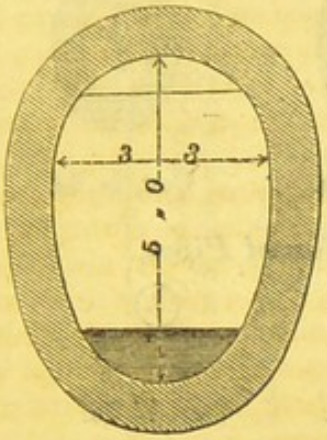
Cost, 2*s.* 6*d.*

These forms of drains are still in use by many builders.

No. 18.
Mr. John Roe.

Transverse Sections of Sewers as at present constructed, with side entrances for flushing.

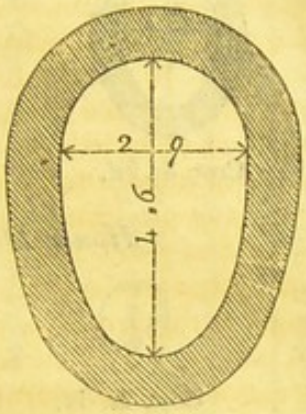
1st Class.



Thunder storm of 1846.

Common runs.

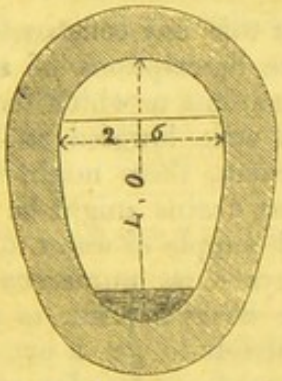
2nd Class.



Cost per foot, including pavements, 16*s*.

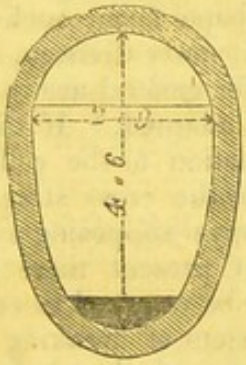
Cost, 14*s*.

3rd Class.



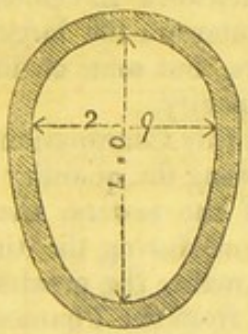
Cost, 12*s*.

4th Class.



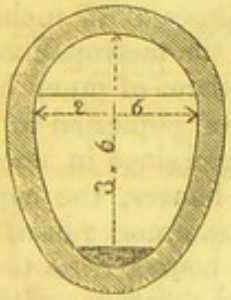
Cost, 8*s*.

5th Class.



Cost 7*s*.

6th Class.



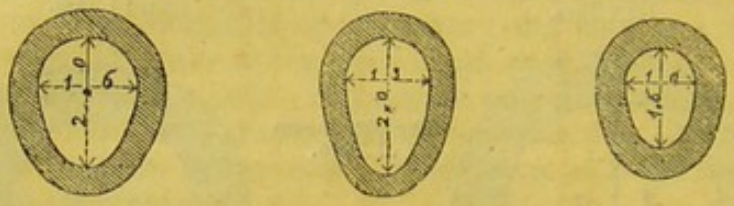
Cost 6*s*.

7th Class.—Egg-shape, 3 feet height by 2 feet extreme width.

No. 18.
Mr. John Roe.

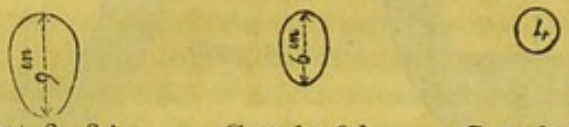
Drains for Courts.

1st Class. 2nd Class. 3rd Class.



Cost, 3*s*. 9*d*. Cost, 3*s*. 3*d*. Cost, 2*s*. 6*d*.

House Drains with Glazed Pipes.



Cost, 2*s*. 3*d*. Cost, 1*s*. 9*d*. Cost, 1*s*. 7*d*.

N.B.—Burnt clay pipes are much cheaper, but not so good for passing filthy water.

Practical Sizes under a System of the regulated Supply of Water.

The egg-shape form, such as are at this day constructed in the Holborn and Finsbury division, are those descriptions of sewers I would recommend for general use in those situations to which they are by their relative size adapted. If the outlets were lowered so as to afford a proper inclination to the collateral sewers, these might be reduced in size; and for the cross streets, tubular drains might be used with advantage, always supposing a regulated supply of water to flow through them; but at present there will always exist numerous cases, where flushing will be required to remove the heavy deposit, or a return made to the old system of breaking up the streets to get it out of the sewers. The largest size of glazed drain pipe made in London at present is 15 inches in diameter.

May we not expect, as a consequence of an extended demand for tubular drains and sewers, further reductions in price, and improvement in quality?—Yes; but at present tubular pipe, exceeding one foot in diameter, is not so cheap as the best brickwork in cement. In fact, at present, glazed pipes of 15 inches diameter are the largest that have yet been formed by the metropolitan makers, but some of them are about to try the making them of much larger capacity.

You have been requested to furnish this Commission with some instances of your gaugings in sewers, showing the quantity of area drained, the number of houses, the capacity of the sewers, the area occupied therein by the common run of water, or during the time the water is letting on to the houses from the water main, the greatest area occupied during a storm, the distance of the sewer from the Thames, and the height of the surface of the street above Thames high-water mark. Will you now give that information?—The following Table exhibits what you require:—

Area drained.	No. of Houses.	Size of Sewer.	Capacity.	Run of Water. Average common run.	Run of Water. Area occupied.	Run of Water. When Water let on from Pipes.	Area occupied.	During greatest Rain, in 1846, Area occupied.	Water closets or not.	Distance from the Thames.	Height above Thames high-water Mark.	Inclination.
Acres.			Feet.	Inches.	Feet.	Inch.	Feet.	Feet.		Chains.	Feet.	
110	..	Old Class 1	13	3	..	..	..	13·00	..	120	36·0	½ inch in 10 feet, a main line.
5	100	Class 2 .	9·0	1¼	0·08	2	0·13	2·50	None.	150	47·0	3 inches in 50 feet, collateral sewer.
2·70	69	Class 5 .	7·65	¾	0·024	1¼	0·06	2·10	None.	166	52·0	
5·15	104	Class 4 .	9·65	..	..	1¾	0·11	2·70	Closets.	145	47·0	5 inches in 100 feet.
1·09	49	Old Class 2	9·09	..	..	2¾	0·33	1·43	Closets.	265	120·0	
0·25	32	Ditto . .	..	..	..	1	0·04	0·33	Closets.	157	110·0	
1·36	41	Class 5 .	7·65	..	..	2¼	0·23	1·40	None.	151	46·0	
2·16	50	Ditto . .	7·65	..	..	1	0·034	1·13	None.	160	51·0	
4·16	120	Class 4 .	9·65	..	..	3	0·23	4·17	Closets.	140	49·0	2 inches in 100 feet, current impeded by height of water in outlet sewer.
0·25	16	Old Class 2	9·09	..	..	¾	0·03	0·30	Closets.	155	102·0	
19·10	482	Ditto . .	9·09	3	0·23	..	..	6·33	None.	140	50·0	2½ inches in 100 feet, current impeded by height of water in the outlet sewer.
1·00	22	Class 5 .	7·65	¾	0·03	..	..	1·13	None.	147	47·0	
1·36	37	Ditto . .	..	..	0·05	..	..	1·25	None.	149	47·0	
1·08	31	Ditto . .	..	..	0·04	..	..	1·20	None.	151	46·0	
3·42	65	2-ft. drain .	3·14	..	0·09	..	..	1·60	None.	180	118·0	12 inches in 100 feet.
0·84	40	15-in. drain	1·22	..	0·17	Engine waste water.		1·22	None.	92	48·0	5½ inches in 100 feet.
SEWERS NOT REQUIRING FLUSHING.												
82·00	..	Class 2 .	..	5¼	..	..	..	..	Closets.	58	77·50	9 inches in 100 feet (a little obstructed at outlet).
86·00	..	Class 1 .	..	3¾	..	..	..	..	Closets.	55	75·00	10½ inches in 100 feet.
5·35	..	Class 2 .	..	1	..	..	..	..	Closets.	105	59·00	14 inches in 100 feet (a drop at outlet).

No. 18. Mr. John Roe.

Having now given your attention during several years to the drainage of the metropolis, and been consulted in respect to the drainage of towns, both at home and abroad, do you believe that a systematic drainage of the whole metropolis can be carried out otherwise than by one administrative direction and under one general survey?—I have already expressed my opinion of the benefit of a general survey of the metropolis. Had such survey been made many years since, a great saving would have accrued in the cost of sewers, as the main lines might have been kept at such a depth as to have allowed a sufficient inclination to most of the collateral sewers in the metropolis, which, with a constant flow of water, might have been kept clear, and the size been reduced accordingly. And now such survey should be made, in order to amend some existing lines, and to afford facilities for future sewage works to be done at the cheapest rate, in the best manner, and at a proper level. Some of the outlets brought up to these divisions do not afford a depth sufficient to obtain more than 1 in 1200 inclination to the main sewers that drain to them, and the inclination in many of the collateral sewers is very little in consequence. I have before stated that to remedy the evils induced by want of a survey in these divisions would cost nearly a quarter of a million sterling. As to the administrative direction of the drainage, I am of opinion that to secure the effective carrying out of an uniform system, there should be a superintending Board, entrusted with adequate authority. The benefit of such a superintending board should also be extended to the whole of the kingdom, or but little good will be effected in sanitary matters.

What would be the effect of the suspension or delay of the existing works for the benefit of a general survey?—No positive evil would arise, so long as works of necessity, such as repairs and the drainage of houses in progress of building, were carried on.

Do you consider that any landlord, adminstering his own money, or any faithful steward administering it for him, would go on without such a survey?—No.

No. 19.

Beriah Drew, Esq.

No. 19. Beriah Drew, Esq.

To what division of the Sewers Commision do you belong?—The Surrey and Kent Sewers.

Are you the surveyor?—I am the clerk.

Do you act also as clerk to the magistrates?—No.

Were you examined before the Health of Towns Commission?—I was.

The Commissioners are desirous of ascertaining the extent of work for house, and street, and main drainage which remains unaccomplished in your district; have you any plans in the office upon which you can rely for making an accurate return of the number of streets within the district which have sewers in them?—There is no general plan, except that before you. The district is divided into three parts, there are three surveyors, and I have no doubt they can furnish such an account; I have none in the office.

Have you sections of all the drains and sewers?—Of existing sewers. I have them in the contracts always, but I have no plan showing the section of a sewer all the way except upon the contracts.

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The sections of the sewers you have, are such as are contained in the contracts?—Yes, in the office.

And they are not laid out upon any uniform plan by which they could all be referred to at a glance?—Not in the office. The district, except as respects that portion added to it by the last Act, is pretty much on one level. It is all under high water mark. The tide would overflow it, perhaps, in some places, eight feet, in others only six feet, and of course, at the extreme ends, it would only just reach it; but we are all under high water mark except the portion which has been recently added to us.

Are you in the habit of distinguishing your drains by main lines and collateral lines?—Yes; but generally speaking it is more the duty of the surveyor to do that than it is mine.

Each surveyor of course has a plan of his district?—Yes.

Each surveyor would have his own plan to produce?—Yes. We have a plan upon which the main lines are marked.

What is the district over which your jurisdiction now extends?—Under the local Acts of Parliament the district extends from Battersea to the river, dividing Deptford and Greenwich. We extend from the river Thames to the base of the hills of Clapham, Camberwell, Hatcham, and Deptford. The new district is south of that to the summit of the hills.

Do your sewers receive all the surface drainage from those hills?—Yes, unfortunately.

Is not it a benefit?—We do not think so. We have the greatest difficulty now to get rid of the water. It has been in the contemplation of the Commissioners for some time, and they are executing it as fast as they can, to make a line of sewer at the base of those hills to carry the water out to Deptford. A portion of the water is now carried out by the Effra river into the Thames from the Brixton washway westward, but there is no such communication eastward.

Have you laid down any plans for that project?—No, it is not yet decided whether we shall carry it out at the upper water-gate or into the river Ravensbourne; and we are not anxious of publishing our intentions, because we find that, when we have to purchase lands for the purpose of such contracts, the price is increased, if it is known beforehand that we are going there.

Have you any survey upon such a scale, as would enable you without any more special survey to work out such a plan?—There has been a survey taken, but it is with the surveyor.

On what scale is it?—I do not know.

With respect to the plans in the hands of the surveyors how are they accessible. Supposing a builder wished to see them, are they considered as public plans available for any purposes of that kind or are they the plans of the architect?—They are the plans of the Commission.

How far would they be accessible to any person wishing to inspect them; would they be accessible in the same manner as if they were in your own office?—Yes, entirely.

Have you a Court-house?—No.

Nor any special office?—Yes, there is an office.

Have you any records there belonging to the Commission?—Yes.

No. 19. Beriah Drew, Esq.

How long have you had that office?—Ever since I was appointed; I think 27 years.

Where is it situated?—In Bermondsey-street.

Is it an office rented by the Commission?—Yes, they make an allowance of 50*l.* a year for it.

Do any officers of the Commission reside there?—A servant is living there.

Is it, or any part of it, occupied by yourself as a solicitor?—No, I am not a solicitor. It is partly occupied by my brother, who has been a solicitor.

Who are the three surveyors?—The upper district is under the care of Mr. Joseph Gwilt, of Abingdon-street; the middle district is that of Mr. Edward I'Anson, of Laurence Pountney-lane; and the lower district is that of Mr. John Newman.

What has been done since you were examined before the Health of Towns Commission in the way of rebuilding, or altering, or improving the sewerage of the district in which you are an officer?—I can produce a list of the improvements and additions since that period. I do not immediately recollect the whole of them. Of course latterly we have been, and are now, restrained from doing works which we wish to do, from the want of money; no money is to be obtained. There are a great number of schemes under the consideration of the Commissioners at this moment, but we are only able to execute a portion of them. Under our Act we are obliged to give notice of any intended new sewer, so that any party may attend and object to the line proposed. That notice has been given since the new Act has been obtained, and perhaps I had better hand in a list of places of which we have given the notice. This notice has been served upon one of the churchwardens, and stuck upon the church doors of all the parishes of the district; but they comprise a very large outlay, and the Commissioners are only able at this moment, in consequence of the state of the money market, and being unable to get an advance from the Exchequer Loan Commissioners, to propose carrying out the following:—

"Sewers, Surrey and Kent. } 1847.

"Particulars of New Sewers about to be executed under notice of 22nd September, 1847.

		Estimated Cost. £.	s.	d.
No. 1.	Cold Harbour-lane, Camberwell and Lambeth	2,587	15	0
17.	Kent street, St. George, and Newington	2,270	0	0
18.	Friar-street, St. George	1,360	0	0
30.	Long-lane, Bermondsey £2740			
31.	And Weston-street 270			
		3,010	0	0
32.	New Cross	2,281	0	0
		11,508	15	0
	Victoria sewer, Peckham	2,445	0	0
		£13,953	15	0"

What is the total outlay for the works of which you have given notice?—I should say 100,000*l.*

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Is that for works of main drainage?—Principally main drains.

How many miles of main drains?—Upwards of 16 miles.

With respect to the sizes adopted in the construction of the sewers, do they remain the same as before?—They vary very little because they are additions to the original lines. When we approach hills where we get a fall, there, of course, they are reduced in size.

What are the dimensions of the several classes of sewers which you are in the habit of using?—The largest is 5 feet by 4 feet; the second is 5 feet by 3 feet; the one more commonly executed is 4 feet 9 by 3 feet 6, and 4 feet 6 by 2 feet 9. Those are the largest sewers; some collateral sewers are executed as small as 4 feet by 2 feet 6, and 2 feet by 2 feet.

Has any alteration taken place in the size or shape of the sewers within the last few years?—No.

Will you give the contract prices of each class of sewers?—A sewer 5 ft. by 4 ft., including digging gangways and gulleys. 22*s.* a foot.
A sewer 5 ft. by 3 ft., including as before, is very nearly the same cost.
„ 4 ft. 9 in. by 3 ft. 6 in., including as before . 17*s.* 3*d.* a foot.
„ 4 ft. 6 in. by 2 ft. 9 in., including as before . 14*s.* a foot.
„ 2 ft. by 2 ft., there being no gangway . . 5*s.* a foot.
But the expense varies according to the soil in which the work is to be executed.

Have you any particular form or size of sewer for draining courts or small streets?—Courts, generally speaking, we should do with a small drain, that is, an 18-inch or 2 feet, at most.

A barrel drain?—Yes; we could not extend that at all, of course; but if it were in a street, we should not have reference to the small piece of sewer we might be executing at the moment, but should look to whether it could be added to thereafter.

Having no general plan of the whole district, how do you know when you are building a sewer in a main street what part of the district is likely to drain into it?—We know it must go into one main sewer, and that sewer we know the depth of and its capability; the execution of a collateral drain is dependent upon the main drain. It would not be dependent upon the whole district, but upon the drain into which it would go.

Must not the size of the sewer you make depend upon the quantity of matter which is likely to drain through it?—Of course.

If you have no general plan, how do you know what quantity of matter is likely to drain into any particular sewer?—We are endeavouring, as fast as we can, to get a sewer into every street; but, of course, we find that we are now overcharged as regards water, because all our outlets are locked up seven hours out of the twelve. We can only sew into the river Thames during the period of low water.

If you had a general survey of the whole of the district, would not that materially guide you as to the size of the sewers which you have to make?—I think the surveyors are quite informed upon that subject. Immediately the first Act of Parliament passed, enabling the Commission to make new sewers, they had a survey made, and ordered that the sewers should be laid down at the lowest possible level, and they have been carried up the country from time to time.

All on one scale?—Yes, with a fall of about a foot in a mile.

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And to a fixed datum line?—Yes.

And those plans are in the offices of the surveyors?—Yes. That which used to be overflowed for months and months together in the neighbourhood of Rotherhithe and Deptford, and which used to be let as common pasture land, is now garden-ground.

You consider Rotherhithe as now very fairly drained, do you?—Rotherhithe will never be very dry. There is so much water in it, so many docks and canals, and so many things of that kind, that the percolation of the water is such as to render that hardly possibly, but it is very much improved.

Have you any plans in reference to the drainage of Rotherhithe in particular?—Mr. Newman has.

Have you any plans for the drainage of St. Saviour's, and the low lying districts of the Borough?—Mr. I'Anson would have.

Have you any reports upon those districts presented to your Court?—No.

You have yourself no plans for draining that district?—No. Mr. I'Anson would have such plans.

Those plans are not deposited in the Court?—The surveyors only bring them to the Court whenever a Court is held, and has that subject under consideration.

Where do they keep them?—In their own offices.

Is there any public office in each district?—They have their own offices. Mr. Gwilt's office is at the back of his house in Abingdon-street.

Are the offices open to the public?—No.

They are offices belonging to individuals?—Yes.

Upon an application for a new sewer, to whom do the parties apply in the first instance?—If it were for a new sewer, they would apply direct to me; but if it were for a drain, or any local sewage, they would go to the surveyor.

One of the surveyors lives in Westminster, another in the city of London, and the other lives in the Borough?—Yes: all that parties could see with me would be the general plan; but if they were to ask me the question which way it would go, I must refer them to the surveyor.

Would not it be for the public convenience to have a plan deposited in your office, by means of which any one who wished to see the line of sewage might see it at once, without reference to the surveyor?—There might be some convenience in it; but I have never found any inconvenience from the other course. We do not find parties disposed at all to make new sewers. It is not like the Westminster district, where they find proprietors willing to do so. We do, indeed, get a contribution sometimes. We have now a contribution from a gentleman, in the Kent-road, of 500*l.*; but that is the only one I am aware of.

Suppose a builder applies to you in reference to certain land he has taken, and through which he wishes to lay down a drain, how do you deal with that?—He sends in a written request to the Commissioners. The Commissioners meet and refer it to the surveyor to report upon it, and his report contains all the information necessary for the Commissioners to decide upon the application.

As to any payment in aid, what is the course?—We have no right to say to a builder, "You shall not come into our sewer." All we can say

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is, "If we make a sewer of such a size, you having the property in the land to be drained by it, shall come into the sewer upon paying the expense of doing so." Suppose a builder were to come and say, "I am going to build so many houses upon such a piece of ground, for my purposes a sewer of 2 feet will be ample:" if the Commissioners see that they can subsequently add to that sewer, or that it would be beneficial that it should be increased, they will take the money it would cost to build the 2-foot sewer, and build one of a larger size, paying the difference out of the public rates.

When the sewer is made for which any party applies, do you take it in charge?—Yes.

Have you no jurisdiction by your surveyor during the time a private sewer is being made?—We have now.

What jurisdiction have you?—Under the recent Act, I consider that all sewers which are to communicate with us are under our control.

Do you send your surveyor to see that a sewer is properly executed?—We have his report afterwards that it is properly done. We do not always put a man to watch the execution of the work. It is upon the surveyor's report that it is properly done, that the Commissioners contribute to it. But it is very seldom they execute sewers themselves. It is generally done through the Commissioners.

Upon the payment of a sum of money?—Upon paying the estimated cost, or paying three-fourths, or half, or whatever the amount is.

What is the general proportion required?—We seldom go beyond half.

Suppose the case of a house in a court, and that the owner wants that house drained, what is his course? Does he apply to the Commissioners or to the surveyor?—He will apply to the surveyor.

Will you narrate the course which he would pursue?—The surveyor would go down, and would then report to the Commission, stating the length of drain that would be required, and the expense of it.

Does the applicant pay the surveyor a fee?—There is a fee of half-a-guinea.

What is your next regulation? Supposing the application is approved, what is your rule as to size or charge? Do you put in the drain yourselves, or does he?—We only put in the portion under the public way, which we consider saves the applicant the necessity of going to any other authority.

What is the size of the drain which you would require him to put in?—It varies from 12 inches to 18.

Have you any smaller than 12 inches?—No.

You have 12-inch brick drains?—Yes, we are now using Doulton's pipes.

Within what time have you put down any of those pipes?—Within this month; but we do not find that they are cheaper to the parties. They may be more effectual.

What is the price of your brick drain?—The slightest is something like 4*s.* 6*d.*, I think.

And the lowest?—There would be very little difference, including everything.

If permission is given, you put it in at a certain charge? Will you state what that charge is?—It depends upon the quantity of digging, and varies from 4*s.* 6*d.* to 5*s.* 6*d.* a foot.

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Will you give the Commissioners a statement of the sizes, length, and expense of the sewers which you have executed since you were examined before the Health of Towns Commission; and the sizes, length, and prices of the works which you propose to execute, and of which you have given notice, with the cross sections?—This is more with the surveyor than myself.

And also what number of house drains have been executed within that period?—I can furnish that.

With relation to the new sewers which you have executed, what proportion of house drains have joined on to them?—I am sorry to say that they are not numerous.

What is the reason that they are not numerous?—I believe it arises from the effluvia of the sewer.

Have not you heard it stated, as a matter of fact, that in those cases where house drains have joined on to your sewers, the people who have so joined have not found it a benefit?—I have.

In consequence of its giving an opening to effluvia which they were previously free from?—Yes.

Have you directed your attention to the means of remedying that evil?—It has been under the consideration of the Commissioners for some length of time. I wrote first to Professor Faraday on the subject.

Will you read his reply?—It is dated—

"*Dundee, 14th August.*

"Sir,—My health will not permit me to enter into the consideration of the many points that are offered to me, nor, I regret to say, into the important one contained in your letter. I have the strongest conviction that of all the ways of sweetening the air passages of sewers in a large town, that of casting the vapours and miasma by myriads of passages into the midst of a dense population is the very worst; it is a return, in part, to the practice of leaving the sewers open. You will, by inquiry, easily find out those who have thought on the question. I have not, and cannot now closely consider it; but I have often thought that the many furnace and engine flues that rise up so abundantly in various parts of London, might be made to compensate in part for the nuisance which their smoke occasions, by being turned to account in ventilating the sewers and burning the putrid vapours generated in them.

"I am, Sir, your very obedient servant,

"M. Faraday."

I also wrote to Mr. Holland, of Manchester. His answer is dated—

"86, *Grosvenor Street, Manchester,*
"*September 3rd*, 1847.

"Sir,—I regret that my absence from home, and other circumstances, have caused a delay in my reply to yours of the 25th ultimo. I am glad to hear that the Commissioners of Sewers for Surrey and Kent, have determined upon trapping the sewers under their control, and that they are, at the same time, alive to the danger of confining the noxious effluvia and gases. These dangers are not confined to the men who may be employed in cleansing, but will be extended to all the inhabitants whose house drains may be insecurely trapped. Indeed, if the sewers be laid on a loose gravelly soil, it is quite possible that the gases of decomposition may extend their noxious influence to a very considerable distance. There is no doubt that the injury may be very considerably abated by the employment of chlorine to decompose the putrid gases, and of quick lime to absorb carbonic acid; but I should be very unwilling to trust to these, or any other chemical means, as you can have no reasonable security that such will always be judiciously employed, or even regularly employed at all, by men so reckless as those you probably have to deal with. The right remedy is the regular removal of all collections of filth from the sewers by constantly repeated flushings and the formation of ventilating shafts. These latter might be economically constructed by connecting the waste water pipes from the roofs of the houses with the sewers, which would form channels for

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the foul air from the sewers for such an elevation, as that it would be neither injurious nor annoying. These simple air shafts would, I believe, be sufficient to allow of the escape of any foul air *in drains kept clear of deposit by constant flushing*, but if more be desired, very perfect ventilation might be effected, by connecting each of the main district drains with the ash pit of some steam-engine furnace; or if that very desirable arrangement cannot be managed, by erecting a chimney, with a small fire to heat the ascending column of air, acting on the same principle as that on which coal mines are ventilated. I do not expect that this will be necessary, but if it be, you will find very full directions for doing it, in a Report by a Special Commission appointed in Paris, composed of MM. D'Arcet, Girard, Parent du Chatelet, and others, published in the first part of the second volume of the 'Annales d'Hygiène Publique, 1829.' The means used at Paris consisted of an iron chimney placed over the gully-hole. in which a fire in a cage was suspended, and kept burning as long as the men were working. By the draught thus created, the foul air in the sewers was removed, and the men enabled to work in safety. For sewers into which the tide enters, or which are liable to fill when the tide rises, it is particularly important that means for the escape of the air above the level of the houses should be provided. As the sewers fill with water, of course the air is displaced, and may cause annoyance far above the direct influence of the tide. In Liverpool this is the case, in streets a mile from the river, and nearly 100 feet above it. The air displaced in the lower part of the sewers escapes by the gully-holes all over the town; and persons far from the river may tell when the tide is rising by the smell thus occasioned. I have no doubt this annoyance might be entirely avoided by trapping the gully-holes, and connecting the waste water-spouts with the sewers, by which the air would be conveyed above the houses. I think you would do well to consult Mr. Francis, Surveyor of Sewers, &c., Town Hall, Manchester, with respect to some improved tube drains and traps he has had constructed. They are made of fire-brick clay, are very cheap, and I think likely to be effectual. I have no doubt, that if you apply for information to the chairman of the Paving and Sewering Committee, Town Hall, Manchester, you will get full information. I believe the drains and traps are manufactured by Messrs. Hall, of Dukinfield, but Mr. Francis will tell you. If any part of this letter is not perfectly intelligible, or if I can give any further assistance in forwarding so important an object as the security of the public from the noxious exhalations of sewers, pray apply to me without hesitation."

—We have another opinion from Mr. Donkin, who is one of our Commissioners. I had sent him a copy of Dr. Faraday's letter. He says:—

"I infer from Dr. Faraday's letter, that he coincides with me, in the general principle, as to the employment of a current of air for the ventilation of the sewers; but to effect this he intimates, that some of the various chimneys already built for manufacturing purposes, in and about London, might be made available for the purpose intended. How far this expedient might be resorted to, I cannot tell; but I apprehend that few chimneys for manufacturing purposes are built larger than required for the manufacture there carried on; and it is, therefore, very improbable that any would be found to answer the purpose, and even if such could be found, it is to be feared that the Commissioners could not secure to themselves their constant use. But it appears to me absolutely necessary, that any chimneys which may be appropriated to the ventilation of the sewers should be built for that purpose, and be at all times under the control of the Commissioners. As to the present state of the sewers, the periodical effects produced by the tides, and the means employed for cleansing them, I have received much information from Mr. Barthram, as well as having personally inspected one of the sluices. From what I have thus learnt, I foresee some difficulties in carrying my plan into execution, but I believe none of these to be insurmountable. Before treating of these difficulties, I should state, that, during every tide, for a certain period—viz., about five hours, the valves and sluices of the sewers are closed, and during that period the accumulation of water and sewage matter becomes such as to nearly or completely fill the sewers. This accumulation of the water in the sewers commences on the valves or sluices being closed; and, as it gradually rises, the mixture of pure and impure air previously in the sewers is also gradually expelled by being forced through the various openings into the streets, thus occasioning the nuisances so frequently complained of. On the ebb of the tide the valves and sluices are again opened, and remain so for a period of about seven hours: the contents of the sewers are discharged into the river, and during such discharge the sewers are again filled with a mixture of atmospheric and foul air; which latter will, at this time, be most copiously produced, in consequence of being

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relieved of the superincumbent pressure of the water. It may be noticed here, that the foul air so produced (forming but a small proportion of the whole contents of the sewers) must be so diluted with atmospheric air as to render it inexplosive. The chief difficulties arise from the very frequent openings or communications between the sewers and the atmospheric air; for if these openings are allowed to remain so numerous as at present, the effect would be that on producing a draught or current of air up the ventilating chimney from a sewer, that current would be supplied, not only from the sewer itself, but from the numerous inlets and openings in question; whereas, to create a draught of fresh air through a considerable extent of sewer, the admission for the fresh air should be at an opening as far from the ventilating chimney as practicable. Means, therefore, must be found, by the employment of air traps, or otherwise, to prevent the admission of air through the various private drains and openings above mentioned. Other openings, such as those in existence, for the purpose of carrying off the rain-water from the streets and roads, form like obstacles, and admit of similar remedies. These remedies being applied, and a ventilating chimney being put into action by a naked fire placed in and near the bottom thereof, would secure the men in cleansing the sewers from any danger, thus effecting one main object required. The other object in view is to remove the nuisance caused by the escape of the noxious gases into the streets through the various openings during the rise of the tide; and this I would propose to effect by the erection of a chimney over the opening intended for the admission of fresh air during the emptying of the sewers, which I would place at the extremity of that part of the sewer intended to be ventilated; thus, in fact, imitating the upcast and downcast shafts used in coal pits. Should it be necessary to prevent a too great influx of air, from neighbouring sewers entering into that under ventilation, I would propose the use of swinging doors, which may be properly called self-acting air valves. The current of air, which it is so desirable to produce, should, in every case, have a downward direction towards the sluices; but the men when cleansing the sewer (as is the practice at present) should proceed in the contrary direction, with their backs to the current of air, as they would thus avoid inhaling the noxious gases arising during their disturbance of the mud."

Have you gauged the collateral or main lines of your sewers at all?—We know the area of the sewers.

Do you know the quantity which really passes through them. Have you gauged any sewers, for example, in a street where there are nothing but cesspools, as compared with the amount of sewer water in other places?—I have not.

No question of that kind has come before the Court?—No; the discharge is very considerable the moment the valve is opened.

As to the sewers in courts or collateral streets, you cannot state the contents?—No; nothing of the kind has come under my notice.

Nor under the notice of the Court?—No.

You are obliged to give notice to the parishes of any lines of sewers you are about to construct. Have you had any objections from parishes as to the nature of the works you intend to carry on, or any snggestions of improvements?—No person was attending upon the subject of those sewers, with the exception of a deputation from Deptford, and their objection was that the Commissioners were not appointed by themselves, and they thought they ought to have the appointment.

There was no objection to the sewage works?—No.

Nor did you receive any suggestion of improvement?—No.

Why are you required to give notices to the parishes?—The Act of Parliament requires it. It is an act which was passed before my time. I expect at that period it was contemplated that sewers would go through private property. The Commissioners found afterwards how difficult that would be, and they have always subsequently made them through public streets, but the notice is still given.

Is not the business of the Commission very much retarded by their

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being required to give such notices?—It is retarded a fortnight only; there is also the expense and trouble of going round to all the parishes, but that is all.

After you have given notice, what is the result?—If the parishes were to come before the Court, and suggest a better line, the Court would take the suggestion into consideration, but I have known no instance of it.

Nor any suggestion as to an improvement in form or a reduction in price?—No. There is an estimate generally, but in the first instance it is a rough estimate; it then goes to the contractor.

Would not it be a matter of great convenience if you had the same jurisdiction as is exercised by the Commissioners of Paving?—The officers of the two Commissions have always acted in concert together.

Would it not be more convenient for you to have the jurisdiction to carry out the work instead of having to go to another body for permission to take up the pavements?—Yes.

Is the whole of your district under one Commission for Paving?—No; there are a great many Paving Commissions, but not so many as there are on the Middlesex side of the water.

How many Paving Boards are there within your jurisdiction?—Thirteen.

Do the surveyors of those various Boards charge you a uniform price for taking up and relaying the pavement?—The Commissioners of Sewers do that; generally it is an agreement with the pavement contractor to do the work, but wherever we disturb any pavements we replace them.

What do you charge per yard for doing so?—It varies from 9*d.* to 1*s.* 6*d.*, according to soil and materials.

The contractor pays you for relaying the pavement, does he?—No, we pay the contractor. If it is necessary to take up the pavements for the purpose of making a sewer, we make that part of our contract; and our contractor makes an agreement with the contractor for keeping the pavements in repair, as to the sum of money which he has to pay him for relaying the pavements.

Do you know whether the contractors of the various Paving Boards charge a uniform rate?—I do not know.

With respect to private works, do you charge a sum at once to them, or have you any means of distributing the charge over a period of time?—We have the power of distributing it.

What are your means of doing so?—They exist under the present Act of Parliament. All sums above 10*l.* may be thrown over 20 years.

Take a case of a sum under 10*l.*, how may that be dealt with?—The Commission decides upon the course.

What may the Commissioners do?—They have said the payment shall not exceed 20*s.* a-year, so that if it is 5*l.* it will be spread over five years.

Supposing it to be a class of house inhabited by labouring people, or one of the fourth class of houses where the payment would be 5*l.*, it would be required to be paid for in five years?—Yes.

Supposing a house to be held by a person who has only the remainder of a lease of five years, he would have to pay in those five years for that which would probably last during thirty?—Yes.

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Would not the circumstance of his having to pay such a sum form in itself a very great obstruction to the application of drainage to cottages of that class?—I am sorry to say that the payment of any money by the owners of small houses very much retards any improvement.

Supposing that cost of 5*l.* to be spread over a period of 30 years, and to be repaid by annual instalments, it would amount to 5*s.* 11*d.* per annum principal and interest at 5 per cent. per annum. If, instead of requiring 1*l.* per annum, or 5*l.* in five years, it were only 5*s.* 11*d.* which was required, would not that be not only more correct in principle, but give an enormous facility to the drainage of that class of houses?—But I am afraid the public would lose a great deal of money in that way.

In what way?—In getting those small payments.

You would charge rates upon that small property?—Yes, but they are generally compounded for by the landlord.

Would he not compound for this 5*s.* 11*d.*?—He would have five years to pay it in according to the present plan.

Would not it be more equitable to him if he had 30?—It might be so.

Would not it facilitate the drainage of this class of houses by persons having short interests—a lessee, for instance, having only a term of five years?—Yes.

And so with all other classes of houses of that description?—Yes, but it would create a great deal of work to be done. There is an instance where the Commissioners are going compulsorily to arch—here (*producing the same*) is a plan of it; here is the name of every individual, the length of feet he has got to pay, some of the cases amounting only to 3*l.* or 4*l.*; and in this little account there are 20 or 30 debtor and creditor accounts to keep.

Would there be more difficulty than in levying every other species of rates?—It would be, generally speaking, added to the rate.

And it would be a convenient consolidation to collect it with the poors'-rates, or with any other?—Yes.

Have you not a separate collection for your sewers'-rates?—Yes.

What is your cost of collection in the pound?—Nine-pence.

At what intervals do you levy your rates?—Up to this time it has been every second year, but we have now an annual rate.

Have not you had longer intervals than every second year?—Not latterly.

You propose to expend 100,000*l.* in the drainage of the district, will that come out of the general rate, or be levied upon those portions to which the new sewers will be applied?—Some small portion will be levied upon the owners of the side of the sewer, but that, according to the Act of Parliament, is only to one-half of the amount.

The rest will be levied over the whole district?—Yes.

Will not some portion of the remainder of the district, which is undrained, have to contribute to that for a length of time, supposing the drainage not to be general?—Yes.

Are not there many portions of your district which have paid contributions to the drainage for many years which have had none themselves?—No new sewers; their drainage has been improved by the works which have been executed, but they have had no new sewers

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brought to their doors. There are some streets without sewers which have paid sewers'-rates.

How many years may they have paid sewers'-rates?—I cannot speak beyond my own time. I should say some have paid rates for the whole time I have been clerk, that is 27 years.

The remonstrances of the parishes have been rather at the money not being expended in their own jurisdiction, have they not?—Yes, on account of their having no voice in its direction, and considering that each parish should have the money laid out in it which it raises, which is very erroneous, because that which is done at the lower part of the level is of as much importance to the middle part as any other.

Supposing the system of parochial representation upon any local Board of that kind, and supposing your present system still to exist of making the whole district pay for any one part, would that representation mend the matter, or make it anything more than a struggle between a majority and a minority to get a particular portion drained?—I do not think it would. The Commissioners now acting are taken from the landholders of the neighbourhood, who are the most interested in the matter, it being considered a landlord's tax, and not a tenant's tax.

Is not that a great inducement to any preponderating influence to endeavour to get their own districts drained first?—No doubt of it.

Do not you think that diffusing the charges over longer periods of time, and making each district pay for itself, would obviate much inconvenience and much injustice of that kind?—Certainly it would as to time, but not as to all the money raised in the parish being expended in it. Of course the new sewers are a very considerable item in the expense.

Parishes have been paying for collateral drainage, as well as main drainage, they having no drainage themselves?—Yes, to some degree.

What money have you paid or are you paying for cleansing sewers?—For cartage of the soil 3*s.* 6*d.* a load.

What is the total amount of money you expend in that way in the course of the year?—In the last year, the foremen, labourers, and cartage cost 3592*l.* 11*s.* 8*d.*

You probably do as much as you can in assisting the flow of the water by flushing?—Yes, but still there will be a deposit.

In what districts are you obliged to cart?—In very few of the main brick-arched sewers; it is more from the open sewers.

Have you any account at all of the quantity of deposits in your collateral sewers?—I should think the surveyors might give you that information, but it does not come under my cognizance.

You have made no alteration in the system of cleansing by carting?—There is considerably less cartage now than there used to be since the plan of raking and flushing has been adopted.

Where it has not been adopted the carting remains the same?—Yes, we have always done as much as we could; clean water and dirty water is the same to us, we have, in fact, too much water.

What proportion of your sewers are kept now cleansed by flushing?—Principally the arched sewers, the surveyors could speak to the proportion.

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You stated that your Act of Parliament was obtained only this year?—Only this year.

Have you any means of judging whether since you have had the power of distributing the payment over a great number of years more applications are likely to be made for drainage?—I think it is hardly known at present; we are endeavouring to make it known as much as we can; we have not had many applications about it, as so many persons are looking at the result of this Commission.

In the case of a sewer being made up a court, have you any power to compel the owners of houses to carry drains into it?—We have the power now.

Do you use that power?—We are intending to do so.

Have you used it at all?—Not yet.

How long have you had that power?—Only within this last year; the Royal Assent was given to the Act on the 22nd of July last. The Commissioners met, and their first object was to endeavour to get money. I was directed to see the Commissioners for issuing Exchequer Bills on loan, but I found that they were without the means of assisting us. I have since that been to most of the principal fire offices and life offices to see if I could get any money from them, and I think the application was only entertained by one. I have since that advertised, the sum named was 50,000*l.*, the Commission, however, only got 8000*l.*

One of your surveyors, Mr. Joseph Gwilt, was asked with reference to the cleansing a sewer:—"Will you state whether the soil taken from a sewer was carted away, or did the men throw it up upon the side of the sewer upon the banks of the road?" The answer is, "They threw it up upon the earth on the banks of the sewers. That has been the invariable practice since I have been surveyor, and it was the practice during the time my father was surveyor; we never carted any away except the soil of sewers crossing public roads." Is that the practice now?—It is pretty much the practice in open sewers which go through pasture land.

He is asked:—"Are you aware of any practical inconvenience arising from throwing up the soil upon the side of the sewer?"—"It is doubtless a nuisance to the owners of the land upon which it is thrown in populous neighbourhoods."—There we cart away, but in open marsh lands and pasture lands we leave it, and there are only two instances we know of in which parties have required us to take it away, and then we did so; but we generally let it lie upon the bank till it becomes of use as manure, and then it goes into the land.

In closed sewers and in populous districts you do not leave it but cart it away?—Yes, we always cart it away in populous places and in all public roads.

As quickly as you can?—Yes.

By sending men and cleansing in the ordinary way immediately?—Yes.

Have you always people at work for that purpose?—Yes.

Would it be generally upon the same day that you cart it away?—I should say always on the same day; the cart is waiting. The 3*s.* 6*d.* we pay includes also the finding of a depôt.

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In flushing, do you ever use any artificial means?—We create a backwater.

You use artificial raking?—Yes; always by men going in and raking first of all.

Was some of this work done at the time of the cholera, the cleansing in open sewers?—There were several sewers done which had never been taken by the Commission, but which were then taken. The Commissioners felt that they were doing what was right; a subscription was raised and a great portion of the expense was defrayed by that means.

Was not there a complaint at that time as to those means of cleansing sewers?—Yes.

Was not it the opinion of your Court that the public opinion about its being injurious was erroneous?—Yes, arising in a great measure from the fact, which was ascertained, I believe, by the members of all the Commissions in London, that not one of the men so employed suffered by the cholera.

Therefore you think that the public were mistaken?—As regards the cholera I do; but that it is a nuisance there can be no doubt.

It is offensive to the smell; but it is not the belief of the Commission that it is injurious with respect to engendering disease?—No.

None of your surveyors or engineers differ in that conclusion?—They do not seem to do so.

How was your Commission created?—By the Crown.

When was the last Commission created?—On the 15th of August, 1840, the 4th year of her present Majesty.

Do you ever have complaints from occupiers of courts and alleys of the want of drainage?—We have had one or two which we have attended to, but with very great difficulty. We found the landlord not at all disposed to pay any portion of the expense. We did it with the assistance of the Commissioners of Pavements. We did not feel that we ought to do so; it was doing work which we thought the landlord should do, and we applied to the Commissioners of Pavements, who felt that the place was not in the state of cleanliness it should be, and they contributed to the expense of making the drain.

Out of the paving-rate?—Yes.

No question has arisen as to the quantity of water in the district, excepting that you are encumbered with too much of it?—Our upland water is too much.

You have never sought then for any aid in respect of water from any companies?—No; we have in different places sluices for letting down water from one level to another.

How do you manage with collateral drains?—We throw as much water as we can into the collaterals, but the main lines are our principal object. I hardly know of a complaint with respect to collaterals. If the main lines of sewer are kept clear the others are generally kept clear also.

What is the size of the collaterals?—They vary. If the Commissioners can foresee that they can hereafter take them up a longer distance they make them of a larger size, but if it is a cul-de-sac, of course it is determined that the drain shall only be of a small size. I should say that in all our main lines of sewers there are none less than 4 feet 6 by 2 feet 9.

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The collateral sewers are affected by the main sewers?—Yes, every tide they are filled; therefore there is the operation of flushing going on. I think unless it is a very high sewer that every one of our sewers is filled with water every tide.

Are you aware of the extent to which water-closets are in use in the district?—Very little.

Notwithstanding that, during the time the sluices are shut the sewers are filled with water?—Yes.

That water you imagine to be water draining from the high ground?—Yes, and partly from the sewer itself. We have rendered land which you could hardly get upon as hard as possible by sewage.

You say that the water comes from the land itself. Is that water influenced at all by the tide?—I do not think we find it so much. It may be influenced by it in some small degree. In executing a sewer at Camberwell some time ago, a great body of water suddenly burst upon us.

Where do you imagine that water came from?—We expect it came from some higher land.

Though water-closets are very little in use, there is always a sufficient body of water flowing off the land into your sewers to fill them nearly during the time the sluices are compelled to be shut on account of the tide?—Yes.

You stated that the men frequently went into the sewers in order to loosen the deposit. How frequently do they do that?—I cannot say how frequently they do it. It would depend upon the surveyor's other work. It is constantly done.

Are you aware whether they do it habitually at certain periods, or do they wait till some complaint is made?—They do it without reference to any complaint. The complaint would not arise from the deposit in a sewer. The public would not know of it.

Would not they know it by the additional offensive smell from the gully-hole?—I fear there is always a sufficiently offensive smell to render that difficult.

Have you a system of man-holes through the district?—Yes.

Are men put down with considerable regularity?—Yes.

Are the gully-shoots under your own control?—Yes.

What is the contract price of putting down a gully-shoot upon the average?—I do not know that I can speak to that. The surveyor can give that information.

You say that you find great difficulty in inducing landlords to support any share of the expense of the drainage?—Yes, landlords of small property.

Are the landlords generally small proprietors in your district?—No, there are some of extensive property; there we do not find so much difficulty; but it is the owners of small houses whose object is to get as much money as they can and to spend as little; they do not conceive that they will get 6*d.* more for their property if they make better sewage.

Do you believe that?—No, I do not; but they are impressed with the notion.

You believe it to be a short-sighted and erroneous notion?—I am satisfied it is so; but I am afraid it operates strongly.

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Is the sewage of small houses generally compounded for by the landlords?—The rates are. We are authorized by the Act of Parliament to take the composition of the poor-rates, and that is generally followed out.

The same mode of compounding for the additional charge where sewers are made in courts would apply to the general sewage rate?—Yes.

When do you expect to enforce the new regulation as respects the drainage into sewers?—The attention of the Commissioners has not yet been so much directed to that, as to arching open sewers in populous parts. They have now eight or ten reports before them; they are now being carried out, and the Court are rather anxious to see the result of those before they proceed with the others. They were rather astonished besides to see the great number of parties who were to be called on to contribute a portion of this expense, and the trouble it would give, and it becomes a question how far it can be done. The object of compelling parties to communicate with sewers was discussed at a meeting of the Commissioners, and it was rather considered that that subject might fairly go by till some complaint was made, and the arching of open sewers, which was a crying and known nuisance, be taken up first.

It is a matter which they are considering?—Yes. The material point which they were considering I should say was to get rid of the effluvia, because they do feel that there is a just complaint made by parties who make communications to the sewers of the effluvia arising from them, which is hardly to be stopped. They make foul air tubes, but it does not always succeed.

The Commissioners consider that, by compelling the owners of houses to join, they would be making them pay for that which might inflict a nuisance upon them?—Yes.

Have you had complaints to that effect, that a communication by drain from a house into the sewer has really made the house more disagreeable to live in or more unhealthy?—More disagreeable I have. I know the fact myself that it is so. I have recently had a communication made at our own office with the sewer, and at times it is so offensive that we hardly know how to sit there.

Does your Act give you the power to summon a party before the County Courts to recover a portion of the charge before you create the expense?—No, not by express enactment.

Do not you think it would be very beneficial to have that power?—We have it now, I think. We could distrain, as I consider that we should have the power of going to the County Courts.

Would not it be more advantageous if you had the power to enforce payment, just the same as you have in the instance of new sewers being made before the sewer is executed?—It would be desirable; but I do not know that the public would like it.

In the case of a new sewer, you say, "Pay so much money, and we will make the sewer?"—That is a voluntary act on the part of the payee.

Would not it be desirable to have that power with respect to small houses?—It would be desirable.

You were alluding just now to the Commissioners' intention of

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covering open sewers in populous districts; where do those open sewers exist in populous districts?—There is hardly a place I could put my hand on but has some wretched open sewers.

Will you name one or two?—There is a very bad one in Christchurch, dividing the parish of St. George from Christchurch. There is another very bad one in the Maze near the hospitals; three or four in St. Olave's: one so bad, that the guardians of the Union were anxious to contribute towards the expense of closing it, the Commissioners declining to pay the whole expense, feeling that it was relieving the landlord, who ought to contribute.

What are those collections of stagnant water behind the Old Kent-road, between that and Bermondsey?—They are ancient mill-streams; they are private property; all the Commissioners can do is, to make the parties keep up the banks and cleanse them.

When you were visited by the severe hailstorm in August, 1846, of course that storm fell upon some districts which were drained, and others undrained, what was the relative amount of drainage; had you any report upon the subject?—None at all; there was very little damage except the breaking of windows.

There was no overflow?—Very little.

How do you account for that?—I rather think our sewers were nearly empty at the time; it had been very dry weather, and there was not much collection in the sewers.

Did you hear any complaints of flooding in those places where there were no sewers?—No, we had no complaints whatever. We have now a very material point before us, which is the crack in the river bank at Rotherhithe, which appears to be getting worse. Mr. Shaw has been down; he is the agent for Lord Carteret, on whose property it is, and I dare say they will attend to it; but it is evidently increasing, and it is supposed to be arising from the removal of ballast out of the river.

Have you any special measures of any kind further than those respecting the sewers before you?—No, except the bank of the Thames. We are very anxious with respect to that, and there appears to be some difficulty about it. We are forming a self-acting trap now for the gully-holes. It is in the form of a dish: when it fills with water it falls and lets the water out and rises again; but we are fearful, till this question respecting stopping the effluvia in sewers is settled, to use it. Those gully-holes are now an escape and safety-valve for the public.

You infer that it might destroy the present ventilation of the sewers?—Yes, as the lower part of the sewers next the outlets gets filled, it drives the effluvia either up through those outlets or up into the country; therefore it is very often smelt at a mile or two distance, as at Liverpool; in fact, wherever there is an outlet.

You have heard the same thing with respect to your own district as occurs at Liverpool, that in the upper districts there is a variation of the smell with the flow?—Yes.

As sewers are now constructed, those gully-holes perform two essential services; they let the surface-water in, and the foul air out?—Yes.

Which of those two do you consider of the most importance?—The letting the water in is absolutely necessary.

No. 19.
Beriah Drew, Esq.

Do you find the deposit in the sewers very considerable?—In some sewers we do. Wherever we get anything like concrete it settles and forms a hard substance. In a macadamised road, for instance, there is always a hard substance under a gully-hole.

Are you ever obliged in those sewers to break the arching of the sewer in order to clean it out?—No; we have always entrances to the sewers by means of those man-holes. When they are built there are man-holes left and covered over with cast iron.

Then, except from the open sewers, you never cast out any soil?—We cast the soil out of those man-holes occasionally; not very often; perhaps once in three or four years.

Do you mean once in three or four years in every portion, or only in some portions?—The surveyor will be able to give the Commissioners information upon that subject. We consider that we have our arched sewers flushed every tide by means of the backwater.

No. 20.

Joseph Gwilt, Esq.

No. 20.
J. Gwilt, Esq.

You are the author of the valuable work called the "Encyclopædia of Architecture?"—I am.

And you are also surveyor of the Lambeth district of sewers?—Yes.

Will you have the goodness to state what, within the last three years, the undertakings of the Commission have been in the district over which you preside?—From the 24th June last, for three years backwards:—

	Feet.
At North Brixton	530
From Kennington Cross to the Horns, Kennington Common	1840
Through the grounds of the Philanthropic Society to St. George's-road	670
In Lambeth Walk	1070
From Alfred-place, through Albert-square, to the Clapham-road	1310

Have there been many drains laid down in small streets or alleys of the district?—I should say in alleys none. In my district the alleys are very few in number; I can hardly bring to recollection what I should call an alley in Lambeth.

Or courts?—Yes, or courts. It is a district which very much differs from the metropolis generally, having been formed recently, within my own recollection almost.

Have the undertakings of the Commission lately been principally main sewers or collateral?—Principally main sewers. As the Commissioners have come into more money they have expended it in main sewers.

Has there been any difference made in the size of the sewers within the last three years?—I should say certainly not.

Nor in the collaterals?—No.

Neither in size nor construction?—No. I think in construction they have lately been made of less thickness than used to be the case.

No. 20. J. Gwilt, Esq.

What is the ordinary size for a main sewer?—They vary according to the extent of the district that they are to drain; the largest size of main sewer in my district has been 5 feet by 3 feet 6; that has been diminished down to as low as 3 feet by 2 feet in the collateral sewers, proportioning the dimensions to the quantity of water the sewer has to discharge.

What quantity of water would a rain of one inch in depth in the hour furnish from each acre per hour to the sewers, from roads and houses?—I beg to observe on the question that the fall of rain mentioned is one which I should say does not ever occur. The average quantity of rain falling in nine years in South Lambeth, was only 22·7 inches per annum. An inch of rain in 24 hours is a heavy fall.

What quantity per acre in the hour would flow from the rural district in such a rain?—This would entirely depend on the absorbency of the soil.

Do you arrange with the water companies to give their supplies of water during the time of ebb tides?—No.

How do you ascertain the quantity of work the sewer is likely to have to do?—We know what the capacity will be from experience, but it is a very difficult matter to provide against a sudden accumulation of water.

Have you any old sewers in your district?—A very large portion of them, I should think two-thirds of them, are old sewers, that is to say, they are old sewers which have been in many cases on the same site replaced by new brick sewers.

Are you quite acquainted with all the old sewers in your district, or do you find some occasionally of which you had no previous knowledge?—I do not think that there is one in the whole place I do not know. I have been surveyor to the Commission 42 years.

Have you an office?—Only my own office.

Supposing anybody wishes to ascertain anything with respect to the sewers, they must come to your office?—Yes.

Where is your office?—In Abingdon-street, Westminster. If I were to take an office in the district, I should be further off from some parts of the district of Lambeth than I am at the present moment.

That is your private office?—Yes.

You state that you have the levels almost in every part of the district, will you have the goodness to furnish one of the engraved plans of the district with those levels marked upon it having reference to Trinity high-water mark as a datum?—The engraved plan is on a small scale, I have therefore furnished a longitudinal section of one principal line of sewer, by which will be seen the levels desired at all its points. It is to be observed that this may be taken as an example of the details possessed by me.

Does the whole of the water from the high lands pass off by the sewer that has its outlet near Vauxhall-bridge?—No.

Does not a portion of those waters pass to London-bridge, or to Rotherhithe, through Mr. I'Anson's district or Mr. Newman's?—The portion eastward of the crest of the high lands passes off into Mr. Newman's district.

Does not a portion find its way into the other sewers in the low land district?—Yes, as in the answer to the foregoing question.

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If all the high lands drained to other sewers than those sewers used for the drainage of the low lands, what area would the low lands' sewers have to drain?—The sewer in my district which drains the high lands takes an extremely minute portion of the drainage of the low lands, not a hundredth part, and that only near the mouth.

Point out that area on the plan?—A small portion of Kennington-oval, and some land to the west, and some 200 or 300 feet in length of the South Lambeth-road southward from Vauxhall turnpike.

What portion of that area, in acres, drains to the deep sewers, and what portion, in acres, drains by mere field ditches on the high level drains?—None.

Is there any general plan of the district laid down to a certain scale and to a certain datum line?—There is a plan of the district drained by the Kent and Surrey Commission reduced from a very large plan taken many years ago, to which the streets, &c., have been added.

Besides this plan there is no other general plan upon which anybody desiring it could at once see the levels of the various sewers in the district?—If wanted, there is in my office.

Will you state what you have in your office to convey that information?—Sections of, I should say, every sewer, certainly of every sewer of any moment in the district.

What is the area draining into that sewer of which you have already given a section?—About 300 acres, or perhaps rather more.

What is the common run of water therein per minute or per hour?—The run varies according to the depth: as an average, the discharge may be taken at about 20 tons per minute.

That plan probably would give you the relative levels of all the sewers in the district?—Yes; it will. It is not in one plan. It is a series of sections brought up from the mouth of each sluice into the upper part of the country.

Longitudinal sections?—Yes.

Have you cross sections of all your sewers as well?—All that have been executed from them. From them, as a basis, the collaterals are run up, and sections are taken and laid down at the time, and then deposited in my office. They would be to the public generally almost unintelligible I should say.

If any builder were to obtain permission to make a sewer, is there any general level of the whole drainage of the area by which he could be guided, or would it be necessary for him or for you to take all the levellings afresh?—There is not a single point in the district, if a builder applied to me to know to what depth he could go, as to which I could not give him information, he could get it in my office, even if I were not there.

Supposing he were a builder of a row of houses, and wished to make a sewer there, would not he have to take all the levellings afresh?—No; that would be done by myself, if there were such a case, if such a thing became necessary, but it scarcely could, for we have levels almost in every part of the district.

No particular alterations have taken place within the last three years, either in the size or the manner of executing works in your district?—I think not.

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Mr. Wagstaffe, who is a surgeon of a parochial district in Lambeth, gives the following evidence:—"Has the condition of your district been materially improved since the last visitation of cholera?—Additional common sewers have been made, but in very few instances, indeed, have house drains been made into them. Even large houses, in which the better classes live, have no drains into the sewers; they continue to have nothing but cesspools; water-closets are very rare, even in the better class of houses, excepting in newly built houses. Then the streets, courts, and alleys, in which the poor live, are wholly unimproved?—They are not improved; indeed, being more crowded, they are even worse, and the quantity of decomposing animal and vegetable matter about them is greater." Is that, in your opinion, a fair description of the district?—I think it is. It is a very common case, after a good line of sewer has been made down a road, that very few of the houses along it avail themselves of the opportunity of draining into it; take, for instance, the road leading from the Asylum up to Kennington-cross:—Seven or eight years ago, a very capacious sewer was made down that road, giving facility to every house in the line to drain into it. I should not like to state the exact number of houses that applied for permission to go into the sewer, but I think I should be strictly within the mark if I said that not 20 of the houses along that line applied for leave to go into the sewer after it had been made.

What class of houses were they?—A very good class; none of them lower than 40*l.* a-year, certainly extending up to 70*l.*, and perhaps 80*l.*

Then those houses would have nothing but surface drainage?—They would have nothing but cesspools.

Do not you think that it would be a great advantage to the public if power was given to every person to come into the sewer when there was one made?—Doubtless. Every person is, and always has been, permitted to drain into the sewer, on application to the Commissioners. It was only in the Act passed this year that we got power to take care that should be done.

Have those powers been exercised at all?—They are in course of exercise. At this moment I am engaged in making out a long list for putting the Act in force in that respect.

Of course, if the better class of houses you have been speaking of would not avail themselves of the opportunity they had of having a drain from their houses into the sewer, the smaller class of houses in the back streets are wholly without the means of doing so?—It is not consequent upon my answer, with great permission, but *à fortiori*, if the rich do not apply the poor do not.

Mr. Drew was questioned why they did not apply; he says, "There is a just complaint made by parties who make communications to the sewers of the effluvia arising from them, which is hardly to be stopped; they make foul-air tubes, but it does not always succeed. The Commissioners consider that by compelling the owners of houses to join, they would be making them pay for that which might inflict a nuisance upon them?—Yes. Have you had complaints to that effect, that a communication by drain from a house into the sewer has really made

the house more disagreeable to live in, or more unhealthy?—More disagreeable I have. I know the fact myself that it is so. I have recently had a communication made at our own office with the sewer; and at times it is so offensive that we hardly know how to sit there." Mr. Wagstaffe being asked, "Have you observed, in houses communicating with the sewers, any instances of noisome smells, arising from their foul condition?" says, "Yes, I have. Is this common in the district?—I have frequently noticed it. Are not the houses frequently flooded with sewer-water, as well as subject to poisonous smells?—Yes, they are. In such cases is not the communication of the house with the sewers a very doubtful benefit?—In these cases it is certainly of doubtful benefit."—I am scarcely prepared to say that that is my opinion, because the improvements which have recently been proposed for trapping the drains of houses, and which I hope will ultimately become universal, would, if not altogether prevent the smell which comes up the drains, very much lessen it. No. 20. J. Gwilt, Esq.

Are the bottoms of your sewers all under high-water mark?—Every one of them, except a sewer which carries off the water from the high lands, falling into the Thames near Vauxhall-bridge. All the others are completely under high-water mark; in short, the beds of them are laid down pretty nearly to low-water mark, with as small a fall as it is safe to give them, from the circumstance of the whole of that district being so much below the level of high-water mark.

How long during each tide are your sluice-gates shut?—Taking an average between neap and spring tides, they run from four to five hours.

Out of the 12?—Yes.

During the seven hours the sluice-gates are shut, the sewer-water is penned up in the sewer?—Yes, the sewer is a reservoir during that period.

Must not that necessarily occasion a good deal of foul gas being evolved?—No doubt of it.

Supposing those traps to be efficacious, where do you propose to dispose of those gases?—That is a matter under consideration. The Commissioners at this moment are consulting chemists to see whether the air cannot be burnt in shafts.

Is that a great difficulty?—It is.

How often do you cleanse out your sewers?—They are in the constant course of cleansing.

What is the cost of cleansing the other districts?—I do not know: it is very considerably more than in mine.

Within your district, what do you pay for cleansing?—It is between 600*l.* and 700*l.* a-year.

Have you any open sewers in your district?—Yes.

What proportion do they bear to the closed sewers?—There are near 14 miles of closed sewers, and about 8 miles of open sewers.

Is there any plan in contemplation now by the Commissioners for closing the sewers?—At this moment there are contracts in existence for covering over two very extensive lines of open sewer.

Of what length?—One is about 1400 feet, and the other about 860 feet.

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How many years, according to your present expenditure, will you be closing those sewers?—Now I apprehend we shall be able to do it in a very short time under the recent Act of Parliament.

Can you do it in any way except by borrowing money?—We cannot do it without borrowing money, however that is a part of the finance which I had rather not speak to.

Do you cleanse out the open sewers?—Not altogether.

Do you do so at all?—Yes, in many case where they lie so dead as they do in a district completely under water, all the rush we have got from above will not wash them away; that will be sufficient in a district which lies sloping gradually down to the Thames, but here we cannot do it.

Are they periodically cleaned out?—Yes.

Can you state at what periods?—There is a rota.

How often do you suppose it comes to the turn of an open sewer to be cleaned out?—I should think perhaps once in nine months.

Is the deposit of filth left upon the side of the ditches or is it carted away?—It is left upon the sides of the ditches except where public roads come, there it is carted away; however, it is very little that is left upon the side in fact. The sewers are now so hemmed in by building that there is not a possibility of leaving it on the spot, it is only where we can find open ground that that is done.

You are understood to say, that the deposit of filth taken from the sewers is carted away from those places where there are buildings. Great complaints are, however, received of the nuisance occasioned to the inhabitants by this practice. Is it not a fact that this filth is left on the banks of the sewers upon which houses densely populated abut?—I am not aware of the filth or casting from the sewers being ever left on the banks of sewers upon which houses densely populated abut. It would be impossible for me to say such a thing has not occurred; if it have, it has been some accidental exception to the general rule.

From the construction of your sewers, has that been altered?—No.

Take the case of a court or alley or small street, say for 20 houses each side, what sized sewer would you carry up?—For 20 houses, I should say 18 inches will drain them.

What sized house-drains would you put to each house?—Nine inches is quite sufficient.

You never put any less than that?—It is difficult to know; we find upon inquiry that the drains which are manufactured do not come cheaper.

Do not they discharge more quickly?—It depends upon the head of water in them and the level at which they are laid.

With the same head of water?—Yes, with the same head of water they discharge more quickly if they are glazed. I do not think they discharge more quickly upon brick.

Have you tried them?—Yes, not in this district, but in other places I have tried them to a large extent.

What have you found the result to be where you have tried them?—I cannot say it is so much in favour of them that I should adopt them unless there were a great difference in point of expense.

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The difference between the rate of discharge of the water is inconsiderable?—I am satisfied it is.

Have you guaged the run of water in your mains or ordinary sewers so as to state what is the proportionate run of water in periods when you have no rain?—No, that would only affect one part of my district, inasmuch as the great portion of the sewers being nearly full at the time they begin to discharge, the run will always be the same.

What is the capacity for holding back-water of the whole of your sewers in the lowland district?—In the main sewers about 27,000 tons, or 972,000 cubic feet.

What is the ordinary height in the sewers at the time of letting off in dry weather?—I should say about three-fifths.

Mr. Hawkins, formerly assistant-surveyor in the Westminster Commission, having measured the quantities, states that the common run of water for 24 hours in the whole of your district is 256 cubic feet per acre; do you consider his calculation to be correct?—I do not considerably differ from Mr. Hawkins in his computation; his calculation, however, I consider under the mark; I should incline to put it at more than 300 cube feet per acre.

Is that so with the collateral sewers as well as the main sewers?—Yes.

Your district is so situated in respect to its being below high water that it is impossible for you to get a quicker fall or discharge than you now have?—I do not see how it is to be done, it has engaged many days, and I may say years of my life to consider it.

Why cannot you get rid of the waters more quickly?—From want of fall.

Do your sewers run in a direct line from their source to the river, or are they very sinuous?—They are in direct lines as nearly as the public ways through which they run will permit. I should not call the worst of them *very* sinuous.

After diverting all the upland waters into separate outlets, if you had area sufficient to hold the back-water that would accumulate in the lowland district and direct outlets in sufficient number, would not the effect be the better cleansing of the sewers?—I am of opinion that whatever outlets might be made for the upland waters it would be desirable to have a command over them for letting down a certain portion on the low lands, by which they (the latter) would be better cleared and scoured.

Describe the manner in which the waters are let off and the periods of the tides at which this is done?—At each sluice is a flap, with machinery to raise it (except at Heathwall, where there are folding gates). As soon as the tide has ebbed below the top of such flap the sluice-keeper raises it, and leaves it till the return of the tide. These flaps being hung opening to the river, are self-acting. Behind, that is, landward from the flap, are placed pen-stocks, which are lowered in case of accident to the flaps.

Supposing you had area sufficient for the back-water that might come from the properly defined low lands district, and your outlets were sufficient in number, so that you could, during the absence of rain, hold the back-water until the tide was somewhat ebbed, would not a greater velocity be obtained for the discharge, and by flushing

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gates fixed at proper intevals, to be shut before the ebb commenced and then let off one after the other, would not that have the effect of elearing the sewers from foul deposits?—I apprehend that there is at present area sufficient in all ordinary cases for the back-water from the low land, and that the outlets are sufficient; yet, with the experiments that have been made in flushing, which, where it can be applied, had been done for a great number of years, I have found, that from the smallness of the height that can be obtained, the sewer cannot be clear sufficiently so as to obviate the necessity of casting.

Is it not advisable that a proper survey should be made and levels taken, to enable a satisfactory examination to be made as to the real portion of the districts that could be drained by what may be termed upland sewers; and what would remain to be provided for as to capacity, number, and direction of low land sewers required?—I apprehend surveys and levels to very nearly the extent implied in this question are already in existence. The districts that could be, or indeed are, drained by upland sewers, are known; their drainage has been formed by naturally made sewers, which, as the population increases, only want the assistance of art.

You have great quantities of water coming from the upland, have not you?—Only one sewer, that is the sewer which falls by the Brixton Washway, and discharges itself by Vauxhall Bridge, which is under different circumstances from the rest of the district.

If you had your choice with respect to the size of tubular drains, setting aside the difficulty of working a small brick drain, you would not make of much less size than nine inches?—No, I should not; they are much less likely to get obstructed, and upon that account I should certainly prefer a drain not less than nine inches. I do not mean to say that less than nine inches would not do, because the run of a 9-inch tube will carry off an immense quantity of water, but it is for the convenience of keeping it open.

The Commissioners have had evidence that the smaller the size of the drain, within certain limits, the better the run, and the less the deposit?—I am prepared to contend that that is not the fact.

Take the case of a 9-inch drain, to what is that the outlet? is not it an outlet to the pipe from the water-sink, or in case of a water-closet, is may be the outlet of a pipe 9-inches in diameter?—The waste-pipe of a water-closet, in the first place, is 4 inches in diameter, and that is not the only outlet that goes from the house, you have the waste water of the cisterns, the waste water of the sinks, and the waste water which washes down the yards, perhaps.

Are they all running at one time?—They may be, and there may be a shower of rain falling upon the house.

Even if it were so, take the case of a fall of rain upon a fourth-rate house, supposing it to be a fall of one or two inches in the hour, what sized pipe would be necessary to carry off that?—I should not think of putting less than a 3-inch water pipe to that alone.

What addition would a water-closet make to it?—There would be a pipe of 4 inches diameter.

Then the other pipe is the pipe from the sink, do not you lead that off with 2-inch pipes?—It is possible that all this may be so, but

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I think in all cases where a house is to be freed from its water there should be somewhat more than enough means of carrying it off.

Supposing a pipe of 3 inches to be more than enough for carrying off the storm water, would not a 4-inch pipe do for ordinary and every-day purposes?—My opinion is that it would not. I should not like to put it in to houses I was superintending.

Are you district surveyor?—No.

It appears that there were in the metropolis, in the year 1841, 270,000 houses. Now, if each were to have at the least a 9-inch drain, as you and architects in general recommend, it appears that the area of the stream or river required to keep them full and flowing would be a stream 1132 feet in width by 105 feet in depth?—Yes.

It is estimated that a supply of water for the whole of the metropolis, supposing each house to have a supply of 125 gallons per diem, or 25 gallons per head, would be given by a circular tunnel or aqueduct 12½ feet diameter. There are in the Kent and Surrey district 55,000 houses, and the supply there would be given by an aqueduct of proportionate size to your number of houses, that is, one-fourth. Such being estimated to be the size of conduits required to bring in water, the sectional areas of the drains and sewers, it is presumed, would not be required of vastly greater size, supposing them to have as good a fall, to carry away that same water. Can you prove any addition of rain water, or even of extraordinary storm water, requiring a system of drainage, of a sectional area more than five times that of the Thames at Waterloo Bridge at high-water, or nearly a thousand times the area of the aqueduct that would furnish the whole supply of water to the metropolis?—I apprehend in providing drains for a house you are to provide against accidents. Therefore I should say it would be prudent always to have drains larger than are actually necessary to guard against stoppages. A stoppage in a small drain stops up the whole orifice; a stoppage in a large one is partial. There may be most likely a means of its running off in some way or other.

Do you dispute the fact that a 4-inch drain from a house keeps clearer than a 9-inch, and is clearer still than a 12-inch?—I certainly do dispute it.

The thing which you deprecate is the stoppage of a drain?—Yes.

What causes the stoppage of a drain?—There are a vast number of causes. The cook will take up the washer of the sink, and let down hard substances which will occasion a stoppage.

It has been stated that the smaller the pipe is generally, the less likely will deposit be to accumulate, the greater will be the force of water concentrated upon the resisting medium, and the less likely is the resistance of that medium to be effectual. What is your opinion upon that subject?—My opinion is this, I will take the case of a washer to a sink being open and the cook throwing down anything that comes to hand. It comes against a 4-inch pipe and blocks it completely up, but the end of a cabbage-stalk will pass into a 9-inch drain and there it will lie and decompose.

That supposes that it originally passes down a 2-inch pipe from the sink; it must cause a stoppage in the 2-inch pipe first?—Many things will pass down to the end of a pipe, and all meet at the mouth of it.

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Still they do not get into the larger drain?—There are other matters that would come into the larger drain.

Do not you know that sometimes servants, or persons living in attics, will throw out substances of all kinds into the gutters. Would not that equally be a reason for making the water-spouts of 9-inches, a diameter as large as chimneys, to carry off accidental substances so thrown in?—Perhaps it would be better in many cases; but we cannot remedy that.

In your Encyclopædia you say, "The architect neglects his duty if he has not provided for perfect drainage in the lowest part of the structure. This must be by the aid of a small stagnant tank, called a cesspool, often the cause of much disease in a family; but by means of a drain into some running stream at a distance from the building, or, if that be not practicable, into some far-removed pond, whose exhalations shall not be blown by the prevalent winds of the spot back upon the place where they were generated in a different form. Neither does the health alone of the family whose comfort is to be provided for demand this consideration of drainage, for the durability of the structure is quite as much involved in good drainage as is the health of the family whose dwelling-place the house is to become. Hence we are the more earnest in pressing the point." Is not this excellent advice applicable *à fortiori* to the whole circumstances of sewerage in your district, the necessity of isolating houses from cesspools in every possible way?—There cannot be a second opinion upon that; I apprehend it is most desirable.

You are still of opinion that it is impossible within your district to do more for the prevention of nuisance arising from the decomposing of the refuse in the sewers?—I have hardly said that.

To accelerate the run of water?—You cannot do that; the fall will not permit it.

Have you ever considered the addition of pipe-water to regulate the run, so that it may be less intermittent in particular places?—Our sewers are full up to the crown every tide in rainy weather.

Are all of them full, branches as well as mains?—I think I might say branches as well as mains; and there it is hanging till the tide ebbs to let it out.

You say "Our sewers are full up to the crown every tide," if this be so, pray what becomes of ordinary rain-water and heavy storms?—When the sewers are brimfull, the water backs up and finds vent at the gullies into the roads.

And you do not think it practicable to quicken the scour in any way, either by altering the size or modifying the shape of the drains?—I do not think it is. I apprehended I might be called before this Commission, and recently I have put some figures upon paper with regard to the shape of sewers.

Further on in your book you say, "When we recollect that a small river, draining a very considerable tract of country, is often in its section only eight, nine, or ten feet superficial, it will easily be conceived that the surplus from the rain-water falling on a mansion is a quantity, even at the most pressing times, requiring little area of discharge to free the place from damp. There are few cases in which the largest mansion would require for its main branch drainage an area of

more than 5 feet, which would be given by a sewer or drain 2 feet by 2 feet 6 inches, supposing its section to be that of a parallelogram; but of course, where the fall permits, there is no objection to larger dimensions." Is there any large-sized mansion which would require such a drainage as that to discharge upwards of 2000 cubic feet of water per minute, for that size would drain nearly 200 acres of the most densely-populated district, with 100 gallons of water supply to each house per day, and a fall of rain of an inch and a half in 12 hours?—The size there is not given for the sake of merely carrying off the water, but that it may be cleaned out at times without breaking the whole sewer to pieces.

You think, even in that case of a private mansion, the application of the system of making sewers so large that a man may get in and cleanse them is desirable and necessary?—That there may be the means of cleansing them—that there may be holes at certain distances apart that may be dug down to, and the silt and soil of the sewer may be got rid of by that means.

You say, further on, "It will hardly be necessary to recommend that drains should, as well for their durability as on other accounts, be constructed with curved bottoms. It is surprising that some (at least one) Commissions of Sewers about the metropolis should still persist in constructing their principal drains with flat bottoms, offering an additional impediment by the increased friction to the more rapid discharge of the water. Thus, for instance, let us take the lower parts of two drains whose running depth of water is 1 foot, one whereof is formed with a semicircular bottom 2 feet wide. The area of the column of water will therefore be 1·5708, and the length of the half-curve will be 3·1416. To obtain, with 1 foot depth of water, the same area in a drain whose bottom is flat and sides upright, we must have the width 1·5708, and the sum of the three sides touched by the water will be 3·5708. Then 3·5708 − 3·1416 = ·4292 represents roughly the difference of friction or impediment in favour of the semicircular bottom in the case stated, nearly $\frac{13}{100}$ of the power being lost by the use of a flat bottom." Will not that principle apply the more you curve it?—You cannot have a greater curve than a circle.

You reply that "you cannot have a greater curve than a circle," but you can surely have a sharper curved bottom to a sewer than a semicircle, and does not your excellent reasoning with respect to the superiority of the curved bottom over the flat bottom equally apply to the superiority of the sharp curve or egg-shape over the semicircle, *where there is only a small run of water in a large sewer?* and is not this the condition, for the most part, of all the sewers except the few main lines?—The point to be obtained is to gain the largest capacity with the least surface of friction; it is much on that account that I object to the sharp curve.

In another part of your work you state that you prefer the semicircular form to the egg-shape?—Yes.

In one of your reports you say, "Independently of the objection to the egg-shape, of its want of a broad bearing, it was found to be so extremely inconvenient for the casters to work in, from the sharpness of the curve whereon in working they have to stand, that I was not at all displeased when the works of Waterloo Bridge, many years after-

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wards, rendered it necessary to change the line of sewerage to meet the altered direction of the streets, so that, fortunately for my reputation, it (meaning an egg-shaped sewer) no longer exists; and if I am left to exercise my discretion, the ovi-form sewer will never again be used by me. I should incline more to a good opinion of Mr. Roe's egg-forms, for I am quite content that he have the credit (if he so consider it) due to their introduction, if he would consent to turn his figure upside down. There are, however, other most important and scientific objections whereto they are liable, upon which, in this general statement, it is unnecessary to enter." By that opinion I presume you abide?—I abide by it; and I would further illustrate it by the paper I hold in my hand, which I will afterwards put in. But I will state the result of it. Taking a sewer, it does not signify what size, say a sewer of 4 feet by 2 feet 9 inches, having a circular-headed top and bottom, and upright sides, 1 foot 3 inches in heigth, it contains an area of 9·3771; it will hold 1381 tons of water in a mile. The friction on its bottom will be as 6·82. Supposing a sewer of the same height and width, formed 4 feet by 2 feet 9 inches, as before its area will be only 8·8194, and it will hold only 1254 tons of water in a mile. The friction on the bottom and sides will be 6·99. I should state that this ovi-formed sewer I have named is one formed by a regular curve, and not by the expedient I have seen adopted of having many radii of curvature, so as to form what a scientific man calls a bungling ellipse; but an ellipse by a continued motion. This ovi-formed sewer is constructed and completed upon the supposition that it is a true mathematical form. The consequence, therefore, is, that the respective frictions of the first and the last are as 6·82 to 6·99, besides the difference of the capacity of water.

Taking an upright-sided sewer, five feet in height and three feet in width, having a circular-headed top and bottom, upright sides two feet in height, containing an area of 13·07 feet; and taking an egg-shaped sewer of the same height, and containing a similar area, and which egg-shaped form enables the same area to be obtained at a less cost than the upright-sided sewers formerly cost for the same area, would not the difference in friction, when the sewer was full, be in favour of the egg shape?—It is assumed by the question, that an egg-shaped sewer, whose area, 13·07 feet, will cost less than one of similar area, with circular-headed top and bottom; but if the sewers are of the same thickness and materials, I do not admit the assumption: putting that, however, out of consideration, I am of opinion that the difference in friction and capacity will be against the egg-shaped sewer. It would have been desirable, in order to obtain a *precise* answer to this question, which does not depend on opinion, to have given the dimensions and radii of curvature of an egg-shaped sewer, by which the *exact* area of 13·07 is produced. They involve a long and troublesome, not to say difficult analytical calculation; and if the lower part be not in the form of a true ellipse, would admit of an infinite number of solutions.

Mr. Hawksley states that the velocity in an egg-shaped oval sewer is to the velocity in a circular sewer as 20 to 19; and the cleansing effect as 10 to 9. Mr. Butler Williams states (page 464) that the egg shape presents this important advantage for the conveyance of water, ex-

clusive of its superior strength and economy over the upright-sided sewer: that when the water is small in amount, the narrowness of the lower part gives a greater hydraulic depth, and therefore produces increased velocity; do you agree with these gentlemen in their calculations?—I am not aware from what work the dicta of Mr. Hawksley and Mr. Butler Williams are quoted in respect of egg-shaped sewers; and being unacquainted with either the formula or process of investigation by which the former has arrived at the results in the question, I am unable to investigate their mathematical truth; until I see such sort of proof I must doubt the accuracy. But in respect of the statement of Mr. Butler Williams, I beg to observe, that I may, I trust, (from much study of the equilibrium and stability of arches, and as the author of a work on that subject that has passed through three editions, and therefore I presume of some value in the public estimation,) be allowed to assert there is *inferior* strength and *absence* of economy in the egg-shaped sewer, and that the upright-sided is far preferable under the former head, and superior as to the latter. If to gain *hydraulic depth* by narrowness be an object, it follows that sewage should be conducted by sections brought to the shape of narrow slits, so to speak. It is, moreover, known that the velocity of running water in a channel is less at the bottom than at the surface. I respectfully differ, therefore, from these gentlemen in their assertions.

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Have you had any experience, or would you state it as a result of which you have no doubt, that an egg-shaped sewer, with the broad end downwards, will, with the same run of water, discharge more quickly, and keep itself clean better than an egg-shaped sewer with the narrow end downwards?—I should say it would clear itself better, because there would be less friction upon a circle than there would be on the parts of an ellipse.

Do not you think that is a fact which may be determined by actual experiment?—No doubt it may.

And ought not it to be?—I can see no objection to it whatever.

Your firm persuasion is that the broad end downwards will, with ordinary runs of water, keep the sewer clearer?—I will discard altogether that supposition. If you have the broad end downwards I do not see the use of curving it, its effect is only to make difficulty in the work. In the case I have referred to, independent of the inclination of the bottom, the velocity would be at the height of the fluids in each, supposing a greater amount of friction is not to be overcome; this may be taken, therefore, nearly as the cubes, or, in a foot forwards, nearly as 260 is to 199, supposing each full to the springing. The capacity of the two inverts taken from the springing line of the semi-circular one is as 2·97 : 1·88, hence in favour of former.

As to the construction of sewers, is your construction adopted by your colleagues in their lines?—We adopt the same.

Does not one of them adopt the circular form?—That has been in particular cases; for instance, in the case of a large sewer running down to Rotherhithe, but the circular form is not the usual one adopted; that was to meet a particular configuration of the land.

In courts, what would be the smallest size of your sewer?—I should say, a foot.

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What would it be in a small street of 50 or 100 houses?—I should say, 2 feet by 18 inches.

Your drains you will always keep at the size which you have mentioned?—Yes, I think so.

Do you use your first-class sewers in any collateral streets?—In some cases they have been, but very rarely; where the street has been a large and important street, the sewer is to be a reservoir; that is the reason of it; it has to receive the accumulation of the water during a whole tide, otherwise the sewers are larger than would be called for.

In the case of a person in a court or alley wishing to drain a single house, he has to apply to you?—Yes.

Then has not he to apply to the Paving Board?—No, we have power to pull up any pavements.

In a road or street?—Yes.

Then the cost of replacement is included in the charge?—Yes.

How much would that be?—No two drains perhaps would come out alike, from the difference in the depth of them. The digging in one case will be half as much again as it is in another.

You have a fee in each case, have not you?—Yes, that is for the going to see the place, to see whether the work can be done, and afterwards to see whether it has been done properly; that fee is 10*s.* 6*d.*, which I am exceedingly glad to say is about being abolished.

With respect to the mode of payment in your works generally, are you paid by salary?—I am.

What may your salary be?—50*l.*

Mr. Drew, before the surveying officers, has given this evidence. He is asked, "Who are the surveyors, and how many are there?—There are three. What are their names?—Mr. Joseph Gwilt, Mr. Edward I'Anson, and Mr. Joseph Newman." Mr. *Elkington.* "Are not these gentlemen paid by the Commissioners on the works executed? Yes. A certain per centage?—Yes. The more the work comes to the better they would be paid?—Yes, the more work that is done, the better they are paid." The following questions are put to yourself; "Have you any other emolument besides the salary and the fees on these openings?—Oh, yes, I have a commission upon the works. A commission on the estimate that you make, or upon the amount of works executed?—The amount at which the work is done. And that commission is upon the new works in the district?—Upon the new works of the district. I have no commission on the general expenditure of the district, the cleansing of the sewer, the superintendence of cleansing of all sewers, and every matter of that kind is included in the 50*l.* a-year. The commission is only on the new works executed?—Yes; in short, if it was not for that, I could not undertake to do the work. It would be impossible, I should be a loser by it. Mr. *Walker.* You say 'cleansing,' supposing a large repairing job, you are allowed a commission on that?—No, nor have I received such a thing; perhaps I may be allowed to state, that for that commission there is first the planning the place; there is levelling the place; the spot at which the work is to be done, it must be levelled up from the main sewer to which it is to be carried; there

is the estimating the work; and there is then the insertion of the plans in the contracts that the clerk prepares; together with a specification of the works; and after that there is the superintendence of them, to see that they are properly performed; and the certifying that they are properly performed to the Commissioners." Do not you think it would be better upon the whole, if, instead of a small salary, you were paid a large one without such per centages?—I should naturally say so, of course.

As it at present stands, may not it be open to the observation, that this payment by per centage upon the works is liable to objection as a bribe on expensive works, or a bias in the judgment against improvements in economical construction?—It is a very frequent objection to all charges in my profession.

Your charge here appears to be a charge for levelling?—Not separately; that is included.

You say for that commission there is first planning the place, and there is levelling?—That is included.

Do not you think if you had a large, general, and comprehensive survey of the whole district, it would be an advantage?—Yes.

Such a survey as the town survey contemplated by the Ordnance of 60 inches to a mile?—Certainly, such a thing should exist.

Would not it save a great deal of separate levelling, and be available for other works in the district?—I scarcely know whether it would, but whether it would or not, such a thing ought to exist, I think, for this reason: of all the streets that are in existence I have levels at this moment, and it is only where new projects of building are about to be carried out such becomes necessary, so that the chances would be that you might even with such a complete survey as that have a point to which you might want to go, from new schemes of building coming there, and yet you might be without a level of it upon your map. There cannot be a doubt about such a thing being most desirable.

That you should have had to refer to not only for your own district, but with reference to the districts surrounding you?—It would be a very desirable thing.

Do not you think it would be a great benefit to all dwelling-houses if those cesspools were removed, even though they were subject to a smell arising from communication with the sewers?—I should by every means try to get rid of cesspools; I have a great horror of them.

Supposing you had occasionally some smell from communication with the sewers, the benefit of removing cesspools from all dwellings would be a greater benefit than that would be an inconvenience?—Yes.

You have some quicksand in your district?—We have.

Have you found any difference in laying down tubular drains upon those quicksands as compared with brick drains?—I consider that tubular drains are more easily laid down.

And will stand and last better?—They will stand and last quite as well; they are of perfect stability.

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You are one of the surveyors to the Kent and Surrey division of sewers?—I am permitted to act as my father's deputy.

How long have you acted as your father's deputy?—About five years.

In point of fact, you are practically the acting surveyor of that division?—I am.

How many surveyors are there under that Commission?—There are three surveyors.

Have they each separate defined districts?—They have.

What is the district which you superintend?—The district that I superintend is called by the Commissioners the Central or Southwark District; it includes several parishes.

Will you name them?—St. Saviour's, St. Thomas's, St. Olave's, the greater part of St. George's, St. John's, St. Mary Newington, and Christchurch.

Does it include any part of Rotherhithe?—It does not.

Your attention is confined entirely to the district which you have just mentioned?—It is, with the exception of cases which occasionally come before the Commissioners when they desire the three surveyors to inspect and report; but that is not a common occurrence.

Were you examined before the Health of Towns Commission?—I was not.

When any new sewer is to be made in the district over which you preside, what do you refer to in order to ascertain the levels and determine the size of the drain which you are to construct?—If it is an entirely new sewer, constructed to drain a certain level, the practice is to take the level of the whole country intended to be drained, by means of a spirit level, and then to judge by the area of the country the number of houses upon it, and the probability of an increase in the number of houses, the size and capacity of the sewer which it is necessary to build.

You must have reference also to the existing drainage?—Precisely.

What plans have you of the existing sewerage which you can refer to in order to guide you in the additional drainage you are about to construct?—Each surveyor has at his office plans of his own district, showing the ancient sewers and the new sewers as they are formed.

Have you any plan made to any particular scale of the whole district, or any levels made to any peculiar datum?—None. The Commissioners are aware that almost the whole of the district on the south side of the river is below high-water mark, varying from a little above high-water mark to as much as ten feet below Trinity high-water mark. But no level in my district is much lower than five or perhaps six feet below Trinity high-water mark. The increase of population on the south side of the river has taken place mainly since Blackfriars Bridge was built. Of late years the increase of houses and population has been very rapid. Formerly a large portion of the south side of London was occupied by monastic establishments; a large portion of that which I have the honour to be surveyor for, to the Bishop of Winchester, called the Park Estate, was in the centre nearly of our present

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district. It was a park, and the surface which was very marshy, being considerably below high-water mark, was drained by a great number of surface drains. Those surface drains were made use of for the purpose of getting heads of water and turning tide-mills, and several of our sewers are still called mill-streams. For instance, we have Pudding mill-stream, Battle Bridge mill-stream, and the Green Bank mill-stream.

That is to say, as this ground became built over, its original mill-streams became of use for sewers?—Yes. The Commissioners, I believe, before the present century, had no legislative powers enabling them to interfere materially with that aspect and feature of the country. But about the year 1809, they obtained powers enabling them to construct deep sewers. The construction of deep sewers dates with the Commission for which I am surveyor, from about the period of 1809. In the year, I think, 1809, in consequence of an application made by the city of London, who I believe are large holders of ground about St. George's Fields, the Commissioners were invited to carry out a deep drainage for the purpose of draining that inland district; and after a great deal of consideration and discussion, both with Mr. Montagu, who then represented the City, and with the owners of property on the bank, and other persons interested, it was determined, for the purpose of getting the most efficient fall, to take the sewer out below London Bridge, for at that time there was a considerable difference between the level of the water above and below bridge. Accordingly, a piece of ground was bought at the end of Mill-lane in Tooley-street, and an outlet was made there a little above the level of low-water mark. I think the invert of the sewer is 15 or 16 feet below Trinity high-water mark. That sewer was carried with a gradual fall to that point almost from where Bethlehem Hospital now stands. That was the first important work which was done in the central district.

What is the level of the sewer at its head?—About 10 feet below the surface of the road at Bethlehem Hospital. But I am speaking from memory. That sewer which we call Battle Bridge Sewer, together with the existing ancient sewers, taking the surface drainage, is the means of sewerage for the parishes of St. George and all in my district lying westward and northward of St. George's parish.

Do you know whether when the Commissioners undertook that work in 1809, they had any general survey taken of the whole of the ground, and any map made out?—I am speaking only what I have heard; but I believe they had a report from Messrs. Jessop and Walker, which must have been, I think, previous to 1809, in which some general scheme was recommended.

You are not aware of any map on any particular scale which was made at that time?—I am not.

There is no map of that date to which you are now in the habit of referring?—No.

Nor any general map of the district to which you could at once refer in order to ascertain the levels?—No. At that time we had sections taken in all directions across the face of this country, to which we occasionally refer, but there is no map.

What sections do you refer to?—Sections of levels. The datum by which we generally work is the base of the obelisk; that is four feet

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above Trinity high-water mark, and all our levels have reference to that datum.

Are the sections which you mentioned laid down upon any large map?—No, not upon any map.

They are not in contour lines or with bench marks?—No, we have no map with contour lines nor any general map showing the levels of corners of streets.

Therefore in any new work you undertake you are obliged to level for the purpose of ascertaining what your work should be?—We always take the levels before we proceed with any new work, but our existing records of all works executed show the level of the ground above the line of the sewer. Whenever we execute a work, whatever it may be, we take the level first, and that level we keep a record of, and to that we can always refer, and learn what the comparative level is between the surface of the ground and the invert of the sewer.

That is along the street under which it runs?—As I stated before, we always have reference not only to the street along which it runs, but to adjacent districts which may be served by means of the sewer about to be constructed.

Would not it be a great advantage to you as a surveyor if you had an Ordnance Survey, or a survey such as the Ordnance Survey made of the whole district?—I think it would.

Would not it save a great deal of trouble and anxiety?—It would lead us to general conclusions certainly, but even if we had such a map, I should never be satisfied to adopt the levels or measurements of any man whatever. If I were about to execute a sewer, I should not be satisfied without taking the levels myself.

Should not you be satisfied if the levels were drawn up with reference to some particular datum line, with bench marks and contour lines?—I do not think I should. If I were about to execute a work, I should like myself to check the dimensions or the levels. I speak not only as surveyor to the Commissioners of Sewers, but in reference to plan-taking in general. One always likes to check a plan before working upon it in any extensive or accurate work.

The moment you found your calculations concur with the calculations laid down upon the general map, it would satisfy you at once, and be a much shorter process than having to depend upon the strict accuracy of your own levels?—Of course.

Since 1844, when the Health of Towns Commission sat, what new works have you undertaken in your district?—We have executed a line of sewer through the parish of St. Mary Newington, along the line of East-lane, from the Walworth-road to the Kent-road. We have also executed a line of sewer from the bridge called St. Thomas à Watering Bridge in the Old Kent-road, up to the Deaf and Dumb Asylum, and then from St. George's Church to the boundary of Bermondsey parish, in White-street. Those are the three principal works which have been executed since that time.

And those are now in action?—Yes.

What new sewers have you at present proposed or planned out?—We are arching over several high level open sewers, which are now very offensive.

Will you state what those are?—The Skin-market Bank-side, Tattle-

court Bermondsey-street, Collingwood-street, Christchurch, Surrey-row Christchurch, Sparrick's-row St. Olave's and Red Cross-court St. George's.

In the plan and scale of these works you have made no alteration, but you have proceeded upon the same plan, and in the same method, which you had originally?—Precisely.

You say your sewers which have been in progress since 1844, are now in action?—All that have been made.

What is your practice with relation to your sewers; do you cleanse them out by hand labour and cartage?—In the deep sewers we have very rarely occasion to resort to cartage. Our plan is to flush the sewers by temporary dams fixed in the sewers till a head of water is obtained, and we place in the sewer three or four men, who with spades lift up the bottom, and loosen it as much as possible, and then let the head of water loose, and so propel the looser material along the bottom of the sewer; and with a view to obtaining a head of water, we arrange as much as possible, in building the low level sewers, to have communications with the high level sewers, and by taking the tide in on these, we get occasionally a large supply of water.

Do you use flushing-gates?—I have put up two or three flushing-gates by way of experiment, but we do not universally adopt them.

What is the practice as to the collateral sewers?—We make no difference between collateral and main sewers. Our district being entirely below high-water mark, it becomes very important with us that we should acquire area, therefore we take every opportunity of making large sewers on the low levels. In the ancient high level where we arch over and discharge at half tide, or a third of the tide, we have much smaller sewers.

Do you happen to know the length of the public streets in your district?—No, I have no idea of it.

Do you happen to know the length of the sewers you have in your district?—I do not know it accurately. I should say the deep sewers would be about six miles at least; the open sewers are perhaps double that length.

Have you any power to compel parties to communicate with your sewers?—Within the last six months we have had.

Have you carried it into execution?—We have not; we have scarcely organized our operations under the new Act yet.

Have you any idea what number of houses in the district have communications into the sewers now?—I do not know; but directly or indirectly, they almost all have some communications either with a high or low level sewer.

Are you speaking from your own knowledge in saying that?—Yes, either to a high level or into the deep sewers they have a communication, that is, that they have an overflow drain from the cesspools.

Into what does that drain?—Ultimately, of course, into the next adjacent sewer; it may have to pass through the backs of houses along a public street before it reaches a sewer.

Do not you think there are many houses in your district which have only cesspools and no communications with the sewers?—There are a great many.

Then there must be a great many houses which have no communi-

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cations with the sewers?—There are; that is, with no direct communication.

Have you ever gauged either the mains or the collateral sewers?—I have tried it often, but have not arrived at any satisfactory result.

How long ago have you gauged them?—I have been occasionally gauging the sewers the last five or six years.

Do the Commissioners understand that the mode of cleansing the sewers you describe is the mode you continue in use even with respect to the new sewers?—Yes, we have used it from time immemorial, and are satisfied with it. In some of the new sewers I am putting up some flushing-gates by way of experiment.

How long have you been accustomed to use a flushing apparatus?—A flushing apparatus in the way we use it has been used as long as sewers have existed.

It has been stated, that there is a great deal of surface water coming down from the higher parts of the district, and that during the time the sluices shut off the sewage-water from the Thames, a great deal of water comes from this district and passes down the sewers so as to fill them with water. What is your experience as to that?—The sewers are sometimes completely full, and more than full.

Is that generally so?—No. On the 1st of August, 1846, the sewers were very full, and one part of the district was a little flooded.

That was during the storm?—Yes.

You do not find that every time the sluice-gates are shut such a quantity of water flows in as to fill up the sewers?—The lower part of our deep sewers is full every tide.

To what extent; how far up from the mouth?—Several hundred feet at least; 700 or 800 feet I should say.

Is that sewage-water, or water which has drained off the higher parts of the district?—In my district it is entirely sewage-water; I am not affected by the hill water in my district.

You comprehend within your district, St. George's, do you not?—Yes, St. George's, for the greater part.

This is the description given of some of the drainage in your district:—"What is the condition of the district in respect to house and street drainage?—The houses are very badly drained; they have mostly cesspools, very few draining into any sewers; but the most depressing influence upon the health arises from the number of open sewers which surround and intersect the district; these ditches and sewers are sluggish, and evolve noxious gases. Typhus fever is always prevalent in the vicinity. What is the condition of the covered sewers?—They emit very offensive effluvia. In the house in which I live we have experience of it. When the wind is in particular directions we have a severe experience of it. Do you consider it an advantage, in the present state of the sewers, to open any communication with them?—I have been led to consider that point, and to doubt it very much; more particularly since the storm of August, 1846, when the water from the sewers was conducted from the drains into the houses and burst through them. A number of houses were flooded with sewer-water; mine was saturated without 4 feet deep; the walls have not yet got rid of the stench. What was the condition of those houses which had no drains to join on with the sewers?—They were certainly

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better off; they had none of the sewer-water." Do you think that a fair description?—As far as my own experience goes I think the accounts of typhus adjoining sewers are greatly over-stated; that is my impression. That is not certainly a fair description of the state of all the houses in St. George's parish. I quite admit that the open sewers are exceedingly offensive.

Are not those open sewers in the midst of a dense population?—In all cases; at all events in my district they are.

And the lowest description of people?—Yes; the Commissioners have only obtained the power to arch those sewers over within the last six months, and I have already a considerable quantity of that work in hand.

What shape do you adopt in your sewers?—Semicircular top and bottom. I have a little deviated from upright walls, more really because it appears to be the fashion than for any other reason.

Have you any of the egg shape?—I am now having a piece of it built on trial, and my father's predecessor, Mr. Alexander, the architect to the London Dock, recommended the building of a piece of egg-shaped sewer in the Dover-road; but subsequent experience induced him to abandon this form, and adopt that which we have now in use.

Dr. Doubleday, speaking of the average age of death in St. Saviour's being so low, says, "I must attribute it chiefly to the open sewers and the general bad drainage of the place. In the neighbourhood of the Mint and Ewer-street the condition of the population is certainly very bad. There not only the drainage but the cleansing and scavenging is very bad and nothing has been done to improve the defective condition of the houses. The circumstances are such as to account for the mortality." He has stated to the Commissioners, that in the low district it is not unfrequent that on the rising of the tide, in excessively high tides, the sewer-water is driven back into the houses?—About four years ago the Commissioners had the banks of the river raised; they issued a precept enforcing it upon the owners of property to raise the banks of the river. Before that period the water used to flow over the banks from the river, and used to flow back upon the low part of St. Saviour's and Christchurch, especially in one wretched locality, Ewer-street.

You say you doubt whether typhus prevails to the extent it is said to do in the proximity of those open sewers and ditches. Have you any, and what assured ground, for your doubt?—I am of necessity a great deal engaged along the line of open sewers, and my only reason for saying so is that I have never heard complaints of typhus. Lately I have paid some attention to the subject, and have often asked people how they have felt, and how they liked the open sewer. I have often heard them complain of headaches and bowel complaints, but I never heard them complain of fever; and it is rather a curious fact that the men in the employ of the Commissioners, who are up to their knees daily in this sort of work, are by no means a short-lived race of men, but rather the contrary; it affects their complexions; they are pale and sallow; but they are strong, hearty men: they live more than the ordinary duration of life. They remain generally a great many years in our employ.

No. 21. Mr. E. l'Anson.

What do you call a good average duration of life?—I was looking at the list of the ages of the men; none of them come into our service very young; their average age is about 45.

Do you know that the average age of some well-conditioned labourers is 10 or 12 years greater than that?—Those men come into the service none of them very young, perhaps 35, or about that age. Taking the average age of about a dozen men, the age of 45 I should say shows a very good average.

You are convinced that the escape from cholera and fevers, and such diseases, of those men who have been in the sewers, is a proof that the popular belief as to the general nature of this sewer-water is an error?—I will not say that it amounts to a proof.

But it is a strong and cogent circumstance in your own mind?—Yes.

And in the minds of the Commissioners of Sewers who are advised by you?—I cannot say that.

Do you employ the same men constantly?—They never leave us. I only know one case of a man leaving; he got a pension at Greenwich Hospital, and he was very desirous of being taken back again.

What is their pay?—4*s.* 2*d.* a-day, except the foreman, who has 2*l.* a-week.

There are many narrow courts and alleys in your district which are reported to be some without any drainage at all, and most of them without any proper drainage; have you any projects for the amendment of those courts and alleys?—We have none.

If you were called upon to put down a sewer in a court or small street, what size should you use?—It depends very much upon the locality we have to work. If it is upon one of the low levels, and the street is sufficiently spacious to enable us to construct a large sewer; we always endeavour to do so.

What size should you adopt?—The average size of our sewers may be taken at 4 feet 9 by 3 feet; and we should, even in a court, construct as large a sewer as that if it did not endanger the stability of the adjoining houses.

Which is the largest size of sewer you have used for a court, and what may be the smallest?—In courts, the smallest, and the usual size, is an 18-inch barrel drain. We have used drains 2 feet by 2 feet 6 inches, and in a small row of houses, more spacious, however, than what is usually understood by the word court, we recently made a sewer 4 feet 9 by 2 feet 6 inches.

Supposing an occupier is desirous of draining his house into a sewer, what sized drain do you require him to put in?—We have hitherto required 15-inch and 12-inch barrel drains; but the question is now under consideration, whether, by adopting glazed tubes, we may not reduce that to 9-inch.

Is that the size you would stop at?—I am not prepared to say that. The Commissioners have resolved to adopt glazed tubes, but we have not definitely settled the size.

Have you recently been to the Westminster sewers, and seen what they have in use?—I went there about a fortnight ago.

Were you not satisfied that smaller drains than you had been accus-

tomed to use were desirable?—Only desirable on account of the expense.

Not on account of anything in regard to the flow?—I think not.

You still think that a 12-inch drain would be a good size to discharge the flow from houses?—I do.

Will you state the grounds for that opinion?—It would be more easy to state the grounds why I doubt the advantage of the 9-inch. Theoretically we know that a tube which presents the greatest area or the greatest friction to fluid passing through it, is that form of tube which is the least adapted for the conveyance of water. Take a 9-inch tube and fill it three-parts full, I apprehend there will be more friction upon the sides there than with a 12-inch tube containing the same quantity of water.

Will you describe the capacities of the ordinary inlets to this house-drain; will there not be the sink in the kitchen, and occasionly the soil of the water-closet, supposing there to be a water-closet?—Yes.

Of course, the flow from the water-closet is occasionly?—Yes.

For that you use a 4-inch soil-pipe?—Yes, vertical.

Why then you do use a 12-inch outlet, an outlet nine times greater than the inlet?—The outlet in some parts of it is nearly level, and it has other things to take besides the soil from the water-closet.

Take the inlet from the sink: through what sized pipes do the water sinks in use in your district drain?—About an inch and a half, or two inches at the outside.

What is the proportion of the size of the inch and half pipe as compared with the 12-inch outlet?—A 64th part of it.

Do you think that an outlet 64 times larger than the inlet is necessary?—No. There is one reason I may state for laying 12-inch brick drains, and that is that a great many of the drains are tunnelled under the roads. The men sink a shaft; the man creeps into the hole, and lays the bricks as he goes on, or he even pulls the bricks under him, and so lays the bricks. The bore in which he lays the bricks could not well be much smaller than of sufficient size to take a 12-inch drain.

You would not make a 12-inch drain for one house, in a court, would you?—It has been our practice.

What is the charge for this entrance from one house into the drain?—The charge up to the present time has been a fee of 10*s.* 6*d.* upon the application.

Does the private individual put the drain in himself?—No, the Commissioners put it in, and they charge the cost of the work.

What is the cost?—It varies from 4*s.* to 5*s.* a-foot in the deep sewers where there is from 10 to 15 feet of cutting, and perhaps 3*s.* a foot upon higher levels where there is less cutting.

Are you district surveyor?—Yes.

Are you not entitled to a fee in addition to that 10*s.* 6*d.* as district surveyor, for all alterations?—I am district surveyor to the parish of Clapham. The Act is rather doubtful upon that point. I once charged a fee upon making a drain, but I thought it was wrong, and I have never done so again.

Are you not aware that some others of the district surveyors have done it?—I am not.

No. 21. Mr. E. l'Anson.

The words of the Act are "every alteration"?—But then, I think the Act has some words about drains, and requiring houses to be drained into the next adjoining sewer.

You have only charged one fee as surveyor?—No.

Are you in private practice?—I am.

Are you surveyor of pavements?—No.

Are any of your colleagues?—One of them is.

In case of any person wanting access to the plans or surveys, he would go not to the Court, but to yourself: does it depend upon yourself whether you show them to him?—Yes. Naturally, any person not meeting with the attention he thought he had a right to demand, would of course have redress upon applying to the Court; but I have never known a case of the kind, nor have I known any case of any application for inspection.

Will you give to the Commissioners a return of the number of house-drains which have been joined to the newly-made sewers, or can you state off-hand what the proportion is?—I can state that in one sewer up East-lane, there have been 30 drains put in within the last three or four years. Those 30 drains probably drain three times as many houses.

Is it your intention to enforce the recent Act?—It is.

And to enforce it upon the same scale of works you have hitherto adopted, with the exception in those courts and alleys of the substitution of 9-inch for 12-inch drains?—The 9-inch and 12-inch drains do not apply to courts and alleys. I have been speaking of house drainage. We mean to enforce the same rules, excepting that, it is in contemplation to abandon the 10*s*. 6*d*. fee, and to adopt 9-inch drains instead of 12-inch for houses; but as to courts and alleys I know of no alteration.

Have you any alterations to propose, to correct the evil of the increasing accumulations of sewage matter?—We are gradually introducing, though with some hesitation, the ventilating gratings in the centre of the streets. The Commissioners have recently written to Mr. Faraday, Mr. Cooper, and to some of the most eminent chemists to obtain their advice and opinion upon the best way of ventilating the sewers; and we are expecting a report from Mr. Cooper upon the subject.

You have expressed the present limit of your proposed alterations?—Yes.

Have you had frequent complaints made of bad smells coming into houses out of the sewers?—No, we have not.

Are you in the habit of using valves at the entrance from the sewer into the house drain?—Very rarely. Where we use them, it is upon the lower levels for the purpose of preventing the return of the water.

You say that you have not heard any complaints made of offensive smells coming from the sewers. The medical men who have been examined have uniformly complained of them?—If they do exist, I can only account for it from the apathy which people so generally manifest in taking steps to remedy any inconvenience to which they may be subjected.

Do not you think it would be a convenience to the public, if the sewers and the pavements were under one jurisdiction?—I think it might.

No. 21. Mr. E. L. Anson.

You say you have heard of no complaints of any smells arising from the drains?—I have heard very few.

The clerk to the Commissioners admitted that with respect to his own office, the smell arising from the drains was often so bad as to make it extremely disagreeable to remain in the office?—It may be so; but we have very few complaints.

Upon what principle are your districts allotted among the several surveyors. Is it according to any natural features?—No; the districts are only allotted by the Commissioners in such portions as they think each surveyor is able to look after.

Are there any boundary lines?—No. We drain through each other's district, and co-operate. The three surveyors meet every week, or every fortnight.

It appears from some papers which have been put in, that the several surveyors use circular forms of sewers, but differing each of them in construction from the other?—I think I know the plans which you speak of. The differences are not material which we adopt.

Will you specify what are the differences between you? What differences of construction will Mr. Newman adopt? Wherein will his sewers of the same size and capacity differ from yours, supposing he has a street to drain?—I think in Mr. Newman's district the ground through which the invert of the sewer is carried is, generally speaking, worse than it is in my district; and where I should use a nine-inch bottom to the sewer, I apprehend he would use a brick and a half.

Should you use it if you were in his district?—I should.

That is, you would still use a brick and a half?—Yes.

Take Mr. Gwilt's. What is the difference between his and the others?—In Mr. Gwilt's district the ground lies generally upon a higher level. The ground falls from Lambeth towards Rotherhithe. His sewers relieve themselves very much upon the lower district. Mr. Gwilt would use sewers of a smaller size than we should generally.

How do they differ in construction from yours?—I believe he uses a semicircular top and bottom, and six to nine inches, upright sides.

If you were under the same circumstances, what, according to your practice, should you use in his district?—I probably should use the same that he does.

You think it is only a change of adaptation to the district?—Precisely.

Are there any differences in respect to the size or adaptation of house-drains or court-drains in either of the districts? Do they vary from yours as to regulation?—No; there is no difference, nor is there any precise regulation.

What is your habit of joining a collateral sewer with the main sewer? Do they all join at right angles?—Our sewers join with the best radius we can give them; I should say not less than 20 feet radius. Then the house-drains would join at right angles.

And the collateral sewers?—The collateral sewers with the best radius which can be obtained. Sometimes we can obtain very little radius.

Have you ever thought in your district of any adaptations of a water supply, with a view to better flushing or better cleansing the sewers?—

No. 21. Mr. E. l'Anson.

I have thought of it frequently. Now that we are about arching over so many of the open high level sewers, it will be necessary for us to make some arrangements with the water companies to get a supply of water. In one case in the Skin-market I have it in contemplation, and shall endeavour io carry it out, to get a pipe directly into the Thames—for it is not above 100 feet from the Thames—with a pump to pump water into the sewers.

How will covering the top, except by excluding some small amount of rain-water, vary the condition of the sewer in respect to its need of water?—The open sewers hitherto have had very irregular bottoms—in some places no paved or arched bottoms at all, and in others so irregular that there were not formerly the same facilities that there are now with a proper invert, but with our present open sewers we have pen-stocks for the purpose of getting at intervals heads of water.

If you improve the form of your sewers, and make them more regular, a less quantity of water ought to work them?—No doubt it would; and that is one reason why, when the sewers were so irregular in form both on the surface and in the sectional area, the quantity of water required would have been so large that we despaired of doing any good with it.

Will those open sewers which you are closing over do permanently for the sewerage of the district?—I apprehend that they are peculiarly suited to our district; they assist so materially and so beneficially in taking off the surface water in heavy falls of rain, for instance, that without them our deep sewers must be made of a very much larger size.

Where do they discharge into the Thames?—The first of any importance in my district is at the Pudding Mill, by Messrs. Horne's coal wharf. There are four or five others along Bankside; then there are about four between London-bridge and St. Saviour's Dock.

At what level do they discharge?—They discharge at different levels.

Will you state the extreme difference?—Perhaps there is six or eight feet difference.

Are there any above high-water mark?—No; all of them, I should say, six feet below high-water mark at least.

Supposing private houses wish to run their drains into those sewers, are they of sufficient depth to carry off the filth of the district?—Those high level sewers run through a very wretched district—small houses where there are no basements—and they all lie four or five feet below the surface, so that for the drainage of that class of houses they are sufficient; and as the district itself is below the level of high-water mark, and the soil inclined to marshy, there is no great inducement to go down for basements. I think that they are peculiarly suited to the physical aspect of the country.

What operation do you apply to those open sewers—anything more than covering them over?—We make a brick invert—in fact, we make a brick sewer of them instead of an open ditch.

Have you ever thought of the necessity of making them like your ordinary sewers?—We have thought of it, but I have just stated that we endeavour to retain our high level intact. We are extending as much as possible our low levels, but we do not lose sight of the high levels.

No. 21. Mr. E. I'Anson.

Supposing the owners of this property should hereafter convert it into a different class of property?—Basements cannot be obtained in that locality; it would be impossible.

Supposing it were converted into a different class of property, those sewers would be of no use to it?—No use to the basements. If we were now to make deep sewers, looking to the reversionary advantage, it would be money ill laid out in my opinion. The neighbourhoods are so distinctly marked in character, that there can be no mistake about it. You would say at once it is not a place in which any good houses would be likely to be built.

In the case of a builder applying to you for a new sewer in any district he is about to cover, what is your mode of charge?—If the sewer is under the public way, and the Commissioners consider that it would be a beneficial thing for the neighbourhood to extend any existing sewers, they do extend the sewer, charging it on the rates, sometimes taking a contribution from the individual. The course they adopt very much is—suppose a man desires to run a drain at a distance of 60 feet from an existing sewer, they say, "It would answer your purposes if you had an 18-inch or 2-feet barrel drain—that would cost you 20*l.*; it will cost us 60*l.* or 70*l.* to build such a sewer as the neighbourhood requires, therefore you can pay us the 20*l.*, and we will find the remaining 40*l.* or 50*l.*;" and that being done they construct a deep sewer.

Does the operation of flushing extend to the whole of your sewers?—My brother surveyors, I think, have tried less flushing than I have, and I have only tried it to a small extent. I am alluding to flushing-gates and the apparatus adopted in Holborn and Finsbury.

Have you moveable water-boards?—Yes.

Does that extend to the whole of your sewers?—Yes.

How often is it your practice to wash them out in that way?—About once a year, in some cases oftener; but many sewers do not require it more than once a-year.

What depth of soil would you find in them at the end of the year?—Perhaps 3 or 4 inches.

Not more?—I do not think there is more. There is a piece of information I gained when I went to Westminster the other day, which I think we should adopt. The greatest obstruction we meet with is at the foot of the traps coming from gullies in macadamised roads. At the foot of every gully-shoot there is an obstruction takes place, which, for a certain distance, makes a deposit behind it. I am convinced that we use our sewer-grates with too large openings. They have made a judicious improvement in Westminster in reducing the apertures between the bars of the grate.

Those improvements have been going on for some years, and you only learnt them a few weeks ago, when you went up at the request of this Commission?—I think I understood that these much smaller openings than usual have been introduced but a very short time. Our modern sewer-grates have openings very materially less than the old ones used to have, so that we have been going on in a course of improvement. But the Westminster Commission, in that respect, have taken a step beyond us.

Can you state what the annual expense in your district of cleaning

No. 21. Mr. E. l'Anson. —— out the sewers is?—The following is an account of the expense of carting and cleansing the sewers in the Southwark district, from the year 1832 to the year 1842:—

The same was read as follows:—

	Men's labour.			Cost of Carting.		
	£.	*s.*	*d.*	£.	*s.*	*d.*
1832	1159	1	7	307	16	0
1833	958	6	5	163	11	6
1834	1027	8	3	109	7	0
1835	1028	3	3	114	19	6
1836	1020	0	9	211	5	0
1837	978	14	5	175	1	0
1838	961	14	11	268	13	0
1839	959	1	11	213	1	6
1840	986	2	11	268	13	0
1841	973	9	6	248	12	6
1842	964	3	4	226	16	0

Can you state what quantity of refuse this paper would denote the removal of?—No; getting rid of it by flushing and drawing it out as we do, the only calculation would be by taking the total length of the sewer, and the mean depth of the deposit.

A great deal of the back-water, the Commissioners understand, that is driven back, is simply sewer water, not Thames water?—No; the Thames water does not get into the sewers at all.

How comes it that in that district, where probably water-closets are not very frequent, such a quantity of sewer water accumulates in the sewers between the times of letting out the water?—There are many manufactories upon the line, and a great expenditure of water from steam-engines.

You do not consider, apparently, that you have an adequate supply of water for cleansing the sewers. You stated that it was your intention to make application to the water companies for a more abundant supply?—There is no great cause to complain of the want of efficiency, a very little assistance would enable us to do all that we want.

But that assistance you feel you do want?—We should be glad of it.

Do you know the amount of supply of water for domestic use?—No.

You do not know how the people in courts and back streets are supplied?—I know how they are supplied, but I do not know how many gallons are supplied to each house; they are supplied by stand-cocks in the courts, and they collect it and keep it in water-butts.

How many days' interval are there between the days of supply?—I think it comes in at intervals of two days. Only the other day I was talking to a man near the Skin-market, and he said that they had been without water for a week. The overflow from those stand-cocks is very important to us in keeping the sewers clean.

How many Paving Boards have you in your district?—I am not able to answer exactly, but I think only two, the Liberty of the Clink, and the Eastern Division of the Borough of Southwark.

Would not it be a matter of great convenience if the paving and the sewers were under one jurisdiction?—I apprehend it would. I may, perhaps, be allowed to qualify that remark, by saying that we never have the least difficulty upon that point. The Commissioners of Sewers

consider themselves, I hardly know why, as the superior power. No questions are ever asked. After giving the notices, we take up the pavements, and they are laid down to the satisfaction of the Commissioners of Paving. No. 21. Mr. E. l'Anson.

If there were but one jurisdiction, you would not have to give those notices?—No.

When you come into contact with another district, you have to give separate notices?—Certainly.

Who settles the price which shall be paid for the disturbance and relaying of the pavements?—The contractor who undertakes the work and the surveyor of the Commissioners of Paving. All our works are let by contract, including making good the pavement, and all connected with it.

Before he enters into the contract, he inquires how much he will have to pay for breaking up and relaying the payments?—I presume he does.

Did you ever hear of any contractor complaining of those charges?—Yes. The only instance I recollect was Messrs. Lee, who executed a sewer in East-lane. I believe they had some little difficulty in arranging about making the road good there, but it was no trouble to the Commissioners of Sewers.

No. 22.

Mr. *John Newman.*

No. 22. Mr. J. Newman.

You are the surveyor of one of the districts belonging to the Kent and Surrey Commission of Sewers?—I am.

Will you state how long you have been so?—I have been so 24 years.

What is the district you superintend?—It consists of the parishes of Bermondsey, Rotherhithe, Camberwell, St. Paul, and St. Nicholas Deptford.

Have you always superintended that area?—I have.

Were you examined before the Health of Towns Commission?—I was.

Before that Commission you stated your general practice in the construction of the drainage of that district?—I did.

Will you have the goodness to state to the Commissioners what has been done in your district in reference to drainage since that period?—There have been some works executed since that period. There has been a sewer executed in the Kent-road; there has been a sewer executed in the parish of Camberwell; and other smaller lengths of sewer in different portions of the district; but those are the main lines since that period. We have not had the means of doing much more.

Can you state the length of main sewer which has been made since that period?—One in Camberwell, the length 3195 feet; the one in Deptford road, 5534 feet.

Those you have mentioned are main sewers?—Yes; they are arched main sewers.

What quantity of collateral or smaller sewerage has been laid down?

No. 22. Mr. J. Newman.

—I am not prepared to state the quantity. A great deal has been done. I cannot exactly state the lengths, but believe them to be about 10,278 feet.

Have you any general plan of your district upon which the levels of all the sewers and the level of the country for the purposes of drainage are marked?—No, I have not. I have got detailed sections of all the different works done, but no general plan showing the levels of the whole area.

Do you think that it would be a great advantage if there could be a general plan laid down of the whole district under the Commission: a plan with contour lines and bench marks, so that you could at once refer to it?—I think that a general plan, showing all the levels, would be very desirable.

When you intend to execute a new work, you are now obliged to take all the levels yourself?—Yes.

When there is a new work to be done, how do you estimate the size of the sewer you ought to lay down?—From the quantity of water it will have to discharge from the seveal localities. An immense quantity of water in my district descends from the high hills of Surrey. It comes down in torrents, and the sewers require to be of greater capacity to hold the water, particularly during high tides.

Is there a general office belonging to the Commissioners of Sewers where such plans as you have are kept, or are they at your own office?—At my own office.

Do you allow the plans to be inspected by any person who wishes to see them?—Anybody who wishes may see any of the plans, and we always give any explanations that may be needed.

What is the general level of that district?—It varies from 3 feet 6 inches to 9 feet 6 inches below Trinity high-water datum.

Is the whole of your district under high-water mark?—No. Part of Camberwell and Deptford, at New Cross, are upon very high ground. It is only the marsh-lands I am speaking of which are so much below high-water mark.

Have you any power to make private individuals drain into the sewers?—We have no such power, except under the recent Act of last July; under which, surveyors on surveys by order of the Board, to see whether the houses are properly drained, may report to the Court, and, if required, the parties are then compelled to make such drains.

In Bermondsey and Rotherhithe, what is the depth your sewers are underneath the surface?—They run from 11 to 15 feet.

Whereabouts do they discharge into the river? How much under high-water mark?—They discharge at low-water mark.

Have they all sluice-gates?—Yes; and pen-stocks.

How many hours do the sluice-gates remain closed?—About five hours and a-half.

During that time are the sewers very full?—Very full indeed, particularly in wet seasons.

How full?—Up to the very crown of the arch, and, many times, much higher.

Does that sewer-water then return up the private drains into the houses?—After very heavy floods. It may have happened in such an immense flood, for instance, as we had on the 1st of August, 1846.

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The water flowed up through the drains of the houses which were not trapped, and through the gullies of the streets, because it happened to be high water at the time, and the sewers were fully charged.

What charges those sewers in ordinary times?—The quantity of water from the heavens.

In times when there is no rain?—From the houses.

Is there so much water used in the houses as to fill the sewers to the extent you state?—My district is a large manufacturing district, and there is an immense consumption of water from the manufactories, from tanneries, fellmongers, and various descriptions of manufacturers who consume an immense quantity of water, which all passes into our sewers.

There are some courts and alleys in your district, are there not?—A great many.

How many do you imagine are drained into the sewers under your superintendence?—I do not think there are many of them; there have been some lately, but I do not think there are many, because the owners of houses refuse to do it. We have applied to them for the improvement of the drainage, and asked of them contributions towards the expense, and we have invariably found an unwillingness to comply with the request and wishes of the Commission.

From the experience of the new drains you have made during the last three years, do you find that the proprietors run their house-drains into the new works?—Very few indeed.

To what do you attribute that?—I attribute it to the expense.

What is the expense?—It may run from four to five or six pounds a house; it depends upon the width of the road.

How do you charge the expense of joining your sewer drains? What is your rate of charge?—It varies very much with respect to the distance of the houses from the sewer, and the sizes of the drains they require.

Do you allow them to put a drain in of the size they wish, or do you point out to them what the size is to be?—I generally point it out to them; some parties prefer one a little larger. It was only yesterday a person to whom I recommended a 9-inch pipe said, "I do not like that, I wish to have a 12-inch drain."

When that point is decided, who puts in the drain? Is it done by you or by the individual?—It is done by the Commissioners under the public way, beyond that the party does it himself.

What is your charge for a 9-inch drain?—From 2*s.* 9*d.* to 3*s.* 6*d.* and 4*s.* a-foot, according to the size of the drain and the depth of ground to be excavated; that includes disturbing and making good the road.

Along the line of the new main sewers you have described, are there not many persons in easy circumstances?—There must be a great many.

Why do you suppose it is that they do not like to make drains?—They cannot get their landlords to incur the expense. In the Camberwell-road, which is the length of three-fourths of a mile, the sewer was put down upon the application of the owners and occupiers of the houses, who stated that they were very badly drained—their basement

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stories were continually damp. The Commissioners, under those circumstances, put down a new sewer, and out of that length there were only eleven applications; they received all the benefit of draining their basement stories because the sewer drains the land, therefore their basement stories became comparatively more healthy than they were before; but they never thought of making drains from their houses into the sewers.

Where do the drains go to?—To a sewer generally at the back of their premises; they have open sewers at the back which is upon a high level, but they have not taken advantage of a lower and deeper sewer.

In the Camberwell New-road have they cesspools or do the privies drain into another sewer?—They generally drain into an open sewer at the back.

Are there many open sewers in your district?—Yes.

Are you doing anything with reference to those sewers?—Yes; we have contracted to a very considerable extent for arching the sewers.

What is the length of open sewer you have contracted for covering?—5057 feet. I think we have about 21 miles of open sewer.

What works do you carry on in order to arch them over? Do you merely arch them over?—We make complete culverts of them.

Do you mean to say that you have now under contract a distance of 21 miles for covering open sewers?—No. I mean to say that the open sewers in the district would amount to that length.

What extent of them are you at the present moment under contract for covering?—Contracts have been entered into to the amount of 2390*l.*

For what length?—5057 feet.

When you put a drain into a house from your sewer, do you charge the expense all at once, or have you liberty to spread the repayment over a certain length of time?—Not for a house, but on application for an extended sewer. Under the present Act there is power to spread it over twenty years, I believe.

Have you had that power long enough to be able to state whether that will induce owners of property to consent more willingly to make the requisite drainage?—No; I have not.

In the construction of your sewers, no alteration has taken place since 1843?—Not in my district.

What is the nature of any alterations which you have in progress, or that you have reported upon or recommended to your Court?—I have recommended a sewer to take off the Surrey Hills water to Deptford, down Deptford-lane, the Broadway Deptford High-street, and to have a new outlet at the water-gate. That is of a large capacity, for the purpose of relieving the present sewers, which are overcharged by the quantity of water coming from those hills.

Would the mouth of that sewer be above high-water mark?—No.

That is the main alteration that you have recommended?—Yes; there are other sewers I have recommended to be made.

Have you made that recommendation upon a survey at all?—Yes.

And you have cross sections of it?—Yes, of every part of it.

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Could you give in a cross section, and mark the line upon one of your maps?—Certainly.

With relation to the new sewers you have made, how often do you cleanse them?—Those new sewers I am now speaking of I apprehend will seldom require cleansing. The work I did last year at Camberwell was the filling up between two points. In consequence of that not being done, there was at the head an accumulation of soil coming from the collateral sewers; but immediately I formed the junction and made my sewer complete, the water descending from the hills scoured and washed away the deposit.

You spoke of the great storm last August twelvemonth as filling the sewers; have you ever had within the same district, within your memory, any similar storms?—Not so heavy as that; but there have been many storms.

What was the depth of fall of rain then, or on the occasion of any other considerable storms?—That I do not know.

Do you know what was the relative depth of the fall in any preceding great storm?—I do not.

Do you happen to know whether within the memory of man it was known that there was such a storm as that in the district?—I have always understood that there never was such a heavy storm.

Therefore that storm was no standard for the ordinary provision requisite in the sewers?—No; I should make them as capacious as possible, in the event of such a storm again.

Did you see in your district any occasion for making collateral as well as main sewers adapted to that severe storm?—No.

Your new sewers are all main lines?—Yes.

In the old sewers it is the practice to cast and cleanse them by hand labour and cartage, is not it?—Not generally; but seldom. One of my sewers, which I am now casting and cleansing, had not been done for 17 years; and the necessity for it now has only been occasioned by the sewer not having been completed so as to enable it to wash down from other main lines upon it.

Medical men have described the general sewage of your district as emitting a very offensive effluvium in the houses as well as in the streets in Rotherhithe. One of them says:—"The houses are badly drained, badly supplied with water, and an open ditch receives the contents of privies. There is a block of houses where the privies hang over the ditch; the paths in the fronts of the houses are unpaved and filthy. The district of Rotherhithe is altogether excessively ill drained, intersected with ditches and stagnant water." "Between Staple's Rents and Lucas-street there is a filthy ditch; there is one in Lower Rotherhithe-street, opposite the plying-place, called the Pageants; another between Thames-street and Russell-street, Lower Rotherhithe; and many others. Many of these places are below high water; and the houses are subject to inundations from these sewers when the Thames overflows. The neighbourhood is always more unhealthy for a considerable time after these inundations, catarrhal and rheumatic affections prevailing." With respect to St. Olave's, a witness states:—"The effluvia given off from the gully-grates is now very offensive indeed. I can speak more particularly of one before my own house. It

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really makes me sick to go out of my door at times. This effluvia is generally productive of disordered health; it induces a low nervous condition and chronic dyspepsia." "Have any applications within your knowledge been made to the Commissioners of Sewers for any remedy?—I do not remember at present any particular cases. I believe that Mr. Newman, who is the surveyor to the Commissioners of Sewers, has been applied to; but he states that nothing can be done to relieve the parish from the effluvia arising from the sewers up the gratings."—St. Olave's is not in my district, therefore no application can have been made to me. I am surveyor of pavements there.

In other districts it is described that the flooding of the houses with sewer-water is very great; and doubts are expressed whether the condition of those houses which join on to the sewers is really better than the condition of those which do not communicate with the sewers. Can you undertake to say that, considering this liability in the district to flooding with sewer-water, and to the effluvia, you would yourself think that there is any adequate advantage to be derived from going to the expense of joining on a house-drain to the sewer?—In my district, from the improvement of the sewage in it, I have but seldom any floodings of water. Years ago, when I was appointed surveyor, we used to be flooded every winter; but now we are not annoyed in that way.

How frequent may the floodings be in your district at present?—They are very seldom.

At each extraordinary high tide?—After a very heavy storm of rain; if it happens to be high water in the river at the time, there may be an accumulation of water.

Do you think that this description given of the state of Rotherhithe and that district is erroneous or over-coloured?—I think there must be some mistake upon that subject. With respect to Rotherhithe, it is clear they are very badly off for water; and it is only within the last three or four years that they have had the advantage of a supply by the Southwark waterworks. It is only within the last two months that a portion of Rotherhithe has had any water at all. All the water that the people got there was from the ditches. Those ditches in Rotherhithe are cleansed every day by the tide. The tide is admitted, it cleanses the sewers, and they discharge themselves at a different point lower down in the parish. So that those houses in Rotherhithe have all the advantage of the tide twice a-day; they are all upon the upper level.

The place therefore from which they get water is the place into which all the filth is thrown?—Yes; the water from the river used to flow down those places at the sides of those sewers where the privies discharge themselves; but that was the only water the inhabitants had.

Notwithstanding the tide coming in, is not there a great sediment remaining in those ditches?—Yes.

Are you not obliged to clean them out occasionally, and throw it upon the banks?—I am obliged to do that constantly.

Then there is no effectual scour?—It takes off a great deal; it

prevents accumulation. Every week I have four men employed in the district, whose duty it is to wash those sewers.

Therefore it requires artificial means frequently to clean them out?—Yes.

What proportion do the covered sewers bear to the open sewers in your district?—I think, taking the new sewers we have done lately, the covered sewers are about 10 miles in proportion to 21 miles of open sewer.

Have not you observed very offensive odours from those sewers and ditches?—Very much so; I have brought down here to-day a specimen of the gully-trap which I have invented, and which our Commissioners intend to adopt, which will prevent the effluvia passing through the gratings into the streets.

Suppose you trap those gully-holes, the offensive gas must escape somewhere, must not it?—Yes; we have in the centre of the streets air-gratings, so that we remove the nuisance from the fronts of the houses to the centre of the street.

How long have you had those central air-gratings?—Two or three years.

How many Paving Boards are there in your district, independently of that you are surveyor to?—I do not know the number; I am surveyor to three parishes in my district.

Are you in private practice?—Yes; and I am also surveyor to the Improvements, to the Commissioners of the Eastern Division of Southwark.

Are there many Boards besides those you are surveyor to?—Yes; Western Division of Southwark, Clink Liberty, Bermondsey Improvements, St. Mary Rotherhithe, St. George the Martyr, St. Mary Lambeth, St. Giles Camberwell, St. Paul and St. Nicholas Deptford.

What is your opinion as to the consolidation of the two Commissions, and putting both the Paving Board and the Commission of Sewers under one jurisdiction?—That is a very important question. My impression is, having paid great attention to paving, that if a consolidation of all the Paving Boards could be accomplished, it would be a great public service.

Will you specify the advantages which would arise from a consolidation of the Paving Boards alone?—In our Paving Boards there are several things to be attended to. There is the paving to be attended to; the cleansing, the lighting, and obstructions and nuisances of every kind have all to be attended to. Those are points upon which I should say great improvements could be made. I think that a uniform system of paving in all the parishes would be very desirable. In my district several streets are intersected transversely and longitudinally by an adjoining district, viz., Crucifix-lane, Artillery-street, Church-street, and Russell-street. As to casting and cleansing, if that were done under one body, and under a powerful and well-directed energy, the whole might be cleansed with greater effect than by the present sub-divisions. The lighting is all done by contract; and I am not aware that there would be any great improvement upon that point. With respect to obstructions and nuisances, they are continually arising day by day. If any obstruction takes place, there is an immediate application to the

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Board, complaining of it, and requiring it to be abated. Having to go to a public Board, unless there is a very good arrangement in the management of the system, there must be frequent difficulties arise, whereas by going to the surveyor or to the clerk, or to the street-keeper, those obstructions and nuisances might be immediately removed. If they could have all those facilities as they do now, I think that would be a great public advantage.

You state that with respect to lighting, as it is done by contract, there would be no great gain by consolidation. Does not lighting also imply the laying down pipes in the streets?—Yes.

Does not that break up the surface?—Yes.

Then is not it of very great importance that the right to break up the surface of the street, or to permit it to be broken up for such a purpose, should reside in the same body that permits the breaking up of the streets for other purposes?—Yes, unquestionably, as far as laying down the mains. My chief difficulty in keeping pavements in the substantial state in which they are arises from the disturbance of the pavements by putting down gas and water pipes.

Your opinion the Commissioners understand to be, that it would be a great public advantage, if the right of permitting the pavements to be broken up for every purpose resided in one and the same authority?—I am afraid there would be difficulties upon that point. Two years ago, a pavement, I think, of between forty and fifty feet in length, half the width of the street, blew up from the bursting of a pipe; it required immediate attention; it was a main pipe. The street became flooded, and had it not been for the great exertion made at the time, there would have been considerable damage done to the inhabitants of that district. There may be some obstruction arise in a main pipe, and at present companies have the power to take up those pipes in cases of accident or any defect in the pipes, without any application to the surveyor or clerk, and twenty-four hours after that they must come forward and produce vouchers of the work done.

Why could not that relief be given as well by a consolidated Board as by disjointed and separate Boards?—It depends upon the system adopted. If the inspectors had power immediately to repair any damage done in any public streets, I think there would be great advantage.

Why should not the power reside in one consolidated Board as well as in several disjointed Boards?—In each parish there is now a surveyor; he is on the spot to attend to anything requiring to be done; he being upon the spot can attend to any representation of the inhabitants or rate-payers of the district immediately. If the Board, however, were a far-removed Board, and the surveyor or inspector were not at hand to attend to those things, the rate-payers generally would not be so well satisfied.

You say that the surveyor is always upon the spot. Is not the parish surveyor generally in private practice?—In the parish of Lambeth the Committee themselves are all surveyors, and in Camberwell there is no professional man; the surveyor there is by profession a gardener, an intelligent and active man.

Will not he be occupied now and then with his garden?—I do not

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think they allow him to be so. He devotes his whole time to his office.

Is not one of the surveyors in your neighbourhood a tinman?—I am not aware of it.

Supposing the case of a man employed in a trade, are you always so sure of his being present and available in case of an accident as a man giving his whole time to the office?—Certainly not.

Therefore, though a man may be in the parish, yet, being in a trade, he may be out on business of his own, and may not be so available as a man at a great distance, but giving his whole time to the subject?—Certainly.

When you are making a new sewer in a street, you send notice to the Commissioners of Pavements, do not you?—Yes.

Do not you think it would be a convenience that both departments being under the same body no notice would be required?—It would be unnecessary. If the same body are the Commissioners of Pavements and the Commissioners of Sewers at the same time, it would not be necessary to give notice.

Would not that be a public convenience?—We have never sustained any inconvenience yet.

Do the Commissioners of Sewers ever raise the question with the Commissioners of Pavements, "Are you going to pave" such a street? "because we are going to make" such a sewer, "so that both works may be carried on in conjunction?"—No, we never raise the question.

Do not you think you ought to know when you are going to make a new sewer whether a pavement is going to be laid down shortly?—That is one object. We give them so many days' notice that we are going to carry out such a sewer.

If it was the same body that difficulty would not occur?—No.

If water companies and gas companies were going to lay down a main, or if you were going to lay down a sewer, would not it be a great advantage that they all should be able mutually to communicate those intentions, so that the whole work might be done at the same time?—That has never happened to me.

Of course continual stoppages of thoroughfares in the streets is a great inconvenience to the traffic of the district?—Of course.

If the works were constructed by a strong establishment instead of a weak one, that is to say, by a consolidated one, would not it enable those operations to be carried on with proportionably increased rapidity?—That is a point of practice.

Do not you know that in point of fact in the city of London the paving in the larger thoroughfares is much more rapidly taken up and relaid than in parishes?—I think not. Last Saturday night I finished a quantity of paving in my parish in a case in which the whole thoroughfare was obstructed, from Gracechurch-street to the Town Hall, for that street alone, which I was obliged to stop up; but it was done in five days; a piece of work from its difficulties, I am satisfied, was never done more quickly, or substantially, in the city of London.

What is the comparative size of your parish compared with the whole city of London?—It is very small.

It is to be admitted, of course, that they have a larger establishment in the City, if they use it with vigour?—Yes; no doubt a larger establishment and greater power may be the means of paving those streets

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upon emergencies with greater rapidity than parishes generally do; but I was only speaking of one case which occurred to myself last week. Knowing the necessity of the case, I had that length of street done with great rapidity. In Duke-street I introduced thin cast-iron slips two inches below the surface to form a foothold for the horses, as this street is very steep, and heavy loads from the wharves and other places pass through it.

What length was it?—I should say about 200 feet, and the width 60 feet. It is at the bottom of Duke-street and Tooley-street.

How many men had you at it?—I think we had at times 13 paviours; as many men as could work with effect.

When stone is worn out with you in a main street, do you pick it down or throw it aside?—The old stone is taken up and redressed and used in secondary streets.

If you have a large district, have not you better opportunities for relaying stone, and using and economizing materials of that description than if you have a small one?—It would be so.

Therefore there is an advantage in that respect, and also the advantage of a large establishment, with great force to remove any obstruction?—Certainly.

In an engineering point of view, is not the adaptation of gully-shoots, and the general arrangements of draining for a street, a most important part of the work of the street, considered as a whole?—Yes.

The inclination of the surface of the street is very important, with a view to the discharge of the surface-water?—Certainly.

As an architect, or a person conducting such works, will you say that they can be conducted separately without disadvantage?—I think they can be most advantageously for the public carried on upon a good system of inspection and survey under one Board.

You do not happen to know probably much of the paving of any other districts than your own?—No.

Have you taken the traffic of your streets at all?—No, our traffic is very heavy. There are a great many wharves.

The consolidation would lead to these advantages, a strong establishment instead of a weak one, officers of higher skill with better pay, more quick execution of the public work in the stoppage of thoroughfares, and a better adaptation of one part of the work to another?—I have given a general opinion upon the subject. In my own parish I do not consider it a weak establishment. They have done their work very zealously, and they have done it with the best materials, as quickly as possible, for the advantage of the public.

Who are your contractors?—There are various persons. A contract of above 200*l.* always goes by public advertisement.

If an application is to be made respecting the pavements, the parties apply to your Board?—Yes.

Would not it be more convenient for parties to apply to the same Board for any work respecting the sewer as well as the pavement?—If you extend it over a large district, you will have so many applications, that even in one day you would not go over them all.

How is it conducted in the city of London?—I am comparing the city of London with different parishes in Surrey. The constant applications of individuals complaining about the pavements, or some

nuisance or obstruction, would be so numerous, that I question whether one Board could undertake to attend to them.

How often does the Paving Board, of which you are surveyor, meet?—Every fortnight, and Committees once a-fortnight.

Complaints are made to the Board?—Yes.

Then, as that Board meets but once a-fortnight, if another Board were established for the whole district, and met somewhat oftener, it would be possible to transact this amount of business?—Every day in such a large locality as the Borough of Southwark there would be applications of various descriptions from individuals so numerous and so incessant, that I apprehend, unless it were divided into Committees, there would be great difficulty for any public Board going through their business.

Have the inspectors or surveyors in that district no liberty of action without coming to the Board?—No; I must summon every one to the Board. A printed summons in every case is laid before the Board.

Supposing a party wishes to complain of a nuisance which may be remedied directly, would not he come to you, and might not you do it without his going to the Board?—It would be desirable if I could do so.

What would there be to prevent that being done if there were a consolidated Board?—If surveyors and inspectors had the power of doing so without bringing the case before the Board, it would be a very great improvement upon the system.

Supposing the Board to be systematized; if there were one unpaved court, would not you have rules laid down for the pavement of that court and the drainage of it, so that it might be fairly intrusted to the officers of the district, instead of its having to go before the Board, occupying the time of the Board with the details of it?—I think such a system, with intelligent officers, would relieve the Board from a great deal of duty.

And the more you systematize, the less there would be of that detail?—Yes; let there be proper officers; let them feel their responsibility to the Board, and, at the same time, let them have discretion to do that which is right in any case that may come before them.

General rules would be laid down which they must follow: the difference would be, that whereas, under the present system, they must come to the Court with every individual complaint, in future it would be regulated by general rules?—Yes.

Would not that be a great saving of time?—Yes; I could often remedy a nuisance which may be complained of; but if I were to do so without bringing it before the Board, I should be reprimanded for doing it, even though it were a case in which it might be a fortnight before the Board would meet again.

Have you ever gauged the run of water in your main and collateral sewers?—Not in the collateral sewers; I have in my main sewers. I had gauges laid down in all my main sewers to Trinity high-water mark, in order to gauge the sewers throughout my division.

Have you made any use of them?—They have been the means of deciding me in laying out all my sewers.

You have been governed, in carrying out your sewers, by your gauges?—Yes.

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Can you give a synoptical view of the flow of water in the gauges?—No, I am afraid not.

You have no gauges at present?—No.

With respect to the sizes of the house-drains, if you had to drain a court of twenty houses, such as would be occupied by the labouring classes, what would be the size of your sewer?—15 inches to 2 feet.

Would your colleagues all use that size?—Each would use his own discretion.

What size is Mr. Gwilt in the habit of using?—I do not know.

Or Mr. I'Anson?—I do not know; it depends upon circumstances very much. Where those fourth-rate houses are, they are continually being choked up. Therefore, in every 25 feet I have a casting-hole, so that the men may cast or cleanse them.

What is the largest, and what is the smallest court and alley size you employ?—I have not had many put down in courts and alleys.

What size of house-drain would you use for a 20-feet front house?—I have taken 9-inch drains, 12-inch drains, and 15.

What size do you most frequently use?—I have adopted 9-inch pipes.

Have you used any pipes?—I am now using them.

How long is it since you began to use them?—Within the last 9 or 10 months.

Why do you fix upon the capacity of 9 inches?—I think, from being glazed inside, they are not likely to get so much obstructed as brick; therefore I have introduced them, that I may, by the experience hereafter determine which to adopt.

Do you deduce the size of the drain you employ from the hydraulic flow?—No.

It will be a discharge drain perhaps to a rain-water pipe 3 inches in diameter; or supposing the place to have a soil-pan and water-closet apparatus, a pipe of 4 inches diameter?—I have never introduced a 9-inch pipe to receive the soil from a water-closet.

The ordinary flow would be from the water-sink in the scullery?—Yes, and the surface water from the back yard and from the privy.

Take the case of the scullery; the pipe there in use may be about 2 inches in diameter?—Yes.

What will be the relation of the size of the 2-inch pipe to the 9-inch pipe?—I should make them the same; if there were a 2-inch lead pipe from a stone sink, I should made the same size to the 9-inch drain.

Why do you employ a 9-inch drain to carry off the discharge from a 2-inch pipe?—I suppose the 9-inch drain to take the surface water from the yard, or from the premises generally.

Can you make out so great an amount of either rain water or house water, or soil from the privy, as to justify you in employing a 9-inch drain?—I have only lately introduced them, and I am watching the progress of those experiments to determine hereafter what will be the best pipes to use under the circumstances.

Previously to that you had used 12 and 15-inch pipes from houses?—9-inches, 12 inches, and 15 inches; 9 inches principally.

And unless you employ this glazed pipe, you would not alter those circumstances in relation to brick drains?—There is one inconvenience in the pipes; in the event of a stoppage, I am obliged to break up two pipes to

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get to the obstruction ; in a brick drain, removing three or four bricks will do it ; therefore in making repairs, the brick drains have the advantage ; but with those well-glazed pipes I do not expect there will be such obstructions. I have had an instance of a 9-inch drain at a charity school, where aprons, stays, and shoes were put down the privy, and they got down and choked up the drain. If that happened in a 9-inch pipe, it would cost me more trouble than removing the bricks to get at the obstruction. I have suggested that half the pipe should be made to open ; that one half should be let down upon the other, so that we might remove the upper part.

The joints not being cemented, might not one length of pipe be taken out of the other?—If they are not cemented, the water will pass through the joints and get under the basements of the houses.

If you deliver water on a wide surface, that is, on a 12-inch instead of a 9-inch, will not you proportionably increase the friction?—Unquestionably.

By increasing the friction and retarding the flow, will not you increase the deposit?—Certainly.

May not the too large size of the drains, therefore, cause an obstruction?—I think it is as bad to make them too large as too small.

Where have you seen too small drains erected?—I am making in Peckham 4-inch pipes to take off the rain water.

What is the area of a third-rate house, with the yard?—A third-rate house would have a garden double the size of the house, perhaps.

What sized pipe would carry off a fall of an inch of rain in an hour from such an area?—A small pipe would take off the rain water.

Is there anything peculiar in the sewage in your district, differing from any other district?—The construction of sewers in my district is very different from the construction of sewers in other districts. My district is so much below low-water mark ; the soil through which I have to drive the sewers is very bad, silty, gravelly, and full of springs ; so much so, that I am going to put up next week a steam-engine to keep down the water while I am executing the sewer.

Where is that?—In the Kent Road.

You spoke of some gully-traps which you had invented, and which were very effectual in the prevention of any nuisance from them?—Yes, This *(producing the same)* is the trap which I have used. I have had one in action 15 or 16 years, and only once during that time has it required any repair. This trap was put down under peculiar circumstances. A butcher complained that his meat was always spoiled from a gully-grate directly opposite his shop window. Of course it was a great grievance, and the Commissioners directed me to see what I could do, either by removing the gully-grate or inventing some trap to prevent it. Removing the gully-trap I objected to, because it altered my arrangements, and therefore I turned my attention to making a new gully-trap. Immediately the trap was put down it was so effective that the man never complained afterwards.

Are you really of opinion that the advantage derived from letting the effluvia escape in the middle of the street instead of the side is sufficient to call for or justify the expense of all those traps?—That is a very important question. The fact is, it would be dangerous for our men to

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work in those sewers had not they air given to them. Before I cause men to go into sewers to examine drains or to repair any drain, I require that the sewer shall be ventilated by having the chambers open for two or three days before they attempt to go in; the escape from gas pipes goes very much into those sewers. I have had men severely burnt: there was one man who was in the hospital six weeks from being burnt in consequence of going into one of the sewers before it was properly ventilated.

Have you had any cholera in the district?—There was in 1832.

Do you know whether the men who were employed in cleansing those open sewers were affected with cholera?—I had 28 men employed during that time, as well as some extra men, and during that time not one of them was ill, and they went into the most filthy places you can imagine.

A great deal of cleansing went on at that particular time, did not it?—Yes, the companies were more liberal during that period in letting their water run than usual.

What is the conclusion you draw from the fact that none of your men were taken ill?—Those men had been working in my district during my time and that of my predecessors for 30 or 40 years. Many of the men have been there during my time 15 or 20 years, and, generally speaking, I have never had any complaint of illness from those men; they have never applied to me for tickets for a dispensary or hospital.

To what do you attribute the fact of those men escaping injury? is it from the use of ardent spirits?—Those men drink ardent spirits no doubt, or they could not get through their work; but, generally speaking, I have never seen those men affected by drinking them. If a man drinks ardent spirits to excess, his constitution is sure to suffer, but I have not found it the case with those men.

Are those men persons of good moral habits generally speaking?—Yes; the men I generally select are men who have been working in the construction of sewers a long time; if I find them industrious men, I like to give the appointment to them.

Is the appointment much sought after?—Yes.

On account of the high wages?—I do not think that the wages are high considering the work they have to do.

What are their wages?—4*s*. 2*d*. a-day.

Do they work daily?—Yes.

What are their hours?—From 8 o'clock in the morning till 4 o'clock in the afternoon.

And they do that daily?—Yes.

How many men have you under your employment?—I have now 20; I have extra men occasionally.

Do the same set of men remain with you long?—We seldom or ever have a change; there is a change only in case of death.

What age do you suppose the oldest man you have with you is?—I think I may have one man 70 years of age, and others varying from 20 to 60, but most of them from 20 to 40; and as to those men also, where one of them has conducted himself with propriety in my service in those sewers, if his boy comes up to proper age, I take him into my service.

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Have you many above 40?—I think some of them are above 40; the average, I should say, was about 40.

From what you have stated, it would appear that your men are selected men?—They are men who are picked out from this circumstance, that they are men of good character and good strength, who are accustomed to that description of work. Many men would not do to go into those sewers.

Why would not they do?—It is such filthy work that they would not take it.

You would not take for the execution of such work the thinly constructed men whom you find pursuing sedentary occupations, such as tailors, and that class of people, would you?—Certainly not.

Then it comes to this, that you pick out the strongest men you can get?—We pick out strong, healthy men, and generally men who have worked in the construction of sewers.

Are there many Irish?—Very few.

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The Commissioners have been given to understand from the evidence of the officers of the Surrey and Kent district of sewers, that the great difficulty in the proper drainage of that portion of the metropolis, arises from the impossibility of obtaining sufficient fall in the sewers, and from the outlets to the river being closed during a great portion of the tide, the most considerable part of the district being under high water mark. You have been requested to examine the locality, and report your opinion whether any means of improvement might be adopted, and how far it might be practicable to raise the contents of the sewers at all periods by pumping. Will you have the goodness to state to the Commissioners your views on the subject?—According to the instructions with which the Commissioners have honoured me, I have examined the principal features of the district, partly in company with the surveyors of the districts. It would be mere repetition, however, to describe the characteristics of the locality, as they have already been accurately given in evidence. There is a lamentable deficiency of drainage, properly so called; great reservoirs, or sewers, constructed for storing the liquid refuse of the district, until the time arrives for its discharge,—forming in fact periodic cesspools,—have been laid to some extent, at vast expense, along many of the main, and some of the secondary lines of thoroughfare; but house drainage into these reservoirs, or of any kind indeed, otherwise than of the most primitive and disgusting order into open cesspools and ditches, is very much the exception to the general rule.

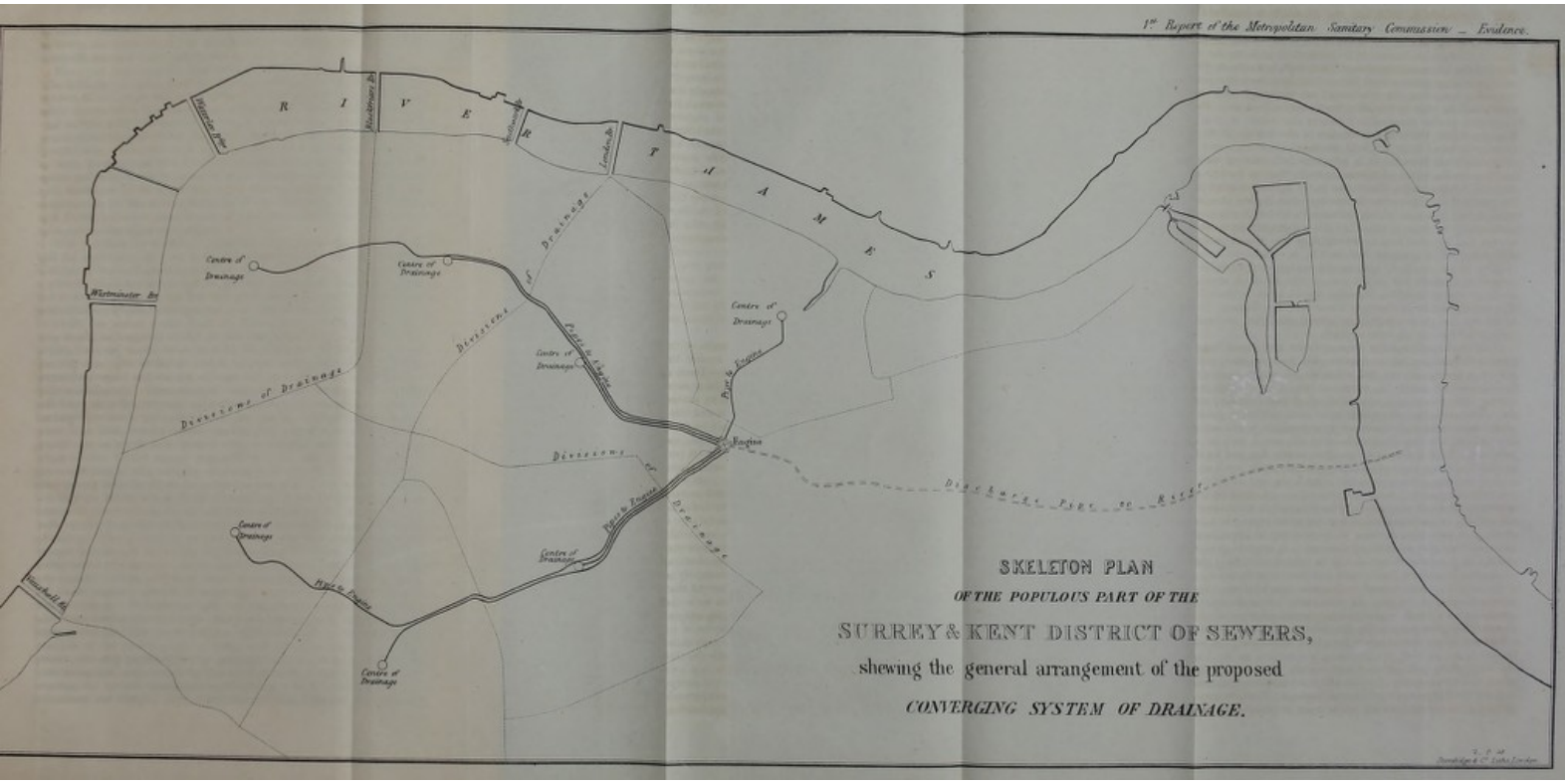
What do you suppose is the reason of so few houses draining into the sewers that are provided?—There is little question, I believe, that the main cause is the immediately heavy outlay that would be necessary, but the advantages of such a house drainage are so very questionable,

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that I believe it will be the greatest hardship on the inhabitants of the district, if the Commissioners be allowed to enforce the provisions of their recent Act, and compel such a drainage, before most effectual means of improvement of the sewers themselves, have been first put in practice.

Do you mean that the inhabitants are better off with cesspools than they would be with drains into these sewers?—I do. Poisonous and disgusting as the cesspool is, I believe that where it is at all removed from the house, there is less danger to the health of the inhabitants, than there would be in a direct communication with such sewers, and for this obvious reason. It is admitted that there is constant deposit in these sewers, which of course is ever creating noxious gas. Under ordinary circumstances, where the outlet is free, a great proportion of the gas is discharged with the current; but in this case, at every tide, twice a day, immediately that the valves are closed, this gas is displaced particularly in time of rain, by the volume of water which fills the sewers, and is then forcibly driven into the houses that communicate with them. The cesspool, bad as it is, is outside the house, constantly open to the atmosphere, and so its noxious influence, at any rate, is somewhat diluted; but in the case of the drain or sewer, the poison newly generated is driven directly into the house in periodic succession. The remedy would be certainly worse than the disease. It is much to be desired that these compulsory powers should be suspended until the remedy for the evil has been applied.

Have you considered the improvements that could be made in the present drainage, so as to remove this inconvenience, and render the sewers generally efficient and available for house drainage?—There is little doubt that much improvement might be effected in the present system, but it could only be carried out at vast expense; and to extend this system over the whole district, so as to render it general and complete, even under such improved arrangements, would not only be ruinous in cost, but the great evils after all, would only be lessened, not removed. With a district so situated, nearly flat, and for the most part several feet under high-water mark, all attempts at providing an adequate natural drainage, direct into the river must end in failure. Do what you will, it must be a cesspool system still. A small additional current of two or three feet may certainly be obtained in some cases by lowering the outfalls to low-water mark, but the advantage of this, carried over a distance of two miles or more, would scarcely be appreciable, and could be carried out only at immense expense. It appears to be absolute that this artificial state of things should be treated artificially, and mechanical appliances brought to bear to lift and discharge the refuse constantly as it is produced. Intermittent drainage is somewhat more barbarous than intermittent water supply. It does seem extraordinary, that with the steam-engine applied in almost every useful relation of life, its adaptation to this great purpose for the relief of flat districts of towns of its refuse and water, should never have been attempted. It was very satisfactory to me to find, on proposing the system to Mr. Chadwick, that the idea of its practicability had already been impressed on his own mind, from observation as to the efficiency and small expense of pumping, for the purpose of agricultural drainage. We have ample experience as to the facility with which refuse may be pumped, in its application,



SKELETON PLAN

OF THE POPULOUS PART OF THE

SURREY & KENT DISTRICT OF SEWERS,

shewing the general arrangement of the proposed

CONVERGING SYSTEM OF DRAINAGE.

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in several instances, to agricultural purposes. It only remains a question as to the best arrangement of the drainage to realize the object in the most efficient and economical manner.

Have you considered the best means of effecting this object?—I have. The difficulty of drainage of flat districts of towns, or where the natural current of the rivers and main outfalls is intercepted by mill-dams and other obstructions, has long been a subject of consideration with me, and further study and inquiry have only added to the conviction of the practicable character of the plan that I desire to offer to the notice of the Commission. It is the same in principle,—with modifications suitable to each locality,—as that I had the honour to propose for both Worcester and Rugby, when consulted upon the improvement of those towns and, confident of its applicability. I am about about to propose the same system for the re-establishment of the drainage of Rome, having, at a recent interview, been honoured with the authority of his Holiness to report to him upon that subject.

Will you have the goodness to describe the system that you propose and the application of it to a district situated as the Surrey and Kent division of the metropolis?—I will endeavour to do so. In considering a plan for the relief of the sewers, and the prevention of the pollution of the river, by pumping, the first idea that naturally presents itself is the establishment of some arrangement at or near to the outfalls in the river, to which the waters would drain by their present course, and whence they would be conveyed in the desired direction. Only one part of the object, however, would be realized by such a plan. Although no longer forming reservoirs of liquid refuse, penned up by the tide, the sewers themselves would still remain unimproved, and would be capable of but little amendment. Their sluggish currents, from want of fall, would still leave their foul deposits poisoning the neighbourhood, and admit of no improvement in the extension of the system. I shall be prepared to show that this remedy would not only be partial and defective, but would cost as much as a general and permanent improvement of the whole system by the means proposed, in which the object aimed at is the establishment of a complete and independent system of drains rather than sewers over the whole area, for the removal of the whole refuse of the district, and to which, in the Surrey and Kent division, the present sewers or reservoirs, as far as they are constructed in the main lines, both on the deep and surface level, would be useful auxiliaries in times of storm. The district to be drained should be apportioned into convenient sections or divisions, the drainage of which would be totally independent and distinct, converging to the centre of each division with any desired current, and from these centres the liquid would be raised by steam-engines, placed at any convenient point in connexion with them by pipes. This skeleton plan of the populous part of the Surrey and Kent district (see annexed plate) will best explain my meaning, it being understood that the divisions of the district there represented, the position of the centre points or wells, and the situation of the engine power, are only assumed for the purpose of illustration, without at all presuming that they would be the most desirable to adopt. These are matters, the correct determination of which, would demand much consideration and study of local circumstances and arrangement. Beyond

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the consideration of these circumstances, the extent of each division would be limited only by the amount of fall that it would be necessary to preserve to allow of a certain maximum size of drain, and the depth of digging that might be thought desirable.

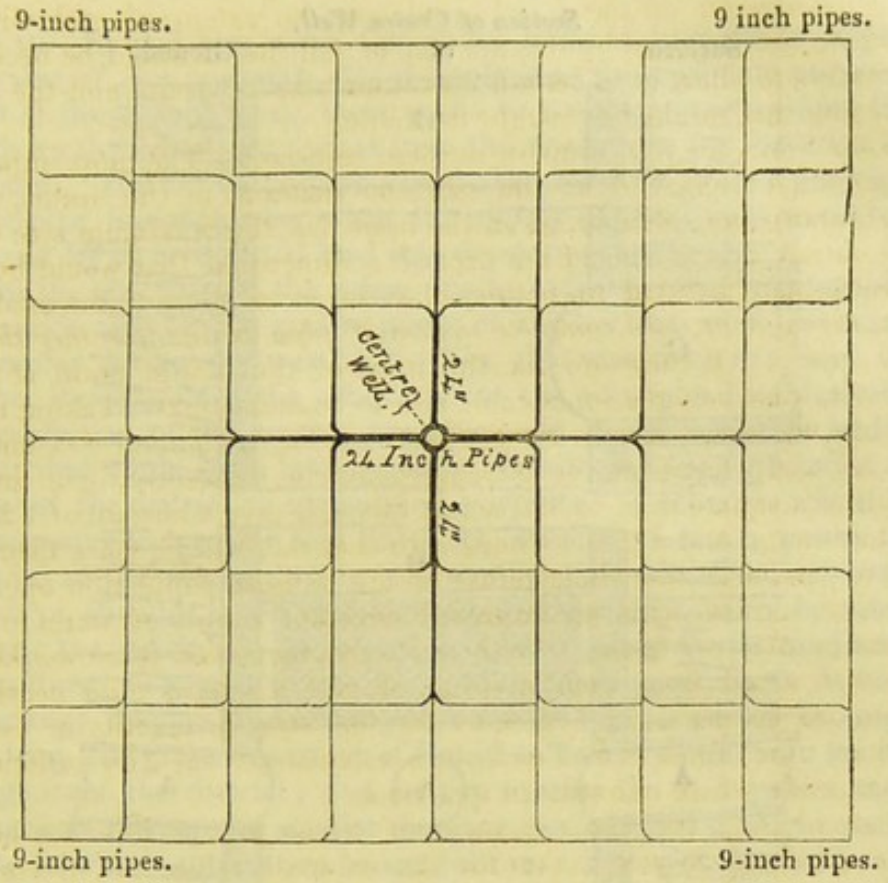
What limits do you propose in these respects?—The most important consideration appears to be the size and material of the drains, and I have founded my calculations on the basis that the maximum size of the main outfall drains should not exceed a dimension that would be conveniently manufactured in pottery clay, so as to allow of the establishment, *throughout, of a complete system of pipe drainage rather than of brick sewers.* I, therefore, fix the limit of the largest drain at 2 feet diameter, that being a practicable size to manufacture. Taking then a perfectly flat area—which is the worst case for calculation—assuming a total fall of 15 feet from the extreme points to the centre, upon an area of half of a square mile or 320 acres, this will give a current of 1 in 250 as a minimum, and a 2-feet drain, with that fall, will be more than sufficient to discharge the whole refuse of the densest population upon that extent of surface, with an improved constant supply of water of 100 gallons per day per house. With such arrangements, there would have to be discharged from each division of half a square mile nearly one million gallons per day; but as by far the largest quantity is used in the busy time, from 9 to 1 o'clock, I calculate a capacity sufficient to discharge the whole quantity in that time.

That is to say, the whole quantity of refuse matter from the houses. What provision do you make for the external refuse of streets?—It would be essential that these drains should be capable of removing also the whole external refuse of the streets and houses. I assume, therefore, that the system should be capable of accommodating a fall of rain equal to an inch and a-half in 12 hours, a good soaking quantity that would soon cleanse the whole surface of the streets and houses, and convey away the refuse. This amount being added to the house supply of water, the total quantity produced at such times in each division would be 200,000 cubic feet per hour.

Supposing the district to be perfectly flat, would you give the same uniform inclination to the whole system of drainage from the extreme points to the centre?—No. The only question for consideration as to fall, would be to fix a safe limit for the total inclination of those continuous lines of the drainage that would have to convey the water from the extreme points to the centre. Having decided upon that, the rate of inclination should be graduated from one end to the other; because the accelerated velocity of the stream, as it would approach the centre outfall, would admit of considerably less inclination of the drainage than at the commencement; or, on the other hand, would admit of a great reduction in the size of the pipes. All the collateral or intermediate branch-drains, it will be seen, would have so considerable an amount of fall, as to afford the opportunity of putting them all in of a very small size.

Will you illustrate the arrangement of the drainage of these proposed divisions, and describe the means of accommodating this quantity of water?—This diagram will best serve to explain the method of arrangement of drainage of each division, in which the progressive increase of

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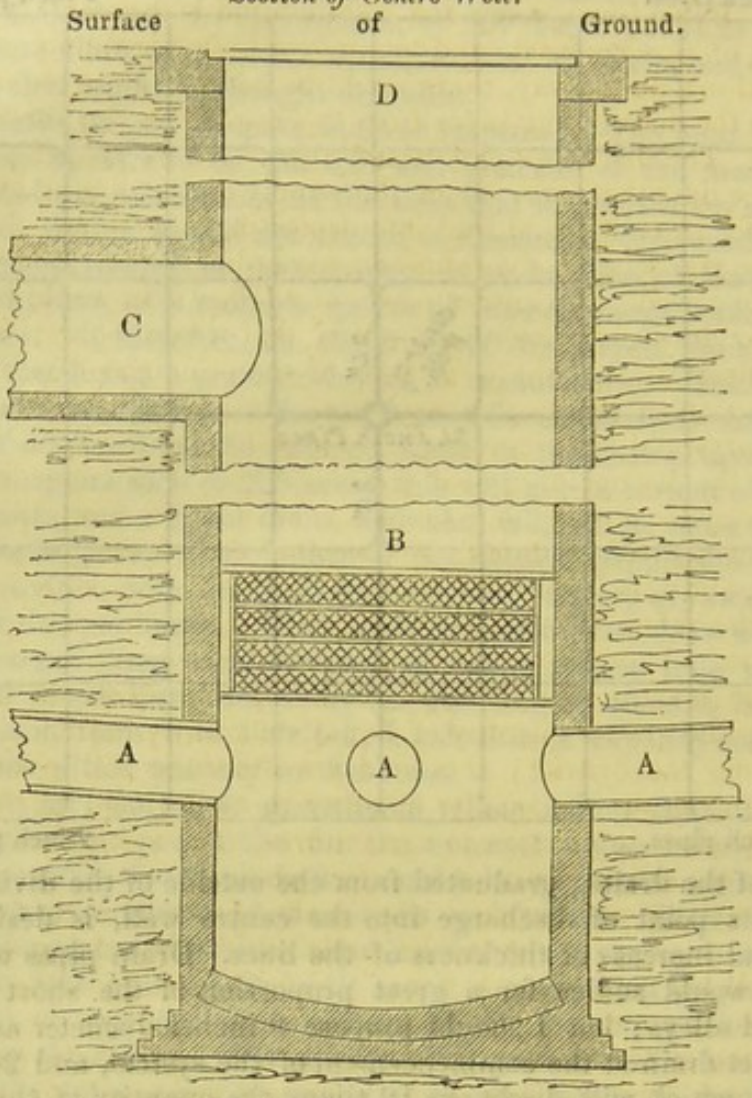


capacity of the drains, graduated from the outside of the divisional area towards its point of discharge into the centre well, is designated by the gradual increase of thickness of the lines. Drain pipes of 6 inches diameter would suffice for a great proportion of the short lengths of courts and alleys; but I should propose 9 inches diameter as the minimum street drain at the commencement of the system, and 24 inches at its outfall, which will discharge 12 times the quantity of the 9 inches, without reckoning the accelerated velocity. From these centre points or wells, to which each division would severally drain, stone-ware pipes would lead to the pumping engines placed at any most convenient spot, whereby the whole refuse of the district would be withdrawn and discharged as fast as it would be produced.

Be so good as to explain more fully the construction of these centre wells to which the drainage would converge?—They would be of the simplest character, as this sketch will serve to show. (*See* p. 306.) As a matter of safety, the wells should be sunk to such a depth below the drains A, discharging into them, as would allow of the settlement of any small matters that might by possibility be conveyed into them. Here they might rest without inconvenience until periodically removed. The pipe to the engine should lead off just above these drains, to which the water would rise; and the pipe should be provided, as in all such cases, with a screen, B, around the well, to prevent the entrance of any solid substances. Another arrangement would be to provide two wells, with a sluice between them, so that the water could be readily diverted from each, for the more ready inspection and removal of solid matter. Higher up, the wells would be provided with an overflow drain, C, which, in case of accident to the engines or other emergency, would convey the rising waters to the nearest reservoir or outlet. The top of each of the wells would be doomed over or otherwise covered, and provided with a

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Section of Centre Well.



man-hole or a side entrance, for the purpose of periodical inspection, and the removal of such small substances as the screen would have prevented passing to the pumps. I describe these arrangements of the well as of a practicable character; but various other plans of a simple kind might answer equally well, or possibly be found superior on further consideration.

Would there be any chance of the accumulation of deposit in these wells?—Not the slightest. The concentrated volume of water pouring into them with great force, at certain periods of every day, would prevent the possibility of deposit. Everything would be clean washed away but those matters that could not pass the screen.

Do you purpose to fix a steam-engine in every division of half a square mile?—No. The engines may be fixed in any spot most convenient and advisable, and there need be only one pumping establishment for the whole district—as is shown in the skeleton plan—to which main pipes would lead from the several centre wells, precisely as would be practised in raising so much water from a well at a distance. From the engines, one or more discharge-pipes, to convey the whole refuse, would lead to the most convenient outlet in the river, as shown by the double dotted line. The arrangement here submitted would offer this great advantage that the pollution of the whole southern bank of the river would at once be avoided, as the liquid refuse could, with equal facility, be discharged at any spot lower down the river, where no inconvenience would arise

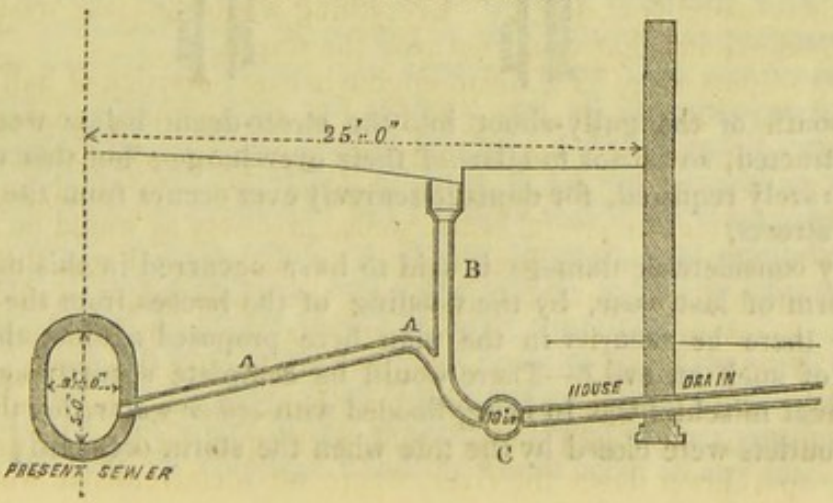
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from it. By-and-bye, when the public mind is brought to appreciate the value of this material, and to apply it to its legitimate purpose, instead of throwing it away, there would be nothing more required than to lay down the distributing-pipes from the engines in the direction of the demand. The discharge-pipe would then serve its proper purpose of a waste-pipe into the river, when the supply of the liquid exceeded the demand for it, or it would lead into depositing reservoirs.

For the pumping of the refuse during ordinary rain, you would have to provide considerably greater power of engines than would be necessary to employ during dry weather?—Yes, that would be so; and it is a further illustration of the adaptation of the principles here described to the perfection of the system hereafter. It is precisely this additional power that would come into operation hereafter for the application of the refuse of the district to agricultural purposes. I calculate that it would be necessary to provide four times the amount of steam power for the removal of the refuse during wet weather that would be necessary on dry days, and this is the very amount that would probably be necessary to raise the refuse the additional height required for its application to agriculture. Thus, in wet weather, when there would be no demand for the sewage manure, the whole power of the engines would be employed in raising the greater quantity of liquid sufficiently high only for its discharge from the district; and in dry weather the full power would be engaged in raising the smaller quantity the additional height necessary for its intended application to agriculture. The system would so work together very satisfactorily as a perfect whole.

The plan that you have described makes provision only for such ordinary rain as you conceive to be sufficient to clear the streets of their refuse. What is to become of heavy rains and storm waters, and waste water from steam-engines?—In this respect the present sewers, or rather that portion of them along the main lines, will be of service, although, under proper arrangements, more adequate provision might have been made for this purpose at infinitely less cost. Heavy rains and storm waters would discharge into these reservoirs in a comparatively pure state, and so find their way to their proper outlet in the river at low tide. Various arrangements for making the communication with these reservoirs may be adopted, of the most simple character, determinable by local circumstances. One of the most obvious is exhibited in these sketches:—

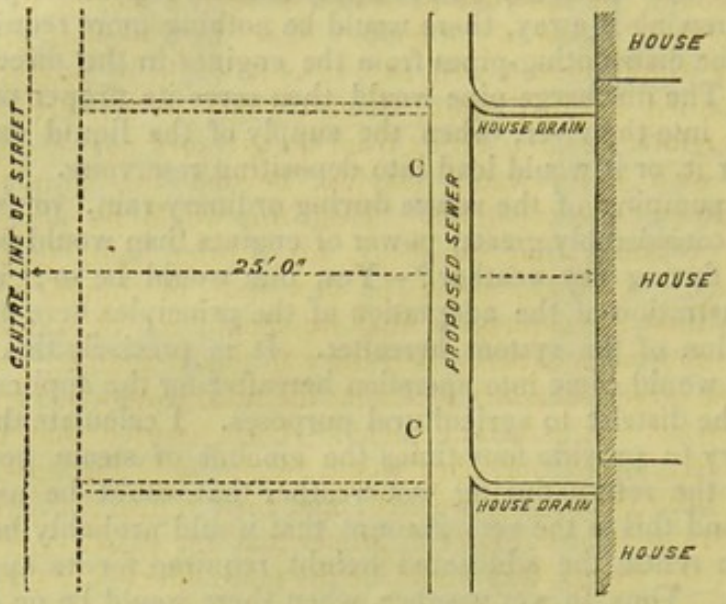
Half cross-section of a Street, showing arrangement of a gully-shoot and overflow drain for storm water.



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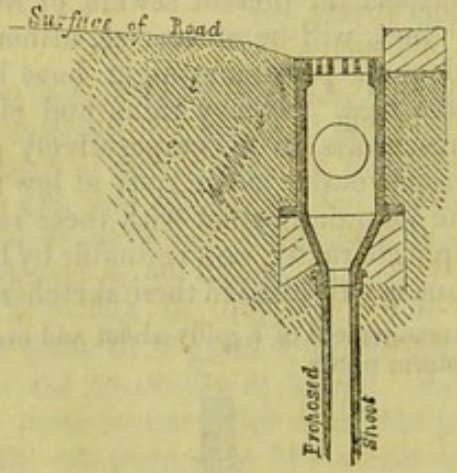
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Half plan of a Street, 50 feet wide, showing proposed pipe-drain at the side, instead of the centre, and house-drains into it.

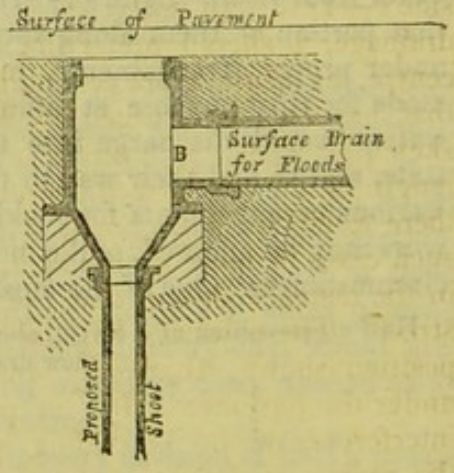


In those streets where the main reservoirs occur, an overflow drain, A, would be constructed into them from the gully shoots, B, so that at such times of excessive rain, when the drains would be charged full, the surplus waters flowing from the streets and houses would rise in the shoots and discharge into the reservoir. In some cases, to avoid flooding of the streets in particular spots in cases of severe storms, it might be advisable to provide a surface drain from the street gully-shoot into the nearest reservoir, as shown in these sketches:—

Section across Street.



Section in a line with Street.



The mouth of the gully-shoot into the street-drain below would then be contracted, so as not to allow of their overcharge; but this would be a case rarely required, for damage scarcely ever occurs from the flooding of the streets.

Very considerable damage is said to have occurred in this district in the storm of last year, by the flooding of the houses from the sewers; would there be security in the plan here proposed against the recurrence of sueh an evil?—There would be complete security against it. The great mischief was in being flooded with *sewer* water, for the valves at the outlets were closed by the tide when the storm occurred; and not

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only so, but the accumulated foul deposits of months before in these reservoirs would, by the rush of water in such a storm, be stirred up also, to add their poison to the flood. Now, by the plan proposed, all sewer water would be removed as fast as it would be produced, and by the fall obtained in every drain, deposit would be rendered impossible. Should, therefore, flooding occur from an extraordinary storm, it would simply be with storm water, leaving, beyond the temporary inconvenience, no evil effect behind. Even this would be possible only on those rare occasions that do occur, for a brief hour, in intervals of several years, but which, under the new state of things, would be so harmless in their consequences, that we should not be warranted in incurring the enormous expense necessary to guard against them.

Would the large reservoirs receiving the flood waters be kept free from injurious deposit in this arrangement?—I feel assured that they would. It must be recollected that they would receive only the waters after the streets had been thoroughly washed, and their refuse conveyed away by the small drains; and under a proper and regulated system of daily cleansing of the streets, this would be the more effectually accomplished; so that any small deposits that could take place in the reservoirs, would at the utmost be the least proportion of sand or silt borne down in the immense volumes of water during extraordinary storms, from the macadamised roads of the suburbs, which might be precipitated when the outlets were closed, but which would be perfectly harmless, as no foul emanations would arise from them. Moreover, they might readily be flushed away, if required.

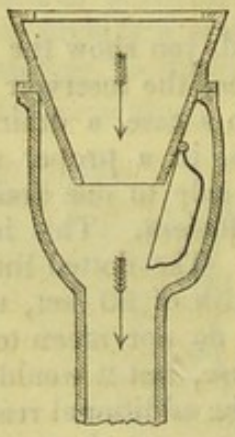
In this half section of a street just exhibited, you show the proposed drain on one side of the street next the houses, the reservoir being in the centre. You would propose then, in such a case, a drain on each side?—Yes. In many cases, in wide streets, in a proper system of drainage, I should prefer the drains on each side to one drain in the centre, as being more economical and more efficient. This is a point that has long been urged by Mr. Chadwick. The dotted lines on the sketch show that in a street of an average width of 50 feet, the whole length of the centre drain would be saved. I do not mean to say that there would be this amount of saving in expense, but it would in many such cases be more economical, and there is the additional reason for it in the instance shown, that the reservoir would occupy the centre of the street. The objection will be urged against placing the drains in the position shown, that they would so frequently interfere with cellars under the pavement; but in putting in small drains, as proposed, this interference would be trifling, and certainly more than compensated by the saving of digging from the surface, and all the annoyance of obstruction of traffic would be avoided besides. I do not put it forward as a plan that could be universally adopted in all wide streets, or that in most cases might be advisable; but I believe that if the trammels of the present routine custom could be broken through, and prejudices set aside, that this arrangement, and many others, might be adopted with advantage, and at all events should be fairly considered.

Would there not be constant danger of choking up, in the small system of drains that you propose, from the numerous large substances of all kinds that are now found in the sewers?—Under proper regulations, I am satisfied that no stoppage whatever would occur in any case. It is

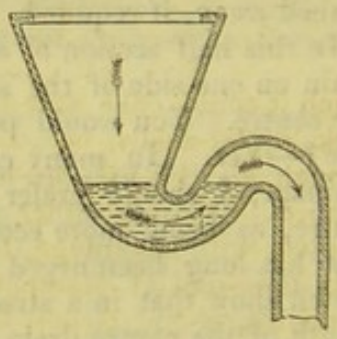
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true that large substances of various kinds—broken china, cinders, oyster-shells, vegetable refuse, brushes, rags, and a host of other matters, —are constantly found in the sewers, being thrown, either carelessly or mischievously, down the yard drain into the sink, or down the water-closet. It would be rather surprising if it were otherwise, for not the slightest precaution is used to guard against it. No immediate inconvenience results, and there is plenty of room and to spare, we may be sure, when we hear from the City Surveyor of Sewers, in his evidence before the Health of Towns Commission, that even coffins and tombstones, a bedstead, and the beadle of the parish lie in them, to be detected only in general explorations. Under a proper regulated system, how easily would these abuses be prevented. Yard drains would not be left unprotected; sink gratings would be effectually secured; surreptitious openings would be impossible; and that form of water-closet basin which will admit of such an abuse, either from the carelessness of servants or the mischief of children, would be at once abolished. The common pan basin, as it is called, is subject to this inconvenience, by reason of its direct communication; but the syphon trap basin, which is more efficient with a good supply of water, and considerably cheaper, will not admit of the intrusion of such matters, as these sketches show:—

Section of Water Closet Pan Basin, showing direct communication.



Section of Water Closet Syphon Basin, showing curved communication.

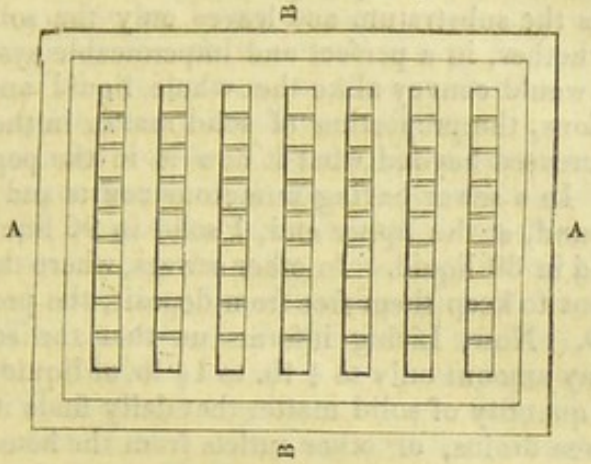


But in a regulated system, with the house-drain of proper construction, and of sufficient size for its purpose, and no more, any substance that could by possibility get into it, and pass through, would certainly never choke the street-drain, constructed in graduated proportion.

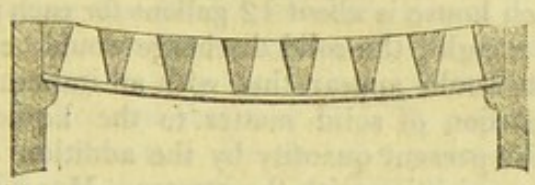
Do not many heavy substances find their way constantly into the sewers through the gully-holes in the streets?—Yes, they do; but entirely from the faulty construction of the street gratings. Mr. Phillips, under the Westminster Commission, has prevented much of the evil by reducing the openings; but these bring another inconvenience—they are apt to choke up. I think that a great improvement would be effected by this form of grating, in which I would make the bars as wide, or even wider, apart than they are now, but affix underneath them, at right angles, a row of thin rod-iron, or narrow square iron. The bars should be considerably bevelled, that is, diminished in thickness from the surface downwards; and thus, while the mud would have no surface upon

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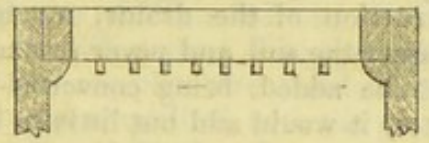
Plan of Street Grating.



Section on AA.



Section on BB.



which it could cake and clog the openings, all large matters, pieces of stick, oyster-shells, or other long and flat substances, which can pass through all the present forms of street gratings, would be effectually stopped. Various other arrangements, however, might probably be adopted, with advantage, to effect this desirable object.

In the event of a stoppage, such a system of drains would still be accessible, would it not, for the purpose of removing any obstruction, without the drains being so large as for men to get into them?—Yes, certainly. Communications may be made by side entrances, so as to introduce apparatus for cleansing; but I feel so satisfied that, with ordinary precaution, it would never be required, that the provision should, at all events, be deferred until experience proved its necessity.

The disgusting practice of cleansing the sewers by hand labour and cartage would be entirely obviated?—Entirely. And according to the statements in evidence as to the cost of this practice, the saving would go half way towards the whole expense of engine power and pumping for the entire populous part of the district marked on the skeleton plan.

You are aware that a very large proportion of the houses of the metropolis are provided only with cesspools, more particularly in these flat districts, which do not communicate with the sewers. Do you feel confidence that when complete house drainage is established, and all this solid matter of the cesspools is added to the sewage water, that it could be pumped without difficulty?—I have no doubt of it at all; and I think that a very few words will remove all apprehension on this head. It is true that the contents of cesspools present a solid and compact

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appearance rather formidable to pump, but the fact is that the liquid portion percolates the substratum and leaves only the solid refuse. It is questionable whether, in a perfect and impermeable system of house drainage, which would convey alike the whole liquid and solid refuse from our habitations, the proportion of solid matter in the sewers would be materially increased beyond what it now is in the populous parts of the metropolis. In a sewer having numerous courts and alleys on each side, Mr. Roe found, at the upper end, 1 solid in 96 liquid; and at the lower end, 1 solid in 39 liquid. In other sewers, where the run of water is always sufficient to keep them free from deposit, the proportion was 1 in 66, to 1 in 80. Now, Liebig informs us that the solid fæces per individual per day amount only to ¼ lb. to 1¼ lb. of liquid, and if we add any conceivable quantity of solid matter that daily finds its way through kitchen sinks, area drains, or other outlets from the house, it cannot go far beyond another pound per individual. The quantity of water daily discharged from each house is about 12 gallons for each person, to which in its relation as to weight, the solid discharge would be at the utmost 1 in 100, so that it would appear that with an impermeable system of drainage, the proportion of solid matter to the liquid would not be increased beyond the present quantity by the addition of those houses which have no communication with the sewers. Many houses, however, have a house drainage for liquid refuse, and still have cesspools, but from the faulty construction of the drains, much of the water, even where this is so, permeates the soil, and never reaches the sewer. Were the cesspools alone to be added, being converted into water-closets, if Liebig be at all correct, it would add but little to the proportion of the whole, being a quarter of a pound solid to 10 or 12 lbs. at least of liquid. In any case, even if the proportion of solid refuse to the liquid of a house were many times greater than it is, pumping would be clearly practicable, for proportions three or four times as great have for years been actually conveyed. Indeed a proportion of 1 solid in only 5 or 6 of liquid has been successfully accomplished in pumping. It may be safely asserted, therefore, that when the adequate and improved supply of water that is so desirable is obtained, the proportions of liquid to the solid, as a question of pumping, will be five or six times greater than what is now in successful operation, and 15 or 20 times greater than an extreme case.

Have you calculated the cost of this improved system of drainage?—I have. It will not amount to more than one-fourth of the system now pursued in the Surrey and Kent district. This Commission has recently given notice of the intended execution of works, involving an outlay of 100,000*l*., to be expended in a few main lines of drainage, which, for the real and important purposes of sewerage—the removal of the liquid refuse from the houses—will be of no earthly benefit to the inhabitants, but will serve only to obstruct future improvement; whereas the outlay of this amount on the plan proposed would actually suffice for the construction of the entire street drainage, including every court and alley, of more than one-half of the most populous part of the district comprised within an area of four square miles immediately south of the river. The perfect drainage of the most crowded district on this system would cost on the average 2*l*. per house, with an annual charge of 2*s*. per house for annual expense of engine power. To repay in 30 years,

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with interest, the whole cost of the public or street drainage, together with complete private or house drainage, with stone-ware water-closet basin, and including the above annual charge for engine power, would involve a rate of 7*s.* per annum, or about a third of the annual cost of emptying a cesspool, were it at all decently kept.

A detailed estimate would, of course, be a work of much time and labour, but have you been able to go into the calculation of the cost of the works of the proposed system in sufficient detail to enable you to determine, approximately, the outlay necessary in any particular portion of this area?—I have no plan of any portion of the Surrey and Kent district to a sufficient scale to do this with accuracy and satisfaction; but having a survey, which I made a few years ago, to a large scale, of the low part of Westminster—a district of precisely similar situation—I have made an estimate of a complete system of sewerage on this plan for that important district. Every court and open space is exhibited on this plan, and having had the levels taken, I have been enabled to arrive at a very close approximation to the actual cost of the works in such a district. In working it out, the fullest prices have been allowed for every item of the account that may be fairly expected under combined and improved arrangements. The division referred to is bounded by the Bird Cage Walk on the north, Vauxhall Bridge-road on the south, Buckingham Palace gardens on the west, and the river on the east, and includes the drainage also of Whitehall and the Government offices. It consists of an area of 353 acres. The result of the estimate shows in round numbers that the complete street and court drainage of the whole of this district may be accomplished, with the provision of engine power, for a sum little exceeding 25,000*l.* This estimate proves also, what has just been stated, as the result of a more general calculation, that in the crowded districts 2*l.* per house would, by this system, be the actual outlay for perfect external drainage, that being the proportion of the densely-populated part of the district. The total length of drainage, including every court and alley, is about 100,000 feet, three-fourths of which, in consequence of the considerable fall that the system affords in all the collateral lines, would be an average size of 9 inches diameter, and one-fourth 18 inches diameter; and the result proves that, as a general rule, the total cost of this system of drainage may be stated at 5*s.* per foot run. We cannot possibly expect an efficient drainage at a less cost; can it be realized in any other way for so little? This may be fairly taken as the approximate expense of an equal area of a similar portion of the Surrey and Kent district; or if put down for each proposed division of half a square mile, or 320 acres, it leaves an allowance of 10 per cent. extra for contingencies. The whole facts apply, however, with equal force to this very district of Westminster, where there is an equal deficiency of drainage, and where, from its somewhat similar position, there is the same impossibility of perfect drainage without the employment of power for the constant removal of the refuse. Whatever expense may be incurred in mitigation of the evils, on the present system, it can only be a mitigation of them; they must still exist. Some trifle may be added to the fall of the sewers; the cesspool may be made a little deeper, but it must still be a cesspool, from which the same foul gases will evolve and rise as now.

You have given it as your opinion that a perfect drainage of the

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districts below high water mark cannot be effected without the application of power. Will you state generally what other advantages you consider would be derived from the adoption of the system or arrangement here proposed for that purpose?—A system of this kind appears not only to give to a flat district all the advantages for drainage now attainable only in the rising or sloping parts of the town, but provides a facility and economy of execution of much importance, not otherwise attainable even in the most favoured localities, as I shall endeavour to explain.

—1st. All observation and inquiry adds only evidence of the fact that the great point to be desired for perfect drainage is *a good fall.* With this one advantage at command all difficulty ceases. Drainage then becomes alike economical and easy. In the ordinary system of draining towns to the natural outfalls, however well situated a district may be in its general disposition in the great requisite of inclination, the difficulty will still occur, in many of the collateral lines, of procuring sufficient current in the sewers to keep them clear of deposit. A good fall in the sewers will keep them perfectly clean with the smallest possible quantity of water, while many times that quantity will fail to accomplish this end without the advantage of a tolerable current. Hence the necessity of systematic and frequent flushing even in the most favoured districts. The importance of this point cannot be too much insisted upon. However perfect flushing arrangements may be, it is but a periodic and partial relief. From the moment that the sewer is so cleared, deposit again goes on, giving forth at each moment its noxious miasma. The poison is still engendered between the intervals of flushing, unless the current of the sewers be sufficient to keep them constantly clear at all moments. Now, with the subdivisions of area here explained, forming, as it were, distinct basins with their drainage converging to a centre point of each, the work may be so laid out as to procure any desirable amount of inclination under the most difficult circumstances that can occur, and thus the object of primary importance, the avoidance of deposit, effectually secured. At a vast saving of expense, the pollution of rivers and the poisoning of the air, by the emanations from the sewers, would be alike avoided, and the formation of noxious gas would be impossible. Although I desire here to lay the greatest stress on the superiority of this method of drainage in low and flat districts, where no improvement of the present system can be rendered adequate, still I cannot help believing that the advantages it would offer would make its adoption desirable also in many other localities.

—2nd. The comparative advantages of a general pipe system of drainage over constructions of brick for the conveyance of refuse in towns would be immense. Now the ordinary plan of sewerage will admit only of a partial use of these pipes for street drainage, even in the most favoured districts, and to that extent will be imperfect. Now the converging system will admit of their universal application to every part of the ramifications of the drainage from the watershed to the outfall, requiring only a construction of brick or other material in the valley lines for the conveyance of the natural streams and flood waters.

—3rd. The more extended and general adoption of the plan will be the more strikingly important, also, when arrangements shall come to be considered for the great question of the application of the refuse to agri-

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culture, for then the works established for the improvement of the drainage of the town will be found so much on the way towards the desired application of it.

—4th. The small and independent action of the drainage areas would afford the greatest facility of execution and management, and, founded on correct calculations, would offer the best guarantee of efficiency of action, avoiding the uncertainties and disputed questions which now arise as to the drainage and outfalls of extensive areas. In the event of such a system being entertained, it is capable, moreover, of immediate application and trial on the smallest desirable scale. It is alike applicable to a village and a metropolis, the one being only a multiplication of the other, involving no risk of enormous works over extended areas, proving, in the end, unsuccessful.

—After long and anxious consideration of the subject, the attainment of these advantages appears to me to comprehend all that can be desired in the most perfect system of town drainage; but in offering this plan to the notice of the Commissioners, I must beg to add that I do so with the desire only of having it submitted to the fullest and most impartial inquiry that can possibly be obtained, and its advantages or disadvantages fairly brought to light. I hold it to be most essential, in a matter of this vast importance to the public welfare, that the opinions of no one man should be advanced or adopted without the most rigid tests and scrutiny. I am far from desirous to thrust forward my own views in opposition to others, but submit them in the hope that good may result from proper investigation of the facts by unprejudiced and competent authorities. The only opinion that I desire to urge strongly, and with confidence, is, that going on with the present system is going on with waste and inefficiency of no ordinary kind, and every day's delay in arresting its progress adds only so much more work to be reconstructed at a future and early period.

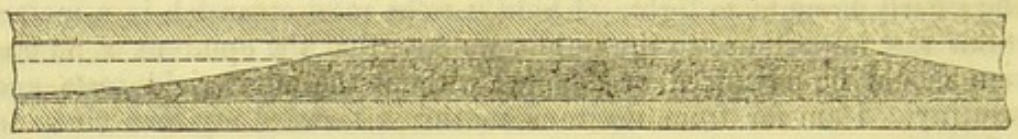
What size of house drain do you consider would be generally sufficient?—I feel satisfied, from long consideration of the facts, and practical observation, that there are very few cases in which a 4-inch drain would not suffice, and if the practical men who contend for 9, 12, or 15-inch drains to houses, would only reason upon the subject for a moment, I am convinced that they must see the error of their practice. A 4-inch pipe with an inclination of 1 inch in 10 feet, will discharge about 14 cubic feet of water per minute; now, an extraordinary fall of rain of 2 inches in an hour will not produce above a-fourth of this quantity on the space occupied by an average sized house and yard. But it is argued that there must be great additional space in the drains to allow for obstructions, when, should deposit accumulate, there would still be some room left for the passage of the water; but if any deposit take place in the small drain, it is immediately choked. Compare the two cases:—A heavy substance gets into a 12-inch drain. The water from the house, being diffused over so broad a bottom, has no power to move it, but a heavy shower may probably send it along some 20 or 30 feet, until it meets with an obstructing inequality. There it stops, a dam for the accumulation of all the soil, grease, and minor substances that, from day to day, are poured into the drain. This accumulation indurates and lengthens, until at last the water forms itself a small sinuous passage through the softest part. A heavy substance gets into

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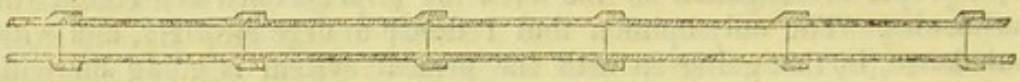
a 4-inch drain, and a great power of water is every day concentrated upon it; but if this, by any possibility, should not be sufficient to send it forward, the first shower of rain will fill the drain, and accumulate a pressure of such a considerable column of water from the external openings of yard drain and rain-water pipe of the house or outbuildings, that no temporary obstruction can for a moment resist.

There would be the same pressure of water in such a case against an accumulated obstruction in a 12-inch drain, would there not?—Yes; there would, when the drain was so far choked as not to allow of the passage of the water; but by the time this had arrived, a great length of indurated deposit would have accumulated,—probably nearly the whole length of the house-drain,—which no such power of water could remove. The consequence would be that each extra rush of water, instead of clearing the drain, would by degrees effectually block up the remaining small opening, by heaping up, time after time, the nearest portion of the deposit on to that beyond. I have attempted in this sketch to show the effect that must, in such cases, occur:—

Section of 9-inch barrel drain—choked up.



Proposed substitute—4-inch pipe drain.



Even if it did clear itself, in such a case the absurdity is sufficiently striking, of providing a drain of such a size that it must first of all get choked before it can clear itself. There is another most important point with regard to small drains that is overlooked. Granting for a moment that the sectional capacity of a 4-inch drain is not equal to that of the waters that may flow into it from all the openings—sinks, area, water-closets, and rain-water pipes—of such a large house as this (Gwydyr House); there would be a pressure of a column of water in the 4-inch drain, when flowing full—as it might in heavy storms—that would, from the increased velocity, render it more than equal for the time to the 9-inch drain as at present put in. I am fully prepared, therefore, to contend that there is scarcely a private house in this metropolis for which a 4-inch drain would not be sufficient, if correctly put in, and with all the junctions thereto securely made, with proper curves. We see that nature throughout, in its rivers and streams, meets its own exigencies in similar ways, but it is only seen to be disregarded. The fact is, that as 12-inch drains get constantly choked, it is hence inferred that they are too small, rather than too large. I am asked by one who should know better, "How *can* a 4-inch drain be sufficient when I have a 12-inch in my house, and yet I am constantly flooded even with that?" and I can only answer, "that it is precisely because you have a 12-inch drain which is improperly constructed, and 9 times too large, that you are constantly flooded." A great horror of cesspools is constantly expressed, and yet the whole present work of house-drainage is a system

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of nothing else. It is only a difference of form and situation, and it is questionable sometimes which is the less mischievous. The condemned cesspool is broad and deep, and outside the house; the favoured one is long and narrow, and sends its noxious vapours directly inside. I am afraid that I have said more upon this point than it would appear at first sight to warrant; but I feel that it is a much more important branch of the subject than is generally supposed. Defective and erroneous in principle as the street sewers are, I believe that they have often to bear a blame that is, for the most part, due to the house-drain. Correct views are quite as essential in the one case as in the other.

It is stated by the surveyors to the Surrey and Kent Commission of Sewers, that they should only prefer glazed pipes to the ordinary brick sewers and drains on account of the expense. The plan you have explained provides a complete system of pipe-drains for the whole of the streets as well as the houses. What do you believe to be the comparative advantages of the two materials?—I believe that a very considerable part of the question of a perfect system of drainage of towns lies in this consideration, and that any attempt to found a general arrangement in constructions of brick, will retain many of the present errors. The glazed pipes are to be preferred in every point of view.

—1st. From their even and glassy surface, there is a great reduction of friction, and consequent increase of the flow with the same quantities of water, which admits of their size being materially reduced.

—2nd. With equal inclinations they will keep themselves clearer of deposit, and consequently be free from the present offensive effluvia of the brick sewers and drains; and being perfectly impermeable, all soakage of the neighbouring ground is prevented, and foul emanations from this source obviated. They prevent, moreover, the soakage of the material of the sewer, from which much effluvia now arises, even where deposits are avoided; the bricks, becoming perfectly saturated with the foul liquid, are constantly giving off offensive smell. The drains of stone-ware would prevent also the entrance of gas that constantly escapes from the neighbouring gas-pipes, and is now often the source of great annoyance.

—3rd. They would forbid the harbouring of rats within them, and no longer form the channel for the entrance of these disgusting vermin into our houses. The glassy surface of the tubes would deprive these animals alike of foothold and of food.

—4th. The tube drains afford great facilities for execution, and improvement in arrangement, from the fact that any amount of inclination may be given to them that may be desirable, without the slightest danger to the material, while the bottom of the brick sewer is often found worn away by the friction of the stream, where anything approaching to a considerable fall is adopted.

—5th. Glazed pipes would be much more quickly and economically laid than brick drains, and would afford great security against much of the defective and careless construction which now characterizes drainage works. It has only to be considered for a moment, how these drains are now frequently constructed, to show the importance of this point in forming drains to houses already constructed. A small tunnel is driven through from the house to the sewer in the street, in which the bricklayer works. The man is naturally anxious to get out as soon as pos-

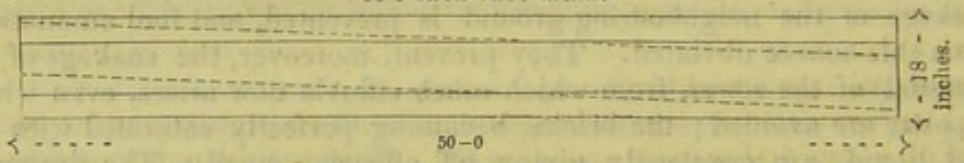
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sible, and as no mortal eye but his ever sees the work, so long as some sort of opening is left, he is content. The bricks of the chief part of the drain are imbedded in earth instead of mortar; and instances have occurred where thin boards have been left for a covering, which have given way, and caused the stoppage of drains in a few months after their construction. With the glazed pipes this would be impossible, being most simple in construction, and laid in lengths, there would be but few joints to make; and if the level were properly set out, the work could scarcely fail to be perfect.

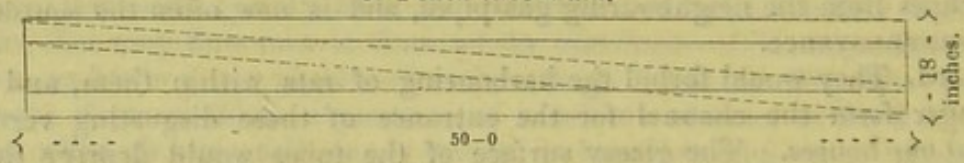
—6th. The pipes would require much less excavation, both from diminished size and less thickness of material; and they could be laid in loose and treacherous soil, where brick-work would fail without great precaution and expense.

—7th. They would afford the advantage of giving considerably greater fall in the case of house-drains, which is very frequently a point of great importance. Take an instance where a sewer in the street is necessarily at such a shallow depth that a brick drain to a basement can be laid only level without any fall, and suppose the length of the drain to be 50 feet. The glazed pipe could be laid, under the same circumstances, at an adequate inclination of upwards of an inch and a half in 10 feet, even if it were to be of the same capacity; but if of 4 inches diameter, instead of the present minimum of 9 inches, it could be laid at a current of more than 2½ inches in 10 feet, being more than double what is now considered sufficient, as explained by these diagrams:—

Diagram, showing 9-inch barrel drain laid level, the dotted lines showing inclination of 9-inch tube drain.



Diagram, showing 9-inch barrel drain laid level, the dotted lines showing inclination of 4-inch tube drain.



—8th. The pipe-drains would never want repair; and thus the only semblance of a reason for building sewers large enough for men to enter them would vanish. They would be, in fact, of everlasting durability. The drain-pipes of ancient Rome are, at the present day, perfect, although of far inferior material to the vitrified glazed stone-ware now manufactured in this country. At the ruins of Trajan's baths, near Civita Vecchia, I recently examined some of these pipes, which are still perfect.

—9th. They would not only be far less expensive, but they would be, what brick drains never can be, perfect in efficiency.

Is there a single point in which the brick drain can be said to be superior or even equal to the stone-ware pipe?—Not one; and I believe that the time will come when every house-drain of brick now existing will be removed, when the importance of proper drainage shall be thoroughly appreciated. It would frequently be a great economy in mere money to

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do so. The drains of a house now, almost as a matter of course, have to be periodically broken into to be cleared of deposit. There is a perpetual expense attending them, which would never occur with a proper pipe drainage, and the foul emanations from them are so constant, that the olfactory nerves of town experience become to a great extent insensible to their presence. It is quite impossible that these brick drains can effect their intended object. If the utmost ingenuity had been exercised to ascertain in what manner bricks could be laid to effect the object of a sieve in letting off the liquid and retaining the solid portion of what passes into it, nothing better could have been devised. Perfection never can be attained until these brick house-drains are removed; and I believe it to be one of the greatest advantages of the converging plan of drainage proposed, that the whole system may be so reduced in size as to abolish altogether the use of brick-work even in the sewers.

There must still be brick sewers for the upland and flood waters in the connecting and main valley lines, must there not?—Yes; that is to say, that there must be a capacity that could not be accommodated by pipe-drains; but when the difficulties are considered under which sewers are frequently constructed; the water that has to be contended with during execution; the shifting, treacherous soil in which they are too often laid; when it is known that the least inequality of work forms a constant impediment to the stream, the friction against which either endangers the ultimate stability of the work, or assists in the formation of deposit; when it is seen how incompatible to the arched form of a properly shaped sewer is the common brick, I feel that it is not the right form or size of material for these constructions; and it is to be hoped that much attention may be devoted to the manufacture of a form of material more suitable to the object, and that means may be acquired of glazing its interior surface.

You consider that the same argument with respect to the erroneous size of house-drains holds good also with respect to the public sewers?—Precisely the same. House-drains are made of extra size to prevent obstruction, and it is the very cause of obstruction. The sewers, however small they may be actually required, are built large enough for men to go into them to clear away deposit, and that very circumstance is the cause of deposit.

You do not think it necessary that men should go into the sewers?—No more so than that climbing boys should go into chimneys; and I believe it to be an equally barbarous and cruel custom.

It is your opinion, then, that the whole system of sewerage as at present laid down, is far larger and more costly than necessary?—Decidedly. Were it not obvious to those who have well considered the subject, it might appear presumption in me to say so, but I believe that the practice in every district, without exception, is most erroneous in this respect, and that in the smaller class of sewers they are generally ten or twelve times the size that there is any necessity for.

Do you think that the assumed necessity for sending men into the sewers is the chief cause of this erroneous size?—No. I am inclined to think that this is a modern idea—a mere justification of the practice. I believe that the great errors that are committed in the sizes of sewers have originated in a total misconception of what is required for storm waters, unless it can be conceived that no thought at all has been bestowed upon the subject.

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You are acquainted with the formulæ and rules laid down for calculation of the sizes of sewers and pipes in works on hydraulics?—Yes, I am.

What appears to be the result of their application to practice?—The science of hydraulics has been a matter of study and interest to the philosopher and mathematician of nearly every age and country. Most elaborate works have been written on the subject, but ingenious as the theories may be that have been established, and the rules deduced therefrom, the conviction is forced upon me, after no little attention to the facts, that their application to practice, in the construction of works of drainage, almost invariably leads to error.

Is this evident in practice?—It is. The assertion may appear extravagant, but I shall hope to make it evident nevertheless. The fact is, that even up to the present moment we have no real data upon which formulæ can with safety be established for application to practice. Mathematicians have, for the most part, founded their calculations on partial experiments, frequently carried out on the smallest scale, in which the most important elements have been really overlooked, and results arrived at strangely at variance with fact. I should be very cautious in passing judgment upon the works of these eminent men; but their calculations almost invariably lead to different results, some to a very great extent. It follows that elements in the calculations have been neglected or variously estimated, or that the formulæ deduced from them are not similarly applicable, although similarly expressed. The rules get applied, however, indiscriminately in practice, and much error is the consequence.

There are certain rules laid down, are there not, universally admitted to be true, upon which calculations may be founded?—Yes, there are; but I think it will soon be seen that these rules are correct only under certain circumstances, and within certain limits, and therefore are not generally applicable with safety to the case in point. Without troubling the Commissioners with calculations and formulæ, the statement of a few simple facts will, I believe, render this evident.

—1st. The velocity of a stream is generally stated to be simply as the square root of the mean hydraulic depth; that is, the sectional area divided by the frictional surface in contact with the stream. The element of gravity is frequently neglected, its ratio of effect being undetermined, although in the larger streams it influences the results to a very considerable extent.

—2nd. The length of frictional surface itself is taken the same, whatever may be the section of the stream, whereas the form and ratio of length of bed to the sides, and the depth of the stream, will materially vary the effect—to what extent is yet undetermined.

—3rd. It is stated as an established truth, under all circumstances, that the velocity of a stream is greatest at the surface, and least at the bottom; but it is evident that this can only be so within certain limits, where the effect of friction overcomes that of gravity. Beyond this limit the highest velocity is found at a point below the surface, varying with the depth of the stream. The relative position of this point is yet undetermined, although in large bodies of water it will materially affect the calculation for ascertaining the mean velocity.

—4th. It is indiscriminately stated, also, that the centre of a full pipe is the point of greatest velocity; but it is evident that this can be true only

with a vertical pipe. Placed horizontally, the point of greatest velocity will be nearer the top surface, the friction diminishing from the bottom to the upper side, and the point varying with the depth or diameter of the pipe.

—5th. The faster water flows in pipes, the less it presses against the sides: but in what ratio is also undetermined.

—These and other points, of which we have no certain information, would have most material influence on the results. With respect to friction, that most important and ever varying item, we indeed know little or nothing. Nevertheless rules are laid down and tables formed, exhibiting the sizes of sewers for the discharge of certain quantities of water, which are indiscriminately applied in practice. Let us look at the result. Suppose that it is required to know the sectional capacity of a main outfall sewer to drain a large district. The table is consulted; a certain size found, and adopted. If the quantity of water required to be conveyed had to be discharged from a reservoir kept at one height, the size there named might be correct for the commencement of the sewer. In the case in point, however, there will not only be the sum of the velocities of the various tributary streams brought to bear in the united volume of water, which is not allowed for, but there will likewise be the accelerated velocity of the main stream itself. Should the main sewer, from the commencement to the outfall, be of considerable length, with a fall more than adequate to the resistance of friction, the accumulated velocity would either allow of a gradual corresponding diminution of the capacity of the sewer, or would be adequate to the discharge of so much additional water, and would consequently be capable of draining so much the greater area than that named in the table. Practice proves this to be the case, and yet these tables are blindly put forward, as guides to the public, without a word of instruction or explanation, and are as blindly followed. I should be very sorry to depreciate the value of the researches into this subject, but I think it extremely important that the erroneous impression should be removed that proper rules have been established for our guidance. Not long since, after exhausting the alphabet in formulæ, I considered that I had a tolerable knowledge of the subject; but further attention to it, in its practical bearing, has only convinced me of the little that I do know, and that to this day no fixed data exist upon which calculations for the capacity of sewers, for drainage purposes, under the usual circumstances of practice, can with safety be established. It seems extraordinary that this great question, the determination of which involves widely extended and expensive research, should, for ages, have been left to the private resources of philosophers and mathematicians, not renowned at any time for their amount of wealth, and that from generation to generation they should have been allowed to sacrifice years of labour, arriving only at partial and imperfect results, for want of aid and encouragement. It would appear to be one of the most important features in the establishment of a Central Board, that they would have the power and opportunity of directing the fullest trials and observations, and collecting and arranging facts for the basis of correct views and calculations. Under such an authority, with the assistance of the first talent, serial experiments might be carried on; for instance, with great advantage, at the Royal Engineers' establishment, or at the Putney College, where, being brought daily under the

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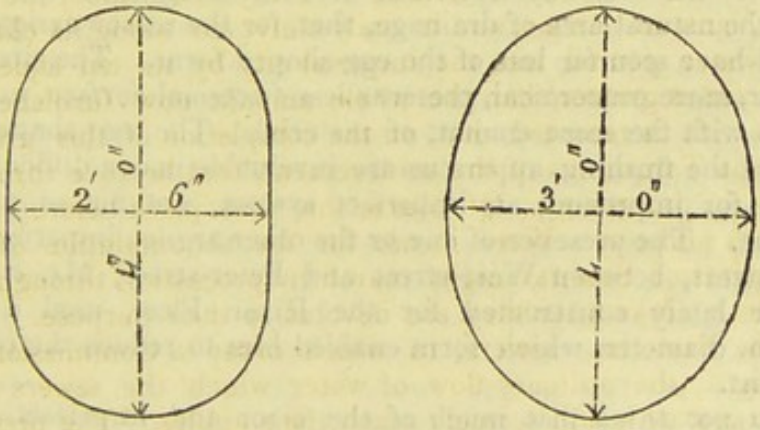
observation of the students, a new school of engineers would thus be forming, the best calculated to put the established views into practice, which had been there imbibed in the course of education. It would be a false economy that would deny ample funds for such a work—a drop in the ocean of national outlay, that would be returned a thousand fold in economy of practical results. Millions erroneously squandered in inefficient works would have been saved in this country alone, had such a responsible authority been long since established; and the annual sacrifice of life which we have now to deplore, as a result of inefficiency, loudly calls for the immediate stoppage of this ignorant waste.

Supposing that there were sound and sufficient data for correctly determining the sizes of sewers for the discharge of certain quantities of water under the varying circumstances required, do you consider the practice of constructing all the sewers of sufficient size to convey the waters of the greatest known storms to be correct?—Decidedly not. The practice is most erroneous, and has tended to bring about the most unscientific treatment of the subject,—that of an equalized system of sewerage in the place of a graduated system. Nature points out to us, in all directions, that it is perfectly unnecessary. Every unsewered town of the kingdom is an illustration of the fact, that the provision of capacity of sewers, throughout the system, sufficient for the waters of extraordinary storms is a great error. This provision should be made only in the main natural valley and connecting lines, to which the waters immediately descend, and where the accumulation calls for an ample passage. In the higher portions of a district, even in the total absence of sewers, storm waters flow off immediately, and do no injury; while the provision of enormous size of sewer, for an event which happens only for a brief space in an interval of years, renders them unfit for their daily and constant purpose. But it is thought to be far grander to adopt a fine large sewer throughout. There has always existed a feeling of admiration for enormous sewers, originating, no doubt, in the just praise awarded to the Cloaca Maxima of the Romans, but unfortunately without reference to the requirements of that great work. The Cloaca Maxima was the terminating line of a system of graduated sewerage so extended, that according to Pliny and Strabo, the city was, as it were, built in the air, and it daily conveyed along its channel the floods of water poured into the imperial city by its ten aqueducts—a supply six times greater than the whole amount now furnished to this metropolis. It is recorded that, on the completion of this great work, so proud was Tarquinius of the achievement, that he rode through it in his chariot in procession. Of course this took place before it was devoted to its purpose. Were it not for the accumulation of deposit, Commissioners of Sewers might march in procession through the majority of their works after they are devoted to their purpose. In some, even of the first-class sewers, in which many a Commissioner could stand upright, the ordinary flow of water which the sewers are constructed to convey would scarcely reach their ankles. The present condition of the Cloaca Maxima should be a serviceable lesson. Although to be admired for its solidity and capacity, its form was erroneous, and having no longer to bear along its course the flood of water to which it was then no more than adequate, deposit has gone on until it is now very much in the condition of too many of our own wretched sewers and

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drains,—nearly choked up to the crown with deposit of filth, perpetually sending forth its bubbles of pestilential gas, and poisoning the neighbourhood. The supply of water that still exists in Rome—and it is now twelve times greater per inhabitant than what is given to this metropolis—unfortunately serves little useful purpose, for being supplied only externally, the merest fraction is devoted to domestic aud cleansing purposes. The bulk of it plays its part at the beautiful fountains, then runs to waste; and—the drainage being deficient—promotes only dampness and decay. Thus do these great works of drainage and water supply—once the chief sources of health and comfort to a prosperous and powerful people,—now spread disease and death around them. The stranger, when beholding those mighty ruins and sparkling waters, is too much engrossed in admiration to heed the danger that lurks within them, or to see the consequence of neglect or inefficiency of works. Were it not so, surely more than one classical Commissioner of Sewers would have produced something more worthy of the lesson than he would there have learned. With respect to Rome itself, let us hope that the enlightened views of Pope Pius, already anxiously impressed as he is with the importance of the subject, will soon lead him to apply the easy remedy, and restore these great works to their legitimate and all important purposes.

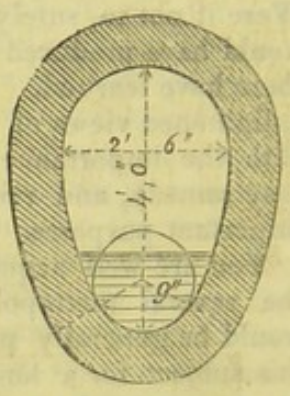
You are well acquainted with the different forms of sewers in use in the several metropolitan districts. Have you considered what form would be generally preferable?—Yes; I have given much attention to this subject for a long time. The flat-bottomed sewer having finally given way to the pressure from without, the sewer next in degree of error is certainly the upright sided form of the Surrey and Kent and Tower Hamlets Commissions. It is opposed to every correct engineering principle. In no one respect is it to be preferred to the circle, and in most to be condemned. It is comparatively weak, costly, and inefficient. Its very appearance is disagreeable; it seems to have outgrown its strength; whereas with scarcely an appreciable addition of material, greater capacity and much increased stability is obtained in the true ellipse.



The superiority of the upright sided form over the egg shape is contended for by virtue of a small amount of friction that, in a cited case, may be in its favour when flowing full; but this is rather begging the question, as the egg shape is adopted for its great advantages in scouring action when nearly empty, that being the general condition of most

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of the sewerage. If prejudice will not admit of the use of the egg shape, and increased height of sewer may be desirable, (a case scarcely possible by the bye, in a flat district,) why not adopt the true ellipse, in every way so superior to the construction now in use? It is, however, obvious to my mind, that where sufficient fall and flow of water can be obtained to keep a small circular form of sewer clear of deposit, all departure from that form is erroneous; the size really required in general being so small as to give that advantage of concentration of water which, in the over-large sewers at present in use, has been sought for by the use of the egg-shape form. To take a case that comes first to view, in looking at the contoured map of the City in the Health of Towns Report:—If Mr. Butler Williams's levels of Cornhill be correct, there is a fall in the length of that street of about 1 in 80, and the utmost area that its sewer could drain under complete arrangements, would be seven acres. Now, the rain-fall upon that area of an extraordinary storm of two inches in an hour would, with such a current, only occupy the space shown in this sketch, and would be accommodated by a circular pipe of the same radius as that with which the invert of the egg-shape sewer is formed for the purpose of concentration of the flow, the whole of the remainder of the sewer being so much waste. This is supposing that a collateral, not a main, sewer would be constructed, although in a main street, and allowing, moreover, a capacity sufficient for very extraordinary storms, which I contend in such situations should not enter into the calculation.



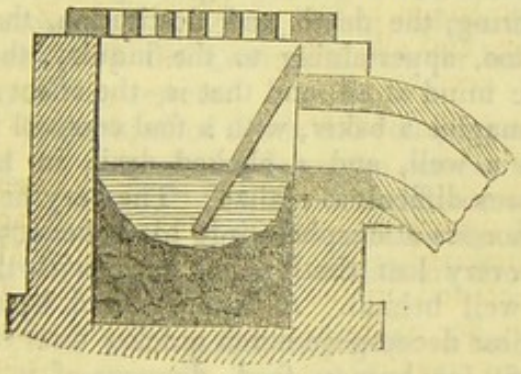
Is not the egg-shaped form to be very much preferred in many cases?—Yes. In the extension of the present system of London sewerage, I think it is in most cases to be preferred. I appreciate most fully Mr. Roe's improvements in this respect, and in the flushing apparatus, for to him the great credit is certainly due of the systematic introduction of both these auxiliaries; but I feel persuaded that if Mr. Roe had had to lay down the whole system from the beginning, and had the command of the natural area of drainage, that, for the reason assigned above, we should have seen far less of the egg-shaped form. The circular form is stronger, more economical, presents less frictional surface, and is more capacious with the same amount of material. The egg-shaped form of sewer, and the flushing apparatus are invaluable under difficulties, and as means for improving an imperfect system, not for adoption in a perfect one. The presence of one or the other argues imperfection. In Victoria-street, between West-street and Peter-street, Mr. Roe has, in the sewer lately constructed for the River Fleet, used a circle of 10 ft. 3 in. diameter, which form enabled him to reduce the cost nearly 30 per cent.

Do you not think that much of the error and imperfection of the sewerage of the metropolis is attributable to separate and independent jurisdiction over one natural area of drainage?—It clearly must be so. The greater part of the difficulty and wasteful expenditure is certainly traceable to this cause. Nothing could have been devised so calculated to produce and perpetuate an erroneous system as this piecemeal separate

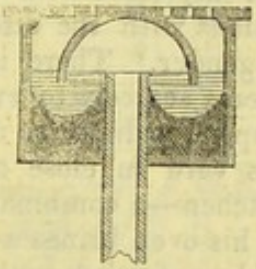
control over the same area; nothing could be more mischievous than the sacrifice of nature's boundaries to those of municipal government; nothing more absurd than the attempt to reconcile one with the other. The consequence is obvious. In the Holborn and Finsbury District alone, we are told that a quarter of a million sterling would be required to render the outfalls of its sewerage efficient, and in another case, Mr. Roe proposes to effect a great improvement by flushing, if he can get permission (!) from a neighbouring Commission. Year after year does an exorbitant waste go on contending with the evil, and year after year have we seen partial, but obvious improvements, springing up in separate jurisdictions, either from prejudice or party feeling, repudiated in others. We can hope for no permanent or general improvement until at least this stumbling block is removed.

What has been the result of your observation of the usual plan of trapping sewers and drains?—The usual plan of trapping is the worst feature of the whole system. These traps retain, in fact, the great objectionable part of the flat-bottomed sewer. All the force of the water for flushing is entirely lost. It is impossible that they can be kept clear of foul deposit. These sketches will show that this must be the case.

Section of an ordinary Trap to Gully Shoots, showing deposit of filth.



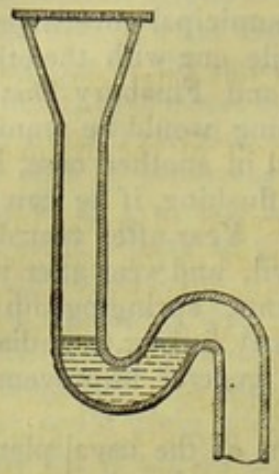
Section of ordinary Bell-trap showing deposit of filth.



The bell-trap of sinks and house-drains is usually of the same character, and equally objectionable. Foul matter collects in the angles, where the water has no power over it, exactly as in the flat-bottomed sewer. These traps are frequently the chief cause of the nuisance they are intended to prevent. I recently met with a case in which a great length of sewer was supposed to be so foul that, notwithstanding all the gully holes were trapped, it created the most abominable odours. On examination, however, I found the sewer perfectly clear of deposit and free from smell, but every trap in connexion with it was filled with decomposing matter that poisoned the whole neighbourhood. What can be more truly absurd than the practice in some of these Commissions, with respect to the trapping of street gullies and the ventilation of sewers? Traps are put to the street gullies next the foot pavement, which prevent the foul air from rising from the sewer, but which nine times out of ten create as much of it themselves, and then another opening is made a few feet further off in the middle of the street to ventilate the sewer, and discharge the foul air that the neighbouring trap is constructed to prevent! A double nuisance is created instead of one, and at double expense. The valve introduced by Mr. Phillips is a great improve-

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Section of Syphon Water-trap.



ment upon any water-trap so long as the sewers are allowed to generate foul gases, for there is a current of the gas through all water-traps, the water absorbing it on one side and giving it out on the other; but with a good supply of water, I believe that the syphon water-trap would be preferable to all others, both for gully-holes and sinks, as not liable to choke or get clogged.

Have you found, in your inquiries, that the public generally have any conception of the extent of the evils with which they are surrounded by reason of inefficient drainage?—They have not the slightest conception of it. Complaints of open ditches and deposits on the surface are loud enough, but the public mind does not realize those equally offensive and injurious nuisances that are concealed from view. It is difficult to convey an idea of the dreadful condition of the soil around and underneath houses where cesspools and inefficient choked-up sewers and drains abound. I have seen the foundations of whole streets of houses, when exposed to make way for improvements, around and beneath for several feet, black with the fœcal saturation of years; but the mind is scarcely yet impressed with the intimate connexion of these disgusting accumulations with the disease and suffering, the death and destitution, they engender. There is a feature, too, appertaining to the inquiry, that seems scarcely to enter the public mind at all, and that is, the effect of imperfect drainage upon food. Imagine a baker, with a foul cesspool in his yard in close company with a well, and a choked drain in his kitchen—a combination by no means difficult to realize. The very heat of his oven brings a stream of poisonous atmosphere into his bakehouse, adding further contamination to every loaf that he has made with the already poisoned water from the well behind. A butcher hard by an offensive gully-hole, finding his meat decompose much quicker than the weather warrants, and already unfit for human food, disposes of it at tempting price to the poor. A brewer sinks a deep well, and drains his neighbours' wells and cesspools too—a flavour something foreign to malt and hops may possibly result. The milkman ties up his cows in ill-drained, ill-ventilated stalls, and wonders perhaps, that they become diseased, but retails his poisoned milk, nevertheless, somewhat more dearly for the loss. I once heard a milkman, under cross-examination in Court, when asked the question whether he did not sometimes add a "leetle" water to the milk he sold, boldly say, "Of course I do; the London stomach couldn't stand it pure." I have no doubt at all that he was right.

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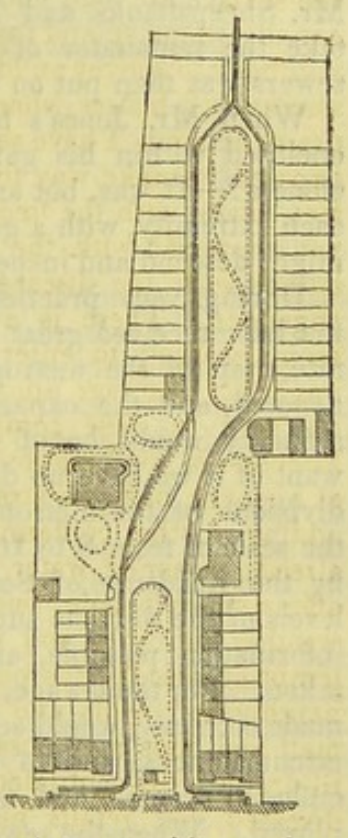
You are the author of the "Encyclopædia of Civil Engineering?"—Yes.

Have you paid practical attention to the subject of the drainage of towns?—Yes, I have.

Have you, as an architect, been practically engaged in works involving questions of the drainage of houses and sewerage in the metropolis?—Yes, I have, in all parts of the metropolis and the suburbs of London.

On these occasions you have had practical observation of the regulations of the several Commissions of Sewers?—Yes.

Have you found any difficulty in executing any of the works you have superintended professionally?—I will, with your permission, allude to two operations in particular which occurred in the district of the Westminster Commissioners. The first was on an estate on the Knightsbridge-road, now partly covered with buildings, and known as Rutland Gate. Rutland House, with its two fields adjoining, being considered as an eligible site for building, I was commissioned by the proprietor to make a plan, laying it out for houses of the first class. After pulling down the house, the accompanying plan being adopted, I then petitioned the Commissioners for leave to construct the sewers.



What kind of sewer did you propose?—One of the second size down the centre, which was not granted. I was then instructed by the officers of the Board to petition for the two, as now constructed, and which are shown on the plan.

Was it intended originally to build the two large mansions occupied by Mr. Sheepshanks and by Mr. Jones, erected under your superintendence?—No, the land was laid out for a continued row of houses on each side, with eight towards the road, commanding a view into Hyde Park.

Had you known this, as the architect of the estate, would you have advised the proprietor to have expended his money in building two sewers?—Certainly not, and the case appears to me to be one of considerable hardship; with the risk of the land letting, and before it could be fairly put into the market, the proprietor was called upon to lay out 2000*l.*, which might have been rendered wholly unnecessary, had it been taken for separate villas or mansions.

After you had constructed these sewers, by the permission of the Commissioners, did any other difficulty occur?—A very grave and important one, for we had no outlet at the lower end, the fence which bounded the estate being claimed by the proprietor of the adjoining land, after uniting our sewage with that in Rutland-street, which ran on the other side of the wall, and which was the natural course of our drainage, or rather occupied the ditch which formerly conveyed the water from

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our estate, our junction was cut off, and instead of our sewers performing their duty, they were destined to become two vast cesspools.

What course did you adopt?—We again applied to the Board of Commissioners, and, after a considerable number of meetings, was informed that they had no jurisdiction over the rights of private property, and, therefore, could afford us no remedy.

What was done by you afterwards?—The matter was then taken up by the solicitors, and eventually the question was referred to arbitration, when it was decided that our sewers should pour their contents into that to which they had been united.

Has all the land beyond the two mansions been covered with buildings?—It is let to a builder; but the works are not yet completed.

Did you find any difficulty in getting repaid the cost of the sewers in this instance?—The first 26 houses paid their proportion of sewage according to their frontage, which was considerable on the plots taken by Mr. Sheepshanks and Mr. Jones; but no builder could be found to take the remainder of the land on the same terms: the charge for the sewers was then put on in the shape of a ground-rent.

When Mr. Jones's house was erected, was not one of the sewers enclosed within his garden, contrary to the usual order of the Commissioners?—It was, but an arrangement was made to have a man-hole at each extremity, with a gate in the fence, so that the officers of the Board might descend and inspect it at any time.

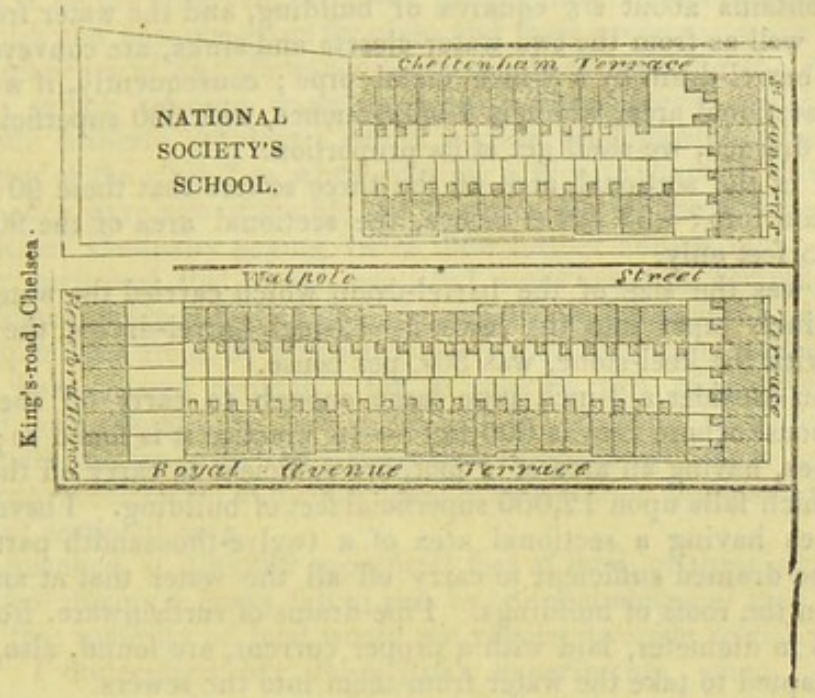
During your practice as an architect and civil engineer, would you not have received great facility if you had been able to refer to an accurate map of the metropolis and its suburbs on which the levels were denoted, and the capacity of the sewers defined?—Most certainly such a survey would be of the highest value; and in consequence of the want of it we have no distinct idea of the manner in which the several divisions of the metropolis in particular are drained. A map drawn to the scale of from 8 to 16 inches per mile, with contour lines as suggested by the Academy of Sciences at Paris in 1742, showing the respective levels of the districts surveyed, would afford the most valuable and useful information possible, and it is a wonder that it has never been undertaken. For the sewage, or laying down water or gas pipes, such a survey, made correctly, would serve the engineer to regulate his works under any circumstances, and to make them more in accordance with the principles of science, and more suitable to the district in which he was employed. When the sewers, with their due increase of sectional area, the water and gas pipes, with their proportions, are correctly laid down, such arrangements might be established that neither could interfere with the other. The plan of a great city so defined would at once suggest the imperfections of its drainage, and exhibit at the same time how it might be improved and rendered perfect.

What was the other estate you mentioned in the neighbourhood of London where you have been professionally employed recently?—At Chelsea, adjoining the National Society's Normal School. The accompanying plan shows its arrangement as well as the sites of 90 houses, the whole of which are either inhabited or in a state of completion.

What sized houses are they?—Their average frontage is about 18 feet.

What is the area of the entire plot of ground which contains the 90 houses, and their streets?—200,000 superficial feet, or a little more

than 4¾ acres; the length of frontages about 2000 feet, and that of the streets something more than half that extent.



What sized sewer was proposed by you for the drainage of the whole of these houses?—I did not propose any particular size; the Commissioners, on the receipt of my petition, referred me to their officers, and I was told by them that I must petition for three separate sewers, together upwards of 2000 feet in length, the internal width of which must be 2 feet 6 inches.

Did you do so?—I did; and before the end of the year 1842 the whole were commenced and completed under the inspection of the surveyors appointed by the Commissioners, and at the expense of my employers, who had the land to let for building.

What sized sewer would you have constructed if you had not been instructed by the Commissioners?—I should have made a barrel-drain about 21 inches in diameter, the sectional area of which would not have been much above 2 feet 4 inches superficial, whilst that of the sewer constructed contained 11 feet 6 inches sectional area, nearly five times as much as was necessary, the expense of which occasioned a cost to each house of 20*l.*; and if we call the interest of this money so expended 1*l.* per annum, we are adding one-sixth to the positive ground-rent, the 90 houses having to pay 90*l.* per annum for the first cost of the sewer, independent of all the annual sewers-rates, &c. To drain this 4¾ acres of land has cost the proprietor nearly 20*l.* per acre per annum for the original outlay in constructing the sewers, and the superintendence to be paid for beside; at which rate the whole of the 370,000 houses of the metropolis would require an expenditure of at least 5,400,000*l.* for the construction of its sewage.

Does this excess of dimension in a sewer affect its useful purposes?—Certainly; for where the sectional area of a sewer is too large, a considerable increase of solid matter is formed during a dry season; the supply of water which runs from the several drains not being sufficient

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to float the contents, only during heavy or regular showers are these deposits removed.

In what manner is the rain-water conveyed into the sewers?—Each house contains about six squares of building, and the water from the roofs, as well as from the two water-closets and sinks, are conveyed into a brick barrel-drain by a 3-inch metal pipe; consequently, if we compare its sectional area, which is 7·0686 inches, with 600 superficial feet, the area drained, we shall get at its proportion.

What is the sectional area of the three sewers that these 90 3-inch pipes drain into?—33 feet 6 inches, the sectional area of the 90 pipes being 4·5 feet only.

What was the size of the barrel-drain which carried the water from these 3-inch pipes into the sewer?—12-inch barrel-drains, the cost of which, with the keel-stone, was 30*s*. per house.

Do you consider a 3-inch pipe large enough to carry off the water from a house whose area is 600 feet?—In practice it is found so; 20 of such pipes, having an area of 1 foot, are sufficient to carry off the rain-water which falls upon 12,000 superficial feet of building. I have found that pipes having a sectional area of a twelve-thousandth part of the area to be drained sufficient to carry off all the water that at any time falls upon the roofs of buildings. Pipe-drains of earthenware, from 3 to 9 inches in diameter, laid with a proper current, are found, also, admirably adapted to take the water from them into the sewers.

Would such a rule generally apply to a large district, or a city?—It might be applied, if the laws of running water were taken also into account, whose velocity experiences a similar acceleration to that of falling bodies in general. Hence 90 houses do not require so large a sewer as the working out of the answer of the previous question would seem to imply. The sectional area of the 90 pipes, 3 inches in diameter, amounting to 4·5 feet, do not require a sewer of that sectional area, nor would the 370,000 houses of the metropolis require so large a sewer as has generally been imagined.

Have any experiments been made upon the subject that you are acquainted with?—Some years since Genneté* inquired into it; but his opinions varying with those entertained by the practical men of his day, several trials were made by the philosophers of Italy to test their truth, among whom Zendrini, who received his instructions under Guglielmini, may, perhaps, be considered the most industrious and successful: but it would be of the greatest possible value to have these experiments of Genneté's repeated upon a large scale, and the consequences of the increase and diminution of volume accurately noticed. The subject has never, in England, been thoroughly, or even satisfactorily, investigated. Most of the experiments upon running water have been made with pipes placed one over the other, discharging their contents from a constant head. Mathematicians have contented themselves by establishing the form of curve which these several currents assume; and where the case of open canals has occupied their attention, they have experimented upon single streams alone, without observing the phenomena of united currents.

If asked to proportion a sewer, do we understand you to say that you

* Genneté's experiments were printed at Paris, 1760.—See Castelli, p. 175.

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would make it to agree with the united sectional area of the drains that fall into it?—Certainly not; for then I should require a sewer of much larger dimensions than practice has found necessary. On this subject, as I have before observed, there is a perfect misunderstanding; most of the tables and formulæ given for pipes and their proportions are in error, in consequence of due allowance not having been made for the additional velocity which running water acquires under various circumstances. The rule hitherto employed would appear analogous to that of the managers of the river Lea when granting a pipe to the New River Company; they gave one of double the diameter upon the condition of the New River Company paying twice their former annual rent. And we are not surprised that, when sectional areas are thus computed, other errors should have occurred, for by doubling the diameters of circles we quadruple their areas, by which rule more than four times as much water would have passed through; for in making this arrangement other natural laws should have been taken into the account: these have been elaborately discussed by the Italian hydraulicians, who have proved the enormous acceleration and consequent augmentation produced by an increase of sectional area.

—For instance, if 130,680 superficial feet of land, or three acres, could be drained during a heavy fall of rain by one foot sectional area of sewer, double that quantity of land would not require two feet sectional area of sewer. I understand Mr. John Roe's experiments, when I consider that they were under the influence of these natural laws. I refer to that part of his evidence where he states that 6 acres 1 rood and 8 poles of land might be drained during the time of a violent storm of rain by a sewer whose sectional area is 2·44 feet only; but because 144 square inches, or a superficial foot, may, under ordinary circumstances, be sufficient for the sectional area of a sewer, to drain 43,560 superficial feet of land, we do not say that one square inch will drain the one hundred and forty-fourth part of that quantity.

Will you inform us of the nature of Genneté's experiments?—They were made to prove that when two streams of water, running with the same velocity, and having both their sectional areas equal, were united in one stream, that their sectional area was not doubled. In Holland it was important to decide this question, for, intersected as it is by canals and drains of every kind, and the land through which they were made being of considerable value, the inhabitants were naturally desirous of giving up as little to water-courses as possible. Genneté had evidence of the *fact* that rivers could be brought together without an increase in their *volume* proportionate to the increase in their quantity, in the confluence of the Rhine and Moselle; but what he particularly demonstrated was that the united streams flowed on with an increase of *velocity*.

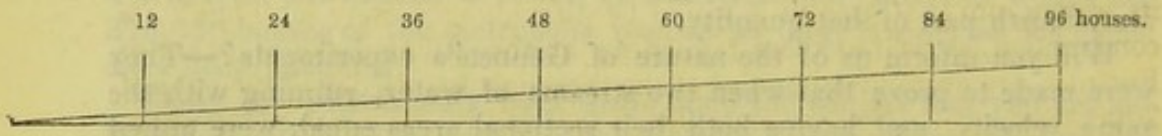
—He seems also to have been fully aware that cutting the banks of a river for the purpose of letting off any portions of the torrent is not so effective in drawing off the water as has been generally imagined; or, in other words, that if a canal had a sectional area of 100 superficial feet when swelled by floods, that 20 canals of 5 feet area each would not have carried off the same water, or so materially have diminished its volume as might be at first supposed.

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—Genneté's views were received by the practical men of his day much in the same manner as they would have been treated, perhaps, at the present time. There were many prejudices to be overcome, and particularly some that were generally entertained with respect to the incompressibility of water. It was argued that you could not compress a double quantity into a less space than twice the area as of each section; that two separate cubic feet of water, when put together, required a vessel whose capacity was equal to hold them both; and that two streams of the same velocity were governed by the same laws.

—When Genneté made his experiments in 1755, in Holland, upon the sectional area of united currents of water, he discovered, after noting the height of the water in the original channel, that he could add another stream of half the original quantity, and afterwards another half, without increasing the height or width of the water in the smallest degree. The water in the stream remained during these experiments at the same height, but it was observed that the velocities of the current were in the same proportions as the additions, viz., as 1, $1\frac{1}{2}$, and 2. He however found a limit to this rule, for when he made the increase three times greater than it was at the commencement, instead of twice, the increase in height was $\frac{1}{4\,8}$ part of the whole height. When he quadrupled the quantity, the increase was $\frac{1}{2\,4}$, and when the quantities were as 5, 6, 7, the increase in height was $\frac{1}{1\,8}$, $\frac{1}{1\,2}$, $\frac{1}{9}$, and so on in continual proportion; thus 96 streams would require $\frac{1}{4\,8} \times 96 = \frac{9\,6}{4\,8} = 2$, or the sectional area must be twice the original height.

—To prove this, Genneté afterwards let off the water by degrees in the same proportions, and he found the same results; the diminutions were in perfect accordance with the previous experiments. Genneté, in his experiments, had a uniform declivity of 1 foot in 1200, and his canals were six or seven inches in breadth.



How would you apply these experiments of Genneté's to the 90 houses constructed under your direction at the King's-road, Chelsea?—In this diagram we have a graduated scale for the increase of the capacity of the sewer for any number of 96 houses.

12 houses	would require a sewer	$\frac{1}{4}$	larger only than	would be required for	one.
24	ditto	ditto	$\frac{1}{2}$	ditto	ditto
36	ditto	ditto	$\frac{3}{4}$	ditto	ditto
48	ditto	ditto	1 or double	ditto	ditto
60	ditto	ditto	$1\frac{1}{24}$	ditto	ditto
72	ditto	ditto	$1\frac{1}{34}$	ditto	ditto
84	ditto	ditto	$1\frac{1}{36}$	ditto	ditto
96	ditto	ditto	2 or three times the original capacity.		

—Each of the 3-inch pipes which conduct the water from the houses has a sectional area of 7·0686 square inches, or 20 of them nearly occupy a superficial foot, notwithstanding this they each are made to discharge themselves into a 12-inch barrel-drain, the sectional area of which is 113·9976 square inches. Suppose, then, we apply our rule to the 12-inch barrel-drain, the capacity of which, no one will doubt, is

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sufficient to carry off the surplus waters from each house; we shall have to multiply 113·9976 by 3, which gives us the product of 341·9828 square inches, or 2·374 feet superficial. A barrel-drain having that area, then would, according to M. Genneté's rule, be sufficient to carry away all that could pour down ninety-six 12-inch barrel-drains; although a drain 21 inches in diameter, whose sectional area is 2·4 feet, appears small for the purpose, yet it would be ample. Had we multiplied 113·9976 by 96, we should have had a product of 10921·7696, or upwards of 75 superficial feet, and more than 30 times sufficient.

—The sectional area of the sewer, built by order of the Commissioners, is by this calculation nearly five times greater than necessary.

—In the invaluable "Raccolta d'Autori Italiani che trattano del moto dell' Acque," printed by Marsigli in 4to., Bologna, 1821-1824, is a mass of evidence bearing upon this subject, from which it is difficult to make a selection. In the notes I have prepared, however, will be found translations of such authors as have more immediate relation to our present inquiry. Frisi alone, of the whole collection, is to be found in an English dress, ably translated by Major-General John Garstin, 4to., London, 1818, which will account for his omission on the present occasion.

You are the author of the Architectural Antiquities of Rome, when, measuring the buildings there, did you notice the manner in which the engineers drained them?—This subject naturally attracted my attention, and I took some pains, when the water was not very high in the Tiber, to examine the Cloaca Maxima now rendered useless, from the deposit at its mouth, and the great elevation of the bed of the river above what it was when this sewer was constructed: it is 14 feet in width, and 32 feet in height; constructed of large and massive blocks of Albano stone called Pepperino, and has a semi-circular vault, formed of three rings of voussoirs. What quantity of land, or portion of the ancient city, poured its waters into it at present it would be difficult accurately to define; its construction, as well as those remaining at the Alban Lake and that of Fucinus, are ample testimonies of the thorough knowledge of the subject 2000 years ago. Had the river Tiber received its due share of attention, and the discharge of its water into the Mediterranean Sea been properly maintained, the sewage of Rome would have been perfect at this day; as would also the drainage of the sites of many of our ancient mansions and religious houses, had the Commissioners appointed to examine the several water-courses in this kingdom continued that active superintendence which Dugdale has reported to have been exercised centuries ago. The statutes of Romney Marsh then gave ample power, and the rivers were never impeded in their course by dams or obstructions of any kind.

Can you describe any large building at Rome, or elsewhere, where there are proofs remaining of what you state?—The Colosseum itself is the best instance I can adduce. It has often been remarked, that the Roman engineers displayed far superior talents, in the carrying off the waters from the buildings they constructed to those evinced by the freemasons or their successors. Before the foundations of these vast amphitheatres were laid, every consideration was given to the best method of draining the vast accumulation of water of every kind which could fall or be accumulated within their area. Not so with the constructions of

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a later time; our cathedrals, in particular, show no evidence of any forethought upon the subject; they spurt forth from numerous gargouilles the rain-water which falls upon their roofs; streams which, falling in a parabolic curve on the ground, sap the very foundations, and render damp the thick walls which circumscribe them. If we examine the Colosseum with attention, to this subject, we shall find that the Roman engineers employed in its construction thoroughly understood the important question of drainage, and that they have left us an evidence of their acquaintance with the principles which regulate running waters, or at least of their practical knowledge of those laws which mathematicians have taken so much trouble to explain. It is to be regretted that this subject has not been referred to by the modern writers of Italy, whose skill and ability would have at once recognised the masterly manner in which the Romans effected the drainage of their city and its suburbs.

—Frontinus, Pliny, and many other Latin authors, in alluding to the aqueducts, conveying copious streams of water, confirm the idea, that neither was science wanting for its supply, nor skill in its distribution.

—The Colosseum comprises, within its walls, an area of 249,840 superficial feet, or nearly 5¾ acres of land. Every inch fall of rain upon its entire area would therefore amount to 20,820 cubic feet of water. Besides the consideration for carrying off so large a quantity as the above, or as frequently happens in Rome, the pouring down of sheets of water during a storm, it was necessary to provide urinals and other conveniences for 70,000 or 80,000 persons constantly assembled to witness the shows and games, and who often remained rivetted to the spot for days together. Such a building had the character of a vast citadel or city, and to preserve cleanliness as well as to effectually drain so vast an accumulation of water and other matter as would be found within it, naturally deserved the most profound consideration, and upon examining its remains, we feel amply satisfied, not only that such was indeed the case, but that the practical development was executed in so ingenious and praiseworthy manner as to excite our astonishment, and to serve us as a model for operations of a similar kind.

—We also find a due proportion prevailing between the sectional areas of the upright pipes and the sewers which received the streams that poured down them; there is a positive evidence that the Roman engineers were acquainted with the laws of velocity of running water, and especially with the fact that a number of small pipes, though charged, did not require a sewer whose sectional area should be equal to their united areas; we are at once struck with this, which could not be the result of chance or accident, for we find it borne out, in several other buildings of magnitude, constructed by these masters of the world.

—The perfect uniformity which prevails throughout the plan of the Roman amphitheatre affords a favourable view of the scheme for laying down its sewers. Its elliptical form, with its eighty converging walls perforated on the ground plan, by four elliptical corridors affording access to the several stairs which conducted to the vomitories, ranged one above the other, all contribute to facilitate the arrangement of its numerous pipes and drains.

—As the arena or interior floor where the games were exhibited was of timber, furnished with several trap-doors, communicating with cages and dens, formed beneath it, and in which the animals were placed, previous

to their exhibition, it was not practicable to have the drainage conducted in that direction; and, indeed, previous to these arrangements being formed, when the amphitheatre was used as a naumachia, and water was allowed to form a vast lake within the podium walls, it would not have been easy to have got rid of this quantity by better means than we find applied here, and which led it away by sewers and drains in the direction towards its exterior.

—At present we have remaining three sewers elliptical on their plan, one surrounds the building on the exterior, at some feet distance from the foundation: the second, 17 inches wide and 3 feet deep, does not pass through either of the two outer corridors for reasons which we shall afterwards give, but immediately behind or within the third row of massive stone piers which terminate the several radiating walls that carry the arches on which the marble seats were placed for the spectators.

—The third elliptical sewer, 17 inches in width, and 3 feet in depth, passes round the outer edge of the third corridor; the foundations of this sewer are as much above that which passes under the radiating walls, behind the third row of piers, as it is above the level of the outer one which follows the contour of the building beyond its foundations.

—Around the inner edge of the podium wall is an open channel deeply cut in the pavement; this with a proper current, conveys the water to numerous perforated sink-stones, whence it is again carried off by 42 small drains into the sewer of the third corridor; 48 similar drains, parallel with the radiating walls, then convey it into the second elliptical sewer behind the third range of piers.

—Twenty radiating drains, 17 inches in width, conduct it afterwards into the outer sewer which communicates with the Cloaca Maxima near the Meta Sudans.

—These several sewers and drains have a uniform, and at the same time, a very considerable fall, following the inclination of the pavement.

—The outer wall of this vast edifice is 157 feet 6 inches in height, and we observe in the brick lining of the inner face of its upper stories 160 indents, which enclose earthenware pipes 9 inches in diameter, the sectional area of each being equal to about ·44 of a superficial foot.

—These several pipes continue through the several floors, and are at last led to others which are contained within the thickness of the radiating walls, and which are directly over the middle elliptical sewer, carried round behind the third row of stone piers.

—The entire number of these perpendicular pipes, throughout the Colosseum, which fall into this sewer, is 160, and their total sectional area being ·44 × 160 = 70·40 ft., whilst the sewer they empty into has a sectional area of 4·25 feet only, or 1 ft. 5 in. × 3 ft. = 4 ft. 3 in.; the area of the pipes together being 16½ times that of the sewer.

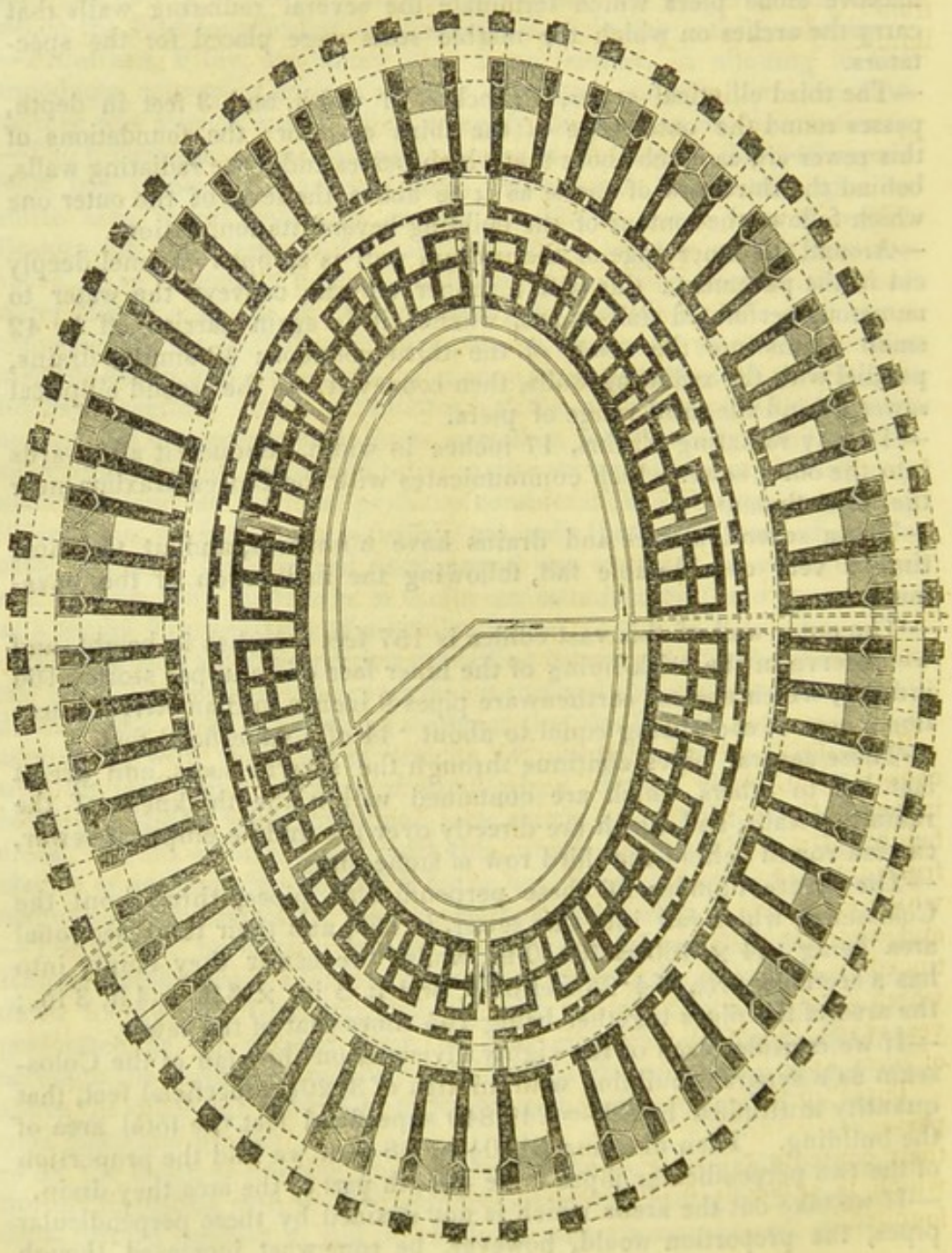
—If we consider each of the eighty divisions on the plan of the Colosseum as a separate building with an area of 3120½ superficial feet, that quantity multiplied by 80 = 249,840 superficial feet the total area of the building. Then dividing 3120½ by 88 feet, we find the proportion of the two perpendicular pipes to be $\frac{1}{35\frac{1}{2}0}$th part of the area they drain.

—If we take out the arena which is not drained by these perpendicular pipes, the proportion would, however, be somewhat increased, though

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then greatly at variance with modern practice; for instance:—209,229 superficial feet being the area of the building, after the arena or open space is deducted, if that is divided into 80 parts, we shall find about 2615 feet, or thereabouts, drained by the two upright pipes, whose united sectional area is ·88 of one superficial foot, or about $\frac{1}{300}$th part of the area of the surface they carry down the water from.

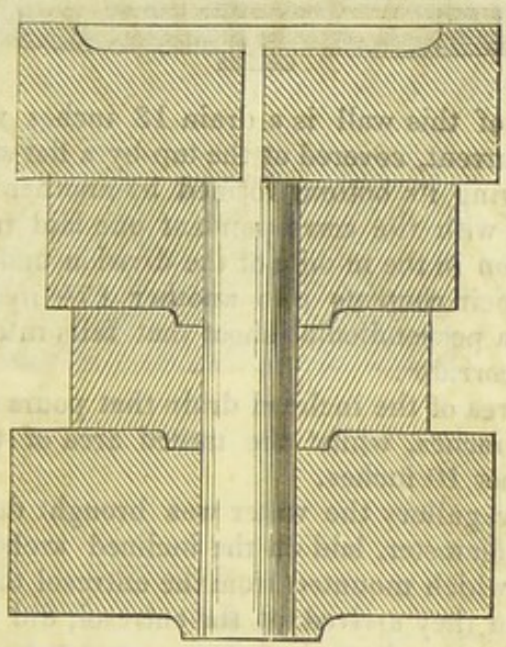
—*The Amphitheatre at Nismes* being better preserved than the Colosseum, exhibits admirably the details requisite for the drainage of its capacious elliptical area. Its total length is 437·5 feet, its width 332·5 feet, hence 437·5 × 332·5 × 7854 = 114,251 superficial feet for its entire content; an inch of rain falling upon this would produce 9,521$\frac{11}{12}$ cubic feet of water.



The arena is 226·75 feet by 125·75, hence its area is 22,394, which, subtracted from the previous sum, gives 91,857 for the area of the portion devoted to the spectators.

—The seats, which are carried from the podium wall to the very summit of the amphitheatre, are distributed into four precinctions; the whole number amount to 35, and as they all have a gentle inclination towards the edge, the water falls from them easily; these seats, being altogether in length 30,660 feet, would accommodate 23,000 spectators.

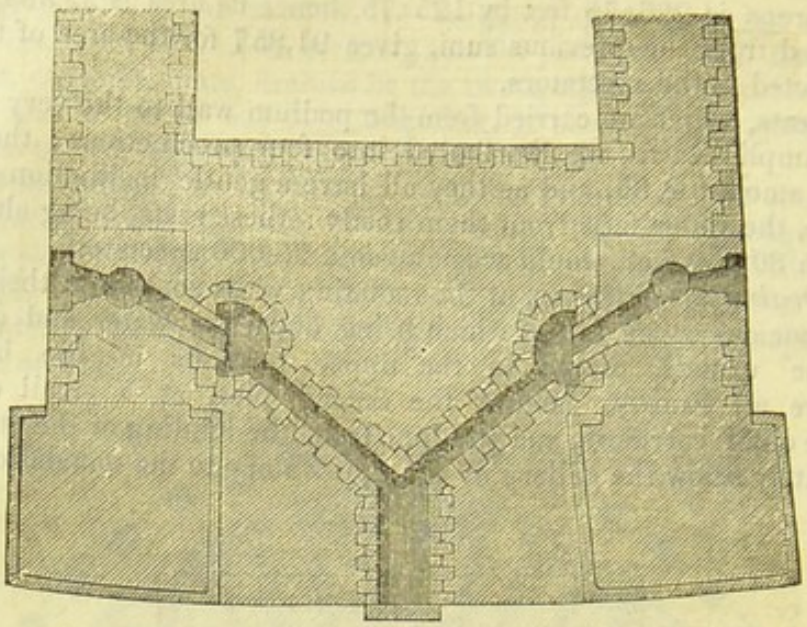
—*Its Drainage.*—Fifty-six of the radiating walls contain in their thickness capacious stone pipes, which bring down the water and drainage from the urinals, placed in the upper portions of the building. They are all situated behind the second pier, at a small distance from the outer corridors, and continue from the landing of the staircases immediately below the gallery of the upper story to the foundations.



These pipes are singular in their construction, and give evidence of considerable thought and ingenuity. Their diameter is from 12 to 13 inches in the clear, hollowed out of the middle of stones about 2 feet in height; the upper course having on its bottom bed a portion of the frustrum of a cone, about 6 inches more than the diameter of the pipe, which sinks into a recess, hollowed out of the stone below to receive it, and which is about 1½ inches deep. To what height these pipes continued originally it is not possible to determine exactly, as the stone which covers them was placed there when the building was repaired a few years ago; but there is not the slightest doubt they carried off the water of every kind from the upper portions of the building.

These 56 pipes, after receiving the water of the several urinals of the passages above, by means of another pipe considerably inclined, deliver their contents into a circular recess, about 28 inches in diameter, and which is situated in the concrete mass upon which the staircases are founded.

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—From the base of this wall is a drain 13 inches wide and 17 inches high, laid with a current, covered at the top by a flat stone of considerable thickness, and having its bottom formed by another of equal strength. This drain unites with the correspondent one laid from the next wall, making its junction in the middle of the division under the stairs; they there discharge their contents into another 17½ inches wide and 21½ inches high into a perpendicular shoot that falls into a sewer continued around the outer corridor.

—The sectional area of the inclined drain that pours its contents into the sewer is 2 feet 7 inches, whilst the united area of the two cylindrical pipes is about 1 foot 10 inches.

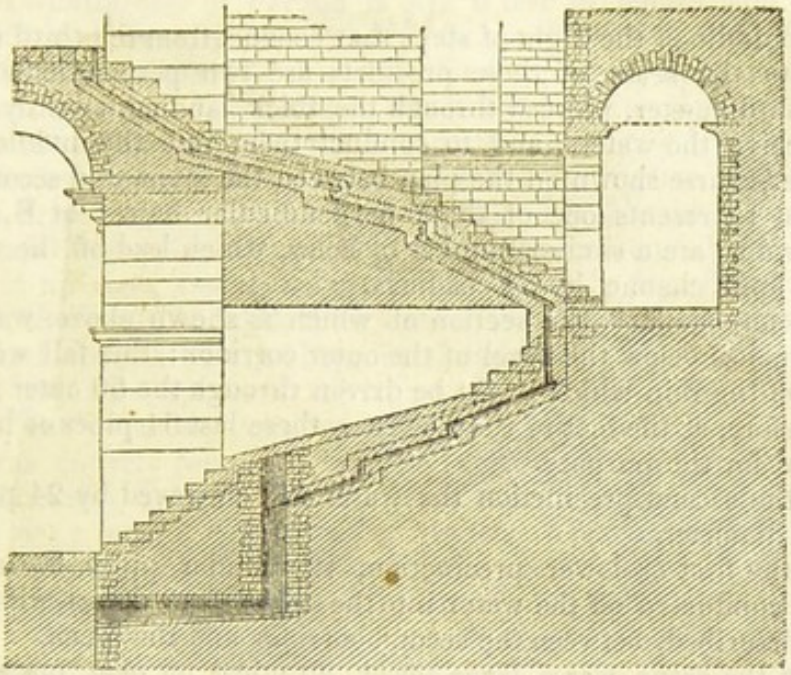
—From the upper gallery the water was brought down by 64 circular pipes 2 inches in diameter, laid on the inclined arches or ramps which carried the steps, which mounted from the entresol to this upper gallery. These pipes, when they arrived at the entresol, did not discharge their contents into the open channel of its pavement, but, after dropping at the last step perpendicularly a few feet, were continued down the arches of the lower flight of stairs almost to the outer corridor of the ground-floor, where they poured into the well made to receive the water of the 64 perpendicular pipes 13 inches diameter already described.

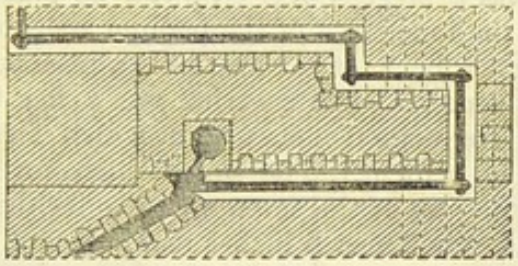
—From the bottom of the steps which led from this gallery or entresol to the vomitories of the second precinction, there were also 64 pipes 2 inches in diameter, which conducted the water into the cave or vaulted room under the flights of stairs that led from the outer corridor of the ground-floor to the entresol.

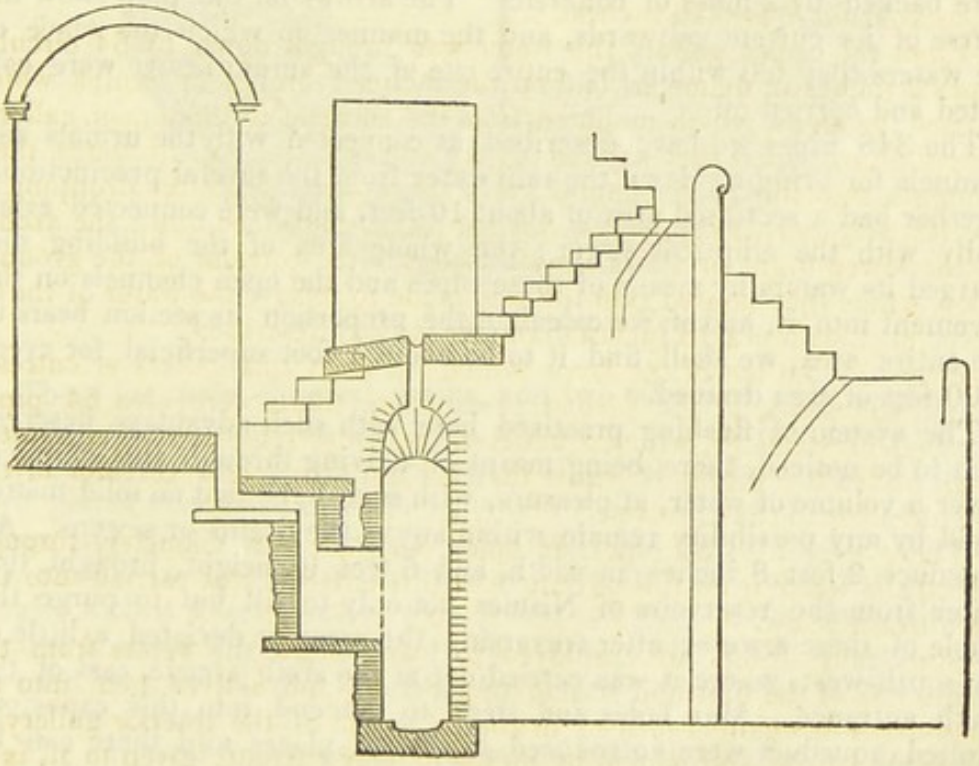
—There were also 32 pipes, or holes, an inch ⅛ in diameter, through which the water from the pavement of this entresol was carried into the open drain below.

—Sixty-four drains are employed to bring down the waters from the vomitories of the first and second precinction, and deliver them into an open drain or channel formed in the pavement of the interior gallery of the ground-floor, and which, by means of four currents given to it, is at last conveyed into the covered sewer which circumscribes the arena.

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—In the middle of the flight of steps that conduct from the third or inner corridor to the seats of these precincts are two perpendicular holes 2 inches in diameter, pierced through the thick landing, slightly dished out to receive the waters, and to conduct them into the middle of the open water-course shown on the plan between the arena and second corridor. A, represents one of these perpendicular holes: at B, on the third corridor, are a similar number of holes, which lead off the water to the same open channel by 64 channels.

—The second gallery, the section of which is shown above, was made 5 feet 5 inches below the level of the outer corridor: this fall was given to carry off the rain which might be driven through the 60 outer arcades, and, therefore, at the foot of the staircase, these last 64 pipes or holes are introduced for the purpose.

—From the second precinction the water was conveyed by 24 pipes, 3¾ inches in diameter.

—From the first or lower precinction, 12 circular pipes, 3¾ inches in diameter, conducted off the water into the channel 23 inches wide, which we have described, between the second corridor and the arena.

—Around the arena was a large sewer, elliptical on plan, placed about 7 feet 10 inches from the inner face of the podium wall, built very carefully with blocks of stone, or, as it is there called, moellon, and covered internally with a fine cement. The covering was a flag 8 inches thick, resting on a course of freestone 6 inches high, which slightly projected over the inner lining of cement. The stone which covered the sewer was nearly level, and the face of the sewer was regular throughout.

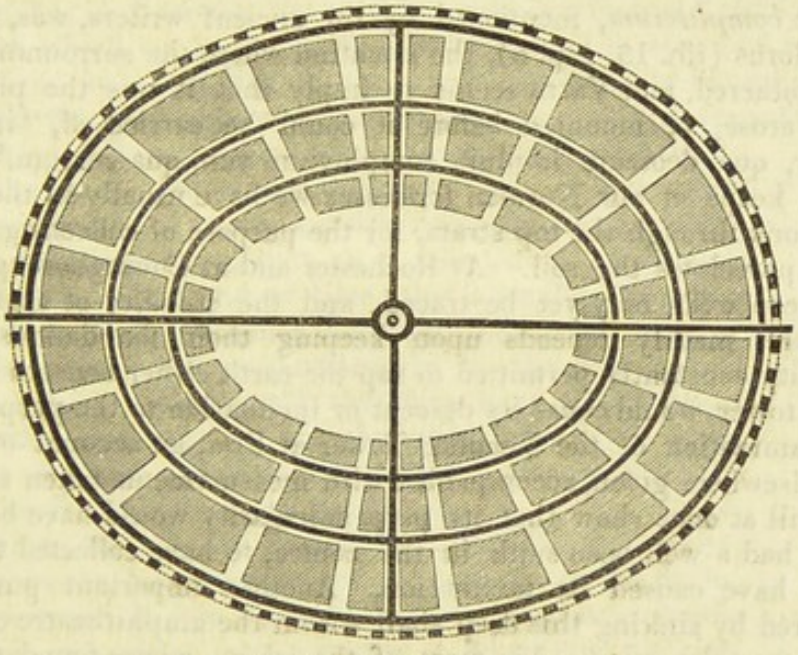
—This sewer internally was 3 feet 6 inches in width, and 4 feet 9 inches in depth, having a sectional area of 16 feet 8 inches: its side walls were 18 inches in thickness, and everywhere these, as well as its foundations, were backed by a mass of concrete. The arrows on the plan show the course of its current outwards, and the manner in which the whole of the waters that fell within the entire site of the amphitheatre were collected and carried off.

—The 348 pipes we have described as connected with the urinals and channels for bringing down the rain water from the several precinctions, together had a sectional area of about 10 feet, and were connected eventually with the elliptical sewer; the whole area of the building discharged its waters by means of these pipes and the open channels on the pavement into it, and if we calculate the proportion its section bears to the entire area, we shall find it to be about 1 foot superficial for every 7000 feet of area drained.

—The system of flushing practised here with such advantage deserves next to be noticed, there being means of driving through this elliptical sewer a volume of water, at pleasure, with such force that no solid matter could by any possibility remain within any of the drains or sewers. An aqueduct 2 feet 8 inches in width, and 6 feet in height, brought this water from the reservoirs of Nismes not only to fill but to purge the whole of these sewers; after traversing the arena it deviated a little to the south-west, where it was carried out at the sixth arcade, east of the south entrance. Man holes and steps to descend into this capacious vaulted aqueduct were introduced in several places, and there can be no doubt that by directing for some hours such a stream of water through it, the greatest cleanliness was preserved throughout all the sewers of the building.

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—*The Amphitheatre at Verona* is 502·6 feet in length, and 402 feet in breadth, and its total area 158,686·3 superficial feet. It has a well sunk in the very middle of the arena, for the purpose of drawing off the water from the various strata, upon which the building is placed; that so refined a method of rendering the substructions perfectly dry was adopted by the ancients, is evident by reference to the description left us by the Marquis Scipio Maffei, in his account of this amphitheatre: this learned writer took vast pains to examine all the sewers and drains as they existed in his time, and although he has not fully described the use of this well, there can be no doubt whatever that it served the purposes we have mentioned, as well perhaps as occasionally afforded a supply of water to the combatants in the arena; it is about 6 feet 7 inches in diameter, and of a very considerable depth; its opening in the time of Maffei was entirely concealed, and he states that it must have contributed materially to drain off the water, and to render the whole area perfectly dry; indeed, this system of drainage was very common in most of the Roman houses, such a well served as the compluvium into which the waters percolating the various strata might be gathered.



Plan of the Amphitheatre at Verona.

—There are three elliptical drains, and two others at right angles with each other, as shown on the plan, neither of which interfere with the foundations of any of the radiating or elliptical walls, except where in two places they pass under the podium wall. These drains are in no place less than 7 feet 9 inches deep, and that which extends through the middle in the longest direction is 5 feet in width, and that at right angles with it 4 feet 4 inches wide, whilst the width of the three elliptical drains is about 2 feet 6 inches on an average; the whole of them are at present very sound, and the large flat flag-stones remain at the bottom of all the greater ones.

—The elliptical drains are not connected with the largest, or that which extends throughout the axes of the amphitheatre, but unite with the drain only which traverses it at right angles. Near the well the four arms

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meet, and form a circular ring, bounded by a wall, so that should the water rise in the well it would have a ready passage in all the four directions, and be poured out beyond the foundations.

—These drains are built up with regular courses of stone, and covered with large slabs of marble, upwards of 13 inches in thickness, and many of these flat slabs are not less than 10 feet in length.

—On the outside of the amphitheatre was an arched sewer, into which all these large drains discharged themselves, which was constructed somewhat like the Cloaca Maxima, and served probably to carry off the superfluous waters from this part of the city into the Adige.

—The flag-stones which covered the drains were in many places perforated with small round holes, and could be easily taken up for the purpose of allowing them to be examined or cleansed; and at the lowest ends of those which cross at right angles, within a small enclosure, was an entrance and a flight of steps for the same purpose.

—Under the several flights of steps, and scooped out of the walls, was a recess at a convenient height, in which was laid a perforated stone, having a pipe or conduit into the drains of the corridors; these carried off the urine and water in a most perfect manner.

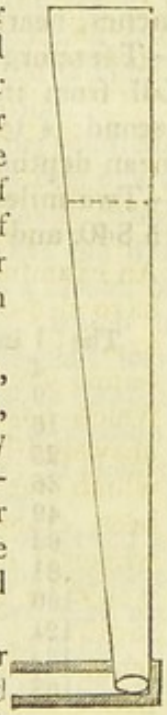
—The *compluvium*, mentioned by the ancient writers, was, according to Isidorus (lib. 15, cap. 5), the situation where the surrounding waters were gathered, and Varro seems to imply that it was the place where water arose, or mounted before it could be carried off, "impluvium dicatur, qua deorsum impluit, compluvium vero qua sursum." In the strong keeps of our Norman fortresses we have usually in the centre a shaft sunk through the top strata, for the purpose of collecting the water which percolates the soil. At Rochester and at Coningborough Castles such deep wells may yet be traced, and the stability of such weighty structures mainly depends upon keeping their foundations dry, for humidity constantly permitted to sap the earth either beneath or around a lofty tower, would cause its descent or inclination to the perpendicular. An examination of the Leaning Tower at Pisa, an account of which I have elsewhere given, accompanied with measurements taken some years ago, will at once show that its perpendicularity would have been maintained had a well been sunk in the centre, to have collected the waters which have caused its inclination. Another important purpose was answered by sinking this deep shaft within the amphitheatre of Verona, which was also practised in most of the others, whose foundations have been examined; the soil never could be saturated with any fluid, for whatever found its way upon or into it, by the leakage of the drains, would be again collected into this well, and there suffered to pass off by infiltration through a lower stratum, which, whatever might be its tenacity, could not affect a weighty building above it; no effluvia could hence be generated, or miasma arise, and the atmosphere of an amphitheatre, where such precautions were used, would be rendered comparatively pure.

—There are many sites of towns and cities on the sides of hills where the stratification inclines towards the valley below, which are damp and unhealthy from the want of similar precautions; the buildings which have the most solid and the deepest foundations being those which suffer the most injury: let us suppose the site of a city to be on the slope of a hill whose inclination is at an angle of 15 or 20 degrees, and that its soil for the depth of 30 or 40 feet is composed of gravel and sand, or

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any other, through which water freely percolates; if we sink an excavation in such a soil, all the water which flows through the entire stratum will enter this excavation and remain there, and if the drains we introduce are not low enough to carry the whole off, we have a moist and soft subsoil to sustain our future erection; a well sunk in the centre through this entire capping, and continued down to a permeable stratum, would in such a case most effectually carry off the water, and leave our foundations dry; or it would perhaps at times mount within the shaft, where it might be conducted away as we see in the amphitheatre at Verona. Great care should be used in forming the catch-water sewers and drains, which are cut at right angles with the stratification; for oftentimes, from their not being laid in deep enough, or without the precaution of sinking shafts down to the permeable strata below, the waters in their current are carried beneath them, and wash away their very foundations; this occurred to a sewer on the Ladbroke estate at Notting Hill.

How would you apply the several experiments you have recited to us, or the formula of Zendrini, Grandi, and Genetté, to the proportions of a sewer, and the drains which fall into it?—Let us commence with one pipe 3 inches in diameter, the sectional area of which is 7·0686 inches, twenty of which we have already supposed equal in area 144 inches or 1 superficial foot, and that it has a sufficient capacity to carry off the water and the drainage from a house which covers 600 superficial feet. This pipe, placed perpendicularly, is nearly 50 feet in height, and of the same diameter throughout; but as the water which passes into it at the top descends with an increased velocity, we may assume, that as it falls through a greater length, in the 2nd second of time, that a smaller diameter would suffice for that distance, and that the bore of the pipe might be diminished proportionately to the increase of velocity. Such a pipe would, therefore, have the shape of an inverted frustrum of an elongated cone, the lower diameter of which would be the sectional area upon which that of the drains must be proportioned.



—The water, after it has passed this diminished aperture, would, however, lose a portion of its velocity, if the drain, which conveyed it into the main sewer, was not properly connected, or made to form a part of it, when it would partake of the effects of the last velocity in the perpendicular pipe. If the perpendicular as well as the inclined pipe were formed in one, its diameter might be diminished throughout, proportionately to its accelerated velocity.

—But we will not suppose the form of the perpendicular pipe altered from the cylindrical, which practice has found the most convenient, but proceed to proportion the inclined drains which conduct the water from it into the sewer. Our house-drains are usually laid with a fall of an inch and a quarter to every ten feet in length; we may call this inclination 1 in every 100, or a fall of 1 foot in 100, which affords a velocity of about 13 feet in a second of time.

By what means do you establish that velocity?—I treat this subject as I would a river or canal. I should first ascertain its hydraulic mean depth, which is the quotient of the sectional area, divided by the length of the outline of the section in contact with the bottom.

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—We have already seen, that when a river flows with a uniform motion, its velocity varies, as the square roots of the hydraulic mean depth, and of the sine of the inclination jointly; and it has also been satisfactorily shown, that the mean velocity of a river, in a second, is nearly ten-elevenths of a mean proportional between the hydraulic mean depth, and the fall in two miles of 126,720 inches. If the velocity be expressed in inches, and increased by its square root, it will give the velocity of the surface; if diminished by its square root, the velocity at the bottom. It, however, appears that the velocity increases a little more rapidly than the square root of the fall.

—Mr. Watt has detailed, in one of his experiments, the velocity he found in the waters of a canal, whose width at top was 18 feet, at bottom 7 feet, and 4 feet deep, and which had a fall of 4 inches to a mile.

—He found the velocity at the top was 17 inches in a second.

,, ,, in the middle 14 ,, ,,

,, ,, at the bottom 10 ,, ,,

The mean velocity being 13 inches in a second.

—To ascertain the hydraulic mean depth, we must divide the area of the section $2\ (18 + 7) = 50$ by the breadth of the bottom, and length of the sloping sides, added together, whence we have $\frac{50 \text{ feet}}{20 \cdot 6}$ or 29·13 inches, and the fall in two miles being 8 inches, we have $\sqrt{8 \times 29 \cdot 13} = 15 \cdot 26$, for the mean proportional, of which ten-elevenths is 13·9 inches, nearly agreeing with Mr. Watt's observation.

—Therefore to find the velocity of a river or sewer from its fall, or the fall from its velocity, we have only to remember that the velocity in a second is ten-elevenths of a mean proportional between the hydraulic mean depths and the fall in two miles.

—Two miles or 126,720 inches, divided by 8, gives us a fall of 1 in 15,840, and with this fall we find a velocity of 13·9 inches in a second.

	Inches.		Inches in a Second.		Velocity.
The	1 inch fall in	15,840 producing a velocity of	13·9	we will call	1
4	,,	,,	27·8	,,	2
9	,,	,,	41·7	,,	3
16	,,	,,	55·6	,,	4
25	,,	,,	69·5	,,	5
36	,,	,,	73·4	,,	6
49	,,	,,	97·3	,,	7
64	,,	,,	111·2	,,	8
81	,,	,,	125·1	,,	9
100	,,	,,	139·0	,,	10
121	,,	,,	152·9	,,	11
144	,,	,,	166·8	,,	12
169	,,	,,	170·7	,,	13

Though in the above table 144 inches rise in 15,840 is not quite 1 in 100, it is the nearest for our purpose of comparison; its velocity being 12, or at the rate of 166·8 inches in a second; we shall therefore, from it, assume that our ordinary drains, with a fall of 1 in 100, have a velocity of something more than 13 feet in a second.

—If we draw up another table, in which we consider the fall of 1 foot in 100 as the minimum, we shall obtain the following results:—

						Velocity.
1 foot fall in	100 feet,	gives a velocity of	13 feet	in a second,	which is	1
4	,,	,,	26	,,	,,	2
9	,,	,,	39	,,	,,	3
16	,,	,,	52	,,	,,	4
25	,,	,,	65	,,	,,	5
36	,,	,,	78	,,	,,	6
49	,,	,,	91	,,	,,	7
64	,,	,,	104	,,	,,	8
81	,,	,,	117	,,	,,	9
100	,,	or perpendicular	130	,,	,,	10

—If then a perpendicular pipe, with an area of 7·0686 inches, discharged itself into a drain, laid with a fall of 1 in 100, its sectional area, by the above rule, ought to be 70·686 inches; a barrel-drain 9½ inches diameter, therefore, which contains 70·8823 superficial inches in its sectional area, would be sufficient for the purpose; for the perpendicular pipe, having ten times the velocity, would discharge 130 feet, whilst the drain was only pouring out 13 feet, therefore the necessity of increasing the dimensions of the latter in proportion.

—If we consider that the diameter of the 3-inch perpendicular pipe is in effect diminished, towards the bottom, to 2 inches, the sectional area of which is 3·1416 inches only, and that the same velocity is continued through the drain that connects it with the sewer, that it is virtually but one pipe, then an area of 31·416 inches, or a pipe of 6·3 inches in diameter, might be found sufficient.

—If the 3-inch perpendicular pipe descended at once into the sewer, we might, without difficulty, take its sectional area, and proportion a sewer to any number of them; but as there are usually several drains more or less inclined, it is necessary to take their fall into consideration.

You have stated that when water descends through a perpendicular pipe, its volume assumes the form of an inverted cone, does this operate beneficially, or otherwise, in keeping the pipe clear?—In many cases, I have observed, when the perpendicular pipe, which conveys the water from the roof of a house, is used also as the soil-pipe to a closet, that the lower portion of it has been coated with a deposit, which has lessened in thickness towards the top; the water in its descent losing volume, it has passed through the middle of the pipe, without cleansing its sides, therefore I have thought, that a slight gradual diminution in the bore of a soil-pipe, would be serviceable to cleanliness; as then the fluids passing through it would be obliged to scour the sides.

In the aqueducts constructed by the Romans, have you observed any other precautionary arrangements for cleansing them?—In the aqueducts, we observe the perpendicular grooves, in which metal doors were made to slide up and down, for the purpose of obtaining a head of water, that could be used to force forward by its weight any impurities that were deposited at the bottom of the water-course.

—The aqueduct at Lyons remains sufficiently perfect to show us that the Romans could carry water down a hill, across a valley, and make it rise on the other side, by pressure only; also, that they knew how to collect any deposit that fell from it in its course, where it would most accumulate. When the fall of a stream is only four-hundredths of a foot for every hundred feet, as in some aqueducts, it was absolutely requisite to have a method of purifying their channels.

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—The aqueduct at Lyons at once suggests to us the means of driving the contents of a lowly situated sewer forward, and causing them to mount to a higher level; where an ordinary velocity might be obtained.

NOTES AND TRANSLATIONS REFERRED TO.

Dissertation on Torrents by J. B. D. C. D. G.

I come now to the propositions of Guglielmini, in which he pretends that a body descending an inclined plane will not acquire a velocity greater than it would have acquired by descending perpendicularly the height of the inclined plane.

This is most true as respects solids. The elements of a solid being bound and tied together, form a heavy mass, the parts of which press each other reciprocally, and the pressure on the plane, on which they rest, is likewise single, as also is the direction; one velocity, one energy and one action being common to all the parts. On the other hand, a fluid is a mass composed of lesser solid elements, but free, and not bound together by any ties, each of which can, so to speak, move in different directions and with varying velocities, press upon each other and oscillate freely. Whence the highest parts press upon the lower, oscillate, and are easily displaced when there is no impediment. When solids descend by a plane, their individual gravity alone operates; which being less than their absolute gravity, generates, at each instant, a degree of velocity less than that which their absolute gravity would have generated, wherefore solids require a longer time to descend by the inclined plane than by the perpendicular; the length of time multiplies the action of the individual gravity, and compensates for the defect of the velocity. Wherefore a solid descending by an inclined plane has a velocity equal to what it would have, falling the same height directly. Hence the product of the action of the individual gravity, by the time of the descent by the inclined plane, being equal to the product of the absolute gravity, by the time of the fall along a perpendicular, their velocities must necessarily be equal. But in fluids the case is different. Besides the properties which they possess in common with solids, they have another, to wit, the pressure exercised by the upper on the lower part of the fluid, the which being added to the impact, increases the motion also, and hence generates a greater effect than a solid would. Neither is it absurd to suppose that the gravity of a fluid generates a greater velocity on a plane than when acting perpendicularly, since this generates in greater time, and with a portion of gravity which in a solid which falls remains, so to speak, idle, but in the case of a fluid, becomes active. John Bernouilli, in his works, gives a problem to find the velocity generated by a body sliding on the hypothenuse of a triangle, whose base is sustained by a smooth horizontal plane, free from any sensible friction, and moving in the direction of the base. He decomposed the force pressing the hypothenuse, or inclined plane, into two parts, one of which is employed in giving motion to the triangle, and sliding it forward; whilst the body descends on the plane, advances the triangle, and communicates thereto a certain rate of velocity; the descending body thus requires a velocity equal to that which it would have in falling perpendicularly, and the triangle has another force generated by that which presses it, whence it results that the sum of the two motions is greater than that which a body would acquire by its simple descent. Wherefore, since the aforesaid force by pressing generates velocity and motion distinct from that which a body, in descending, generates; in like manner it is applicable to water pressing on the lower films, and by pressing, communicating additional force to them. Besides, there are other reasons corroborative of this truth, among which is the fact, that it is necessary to spread the accelerated velocity of water passing from a larger to a narrower section over a mean of pressure.

Galileo says, "I have been carefully considering and going through various problems to investigate the acceleration of water having to pass through a narrower channel, also whether it has the same declivity in both." The greater number of authors solve the point by increasing the height of the water, and hence the pressure, thus generating a greater velocity. Eustace Manfredi thus expresses himself:—"The same water passes through a lesser as through a greater section, wherefore it is forced to pass with a greater velocity, precisely as will be the case in a vase in which the surface of the water may be at a certain height above the summit of the aperture." Guglielmini, to the same effect:—"The upper parts press the lower, and oblige them to receive a force, which being compelled to act, produces the same degree of velocity which the descent would have given them." We might quote other authors, who account for the increased

velocity in narrower sections by having recourse to the pressure generated by the height of the upper parts, only they are in doubt on this subject, whether to attain so great a velocity it be necessary that the upper water should increase in height till it becomes stationary; not being able to believe that the upper water which is in the act of running is capable of producing a new increment of velocity in the lower. But experience teaches us that if the breadth of a section be diminished one-half, the water will not rise that half, as would appear necessary; if the velocity does not increase, it increases at least very little, either in section or at the base, where the reduced sections are of the same breadth, since the water retained by the narrowing of the piers of a bridge is but slightly raised. Wherefore it is necessary that the velocity increase without having regard to any new inclination, which is always the same, but only by an increase of height which causes a pressure on the lower water which is in the act of running, whence I deduce the argument to strengthen my opinion in the case in which the velocity, arising from the inclination, is equal or greater than that which might have been generated by the pressure. Let us take two cases, one which allows the same measure of water to pass through one section twice as little as the first preserving the same inclination, the other in which the velocity increases till it becomes twice as much.

But whence comes such an increase of velocity? what is the principle, what the nature of it? To say with Genneté, that twice the quantity of water doubles the velocity, is not to adduce a proof but to advance a mere assertion, which either supposes or requires it. I do not think that a true philosopher will perceive in the increment of so much water the principle of so great an acceleration. It behoves us to examine the genesis of such a phenomenon, and to observe the mechanism which nature adopts therein. And, firstly, two epochs of time are to be distinguished, one the first perceptible moment in which the section is reduced to half. Now, at this first instant, the water must swell and rise much above its first level, in which rise it generates a proportional velocity. But in the very act in which such a velocity is generated, the water begins to fall, wherefore the present case holds good, that the sections are in reciprocal proportion with the velocity. The water does not fall in this manner, wherefore it returns to its first level, or a little higher, there being a constant principle which compensates for a portion of the velocity destroyed by successive obstacles. Water in its course meets with continual resistance which diminishes its force, wherefore there remains in the water a constant principle which supplies and renews any decrement of velocity which the resistance may produce. Now this principle is, that whatever small increase of height above the original level causes pressure causes also velocity. Arrived at which point the water maintains the same height, which I have elsewhere designated equilibrium and constant state. Observers have not paid attention to the first epoch in which the water swells, is agitated, balances itself, but only have considered the other in which it acquires equilibrium, state, law. All this takes place so quickly that the swelling, sinking, and equilibrating hardly are evident to our perceptions. If, as I believe, the experiments of Genneté were true, according to which a river doubles or triples its water without raising its level, then it would be correct to say that it was free from any sensible resistance. This might be the case in an artificial river of short length, over a level bottom with smooth sides, and furnished with clear water. But in a natural and turbid stream, where the resistance, and that considerable, will never be wanting, it is not likely that when reduced to half its original section, it preserves its former level. This being determined, to come to the question above proposed, I resolve it thus:—Either the velocity begins to increase by the water beginning to swell, or the whole mass increases. If the first takes place, then the height being small, and hence the pressure being likewise small, the velocity generated will be also small. It is not that so small a velocity is added to so great, which it derives from an inclination, contrary to the sentiment of S'Gravesand. If the second takes place, it being then the velocity which increases, is equal to, or is less than that which results from an inclination, and not having any other generating principle than the pressure, it is clear that it acts when the velocity which generates itself is less or equal to that which was before generated by the inclined plane. Now I repeat, therefore, that the water as it strikes the bottom presses the lower films which run, spread out upon it, by which the pressure is communicated from above downwards. I agree with what Manfredi says, that "all the lower strata of water may be regarded as so many bottoms, or actual planes, with regard to the upper planes which run upon them. Hence these fluid planes are sensible of the same pressure of running water which they would sustain if it were stationary at an equal height." To me it appears an incontestable truth that water which presses the bottom should press all that portion by which the pressure is

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communicated, otherwise if it does not press all that which forms the middle, it will never arrive at the bottom of it, which is contrary to all experience. If this bottom be of a curved form, concave towards the water, the pressure will have the action of a centrifugal force, the which conspiring with the former, will increase the momentum, and thereby its energy and velocity.

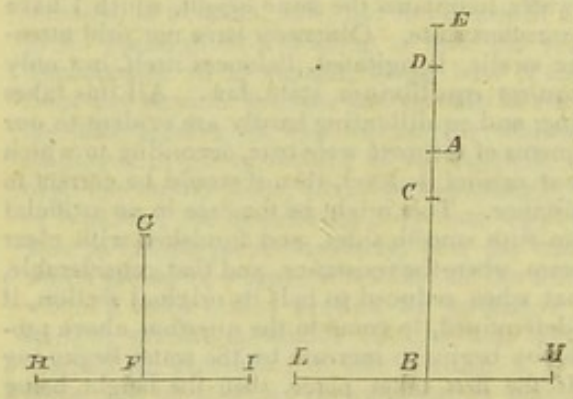
BERNARDINO ZENDRINI, della Città de Ravenna.—*Delle acque Correnti.*

CHAPTER VI.

Of the Union and Division of Running Waters, with the Laws of their Increase and Diminution.

I. A river which unites with another does not cause this latter to rise in proportion to the quantity of water which it brings, as would be the case supposing water to be considered as a solid, but only increases the height by as much as the greater or less velocity of the influent or recipient may permit. On the contrary, if a river in the middle of a canal be diminished by a certain quantity of water, it ought to be lowered proportionally to the velocity of the canal of derivation and the river from which the water is abstracted, and such an alteration ought to be perceived not only at the lower part at the point where the water is added or subtracted, but also in the upper. In which law, however, there is much obscurity; what appears certain is, that both in the case of the union and of the separation that the surface continually adapts itself to the alteration in a regular progression, and although the impression arising from such an anomaly does not disturb the whole level of the river if it runs over a long course, it reduces the problem to find the point where the disturbed mixes and unites with the undisturbed surface after following the oscillation of the water, which point in geometric rigour ought to traverse the whole length to the source of the river, since it would describe a regular curve; but the course of the water encounters so many impediments and obstructions, that these laws do not really obtain. And in every river there is, in fact, a point beyond which the regurgitation does not take place. That, however, as much as possible, we shall treat of in another chapter, when speaking of the falls of rivers, of their highest rise and lowest levels.

For the present it will be sufficient to seek the elevation or depression which will be produced in a river by the addition or subtraction of a quantity of water.



II. Suppose A B to be the height of a recipient previous to the influx of another stream, let L M be its width in a given section, F G the height of the influent stream before the union, H I its width. Supposing this latter introduced into the recipient, it ought to experience a certain rise. What will that rise be? Since the additional water ought to conform to the width of the section of the recipient, conceive the height F G of the influent altered to that of the recipient A E, then the water of the one will have passed into the other, and since this fresh water presses upon the other, that of the recipient will be obliged to lower its surface, and from the point A will be brought down to C; likewise the point E will pass to D and E D = A C, and consequently B D will be the entire height of the recipient after the addition of the influent water. Calling A B = d. A E = x = C D. B D = z. F G = b. H I = a. L M = c. The velocity of the recipient before receiving the influent, u. Its velocity after having received it, but before it could exercise any pressure and reduce it to equilibrium; that is the same which it would have if the water of the influent ran in the width of the recipient = t, the velocity which the recipient really has after the union and after the waters have equilibrated in their course = q, and finally the velocity which the influent had in its own level before the union = r. Then since the two masses of water of the influent and recipient in a given and equal time can pass separately in the level of the recipient, they ought to be able to pass together through the aforesaid recipient. Hence the equation $d\,u + t\,x = q\,z$ and $z =$

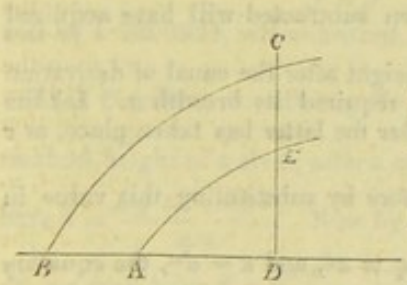
$\frac{d\,u+t\,x}{q}$ first general formula; now since equal masses of water pass in equal time both through the influent separately and through the aforesaid influent when reduced to the width of the recipient, we shall have $c\,t\,x = a\,b\,r$, whence $x = \frac{a\,b\,r}{c\,t}$ and $z = \frac{c\,d\,u + a\,b\,r}{c\,q}$ the second general formula expressing the whole height B D; wherefore A D, which is the whole increment produced by the influent above the first state of the recipient will be $\frac{c\,d\,u + a\,b\,r - c\,d\,q}{c\,q}$.

III. *Corollary* 1.—If the velocity be a mean proportional to the height, we shall have A D $= \frac{d\sqrt{d} + x\sqrt{x} - d\sqrt{z}}{\sqrt{z}} = z - d$, which reduces itself to $z = \sqrt[3]{(d^3 + 2\,d\,x\sqrt{d\,x} + x^3)}$ and A D $= \sqrt[3]{(d^3 + 2\,d\,x\sqrt{d\,x} - x^3)} - d$, in which $x = \frac{b\sqrt[3]{a\,a}}{\sqrt[3]{c\,c}}$, as is obtained by substituting in the formula $c\,t\,x = a\,b\,r$, the values of t and r, which are $\sqrt{x}$, $\sqrt{b}$, which value of x substituted for that of t, will give the value of A D.

IV. *Corollary* 2.—On the supposition of Castelli and of Barattieri, that the velocity will be as the height, we shall have $z = \sqrt{\left(d\,d + \frac{a\,b\,b}{c}\right)}$ and A D $= \sqrt{\left(d\,d + \frac{a\,b\,b}{c}\right)} - d$.

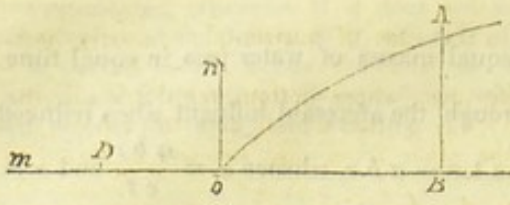
V. *Corollary* 3.—And consequently if $u = d^m - r = b^n\,q = z^\phi$ where m, n, ϕ are numbers which may be integers or fractions expressing any power of the height by the velocity, we shall have the general formula $z = (d^{m+1} + a \times c^{-1}\,b^{n+1})^{\frac{1}{\phi+1}}$, in which x being already eliminated, it only remains to substitute the values of d, a, c, b, taking the aforesaid exponents as fixed, supposing $z\,d$ unknown, the aforesaid formula will give the general equation of the whole curve of the increment of the river by the addition of the other stream, the abscissa of which will be z, the ordinate d, or more generally making $u = d^{\frac{m}{p}}$, $r = b^{\frac{n}{p}}$, $q = z^{\frac{\phi}{p}}$, we shall have $c\,z^{\frac{\phi+p}{p}} = c\,d^{\frac{p+m}{p}} + a\,b^{\frac{p+n}{p}}$, and that $z^{\phi+p} = \left(\frac{c\,d^{\frac{p+m}{p}} + a\,b^{\frac{p+n}{p}}}{c^p}\right)^p$, and we shall be able to determine the relation of z to d in the following manner:—

Let $d^{\frac{p+m}{p}} = b^{\frac{m}{p}}\,y$; now $d^{p+m} = b^m\,y^p$; we shall have $z^{\phi+p} = \left(y + \frac{a\,b^{\frac{n+p-m}{p}}}{c}\right)^p \times b^m$. Construct the curve A E expressed by the equation $d^{p+m} = b^m\,y^p$. Take B A $= a\,b^{\frac{p+n-m}{p}}$, and from the point B describe another curve, which has for its equation $z^{\phi+p} = \left(y + \frac{a\,b^{\frac{n+p-m}{p}}}{c}\right)^p \times b^m$, we shall have D E $= d$, C D $= z$, and the intercepted portion C E will be the increment required.



VI. *Scholium* 1.—In the simplest case of the velocity in proportion to the height, using the first formula of the preceding corollary, change this into $d\,d = z\,z - \frac{a\,b\,b}{c}$, the

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equation of the equilateral hyperbola b A, of which as well as the parameter $b\ n$ as the diameter $b\ m = \frac{2\,b\,\sqrt{a}}{\sqrt{c}}$, wherefore D B will be the height after the union of the water, and B A the height which the recipient will have on first receiving it. And by the properties of the equilateral hyperbola, the square of B A being equal to the rectangle B $m \times b$ B, that is, to the difference of the squares D B, D b, we shall have analytically $d\,d = z\,z - \frac{a\,b\,b}{c}$, which is the equation proposed; whence appears the method of describing such an hyperbola, so as to contain every possible case of increment arising from an addition of water. And calculating with the second formula the two parabolas of the preceding corollary, we shall have $d\,d = b\,y$, B A $= \frac{b\,a}{c}$, and $z\,z = b\,y + \frac{b\,b\,a}{c}$; and if for $b\,y$ we substitute its equivalent $d\,d$, we shall have $z\,z = d\,d + \frac{b\,b\,a}{c}$, the equation which is found and constructed above.

VII. *Scholium* 2. If the velocity is as the root of the height, the equation resulting from the first formula of § V will ascend to the sixth dimension of the unknown quantity, and the progression will be $c^4\,z^6 - 2\,a^2\,b^3\,c\,c\,z^3 + a^4\,b^6 - 2\,c^4\,d^3\,z^3 - 2\,a^2\,c^2\,b^3\,d^3 + c^4\,d^6 = o$, which does not transcend the limits of a cubic equation; but with the second formula $\frac{m}{p} = \frac{n}{p} = \frac{\phi}{p} = \frac{1}{2}$ we shall have $z^3 = \left(y + \frac{b\,a}{c}\right)^2 \times b$; and supposing $d^3 = b\,y^2$, A E will be the parabola expressing the aforesaid equation, and B C that of $z^3 = \left(y + \frac{b\,a}{c}\right)^2 \times b$, without otherwise embarrassing itself in the resolution of the aforesaid equation, already sufficiently complicated.

VIII. The converse proposition to § II. deduced from the formula there enunciated, which gives the height of a river from which a quantity of water is deducted, to find the section of a canal, such as shall discharge the same quantity of water, and whose height B D shall descend to B A. The equation $c\,q\,z = c\,d\,u + a\,b\,r$ is then changed into $a\,b\,r = c\,q\,z - c\,d\,u$, which solves the problem. Let it be required to diminish it by such a quantity of water as may have to the first, before the subtraction, the ratio of l to p, whence we shall have the analogy $c\,q\,z : c\,d\,u :: l : p$, by making $r = b^n$, and $u = d^m$, we have $b = \left(\frac{c}{a} \times \frac{l-p}{p} \times d^{m+1}\right)^{\frac{1}{n+1}}$ whence we deduce the height of the canal of deduction $d = \left(\frac{a}{c} \times \frac{p}{l-p} \times b^{n+1}\right)^{\frac{1}{m+1}}$ formula, which denotes the height which that river from which the water has been subtracted will have acquired after such deduction.

If the water of a river be diminished by a given height after the canal of derivation be opened, and the height of the effluent b is noted, required its breadth a. Let the first height before the deduction be to the second, after the latter has taken place, as e to f; hence $z : d :: e : f$; whence $z = \frac{d\,e}{f}$. Therefore by substituting this value in the general formula, since we have already $r = b^n$, $q = z^\phi$, and $u = d^m$, the equation will be reduced to the following; $a = c\,\frac{e^{\phi+1}\,d^{\phi+1} - f^{\phi+1}\,d^{m+1}}{f^{\phi+1}\,b^{n+1}}$, in which a and d are the unknown quantities, and c, f, b, z, the given quantities; or else, if a certain breadth be given, and the height remains unknown, we shall have $b =$

$\left(c\frac{e^{\phi+1}d^{\phi+1}-f^{\phi+1}d^{m+1}}{af^{\phi+1}}\right)^{\frac{1}{n+1}}$. Now in the case of horizontal, or nearly horizontal streams, the canal of derivation being open, whose bottom regulates also the height of the water of the river; that is to say, the portion which acts to produce the greater or lesser quantity which it deducts, the other remaining inactive in regard to such a canal of derivation, the formula will be $d=\left(\frac{e}{f}\times\frac{c\,z^{\phi}}{a+c}\right)^{\frac{1}{n}}=b$.

IX. *Corollary* 1.—In the second formula of the preceding paragraph let $m=n=1$ we change it to $d=b\times\sqrt{\frac{a\,p}{c\,l-c\,p}}$ in which if $l=4000, p=3500$, numbers expressing the quantity of water which passes through a given section of the river both before and after the subtraction of the water, $b=10$ feet, $a=200$ feet, $c=300$ feet, performing the proper operation, the logarithm of $d=1\cdot3345034$ answering to $21\frac{122841}{262031}$. The value of the first height before the diminution will be $z=\frac{d\sqrt{l}}{\sqrt{p}}$, where d being known, all the other quantities will be known also, and will be $23\frac{8858}{924117}$ feet.

X. *Corollary* 2.—Making $m=n=\frac{1}{2}$, which is the case of Torricelli, Mariotti, and others, transmuting the aforesaid second formula into $d=b\sqrt[3]{\frac{a\,a\,p\,p}{c\,c\,(l-p)^2}}$, and $z=\frac{d\sqrt[3]{l\,l}}{\sqrt{p\,p}}$, substituting the proper quantities and placing the values of the quantities l, p, b, a, c, as above, the logarithm of $z=1\cdot4846658$, the number to which is $30\frac{75446}{142405}$, from which it appears that if the river be lowered by the water, diminished by the effluent so that the first height shall be to the second after the diminution as $23\frac{8858}{924117}$ to $21\frac{122841}{262031}$, the quantity which passes through a given section below the point of diminution, before the water is subtracted, will be to the quantity which passes through the same section after the water is subtracted as 40 to 35 in the first case, and the height in the second case as $30\frac{75446}{142405}$ to $27\frac{146407}{137942}$.

XI. *Corollary* 3.—Taking the third formula of the preceding paragraph, in which we have supposed e, f, d, b, c given, making $n, \phi, m=1$, by the hypothesis of Castelli, let us seek the width of the canal of derivation. We shall have $a=\frac{c\,d\,d}{f\,f}\times\frac{(e\,e-f\,f)}{b\,b}$. Suppose $e:f::9:8$, $d=20$, $b=18$, $c=300$, the logarithm of $a=1\cdot9929051$, corresponding approximately to the number 98, of so many feet will be the width of the canal of derivation, that the first height may be to the second, after the water is diminished, as 9 to 8; but on the supposition that $m, n, \phi=\frac{1}{2}$, will be the formula changed to $a=\frac{c\,d\sqrt{d}}{f\sqrt{f}}\times\frac{(e\sqrt{e}-f\sqrt{f})}{b\sqrt{b}}$, and the logarithm nearest to a will be $1\cdot8900925$, whose nearest number, 78, will be the width required.

XII. *Corollary* 4.—Using the general formula, $z=\frac{c\,d\,u+a\,b\,r}{c\,q}$, to obtain the residual height of a river, after a certain quantity of water has been subtracted, we shall have $d=\frac{c\,q\,z-a\,b\,r}{c\,u}$. Now by substituting for q, r, u, their respective values $z^{\phi}, b\delta, d^m$, we shall have $d=\left(\frac{c\,z^{\phi+1}-a\,b\,\delta^{\phi+1}}{c}\right)^{\frac{1}{m+1}}$; if then ϕ, δ, m will be equal each to $\frac{1}{2}$, we shall have the equation,

$$d^3-\frac{2\,a^2\,b^3\,d^3}{c^2}+z^6-2\,d^3\,z^3-\frac{2\,a^2\,b^3\,z^3}{c^2}+\frac{a^4\,b^6}{c^4}=0.$$

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Or if, for greater simplicity, we reduce it to the following expression, $d = \sqrt[3]{\left(z^3 - \frac{2zcx^3\sqrt{bz}}{abb} \times x^3\right)}$; and since $x = \frac{b\sqrt[3]{aa}}{\sqrt[3]{cc}}$, we shall have—

$$d = \frac{1}{b}\left(\frac{\sqrt[3]{cc}z^3 - 2cabz\sqrt{bz} + aab^3}{\sqrt[3]{cc}}\right).$$

XIII. *Corollary* 5.—Using the preceding formula, in which we have constructed two parabolas, according to what has there been laid down,

$$c\,d^{\frac{p+m}{p}} = c\,z^{\frac{\phi+p}{p}} - a\,b^{\frac{p+n}{p}}, \text{ and thence } d^{\frac{p+m}{p}} = z^{\frac{\phi+p}{p}} - \frac{a\,b^{\frac{p+n}{p}}}{c}$$

now $d^{p+m} = \left(z^{\frac{\phi+p}{p}} - \frac{a\,b^{\frac{p+n}{p}}}{c}\right)^p$, and making $z^{\frac{\phi+p}{p}} = b^{\frac{m}{p}}\,y$ we have, making the necessary substitution $d^{p+m} = \left(y + \frac{a\,b^{\frac{p+n-m}{p}}}{c}\right)^p \times b^m$. Now let B C be the curve whose equation is $z^{\phi+p} = b^m\,y^p$. Take B A $= \frac{a\,b^{\frac{p+n-m}{p}}}{c}$, and from the point A describe another curve A E, expressed by the equation $d^{p+m} = \left(y - \frac{a\,b^{\frac{p+n-m}{p}}}{c}\right)^p \times b^m$, we shall have D E $= d$, C B $= z$, and C E the required difference of height.

XIV. *Scholium* 1.—We shall give some examples of the fall of the surface of rivers, produced by derivative canals, as they have been called, and these examples will be taken from the Adige, which, as is known, affords many such, and on which I had cause, at various times, to make several observations for its general regulation. It was found,

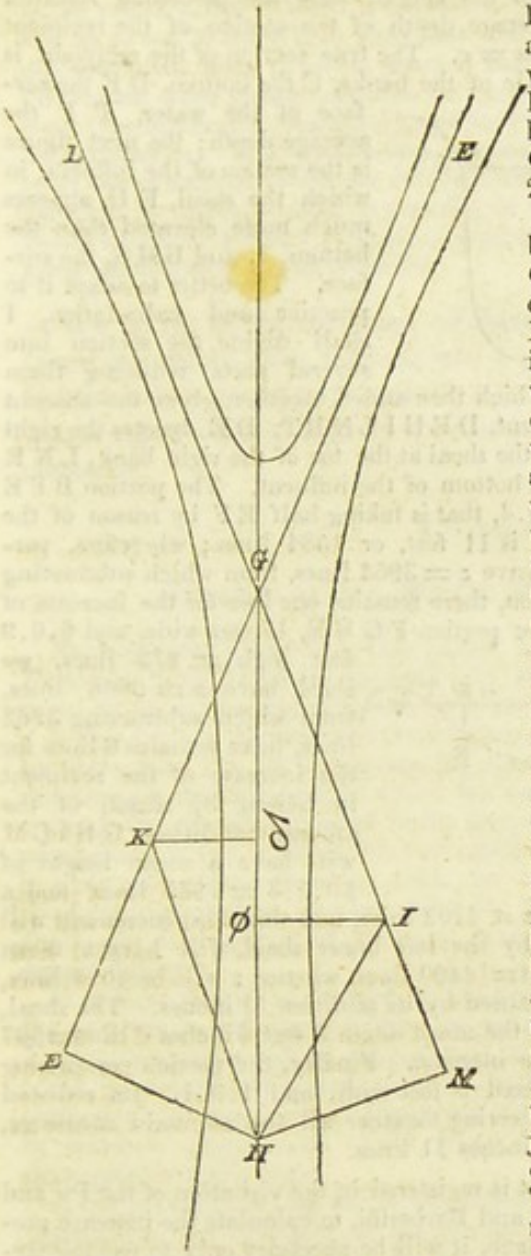
1st. That the Bova della Badia, in flood time, measures 10.7.4 Venetian feet, or 1528 lines, above the sill; a its breadth is 12½ feet, or 1800 lines. The reduced height of the Adige, opposite it, at flood time, was 11.3.1, or 1621 lines, being 402 feet wide, or 57888 lines; now by a preceding rule, § VI., in which we supposed the velocity as the height, having $x = \frac{b\sqrt{a}}{\sqrt{c}} = 269$, and consequently $d = \sqrt{(zz - xc)} = 1598$, which being subtracted from the height of the Adige before the diminution, there remains 23 lines, that is, 1 inch 11 lines for the required diminution.

2nd. At the mouth or sluice of the Sabbadina we found that z = 19.1.11, or 2759 lines; b = 9.2.11, or 1231 lines; a = 27½ feet, or 3960 lines; c = 2280 feet, or 30210 lines, whence x = 554 and $d = \sqrt{(zz - xx)} = 2703$, which, deducted from 2759, the first height gives 56 lines or 4⅔ inches.

3rd. At the sluice of the New River, when it was of wood, it was found that z = 10.8.4 = 1480 lines, b = 4.10.8 = 704 lines, a = 60 feet = 8640 lines, c = 318 feet = 45792 lines, and x = 305, and d = 1448, giving 2⅔ inches for the diminution of the Adige.

4th. At the Fossa Bellina, which is the lowest of the derivatives with respect to the sea, it was found that z = 10.11.8 = 1580 lines, b = 4.4.2 = 626 lines, a = 60 feet = 8640 lines, c = 258 = 37512 lines. Whence x = 301 and $d = \sqrt{(zz - xx)} = 1531$, which, subtracted from 1580, leaves 29 lines for the diminution of the Adige, that is 2 inches and 5 lines.

5th. But at Castagnaro, which is the first and farthest from the sea of all, it was found that z = 14.2.10 = 2050 lines, b = 1491 lines, a = 35064 lines, c = 95040 lines; dimensions taken above the two falls on each side of the Cunetta, which remains in the middle, the result of which, calculated separately, will be x = 950 lines and d = 1816 lines, a sum which diminished by 2050 lines, leaves 234 lines, or 1.7.6, for the diminution of the Adige at flood-tide, by reason of the diversion, which the two falls are able to produce on each side of the Cunetta. Calculating, then, the diminution



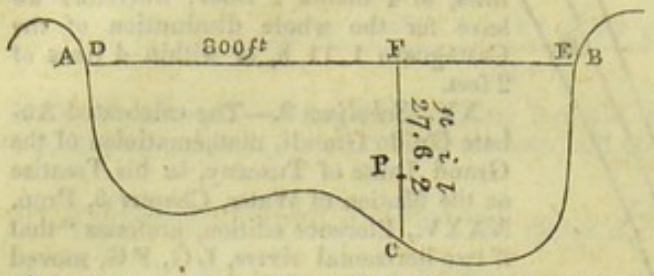
of this, we have $z = 2050$ lines, $b = 2127$ lines, $a = 3816$ lines, $c = 95040$ lines, as above, whence d = nearly 2000 lines, which, subtracted from 2050, leaves 50 lines, or 4 inches 2 lines; wherefore we have for the whole diminution of the Castagnaro 1.11.8, or within 4 lines of 2 feet.

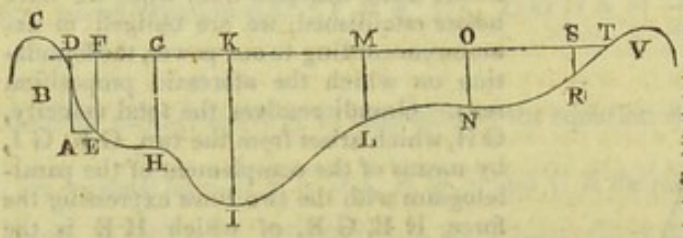
XV. *Scholium* 2.—The celebrated Abbate Guido Grandi, mathematician of the Grand Duke of Tuscany, in his Treatise on the Motion of Water, Chapter 5, Prop. XXXV., Florence edition, professes "that if two horizontal rivers, L G, F G, moved with a velocity, I G, G K, be united in one trunk, whose velocity and direction will be G H; and, on the other hand, supposing the said trunk, H G, has the velocity H G, it ought, with the retrograde motion, to divide itself into two branches, G L, G F, they will not regain the velocity, I G, K G, equal to the first, unless the angle, L G F, be a right angle," the which being different from what we have before established, we are obliged to examine, according to our power, the foundation on which the aforesaid proposition rests. Grandi resolves the total velocity, G H, which arises from the two, G K, G I, by means of the complement of the parallelogram with the two lines expressing the force, H E, G E, of which H E is the perpendicular let fall on G K produced; but if conversely, says he, the trunk, H G, be resolved into branches, whose velocity shall not be the same, as on entering the trunk it may be greater or less, and will only be equal in the case when the angle, L G F, is a right one. The direction of the velocity, G H, resulting from the conjunction of the two laterals, G I, G K, is exactly what all staticians have laid down. To have a clear proof: on the line G H raise the perpendiculars, K δ, I ϕ, and the velocity G K will be obtained, resulting actually from the two, G δ, δ K, and the velocity, G I, in the two others, G ϕ, ϕ I, of which K δ, ϕ I, nowise contribute to the progressive motion, but only G δ, G ϕ, then G δ + G ϕ are equal to G H, as is more easy to demonstrate; then each quantity denotes really the velocity with which the water in the trunk moves after receiving the influents, and it is to be noted that the prevalence of one perpendicular, K δ, above the other, I ϕ, will only oblige the branch to bend a little from its course. Wherefore the illustrious author then considers the converse of the proposition, that is, when the trunk passes into the branches, to resolve the velocity, H G, into two, H E, E G, and says, that in G F the water will run with the velocity, G E, greater by the acute angle than G K, the which will be true, whatever bend and through whatever arm, G E, all the water of the trunk may flow, whilst H G does not express all the velocity, the same quantity not going through G E which did when G F was considered as an influent, it results that H G ought to resolve itself in another shape than that which is the case, that is, considering G ϕ by the velocity G I, and G δ by the velocity G K, whence the original velocity, G K, G I, in the two canals respectively will be precisely restored, now reputed as different branches, G F, G L; whence the conversion of the influents into diffluents will not change the velocity; in either case it will be retained, provided it be not changed by any external circumstance.

XVI. *Scholium* 3.—I think it will not be superfluous to give an example of the increase of height which a river really acquires from the reception of another. We will

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suppose the velocity a mean proportional of the height, using the preceding formula $z = \sqrt[3]{(d^3 + 2dx\sqrt{dx} + x^3)}$. The average depth of the section of the recipient $= 3962$ lines $= d$ its breadth 115200 lines $= c$. The true section of the recipient is figured, in which A and B denote the profile of the banks, C the bottom, D E the surface of the water, P F the average depth; the next figure is the section of the influent, in which the shoal, E H, appears much more elevated than the bottom, I, and B M S, the surface. The better to adapt it to practice and calculation, I shall divide the section into several parts, reducing them one by one to the section of the recipient, which then added together, gives the amount of increase. In the section of the influent, D E H I L N R T, D E denotes the right bank, R T V the left, E H the bottom of the shoal at the toe of the right bank, L N R the bottom on the left bank, and H I L the bottom of the influent. The portion B F E must be considered of the mean height 3.0.4, that is taking half E F by reason of the triangle, B F E or B A E; the base, B F, is 11 feet, or 1584 lines; wherefore, performing the necessary operation, we shall have $z = 3963$ lines, from which subtracting 3962 lines, the average height of the section, there remains one line for the increase of that portion, B F E. Likewise through the portion F G H E, 17 feet wide, and 6.0.9 feet high $= 873$ lines, we shall have $z = 3968$ lines, from which subtracting 3962 lines, there remains 6 lines for the increase of the recipient in height by reason of the aforesaid addition. G H I L M will have a mean height of 13.5.3 $= 1935$ lines, and a width of 126 feet $= 18144$ lines, whence $z = 4102$ lines, and this third increment will be 11 inches 8 lines. M L N O, formed by the left lower shoal, will have a mean height of 1333 lines, and width of 100 feet$=$14400 lines, whence z will be 4026 lines, and the height required for the increase caused by its addition $5\frac{1}{3}$ inches. The shoal, O N S R, is 26 feet$=$3744 lines wide, and the mean depth 3 feet 6 inches 3 lines$=$507 lines, and $z = 3966$, giving 4 lines for the increase. Finally, the portion comprising the escapement of the bank may be considered 8 feet wide, and 1.9.1. Its reduced height not giving any sensible increase, collecting together all the aforesaid measures, we shall have the total increase of 1 foot 5 inches 11 lines.





XVII. *Scholium* 4.—According to what is registered in the visitation of the Po and Reno, made in 1693, by Cardinals d'Adda and Barberini, to calculate the increase produced in the Po by the addition of the Reno, it will be necessary only to use the preceding formula, as likewise to find the same effect at the general visitation of 1720. Taking the data of 1693 aforesaid, supposing the average height of the Po without the Reno at Lagoscuro 31 feet$=$372 inches, the height of the Reno at the pass of Annegati, that is $b=9$ feet$=$108 inches; the width of the Reno there 189$=a=$2268 inches; the width of the Po at Lagoscuro 760 feet $= c=$ 9120 inches, where $x = 3$ feet 6 inches, $d^3=51478848$; $2dx\sqrt{dx}=3906000$ and $x^3=74088$ numbers, which added together make 55458936, whose logarithm is 7.7439015, which divided by 3, to obtain the cube root, gives log. 2.5813005, the number to which is $381\frac{3745}{10381}$; and since the fraction answers to 4 lines, if 372 is subtracted from 381.4, there remains 9 inches 4 lines for the increase required according to the aforesaid supposition.

XVIII. *Scholium* 5.—In a report presented by Guglielmini at the time of the visitation, and which was registered in the Acts of it, and printed in the Florence Collection, in which he calculates the rise at 8 inches 9 p. only, but the difference between us arises from his having taken the nearest numbers, neglecting fractions. Eustace Manfredi, in his answer to Giovanni Ceva, says, in reply to the other proposition, "To say truly we shall find that the $9\frac{3}{8}$ inches found by Ceva, is one inch more than what results from the former calculation of Guglielmini, and that by a small error of a fraction," &c.—See Manfredi's Notes to Guglielmini's book on the Nature of Rivers.

XIX. *Scholium* 6.—In all the above examples we have supposed, for the calculation

of the velocity, that it is either a direct or mean proportional to the height of the water, and so as not to differ from what has been laid down frequently by many renowned authors; and, also, to give a proof of the manner of employing the formula we have discovered, when greater precision is required, the velocity must be found by an instrument (the hydraulic pendulum), and the formula used which we have given in a preceding chapter. It is possible that in some cases we may not be able to employ the rules above referred to for the velocity without making great errors; thus, to seek out the truth as unequivocably as possible, in cases of much importance it is well to calculate by many different methods, observing the difference resulting from each to determine afterwards the most probable.

—We have, in the writings of Zendrini, much more that is highly interesting upon this subject, but I will now lay before the Honourable Commission another translation taken from Guido Grandi, which also treats upon rivers, and is particularly valuable for the information it contains.

Guido Grandi.

Treatise on the Motion of Water.—Book 2, cap. 5.

Proposition XXXVII.—Our author has taken considerable pains to construct a Parabolic table, given in his work; by a reference to which, much labour will be saved by those who desire to make similar investigations, he thus describes it:—

"This table is divided into three columns. The first containing a natural series of numbers from 1 to 1800, representing equal parts, as inches or other measures. These numbers are the heights from which the water falls. The second column contains the roots of the opposite numbers in the first, and expresses the velocity of the water, corresponding to the height in the first column, in integers and decimals; when the root is somewhat greater than the truth, the sign + is prefixed, and when less —. The third column contains the product of the first and second, and must be read off as exceeding or falling short of the truth, according as the sign + or — is prefixed to its second factor.

It is clear that if the numbers of the first column express the height of a parabola, the numbers in the second will be its ordinates, when its *latus rectum*, or parameter, is 1, or at least, they will be proportional to the ordinates in subduplicate ratio of unity to the *latus rectum* of a given parabola, and the numbers in the third column will be the rectangles circumscribing the parabola which has unity for its *latus rectum*, and will be moreover proportional to the area of the parabola, which is always $\frac{2}{3}$rds of the circumscribing rectangle.

If the parabola has $2\frac{1}{4}$ for its *latus rectum* in terms of the first column, all its ordinates are to the ordinates of the parabola of the same height, having 1 for its *latus rectum*, in subduplicate ratio of $2\frac{1}{4}$ to 1, that is, as $1\frac{1}{2}$ to 1, or as the circumscribed rectangle to the parabola, it is clear that the parabola whose *latus rectum* is $2\frac{1}{4}$ will be equal to the rectangle which circumscribes the parabola whose *latus rectum* is unity; but such a rectangle is equal to the product of the base by the height, which is the number opposite in the third column, therefore the numbers in the third column express the area of a parabola whose *latus rectum* is $2\frac{1}{4}$, and is proportional thereto when the *latus rectum* is any other quantity.

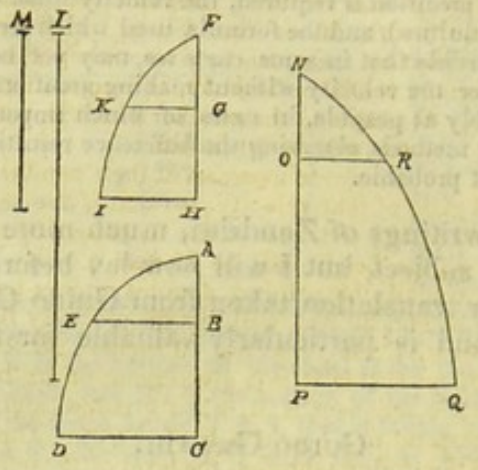
Moreover, since the numbers in the first column express the height of water standing in a vessel, or the distance of each particle of running water above its base, and the numbers in the second column representing the velocity caused by such a height, the numbers in the third column express the quantity of water which will issue through such a width in a given time, through a hole or section whose height would be equal to the whole distance from the surface of the water or origin of the river, and the base of such a section, as the number in the first column.

The difference of numbers of the third column will be the quantity of water which escapes in an equal time through a hole or section of equal breadth, and of a height equal to the difference of the corresponding numbers of the first column.

By adding two or more numbers together of the third column we shall have the sum of the quantity of water carried in a given time through several canals of the same width, whose sections correspond to the numbers of the first column; and the aggregate of such numbers, or the nearest thereto, in the third column will correspond to that

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number in the first, which indicates a height capable of comprising the channels united, as will be better understood by the following examples:—



1st. Given two streams, the breadth of the first of which is L = 760 feet. The velocity of the surface B E, corresponding to the fall A B of 1 foot (which, according to Guglielmini's table, is equivalent to 216 feet 5 inches per minute, that is, $3\frac{3}{4}$ feet in a second, or $2\frac{3}{4}$ miles per hour), the height of the surface B C = 30 feet, whence A C 31 feet; then the whole parabola A E D C, according to the third column of our table opposite 31 feet, will be found 7175·88, from which substracting the parabola A E B, which is found in our third column to be 41·52, the parabolic trapezium B E D C will be 7134·36, and this will be the scale of the velocity of the section B C, which multiplied by the breadth L gives a quantity of water = 542211360.

The second stream having a width M=139 feet, its superficial velocity will be G K, depending on the height F G, 8 inches (which gives, by Guglielmini's table, a velocity of 176 feet in a minute, rather less than 3 feet in a second, and 2 miles 56 perches in an hour). The height of its surface G H is 11 feet, and consequently F H 11 feet 8 inches, corresponding in our third column to the value of 1656·20 for the parabola F K I H, from which subtracting the parabola F K G, which our table gives opposite 8 inches as 22·64, there remains the trapezium G K I H 1633·56, which is the scale of the velocity of the second stream, which, multiplied by the width M, gives the quantity of water passing in a given time through this river = 227064·84; whence, the two quantites carried by both the rivers will be 5649178·44. Supposing they flow together, without increase of velocity, B E = O R; and let the height O P, at which the united water runs, be the unknown quantity, then since O N = B A through R, and with the axis N P, describe the parabola N R Q P, the truncated parabola O R Q P will be the scale of the velocity of the united rivers, which multiplied by L = the sum of the two quantities = 5649178·44, which divided by L gives a quotient 7433·13 = the parabolic trapezium O R Q P, and adding the parabola N R O = 41·52, we shall have the parabola N R Q P = 7474·65, the nearest number to which in the table is 7464·28 corresponding to a height of 31 feet 10 inches. This number sought being rather more than the tabular value, it will be found by proportional parts that $\frac{1}{3}$ must be added. Therefore N P = 31 feet $10\frac{1}{3}$ inches, and O P = 30 feet $10\frac{1}{3}$ inches; therefore the union of the streams raises the level B C $10\frac{1}{3}$ inches.

But if, at the conflux of the rivers, the velocity B E augments, becoming O R, so that the height N O depending on it exceeds A B by 1 inch, the parabola N O R, corresponding to a height of 13 inches, will equal 46·93, which, added to the trapezium R O P Q, found previously to be 7433·13, we shall havs the total parabola N R Q P = 7480·06, the nearest number to which, 7464·28, corresponding to 31 feet 10 inches; but since this is rather too little, we must add $\frac{1}{2}$ for the proportional part of the difference, whence N P = 31 feet $10\frac{1}{2}$ inches; from which N O = 1 foot 1 inch, being subtracted, there remains O P = 30 feet $9\frac{1}{2}$ inches, making the total increase in this case $9\frac{1}{2}$ inches.

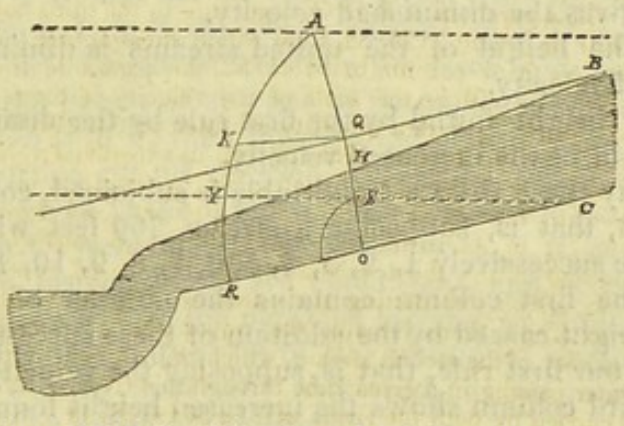
But if we suppose with Guglielmini, and which is not improbable, according to actual observation, that the scale of the velocity in a given section is an an entire parabola and not a truncated one, the velocity, as in the case of vessels, depending only on pressure, whence the surface alone acquires velocity when it is communicated by the lower

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water, which transports it; the calculation will then be more quickly effected. Wherefore A C = 30 feet, the height of the first river, and F H = 11 feet, height of the second. The parabola A E D C = 6829·20 in our table, which, multiplied by the width L, 760 feet, gives for the quantity of water 5190192·00, and the parabola F I H = 1516·68, which multiplied by the width M = 139 feet = 210818·52, whence the sum =5401010·52, which, divided by the width L, gives, when the velocity of the surface is not increased, the parabola N Q P = 7106·59, corresponding to a height of 30 feet 10 inches, corresponding in the table to the number 7118·80, which is rather more than the preceding; wherefore the rise will be 10 inches.

Then if the velocity of the two rivers increases at their confluence, the height will be reduced in the reciprocal ratio of that velocity; so that if the velocity be increased $\frac{1}{100}$, the height will be reduced to 30$\frac{1}{2}$ feet, that is, the increase will only be about 6 inches; if the velocity increases $\frac{1}{25}$, the height will be 29 feet 8 inches; so that the height, in place of increasing, will actually be reduced about 4 inches by the union of the two streams; so likewise the height, 30 feet, will remain precisely the same when the velocity is increased by $\frac{1}{36}$, since 37 : 36 : : 30 feet 10 inches : 30 feet.

Example 2.—The influent C B D R in a given point of its bed has the height O H, having a free influx into the recipient R M, when it is low, and its superficial velocity in H is what would correspond to a height A H of 4 feet. Then, raising the level N S of the recipient, regurgitation follows through the level of the influent. It is required to find the increase in the height O H = 7 feet? Suppose it to increase as far as Q, draw the parabola A K R. with its ordinates H Y, Q K; let O S, cut off by the prolongation of the level of the recipient, = 3 feet; the whole height A O will be 11 feet, and by the table the parabola A O R = 151668; the other, A H Y, 4 feet high, will be 332·64;



whence the trapezium H Y R O will be the scale of the velocity, and the quantity of water passing in a given time through the section H O = 1184·04. If the parabola S P O be 3 feet high, its value in the table = 216·00; then by the preceding Prop. XXXVI., the parabolic trapezium Q K Y H, being equal to the aforesaid parabola S P O, will be 216·00, which substituted from the total value of A H Y, there remains the parabola A Q K = 116·64. This number not being precisely to be found in our table, find the next highest, = 117·60, which corresponds to a height of 2 feet; whence we arrive at the conclusion that the regurgitation at the point O has raised the water 2 feet more than the first, supposed to be 4 feet.

—To facilitate the practical application of the principles contained in Grandi's proposition, the following rules will be found convenient:—

—The height and width of the section of both the influent and the recipient being given in each case and their velocity being equal.

—1. When the velocity of the united streams is the same with that of each separately, to find the increased height of the united section.

—Find in the table the parabolic value in the third column corresponding to the given height of the recipient in the first. Multiply this value by the given width. Perform the same operation for the influent, we shall then have obtained the quantity of water brought down by each. Add these two quantities together. Divide their sum by the width of their united section, which may be either that of the influent, or of the

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recipient, or greater or less than either. Find the quotient obtained by such division in the third column of the table, opposite to it in the first will be found the height of the united sections.

—2. When the velocity of the united streams is increased to find the height of the united section.

—Divide the height found by the preceding rule by the number of times by which the velocity is increased, the quotient is the height of the united sections.

—3. When the velocity of the united streams is diminished, to find the height of their united section.

—Multiply the height found by our first rule by the number of times by which the velocity is diminished, the product gives the required height.

—4. When the height of the united streams remains the same, to find their increased velocity.

—Divide the height as found by the first rule by the original height, the quotient will give the increased velocity.

—5. When the height of the united streams is increased, to find their velocity.

—Divide the height found by the first rule by the increased height, the quotient gives the diminished velocity.

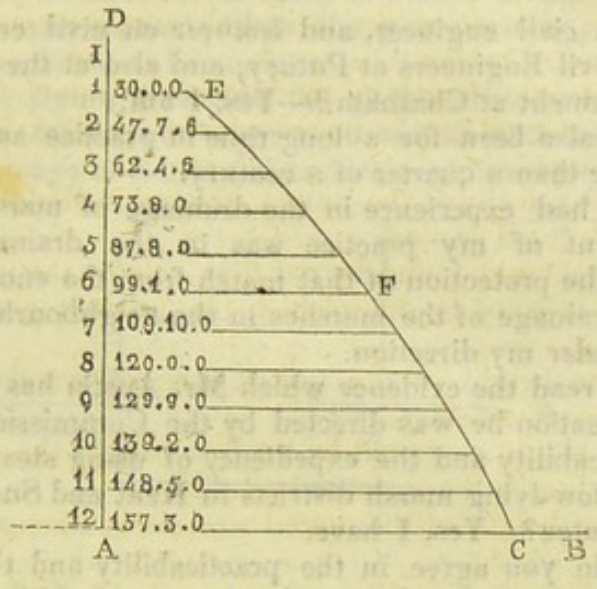
—6. When the height of the united streams is diminished, to find their increased velocity.

—Divide the height found by the first rule by the diminished height, the quotient will be the increased velocity.

—To exemplify these rules a small table is subjoined, constructed from Grandi's data, that is, supposing a stream 760 feet wide and 30 feet high to receive successively 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, similar influents. The first column contains the number of influents; the second, the height caused by the addition of these successive streams as calculated by our first rule, that is, supposing the velocity to remain the same; the third column shows the increased height found by Genneté, the original height, 30 feet, being here increased by the addition of $\frac{1}{48}$, $\frac{2}{48}$, $\frac{3}{48}$, &c. The fifth column shows the increased velocity requisite to produce the height shown in the third; thus supposing a stream 760 feet wide and 30 feet high to receive two other similar streams, the increased height, according to Genneté, will be 30 feet 7 ,, 6 inches, and to produce such a height the required velocity will be 1·97233. Either of these numbers is deducible from the other by one of the preceding rules; thus, supposing the height 30 feet 7 ,, 6 inches to be given, and the velocity to be required, by Rule 5, dividing 62 feet 4 ,, 6 inches by 30 feet 7 ,, 6 inches we obtain a quotient of 1·97233. Supposing, on the other hand, the velocity 1·97233 to be given, we obtain the height by Rule 2, since 62 feet 4 ,, 6 inches ÷ 1·97233 = 30 feet 7 ,, 6 inches. The fourth column shows the increased velocity required to maintain a constant height of 30 feet, and is found by Rule 4.

—It is found that the several increments of either height or velocity are as the ordinates of a parabola whose axis is divided into the same number of parts as there are required velocities. Hence an elegant method of finding the intermediate heights or velocities when the two extremes are given. Suppose, for example, we require to find the several heights indicated in our first column. Find the height required

for twelve streams by our Rule 1. Draw A B, and from a scale of equal parts set off 157 feet 3 inches from A to C, at A erect a perpen- No. 24. E. Cresy, Esq.



dicular A D to A B, and set off twelve equal parts thereon, and draw through the points 1, 2, 3, &c., lines parallel to A B, on the parallel 1 E, set off the first height 30 feet from the same scale as A C. Then by Rule 1 find the height of any one of the intermediate streams, as 6. and set it off from 6 to F, then through the points E, F, C, describe a parabola, the portion cut off on each ordinate by the curve will be the several numbers given in the table as measured by the scale from which 1 E, 6 F, and A C, were taken; the abscissæ 1, 2, 3, &c.. may be set off by any scale, provided they are equidistant, and according as they are wider or narrower, will the parabola increase or diminish its curvature. It is evident that in the case of 100 additional streams the labour of calculation will be materially shortened, as no more than three values need ever be found arithmetically.

—In like manner either of the other values shown in our table may be represented parabolically. Column 5, for example, by setting off 1·34203 on 1 E, 4·33793 on A B, 3·04897 on 6 F, and describing a parabola through those points.

No. of Streams.	Increased Height for a Constant Velocity.	Height as given by Genneté.	Velocity to maintain a Constant Height.	Velocity to produce Genneté's Height.
	Ft. In. '	Ft. In. '		
1	30 „ 0 „ 0	30 „ 0 „ 0	. .	. .
2	47 „ 7 „ 6	30 „ 3 „ 9	1·58475	1·34203
3	62 „ 4 „ 6	30 „ 7 „ 6	2·07916	1·97233
4	75 „ 8 „ 0	31 „ 3 „ 0	2·52222	2·42133
5	87 „ 8 „ 0	31 „ 10 „ 6	2·92222	2·75032
6	99 „ 1 „ 0	32 „ 6 „ 0	3·30277	3·04897
7	109 „ 10 „ 0	33 „ 1 „ 6	3·66111	3·31572
8	120 „ 0 „ 0	33 „ 9 „ 0	4·00000	3·55555
9	129 „ 9 „ 0	34 „ 4 „ 6	4·32500	3·77454
10	139 „ 2 „ 0	35 „ 0 „ 0	4·63888	3·97618
11	148 „ 5 „ 0	35 „ 7 „ 6	4·94722	4·66081
12	157 „ 3 „ 0	36 „ 3 „ 0	5·23333	4·33793

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William Ranger, Esq., C.E.

You are a civil engineer, and lecturer on civil engineering at the College of Civil Engineers at Putney, and also at the Royal Engineering Establishment at Chatham?—Yes, I am.

You have also been for a long time in practice as an engineer?—Yes, for more than a quarter of a century.

Have you had experience in the drainage of marshes?—Yes; the commencement of my practice was in the drainage of Pevensey Marsh, and the protection of that marsh from the encroachment of the sea. The drainage of the marshes in the neighbourhood of Worthing have been under my direction.

Have you read the evidence which Mr. Austin has given in relation to the examination he was directed by the Commissioners to make as to the practicability and the expediency of using steam power for the relief of the low-lying marsh districts in Kent and Surrey from sewage and storm water?—Yes, I have.

How far do you agree in the practicability and the expediency of such a mode of relief?—I agree in the practicability of the relief by steam power; I agree also in principle as to its expediency; I believe it is the only principle on which relief for the district may be obtained; but I have not yet sufficiently considered the detailed arrangements proposed, nor is it necessary to express an opinion upon them.

Will not the principle of the application of steam power for the purpose, give the advantage of relieving that district or any similar district from the necessity of draining directly into the river, or into the river at all?—Certainly.

Have you read the evidence in relation to the sizes of sewers and house-drains in general use in the several sewer districts in the metropolis?—Yes, I have.

How far do you concur in the general statements of Mr. Phillips, Mr. Roe, and others on that topic?—There can be no doubt that there can be no more water go out of a house than goes into it, the discharge cannot surpass the supply, and we have the means of ascertaining pretty accurately the supply of rain as of pipe-water, and that these justify no such sizes as are used.

Will you be so good as to state your view as to the possible economy of construction?—The grounds upon which I object to any extension of the present system of conducting drainage works of the metropolis are three-fold.

—1st. That of the Commissioners proceeding in a mode alike repulsive to nature and science.

—2nd. That of their proceeding with *permanent* and *costly* constructions in lieu of acting upon a defined principle.

—3rd. The incurring an unnecessary and worse than useless expense, without accomplishing any one of the following objects:—

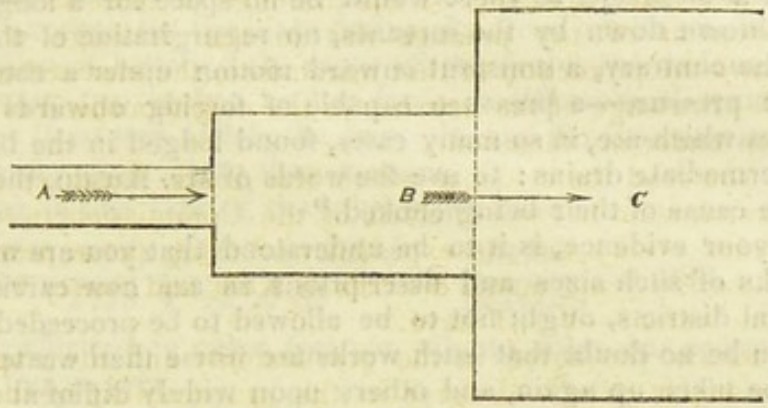
1st. The securing a perfect drainage from every class of buildings at a reasonable and bearable cost.

2nd. Efficient drainage maintainable only by a supply and use of water from other sources than those emanating from the interior or roofs of the buildings.

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3rd. That of employing a minimum quantity of water to accomplish a maximum effect; the object itself being twofold, viz., to force forward any sediment proper to be admitted into the sewers, and dilute the gases evolved, at least those which are found to be noxious.

—The annexed figure illustrates the progressive increase at present given to pipes, drains, and sewers connected with each other, and used in the drainage of courts (where drainage is employed):—

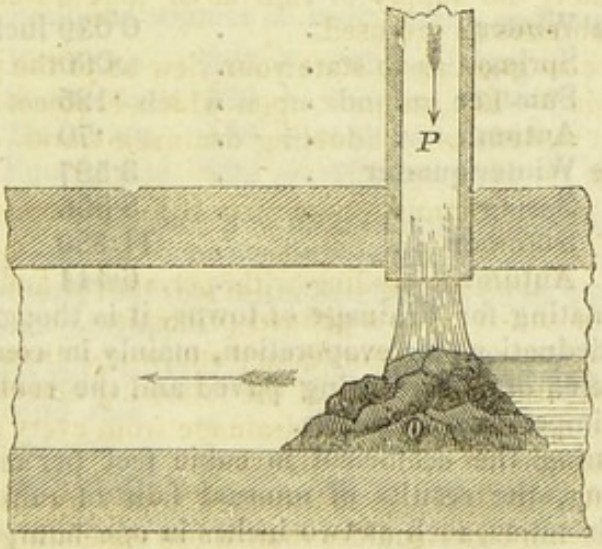


A, denotes the drop or soil-pipe.
B, the intermediate drain between A and C.
C, being the common sewer.
A, is 3-inch drain.
B, is 9-inch ditto.
C, is 2 feet 2-inch ditto.

And the chief, if not the only reason assigned for making B, the intermediate drain, 9 inches diameter, is that of preventing its stopping or choking.

—That the size of the drain tends to prevent its choking, is an erroneous opinion, it having directly a contrary effect; as is well known to artificers employed from time to time in removing obstructions.

—In a majority of cases, the soil or drop-pipes terminate just within the introdos of the drain, and at right angles thereto, as per annexed figure in section—



P, drop-pipe.
O, denotes the obstruction.

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That obstruction arises from the servants throwing down the water-closets rags and dish-cloths, is beyond dispute, those being the articles found at the position shown in the diagram; and forming a nucleus for other substances, which necessarily go on accumulating until the drain is choked.

Now, if we suppose the drop-pipe elongated, so as to reach the sewer with a proper curve in lieu of angles which ought always to be avoided where it diverges from a vertical, there would not only be no possible chance of a stoppage, as there would be no space for a lodgement of articles thrown down by the servants, no regurgitation of the waters, but, on the contrary, a constant onward motion under a considerable hydraulic pressure—a pressure capable of forcing onwards the very substances which are, in so many cases, found lodged in the bottoms of these intermediate drains: to use the words of Mr. Austin, their "very size is the cause of their being choked."

From your evidence, is it to be understood that you are of opinion that works of such sizes and descriptions as are now carried out in the several districts, ought not to be allowed to be proceeded with?—There can be no doubt that such works are worse than waste, and will have to be taken up again, and others upon widely different principles applied. Going on in any one district without a general survey ought not to be permitted, even on the chance of getting right by accident.

—By the present Building Act, at the instigation of architects, houses and buildings are classed under four separate heads, the test being in the number of *squares* contained upon plan, one square containing 100 superficial feet.

—Thus any house or building containing from 1000 to 1400 square feet in area are called "First rate." From 600 to 1000 square feet, "Second rate"; from 400 to 600 square feet, "Third rate;" and under 400 square feet, "Fourth rate."

—The sewage in towns may be considered as emanating from three sources: 1st, rain-water from roofs; 2nd, from yards and areas; 3rd, water supplied to interior of houses.

—The average quantity of rain falling in England, being taken at 36 inches, or ·098 inches per day, and the evaporation according to Howard,—

In Winter	0·039	inches per day
Spring	·090	,,
Summer	·125	,,
Autumn	·70	,,
or, In the Winter quarter	3·587	,,
Spring	8·856	,,
Summer	11·580	,,
Autumn	6·444	,,

—But in estimating for drainage of towns, it is thought expedient not to make any deductions for evaporation, mainly in consequence of the yards, areas, &c., of houses being paved and the roofs in most cases covered with impervious materials.

—In determining the coefficient in cubic feet per minute from each rate of building, the results of unusual falls of rain have not been adopted, for instance, such as two inches in one hour, for two reasons. First, in cases of an extraordinary fall, the gutters to roofs are capable

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of holding the excess over an ordinary fall until it can be passed into and downth e stack pipes.

—And I think it would be unwise to increase the sectional areas of the sewers and drains to meet an unusual case: particularly when the doing so would materially increase the aggregate and permanent expense.

—I should prefer making chambers in the areas at the head of drains to receive any possible excess in quantity beyond that taken in determining the coefficient; such a mode would, I conceive, not only reduce the expense for the main drains, &c., to a minimum, but would have the effect of assisting the scour of the drains themselves.

—In adopting two inches, as the basis, a difference of opinion may exist, but as it.no way affects the principle, and for the reasons already stated, I prefer adhering to that measure.

—According to this view of the subject, we have

$$\frac{(10 \times 12) \times (10 \times 12)\,2}{1728 \times 12 \times 60} = \frac{28800}{1244160} = \cdot 023$$

for c, the coefficient in cubic feet per minute, from one square or 100 superficial feet in area.

—Taking each class of buildings at the greatest allowable area, we have for the

First rate	$14\,c =$	$14 \times \cdot 023 =$	0·323
Second rate	$10\,c =$	$10 \times \cdot 023 =$	0·230
Third rate	$6\,c =$	$6 \times \cdot 023 =$	0·138
Fourth rate	$4\,c =$	$4 \times \cdot 023 =$	0·092

cubic feet of rain water to be discharged per minute, by drop or stack pipes from the roofs of the different rates of buildings.

—If we assume the area of yards, courts, &c., to each rate of building in the ratio of 3, 2, 1, and 1, we shall have for the surface water from those sources,

First rate	$14 \times 3\,c =$	$14 \times 3 \times \cdot 023 =$	·926
Second rate	$10 \times 2\,c =$	$10 \times 2 \times \cdot 023 =$	·460
Third rate	$6 \times 1\,c =$	$6 \times 1 \times \cdot 023 =$	·138
Fourth rate	$4 \times 1\,c =$	$4 \times 1 \times \cdot 023 =$	·092

—And from the combined sources of roofs, areas, and yards, &c.,

First rate	·323 + ·969 =	1·292
Second rate	·230 + ·460 =	·690
Third rate	·138 + ·138 =	·276
Fourth rate	·092 + ·092 =	·184

Total discharge in cubic feet per minute from each rate of building exclusive of the quantities from the interior of each rate of building.

—Upon the hypothesis that this latter discharge equals the supply, and taking the supply as follows,—

First rate	buildings	at	800	gallons per day
Second rate	,,		500	,, ,,
Third rate	,,		200	,, ,,
Fourth rate	,,		100	,, ,,

—Then by adopting Professor Cowie's suggestion, viz. that it is more convenient to employ one uniform measure in all calculations relating

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to one and the same subject, using, in this case, cubic feet in lieu of gallons, we have by reduction: From a

$$\text{First rate building, } \frac{800 \times \text{(say) } 278}{1728} = 128{\cdot}70$$

$$\text{Second rate } \frac{500 \times 278}{1728} = 80{\cdot}43$$

$$\text{Third rate } \frac{200 \times 278}{1728} = 32{\cdot}17$$

$$\text{Fourth rate } \frac{100 \times 278}{1728} = 16{\cdot}08$$

cubic feet of pipeage water from each rate of building per day.

—But as these quantities may be considered as being discharged in the course of two hours out of each day, we have from the

$$\text{First rate } \frac{128{\cdot}70}{2 \times 60} = 1{\cdot}07$$

$$\text{Second rate } \frac{80{\cdot}43}{2 \times 60} = {\cdot}67$$

$$\text{Third rate } \frac{32{\cdot}17}{2 \times 60} = {\cdot}26$$

$$\text{Fourth rate } \frac{16{\cdot}08}{2 \times 60} = {\cdot}13$$

cubic feet of discharge per minute from each rate of building.

—And the total quanties to be discharged from the three combined sources per minute, in case of rain during two hours each day per minute, will be from—

First rate	1·292	+ 1·07	=	2·299
Second rate	·690	+ ·67	=	·757
Third rate	·276	+ ·26	=	·302
Fourth rate	·184	+ ·13	=	·197 cubic feet.

—In case of a fall of rain for the remaining 10 hours of each day, from—

First rate.	1·292
Second rate	·690
Third rate	·276
Fourth rate	·184

cubic feet discharge per minute from roofs, areas, and yards.

—But in estimating the area proper for the sewers or conduits, it will be necessary to adopt the quantities from all the sources; therefore, the discharge could be effected in two hours in cases of rain.

—Assuming the area is made in a proper ratio to the quantity, the drains would run full for that period; and during the remainder of the day, the ratio would be,

First rate buildings, as	1·292	: 2·292
Second rate ,,	·690	: ·751
Third rate ,,	·276	: ·302
Fourth rate ,,	·184	: ·197

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—By adopting the area due to the largest quantities, we should have not only sufficient space for running the sewage, but also in all cases, ample time for running through the several sewers additional waters for scouring, say daily; although, in cases of rain, the latter means need not be employed.

—Then, by adopting the following notation,—

c = the co-efficient, or quantity of rain water, in cubic feet, per square of 100 superficial feet per minute.
s = the squares of roofing.
s' = the squares of areas, courts, and yards.
p = pipeage water per minute in cubic feet.
n = number of houses.
l = length of street.
f = fall of street or sewer.
b = breadth of street.
s'' = squares of road surface.
q = quantity to be discharged per minute into the sewer at upper end of street.
Q = quantity to be discharged in cubic feet per minute at lower end of street or outlet of the sewer.
D = diameter of the sewer or drain.

—Then we have—

$$q = \{ c\,(s + s') \times 2p \} \quad . \quad . \quad . \quad . \quad . \quad (1.)$$
$$Q = \{ c\,(s + s') + (n\,p) + (s''\,c) \} \quad . \quad . \quad (2.)$$

—Take an actual case, say that of a street containing 100 first-rate houses, each having a 30 feet frontage: width of street 70 feet between area and fencing; the fall or inclination being 1 in 100:—required the diameter proper for the sewer.

—It is proposed in this example to depart from the true principles, so far as relates to the uniformity in diameter of the sewer, by making it of one size, not tapering; but of course the equations are applicable to either case.

—Then $l = 30\,n = 30 \times 50 = 1500$

$$s'' = \frac{l\,b}{100} = \frac{1500 \times 70}{100} = \frac{105{,}000}{100} = 1050.$$

$$Q = c = \cdot 023 \times (s + {}''14 + 52) + (n\,p = 50 \times 1{\cdot}07) + (s''c = 1050 \times \cdot 023 = 253{\cdot}350, \text{ say } 254 \text{ cubic feet.}$$

—Then by Professor Cowie's formula we have

$$D = \cdot 04547 \sqrt[5]{Q^2 \frac{l}{f}} = 1{\cdot}046,$$

for diameter of sewer and velocity = 4·919.

—Upon the same principle drains for streets of second, third, and fourth-rate houses may be completed; and the diameters (D) for each of the following cases will be found equal to the numbers given.

—Case 2.—Consisting of a street of second-rate houses, 100 in number, each having a frontage of 20 feet; width of street, in clear area

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fencing, 50 feet; then, by equation, (2) Q=148, and D by the formula,

$$= \cdot 04547 \sqrt[5]{Q^2 \frac{l}{f}} = \cdot 8429 ;$$

The diameter absolutely necessary for draining the street.

—Case 3.—That of a street of third-rate houses, say 100 in number, each having an 18 feet frontage; width of street between area fencing, 40 feet: then by applying equation 2, and the formula given by Professor Cowie, as above, we have, D = ·5957.

—Case 4.—Is a street of fourth-rate buildings, say 100 in number, each 16 feet frontage; width of street 30 feet: then, by equation 2, and the formula, D = ·5282.

—Having ascertained the area due to the sewer in each case at its outlet, it may be worth while to consider its form: and whether, under the actual circumstances, any additional hydraulic depth is obtained by using an oviform section. Upon the subject itself there is much difference of opinion. From the excellent evidence of Mr. Phillips, we learn that "in 19 out of every 20 sewers, the streams are only mere dribbles at any time."

—And, of course, the actual hydraulic depth cannot in any case exceed the depth of the running stream; it appears to me that no advantage whatever in this respect can exist in the oviform sewer, so long as the running stream does not equal twice the radius used in describing the lower arc of the oviform section. Upon examining the section, it will, I believe, be found exactly the reverse, that is in a circular drain, whose diameter shall be equal to twice the radius employed in describing the lower part of the oviform sewer, and the running depth of water exceeds the versed sine of the lower arc which, in section under consideration is 3 inches, and not exceeding 18 inches in depth, there will be a greater hydraulic depth in the circular than in the egg-shaped sewer, and, of course, less friction.

—It is quite possible in extreme cases that there may be some slight advantage in the oviform section, but from all the circumstances with which I am acquainted, this can only take place in one-twentieth of the sewers, for the reasons above stated, as will be evident upon inspecting the section itself, with the running depth of water marked thereon.

—There is one other question that presents itself, and which, I think, should be considered, irrespective of the defective nature of the materials employed.

—By reducing the sectional area of the several sewers to a ratio due to the stream, and which ought to be done, we necessarily expose the drain or sewer itself to an hydraulic pressure; this will render it necessary to consider the cohesive powers of the materials, and which would, of course, be considered before determining the thickness of the tubes. It is irrespective of the cohesive power of the materials in themselves that we ought to bear the subject in mind: as it appears to me any bonded, much less cementitious masonry, and brickwork cannot be otherwise considered, is altogether unfit for constructions when employed, as the sewers would be, if systematically laid out in section, &c., to a hydraulic pressure.

—Independent, therefore, of the objection which I think may reasonably be urged against cementitious masonry, bricks in themselves are not the most suitable materials to be employed; the absorbing and

conducting powers, especially the former is of importance, and this I find, as the result of some experiments, in the following ratio:

Fire-bricks absorb moisture by weight. .	500 / ·32
Stock bricks.	500 / 109·0
Malm brick	500 / 116·0

—*Drainage by Engine-power.*—It is proposed to take the Surrey and Kent districts. These together, according to the report of Mr. Gwilt, contain about 55,000 houses. In the absence of more detailed information, for the purpose of the following estimate, I have arranged them under their several rates, thus:—

First rate	10,000
Second rate	10,000
Third rate	15,000
Fourth rate	20,000

And for the total drainage, exclusive of roofs and yards, we have, (10,000 × 1·07) + (10,000 × ·67) + (15,000 × ·26) + (20,000 × ·13) = 10,700 + 6,700 + 3,960 + 2,600 = 23,900 cubic feet of pipeage water per minute for a period of two hours per day.

—And from the roofs, yards, &c., according to the progression already named in a former part of this evidence, we have, (10,000 × ·969) + (10,000 × ·460) + (15,000 × ·138) + 20,000 × 1·38 = 9690 + 4600 + 1575 + 2760 = 18,620 cube feet per minute during the fall of rain, equal to 2 inches per 12 hours, neglecting any deduction from evaporation.

—Taking the horse-power equal to raising 3,300 lbs., or 53·2 cubic, 10 feet high per minute, we shall require for the pipeage drainage.

$$\frac{23,900}{53·2} = 451 = \text{horse-power for two hours each day.}$$

—And for rain-water, upon the foregoing data,

$$\frac{18,620}{53·2} = 351 = \text{horse-power during a fall of rain.}$$

—The total quantity of sewage from 55,000 houses per day of two hours, is equal to

$$23,900 \times 2 \times 60 = 2,868,000 \text{ cubic feet.}$$

—According to the reports on the Cornish engines, the estimated cost for raising 10,000 gallons, or 1666 cubic feet of water 100 feet high, may be taken at ·548 pence, exclusive of interest on outlay for engines, pumps, repairs, machinery, and buildings, but including all other expenses.

$$\frac{2,868,000 \times ·548}{1666} = \frac{1,557,664}{1666} = 942·77 \text{ pence per day,}$$

or 1433*l.* 15*s.* per annum, for engine-power upon the foregoing basis. On the credit side of the account, we should charge the total amount of the annual cost (money paid at present for clearing out the sewers).

—But as the whole amount of engine power will only be required in cases of rain, it is worth while to consider the practicability of making

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use of the surplus power for procuring and discharging regular currents of water through the drains for the purpose of scouring.

—Taking the outlay for pumps, engines, &c., at 50,000*l.*, and at 8 per cent., and apportioning the charges in the following ratio, say,

First rate buildings	. .	$\frac{1}{2}$
Second rate ,,	. . .	$\frac{1}{4}$
Third rate ,,	. . .	$\frac{1}{6}$
Fourth rate ,,	. . .	$\frac{1}{8}$

—And the charge would be, for

A first-rate building	. .	·2
Second rate ,,	. . .	·1
Third rate ,,	. . .	·04
Fourth rate ,,	. . .	·02 £. per annum.

—It is not considered necessary at this time to enter into a detailed description of the engine itself, or other works connected therewith, or upon the pumps to be employed, beyond pointing out some of the advantages to be derived from the use of a particular kind, technically called "plungers." The action is the same as that of the common forcing pump, possessing for the proposed kind of drainage two very essential advantages.

—First, in lieu of the ordinary piston, which has to be extracted (withdrawn) for repair, the wear being confined to the stuffing box, which is in a position to admit of whatever may require being done with great facility and despatch. In fact, as easily as the stuffing box of the engine itself.

—The packing consists of a simple gasket of hemp and tallow, seldom wanting to be changed, as it is easily compressed from time to time, so as to form a perfect contact by the screws. Besides, a renewal of the packing is easily done, not requiring more than two or three men to effect.

—The packing of the plunger is not only a cheaper material than the leather of the boxes, but from its position, is more durable, lasting a much longer time.

—Experience in these matters cannot fail forcibly to suggest the great advantage to be derived from the use of plungers. The points of discharge may be into, towards, or from the river Thames, not, as at present, on the shores of the river immediately in front of much valuable property—the effect of the present most objectionable points and levels of discharge, to be fully estimated must be seen ; and a visit any day to the shores, say opposite Richmond-terrace, nay, every part of the river opposite and near where the present sewage has outlets. The numbers and relative position appear to me as follows :—

—In the Westminster district there is a total of about 20 outlets, viz.,

8 above Vauxhall Bridge.
4 between the latter and Westminster.
4 between Westminster and Waterloo Bridges.
1 below Waterloo Bridge.
3 into the Kensington Canal.

—In the Tower Hamlets districts—

15 open into the Thames.
4 into the river Lea.
2 into Limehouse Dock.

Being a total of 21 outlets.

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—On the Surrey side—

19 outlets are shown upon the plan.

—It can hardly be necessary to state that, in the event of the use of engine power, these outlets (even should it turn out that they are in proper places) would be concentrated.

—In case the drainage should take a direction from the Thames, the points of discharge would of course be arranged so as to render the sewage of the greatest productive value. This is, however, in itself a mere matter of detail rather than of principle.

—Whichever mode be adopted for remedying the present defective system, or rather mode, for it does not appear to me worthy of the former expression, there are no engineering difficulties in the way of carrying out a system upon true principles.

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John Roe, Esq.

(*Third Part.*)

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J. Roe, Esq.

Have you read Mr. Austin's evidence in relation to the practicability and expediency of relieving the low and flat districts of the Surrey and Kent division of sewers, by the employment of steam power for pumping the sewage and rain water?—I have.

How far do you agree in the practicability and expediency of this mode of relief?—I have no doubt of the practicability of relief by steam power; and if the run of water in the sewers is to have free action at all times, the expediency of adopting that mode of relief is self evident.

Will not the principle of the application of steam power for the purpose, give the advantage of relieving this or any similar district, from the necessity of draining directly into the river, or into the river at all?—Yes.

How far do you agree with Mr. Austin, in the plan of converging drains that he proposes, whereby any required amount of fall is obtained throughout the whole system, and thence the practicability of adopting pipe-drains?—The plan of converging drains suggested by Mr. Austin for the purpose of adopting pipe-drains in lieu of sewers, I consider to be one that may be used to great advantage.

You believe, that if a sufficient fall can be insured in every drain by such a system, and with a supply of water, the drainage may be made perfect?—I do.

What is your opinion as to the comparative cost of this system, and the present one pursued in the Surrey and Kent district?—My opinion as to the comparative cost of this system of pipe-drains, and the existing system of brick-sewers to complete the drainage of the lowland portion of the Surrey and Kent district is, that Mr. Austin has not over-rated the pecuniary advantage of the one over the other.

You have stated your opinion as to the superior efficiency of this system. In order to complete the sewerage of the low part of the Surrey and Kent district, so that every street and house should be properly drained, which do you consider would be the preferable course, even as a question of ultimate economy, the adoption of this

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system, or the extension of the present?—The adoption of this system would be the preferable course in my opinion.

Do you agree with Mr. Austin as to the size of drains required for houses?—I do; if those drains are to be constructed under the control of the Commissioners' officers to secure a proper material and inclination. A 4-inch drain, with an inclination of 1 inch in 10 feet, would discharge all the water produced by a fall of 2 inches depth of drain in one hour upon a first-rate house, with more area for gardens, &c., than is usually allowed. But, in almost every instance, an inclination of 2 inches in 10 feet may be obtained, and 3 or 4 inches in 10 feet in numerous cases; yet even where this opportunity has presented itself, the builders have not availed themselves of it, but have carried the drain nearly on a level from the back to the front of the house, and connected it with the sewer by a fall of several feet in a short length in the street; no wonder, therefore, that 9 or 12, or 15-inch drains choke up under such circumstances. I knew an instance of a 9-inch brick drain to a house in a square in Islington becoming so offensive from foul deposit lodging therein in less than two years after the house was built, that the family were under the necessity of leaving; upon which the owner caused the brick drain to be taken up, and a pipe-drain to be laid down; since which time (about three years) no complaint has been made. In January, 1842, Mr. Chadwick suggested to me the propriety of trying tubular drains, as he considered they would be beneficial and economical in drainage generally, and requested me to try the making of several sorts, to ascertain the cost and efficiency. Accordingly, I caused experiments to be made in the burning of common clay, to define the thickness of rim that could be obtained without artificial drying. I also tried the making tubular pipes with cement and various articles mixed therewith, specimens of which may be seen at the Sewers' Office, Hatton-garden; and the first glazed stoneware pipes for drainage made in the metropolis (or elsewhere I believe) were formed from my instructions, in consequence of Mr. Chadwick's desire to obtain a smooth surface for tubular drains. From the time of the first experiments I have recommended tubular pipes for drainage to builders, and since then, Mr. Dennis of the Caledonian-road, Battle-bridge, has manufactured them in cement, and is probably the first person in London who has used them systematically for the drainage of whole streets. There was evidence subsequently given in the Report of the Health of Towns Commission (1844) tending to confirm the justness of Mr. Chadwick's idea as to the pecuniary saving to be effected by the use of tubular drains. As regards their efficiency, I have not the slightest doubt. I know instances of 3-inch iron pipes put in 15 years since for house-drains, of which no complaint has yet been made—and in one case the drain is upwards of 100 feet in length; and glazed stone-ware pipes, well made, are equal to iron for passing drainage.

If you were a steward or responsible adviser of any landlord requiring to drain such a district, would you, either on the score of efficiency or ultimate economy, consider it right to go on with the present works?—I have already expressed my opinion of the propriety of withholding the construction of new works, until a complete survey and levels of the metropolis shall have been taken; on the plan formed from such

survey the length, cross section, and level of every existing sewer should be marked. From these sources of information, a well digested and comprehensive plan of drainage for both sides of the river should be formed, before any but works of necessity are performed. In the mean time, for the preservation of health, during this necessary delay of works, every sewer through which a man can pass, whether on the north or south bank of the river, could be kept free from foul deposit by flushing with the water that accumulates in, or passes through the sewers. And the smaller sewers may be similarly benefited by having an extra supply of water judiciously used.

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No. 27.

The Rev. *Morgan Cowie*, M.A.

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You are, as we are well aware, the Principal of the College of Civil Engineers, Putney?—Yes.

The Commissioners were informed that you had paid especial attention to the science of hydraulics, as connected with engineering?—Yes, I have. Hydraulics does not form part of the regular course of mathematical instruction in which I had been engaged, previously to my appointment at Putney. The results of hydraulics depend, indeed, more upon experiment than upon theory. I was thus obliged, on being appointed, to give considerable time and attention to this subject, and to the experience of foreign engineers, French and German.

The Commissioners were desirous that you should see some of the evidence which they have received on proposed applications of hydraulic science to the improvement of the sewerage and drainage of towns, particularly that given by Mr. Roe, Mr. Phillips, and Mr. Cresy. Have you read it?—Yes, I have.

Will you favour them with some observations upon the evidence?—The former inquiries appeared to me to point out clearly the evils of the existing practices. I would observe generally on the results of the investigations which I have had an opportunity of considering, that their promulgation will be of very high public importance, as they will promote a considerable and extensive advance in hydraulic science, and constitute the first great practical step towards the remedy of the evil of the defective drainage of our towns.

—I will first observe upon the evidence of Mr. Phillips, which I think highly important.

—I have read this evidence with peculiar pleasure; though Mr. Phillips disclaims being a scientific man, he shows that he is well acquainted with the scientific authorities on this subject. The cases he discusses are extremely well explained, and the principles he employs, even where he disagrees with scientific writers, are, for the most part, stated with accuracy and distinctness.

—I have the honour to subjoin several remarks which occur to me, relating to this inquiry:—

1. As to *gauging*.
2. As to the *velocity* with which fluids will discharge themselves in pipes not kept constantly full, with different inclinations.
3. As to the *capacity* necessary for receiving and carrying off united streams.

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4. As to the nature of the substance of the channel; what influence it has on velocity.

—1. The gauging.

—Complaints are made that the formulæ investigated by mathematicians and others do not give accurate results. I should ask in reply :—

—1st. How the *accuracy is tested?*

—2nd. How was the experiment made for finding the data required in the formulæ?

—Mr. Phillips gives correctly the rules adopted (not from theory though by mathematicians, but from experiment) for determining the mean velocity when the surface velocity is known, except in the case of M. Prony's formula, for finding the mean velocity (v) from the surface velocity (V)

$$v = V\frac{V + 2{\cdot}37}{V + 3{\cdot}15} \text{ in metres.}$$

or in feet,

$$v = V\frac{V + 7{\cdot}776}{V + 10{\cdot}335};$$

in small velocities it would not be safe to take an approximation to this rule.

—The method given of finding the surface velocity is very rough, and depends for its accuracy *entirely* on the dexterity of the observer. Several methods of finding velocities of currents are in use, but *all* are defective in some point or other. Woltman's Tachometer or Hydrometric mill is the best. But in the case of sewage water, there may be difficulty in applying these rules. I therefore think Mr. Phillips has stated wisely that the best plan is to gauge directly by barring the channel, making an aperture of given breadth, and then calculating the velocity of the current from the ascertained discharge in a given time. Here, however, Mr. Phillips has unfortunately applied the formula, relating to waters discharged from a still reservoir, and not to waters arriving at the aperture with a given velocity.

—The proper plan, on his own method, would be this,—bar the whole section by boarding it; let a rectangular slit be made whose breadth is *in feet* (l), and the height through which the water flows (H); let the breadth be small, compared with the breadth of the section, then the number of cubic feet discharged $= \frac{2}{3}(l\,H - \overline{H}) \times 4{\cdot}813$. So that by noting H, as Mr. Phillips proposes, we could find the quantity of water.

—The more accurate formula would require us to know (v) the mean velocity of the water; but this will have little influence unless (v) is considerable. Taking it into consideration the quantity discharged in one second in cubic feet, would be,

$$\tfrac{2}{3}(5{\cdot}3)\,l\,H\sqrt{H + {\cdot}035\,v^2},$$

or

$$(3{\cdot}5)\,l\,H\sqrt{H + {\cdot}035\,v^2}.$$

—In all cases where the formulæ are to be applied to large masses of water, I should give more close and accurate values to the coefficients, continuing them to several decimal places.

—The present formulæ are derived from very accurate experiments made by M. Castel, Engineer of the *Etablissement des Eaux* at Toulouse.

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—Mr. Roe finds that Mr. Hawksley's tables, calculated, as I suppose, from his formula, give incorrect results. The formula in question, is for velocity of water through a *tube* of considerable diameter.

$$v = \cdot 77\sqrt{\frac{h\,d}{l + 1\frac{1}{2}\,d}}.$$

v = velocity in yards.
h = head of water in inches.
l = length of pipe in yards.
d = diameter of pipe in inches.

—This reduced to the form where all the dimensions are given in *feet*, would be,

$$v = 48\cdot 01\sqrt{\frac{h\,d}{l + 54\,d}}.$$

—M. Poncelet gives a formula, investigated, I believe, by Navier, and which, when applied abroad, has given very accurate results, of which the following is the expression in English feet :—

$$v = 47\cdot 95\sqrt{\frac{h\,d}{l + 54\,d}}.$$

—This differs from Mr. Hawksley's, by such very small quantities, that I conclude both to be the same, and therefore that Mr. Hawksley's is correct, when correctly applied. Poncelet's formula gives very correctly the quantity of water which is furnished to the town of Metz from Scy, and therefore should not be at fault elsewhere; by the formula, the quantity of water delivered under a constant pressure at Metz in 24 hours, was calculated to be 262·656 C.M., and was found to be accurate within 2 or 3 cubic metres: in all these cases the tube is supposed to be constantly full.

—2. As to *velocity*.

—In an open canal, the mean velocity being (v) in feet.

c, the wet contour.
s, the area of a section of the fluid.
$\frac{s}{c}$, is the hydraulic mean depth.
g, the force of gravity.
$\sin i$ = sine of angle of inclination.

$$g \sin i = \cdot 0035855\frac{c}{s}\,(v^2 + \cdot 02028\,v).$$

—These constants have been determined by Eytelwein from experiments made on 91 canals and rivers, involving considerable variation of velocity and magnitude of section: and this is the accurate formula, from which the approximate common rule (of taking $\frac{1}{10}$ of the mean proportional between the hydraulic mean depth and the fall in two miles) is derived.

—This law connects the inclination with the velocity; and if the latter term be not neglected (which it generally is, to avoid trouble), I feel confident it will give accurate results.

—It tells us at once what inclination we must have to secure a given mean velocity. I should observe, however, that this inclination is the inclination of the *surface of the fluid*, not of the bottom of the canal or tube.

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—Eytelwein's great discovery was, that the velocity was independent of the latter inclination, and only depended on the inclination of the surface of the fluid in the case of canals and rivers.

—It is still, however, desirable to know how this formula is modified by the specific gravity of the fluid.

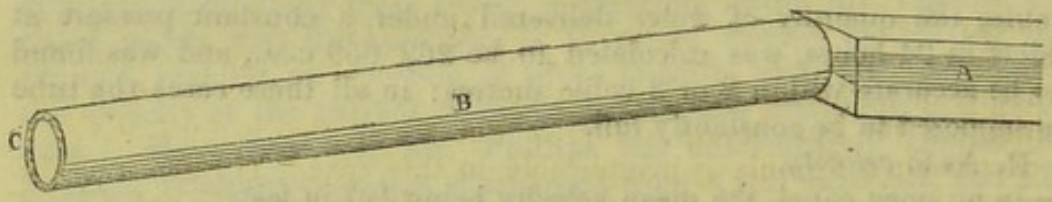
—I am not aware that any experiments have been made to ascertain how it would be modified, at least, in the case of large tubes. The Chevalier Du Buat, in tubes of small diameter, found that dirty water would not flow so fast as rain water, which we should have expected; but the diameter of his tube was so small, (five lignes) that the results obtained are not sufficiently practical to guide us in this matter.

—Mr. Phillips has calculated, by a formula which only agrees approximately with the true one, what velocity will be given by one of his egg-shaped sewers, of given dimensions, and given inclination, kept constantly full, and he finds that experience shows a much larger velocity; for he says that he has known larger areas drained by smaller conduits; so that he concludes "*Absurdly large as practice demonstrates the present sewers to be, the theories would make them larger.*"

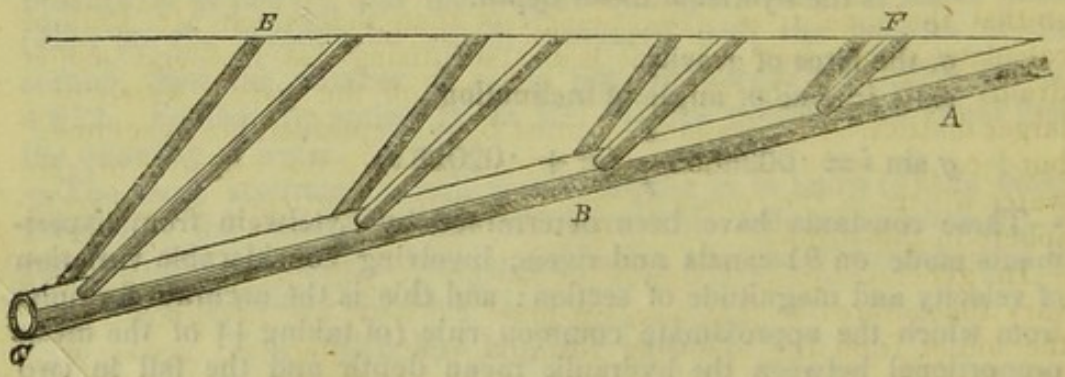
—I think Mr. Phillips has not sufficiently considered the case.

—The formula he calculates from refers to a canal conveying constantly the same body of water, and at the same velocity from one end to the other, and does not contemplate the constant addition of quantities of water, arriving with various velocities.

—The formula applies to a case like this.



—The sewer B., leading from a reservoir A., where the height does not vary, to an outlet C.



—The case he tests the formula by, is like the figure above; one main sewer, from A. to B. and C., receiving in its course a number of smaller sewers, down which the water will rush from the upper surface with various velocities, increasing as we proceed from F. towards E. In all these cases, the velocity of the water passing on from B. to C. will be increased. The water coming down A C and E C will have fallen through the same vertical height, and if it had fallen *freely* would have

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the same velocity, but the water down A C has been retarded by the friction along A C, and that down E C by the friction along E C; the former retardation will be greater than the latter, and therefore velocity less in the former than in the latter case. So that we not only have the velocity in A C variable (which is supposed in the formula to be uniform), but continued additions of masses of water with different velocities. It is clear, therefore, that the motion in A, B, C, cannot be *uniform*, and consequently that he has applied the formula to a case where it does not apply properly.

—The reason, then, why Mr. Phillips finds theory at variance with practice, is this:—The velocity in the sewer will not be uniform, because the stream receives constant accessions, moving with different velocities.

—I would calculate in the following way:—

—Suppose a sewer 5 miles long, with a fall from one end to the other of 200 feet, *i. e.*, a fall of 40 feet per mile, and suppose it to receive additions of water at every half mile by sewers of given dimensions, the water coming down these sewers will have fallen through 20, 40, 60, 80, &c., feet; and I should calculate the velocity with which each feeding sewer would bring its tributary waters into the main sewer, and calculate the continual acceleration, and so find at last the velocity at the outlet.

—It is true that the mean velocity is uniform, when the resistance arising from the friction of the channel is equal to the accelerating force which gives it motion. But if the accelerating force is *greater* than the resistance arising from friction, the mean velocity is not uniform, but *accelerated*, and we shall have a constantly increasing mean velocity from the head of the sewer to the outlet. I apprehend this is the case in practice. Not having Mr. Roe's gaugings I cannot tell whether or no he has found an increasing mean velocity towards the outlet, but the facts would authorize one to say that it must be so.

—Eytelwein's formula is inapplicable to this case. It refers only to an *open canal, where the mean velocity is uniform from the canal head to the outlet.*

—I would further suggest that in estimating the quantity of water to be drained over a given surface, no allowance is made for evaporation; so that the quantity of water being less than that which Mr. Phillips calculates would drain away, it is not surprising that he found smaller drains than those he calculated, carrying off the surface waters of a larger district. The evaporation must be very considerable in summer; but I cannot refer to any tables which give us the quantity of rain water which, in the course of the year, will be returned to the atmosphere in this manner.

—In general, in short drains or sewers it will be inconvenient to vary the calibre: in that case, we must calculate the necessary size of the outlet from the following formula, which I dare say agrees with Mr. Hawksley's, but which is taken from M. Morin's Aide Mémoire de Mécanique Pratique:—

Q = cubic feet to be discharged per minute.
l = length of sewer.
f = fall in the length (l). All expressed in feet.
D = diameter of sewer in feet.

$$D = \cdot 04547 \sqrt[5]{\frac{Q^2 l}{f}}$$

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—This will give an accurate result in all cases where the velocity $\left(\text{which} = \cdot 0212\frac{Q_2}{D}\right)$ is not less than 2 feet per second.

—3. It is a well-known principle in hydraulics, that if a tube be kept constantly full, the velocity will adjust itself so as to be inversely as the area of the section.

—If, therefore, one end of a tube be open, there cannot be any necessity for enlarging it as it receives tributary streams in proportion to the sections of those streams. All that would be necessary would be to take care that the section was so large towards its extremity that the fluid should not attain a velocity which would injure the structure; and having given the maximum quantity of water to be conveyed by the sewer, we should see that the outlet size was large enough to convey this quantity with convenient velocity, and then gradually (at junctions where the tributary waters are considerable) reduce the section of the drain, proceeding upwards from the outlet. But if the final velocity were such as not to injure the work, or dam up the waters in small tributaries, I see no reason to increase the section from one end to the other of the ramified system.

—If we could secure a constantly full sewer, discharging itself above high-water level, it would prevent the evolution of noxious gases to a considerable extent.

—The scouring power of water is very great. I believe Mr. Hopkins, of Cambridge, has calculated it to be as the seventh power of the velocity, but I quote from memory

—4. I am rather inclined to think, from general considerations, that the influence of the material of the channel, on the velocity, would be small. In most cases the tube gets *lined*, as it were, with a film of the fluid, which remains stationary, or nearly so, and in that case the only friction is the fluid rubbing against itself, the moving fluid against the stationary fluid. Mr. Roe has made experiments on this subject, which show a greater difference than I had anticipated in favour of glazed tubes; and it probably may be the case, that in "mere dribbles," as the streams are in many cases, the glazed tubes would have an advantage, because of their allowing no percolation or absorption.

—But further experiments on such a point would be highly interesting and useful, as well as those referred to above on the rate of flow of fluids of different specific gravities.

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No. 28. Mr. *Alderman Musgrove*, and *John William Unwin, Esq.*

Mr. Ald. Musgrove, and J. W. Unwin, Esq.

(*To Mr. Unwin.*) You are clerk to the Tower Hamlets division of sewers?—Yes, I am.

Have you perused the evidence of your surveyor, Mr. Beek?—I have just had an opportunity of doing so.

You are aware of the general tenor of it?—Yes.

Are there any comments which you are desirous of making upon that

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evidence?—I am not aware that there are. I should say certainly that I agree with him in thinking that the sewerage and drainage of the district of the Tower Hamlets is in a very improving state. Every year we have been going on increasing our sewers, and also extending the outlets, and the number of communications has increased very considerably. In consequence of a suggestion from one of the Commissioners I have prepared a statement, showing the number of feet of sewer executed, and also the number of drains communicating with the sewers, and the number of drains communicating with the sewers of the Tower Hamlets generally since the year 1838. In the year 1838 we extended our sewers 5555 feet; there were only two drains communicating with that extent of sewerage; the entire communications throughout the district in that year were only 31. In the year 1839 there were 2137 feet of sewers constructed; there were 27 persons communicating with them; and the total communications in that year were 80. In the year 1840 there were extended 8577 feet of sewer; there were 50 persons communicating with such extension, and the total number of communications in that year was 84. In the year 1841 there were 13,841 feet of sewer; 58 persons communicated with the sewers so extended, and there were 110 communications throughout the district. In 1842 there were 5541 feet extended; there were 103 persons communicated, and there were 152 throughout the district. In the year 1843 there were 4054 feet of sewer extended; there were 70 persons communicated with that additional extent of sewerage, and throughout the district there were 122 communications. In 1844 there were 3587 feet of sewer extended; 54 persons communicated with such additional sewer, and there were 104 communications throughout the district. In the year 1845 there were 13,402 feet of sewer extended; there were 96 persons who communicated with it, and throughout the district there were 140. In the year 1846 there were 6522 feet of sewer extended; 125 persons communicated, and there were 178 throughout the district. In 1847 there were 13,170 feet of sewer extended; there were 165 persons communicated, and 182 communications throughout the whole district. In addition to that I should also mention what is stated in Mr, Beck's evidence, that the amount of sewerage that has been arched over has been so great that there has been none left to be arched over.

You have stated that that is the additional amount made since 1837; how much of that is entirely new, and how much merely drains arched over?—The whole of that which I have mentioned is new.

What in your opinion is the reason why so few people have sought to run private drains to the sewers?—I always thought this was the reason. Generally speaking those houses are let for a term of years; the tenant says, "Why should I go to the expence of making a drain for the benefit of my landlord?" The landlord says, on the other hand, "Why should I go to an expence to create a benefit for my tenant, when I shall not have the reversion beyond the next twenty years perhaps?"

What is the charge for making a communication from a private house to a sewer?—There is no charge whatever, except for the first three feet, which we do ourselves; we do it in cement, and our contractor receives the sum of 17*s*.

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Is the party confined in making his communication to any particular size?—The first three feet is always twelve inches.

Do you confine a proprietor or occupier of a house to any particular size in making his communication with your sewer?—I can hardly answer that question—it is more the province of the surveyor.

Do you think that if that expense were to be spread over many years it would be more willingly incurred by the party interested?—I should think it might; or if there were a power given to the Commissioners to compel the landlord and the tenant to join between them, apportioning the expense between them in any way which might be considered equitable; that might have a tendency to increase the number of communications.

Are the Commissioners able to allow the expense to be apportioned over several years, or must they compel the person to pay immediately the 17*s.*, or whatever the charge may be?—They must compel the person to pay the 17*s.* immediately. He is never allowed to take the order out of the office without.

In this extension of sewers, which has been made during the last eight years, who paid for them?—They have been paid for out of the rates; but in some instances there have been contributions.

What is your practice in that respect?—We are, generally speaking, governed by circumstances. When there is a sewer to be constructed which is very beneficial to an individual, and which we consider more beneficial to him than to the public, we take a contribution from him. The highest contribution I have ever known was only two-thirds.

How do you proceed in such cases?—Generally speaking, an individual comes to the Commissioners; he says, "I require a sewer to be constructed up a certain street, the whole of it being my property." The Commissioners say, "It will be of some benefit to the public, no doubt, but it will be of far more benefit to you; in that case, therefore, they expect you will contribute." In the case I refer to, of Duncan-street, Whitechapel, the cost of the sewer, I believe, was about 120*l.*, of which the applicant contributed the sum of 80*l.*

Are you in the habit of collecting the rates in the immediate district in which a sewer is made to pay for the works which you do; or do you collect them all over the district, first in one part of it and then in another, according as the last contribution has been made?—We are tied down to a division of the district, which is called levels, in consequence of a decision of the Court of Queen's Bench. Therefore, we can only make the inhabitants of a particular level contribute to the maintenance and improvement of the drainage of that level. Therefore, sometimes some levels contribute and others not.

In short, the collection of the sewer-rate has no reference whatever to the locality which has had the benefit of the work?—The Commissioners, in extending the drainage in any locality, consider that they benefit the whole level.

The whole of the Tower Hamlets district is not in your division, is it?—No, it is not. In the first place, Poplar and Blackwall Marsh are excluded; St. Katherine's also is excluded; and there is a portion of the parish of Bromley, which is called Bromley Marsh Level, that is excluded. The parish of Shoreditch is in the Holborn and Finsbury district of sewers, though it is in the Tower Hamlets division for every thing else.

Are you masters of your own outfall entirely?—Entirely.

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So that it would be a matter of indifference to you whether those exceptions you have mentioned should be thrown into your district or not?—I will not say that. With submission, I think it would be a considerable advantage. I have heard many of the Commissioners express the opinion, that if we could carry an outlet through Blackwall it would be beneficial.

Why?—We should get a more rapid exit to the Thames.

Would the outlet be better?—I should think so. I do not know it practically, but it would go more directly into the river, no doubt.

Do the householders contribute nothing more than the 17*s.* you mention? have not they anything to pay for joining the actual drain?—Nothing is paid by them except the actual cost of the drain, and of that we take 17*s.* for the portion we do.

Do you allow more than one house to drain through one communication into the sewer?—Yes.

How many should you allow?—I am afraid that is a question rather for the surveyor than for me, but I believe the notion of the Commissioners is this, that it is not desirable that the sewer should be too often broken into; therefore, when we can make one drain serve for several houses, it is thought desirable to do so.

With respect to the houses you have drained, have you had any complaints from them of the stoppage up of the drains?—No.

Nor complaints of smell arising from the drains?—Very seldom; I will not say we never have, but very seldom.

Do you think that such complaints are numerous in relation to the number of houses which have drains?—I think not.

Your Commission is under the statute of Henry VIII., is it not?—And the statute of the 2nd and 3rd William and Mary, which has reference to the City of London, and also to the out parishes of London in Middlesex.

Is that the general statute?—No; the general statute is the 23rd of Henry VIII., which extends throughout the whole realm. The 2nd and 3rd of William and Mary extends to the city of London and the out parishes.

All your Commissioners are appointed, of course, by the Lord Chancellor?—Yes.

What are the powers that you find deficient in those Acts. What are the powers which you would propose to apply to Parliament for?—I should like to defer answering that question till I have got before me on paper the provisions of the Bill that we are about to apply for. I certainly think we should have the powers which are given to the Commissioners in Westminster. Among others, I should ask for a much more summary power of removing nuisances, and encroachments upon the sewers, something very analogous to the power possessed by Justices of the Peace, in summoning a party before us, and ordering him to remove the nuisance. I took the liberty of making a suggestion of that kind to the Commissioners on the Health of Towns.

What sort of nuisances or encroachments do you refer to?—Stoppages in the sewers, or in any way building over them. At present they cannot be removed without the intervention of a jury.

It is in fact simply to remove the cumbersomeness of the present process, occasioned by the intervention of a jury?—Yes.

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What other alterations do you propose?—I should rather prefer getting the Bill drawn out before I answer that question.

What are the main defects which you find in the working of the statutes under which you now proceed?—I should think a very great improvement would be, that which would allow us, in making a presentment, to avoid presenting the party by name. I think we should have a power to compel the vestry clerk to give us a copy of the poor rates. We should also have the power, I think, to compel landlords of small houses to compound. I think, also, we should have the power which other public boards have, that no one should commence an action without giving us notice of action.

Those are the general powers which you seek?—Yes.

Have you paid collectors to collect the rates?—Yes.

Are they collectors who give their whole time to it, or are they in trade?—Some of them are in trade and some of them are collectors of other rates. The remuneration they get from us would not be sufficient support for them. We pay them a poundage of 8*d.* in the pound.

How often do you collect the rates?—About once in three years upon the average.

Have you not had complaints of practical inconveniences arising from that mode of collection of the rates at long intervals?—I do not think so. We generally get our rates in within a twelvemonth.

With that state of property which you describe as being much held by lessees and persons with limited ownership, must not the rate at times fall very heavily upon those persons?—I think it must do so.

Do you know the number of houses in your district?—I do not remember at this moment.

Do you know what proportion of the houses communicate with sewers?—A very small proportion indeed.

You have not the paving district under your jurisdiction, have you?—No.

What is your opinion of the paving district and the sewers being consolidated?—I am afraid that in so large a district as the Tower Hamlets, the burthen would be too heavy for one set of Commissioners. The district consists of 21 parishes, and in those 21 parishes there is every description of property that can be mentioned.

How many different Paving Boards are there in your district?—I do not know.

Where is the outfall of your sewers?—They are all into the river Thames and into the river Lea.

Lower down than Blackwall?—No. Betweeen Blackwall and St. Katharine's Docks.

Into the Irongate sewer?—Yes; that belongs to us. It is one of our principal outfalls.

In case an owner of houses in a court or alley requires any house to be drained, has he, in addition to the notice to you, to give notice to the Commissioners of Pavements?—He must get permission from the Commissioners of Pavements.

Has he any fees to pay to the Commissioners of Pavements?—I do not know.

The Commissioners of Pavements make their own charge for laying

down the pavement, do not they?—They make their own charge to us when we take up the sewers, but we thought upon one occasion we were overcharged, I was desired to write a circular letter to all the Paving Boards in our district, and we have since been charged only the contract prices.

Cannot you inform the Commissioners how many Boards there are?—I believe that there are 15.

Is the lighting under your jurisdiction?—No.

What is your opinion of consolidating the lighting also with the paving?—I think the principle is very good if it did not impose too heavy a burthen upon the Board.

Would not that depend upon the times of meeting of the Board?—I think the duty would be too extensive for any one Board to perform. Only think of what must be the municipal business of 21 parishes.

Compare it with the whole city of London?—In the city of London the streets are all made and paved.

Compare it with the Westminster district of sewers which is larger than all the rest upon the north side of the metropolis put together, and the property more various?—But the Westminster Commissioners of Sewers have nothing to do with paving or drainage.

It is the opinion of their officers that the consolidation will greatly facilitate their business?—I have already given my opinion on the subject.

Mr. Alderman Musgrove.—I quite think it would facilitate the business of the Commissioners of Sewers if the departments of lighting and paving were consolidated with it. Might I also be permitted to add a few words to what Mr. Unwin has stated with reference to the powers sought to be obtained by the Commissioners under the proposed Bill. They are much more extensive than has been adverted to, I think; for instance, some of the powers which are sought for would enable the Commissioners to make an annual rate. They would also be desirous of having the power to make sewers in private courts and alleys in crowded districts, and to compel the landlords to pay for the construction of those sewers in case of their refusal to do so. They would also seek power to remove stagnant pools of water and every offensive matter upon private property; that is to say, to compel the owner of such property within a limited period to remove it; and in case of his not doing so, that the Commissioners should be able to do it, and charge him with the expense of doing it.

Have you been long in connexion with the Commission of Sewers?—I have been connected with the Commission for many years. I have been chairman only during the last two years.

You probably have observed the working of the combination of sewage and paving which exists under the Corporation of the city of London?—I have. I am a member of that Commission.

Making a comparison of the working of the united Commission, are you of opinion, from your observation and experience, that a similar consolidation would be of advantage to the Tower Hamlets division?—It would be much more laborious in the Tower Hamlets division, but I am sure it would be to the advantage of the public if it were practicable.

Do not you think with respect to the extra labour that by a judicious

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distribution among well-qualified paid officers any increase of duty might be advantageously met?—Yes.

In your experience as chairman of the Tower Hamlets division the Commissioners may probably assume that you have observed difficulties to occur in respect to the area of the drainage not being, perhaps, conformable to the natural level of drainage, which would imply a power over the outfall of the places drained?—We have had considerable difficulty. I believe it has been the practice of the Commissioners, in every instance where it has been possible, to remove those difficulties. I have an instance now where we shall be enabled, I think, to remove an obstruction to the extent of 11 feet in the neighbourhood of Hackney-Wick, upon the very spot where there was a report of two children having died from the effluvium of the sewer, which I may take this opportunity of saying was not from the sewer, and also that the Commissioners of Sewers have no control over it at all. By the proposed arrangement we shall be able to obviate that difficulty and inconvenience. In the case of this dam, which has been there now for, I believe, 150 years, there was an action brought some years ago, but the Commissioners were unsuccessful, it being private property. I have now proposals from the parties interested in it, upon constructing a sewer in another direction, whereby the public will be greatly benefited, to give up that dam, whereby we shall get a fall of 11 feet 6 inches in that particular district, and thereby drain for miles all the parish of Hackney, extending to the Holborn and Finsbury Commission, relieving a district there where there has been some complaint, in what is termed the Stoke Newington portion of the district. The Commissioners, however, ought to have the power to do a thing of that kind, and we are seeking for such power by the Bill, without being under the necessity of resorting to private arrangement.

(*To Mr. Unwin.*) Do the Commissioners understand you to say that you have no open sewers?—We have no open sewers in densely populated districts, with the exception of a portion in the parish of Hackney.

Has not that been complained of very much by the inhabitants?—I believe the principal complaint they made was that we made sewers into it.

What do you pay per annum for cleansing the sewers?—The average is about 550*l.*

Do you know of what quantity that would imply the removal?—No, I do not know that; the charge for removing is about 6*s.* a cubic yard.

(*To Mr. Alderman Musgrove.*) Seeing the inconveniences which result from a separation into different divisions of what may be called the natural area, the outfall being in one, and the head of the main sewer being in another, do not you think that the districts should be revised with a view of settling the jurisdiction more in coincidence with the natural area of the drainage, so that the whole of the drainage of one natural area might be conducted upon one plan by one set of officers?—Yes; in the Holborn and Finsbury division they have the outlets in some instances through the Tower Hamlets division, and in some through the city of London. There can be no doubt that it would be desirable that there should be a controlling power over that

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area, so that there might be no difficulty of co-operation between one Commission and the other, though I do not recollect any instance where there has been a difficulty arising out of the present system; that is to say, the outlets are all preserved for the accommodation of the other Commissions.

Are you sure that persons having part only of any natural drainage area are likely to see all the inconveniences likely to result from a separation of the jurisdiction?—I think where there has been that co-operation which has existed so long between the several Commissions, no difficulty is likely to arise.

Are you aware whether the surveyors of the different districts act upon one uniform plan of construction and procedure?—They do not. Surveyors will differ, like other persons, in opinion as to the construction of their sewers, though I do not know of its being carried to any extent whereby the public is injured. Our surveyor may have his opinion as to the particular construction of a sewer; and the surveyor of the Holborn and Finsbury division may have a different opinion; and they may both be right.

Are not sewers constructed very much upon the ideas which surveyors entertain as to the use which may be made of them hereafter by other portions of the district draining through them?—Yes. At all times a sewer, when it is intended to be built, is built with that view to afford all the accommodation which it is possible hereafter may be wanted.

Do you not see the great advantage that would result from one uniform system being pursued in all districts which the features of the country would indicate to be the area of drainage of that portion of it?—There can be no doubt that that would be an advantage.

You have observed that two surveyors may have different opinions as to the sizes and sorts of drains to be constructed, and both be right. The surveyor of the Holborn and Finsbury division is of opinion that a 4-inch tubular house-drain, of the capacity of 12½ inches, is fully large enough for carrying off the water from a house; from the regulations of your Court, it appears that your Court, and probably your surveyor, is of opinion that a 12-inch square drain, of the capacity of 113 inches, or nine times greater than the other, is best for carrying off the drainage of a house. In such a case as that, and with such differences between the divisions, can both be right?—No; but I have no recollection of an instance of that kind. I have not heard that the surveyor to the Holborn and Finsbury division recommends a 4-inch tubular drain from the house to communicate with the sewer, and that the other recommends a 12-inch drain. It is quite evident, if that be so, that they cannot both be right; I never heard of it.

Has the Court ever directed or thought of any gauging of the drains from houses or of the sewers, with a view to determine the capacity of those drains or sewers?—I believe not; I have no recollection of the surveyor doing anything of that kind.

Should a large system of drainage, in your opinion, go on without some such reference to the capacity and the quantity of the water to be carried off?—I think not.

But it has gone on for many years, has not it?—To a certain extent it is possible.

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With reference to a survey being made of the whole of the metropolis, and one general plan being laid down upon a uniform scale, do you think it would be valuable for the purposes of sewerage?—Yes.

A plan, of the accuracy of which there could be no doubt, and to which every one could refer who wished to do any work of the kind?—It would be very desirable for all those who have to administer the law of sewers as well as for the public.

(*To Mr. Unwin.*) Have you many courts which are not paved at all in your district?—Yes, a great many.

Do not you think it would be very desirable, for the sake of the health of the inhabitants, that those courts should be paved?—I think it would.

Is your system of cleansing sewers by manual labour?—Yes.

Is the area of the sewers such as to allow your workmen to perform that operation safely?—Yes, we believe so.

Have you any system of ventilation in the sewers to effect that?—I think we have not.

You have gully-holes communicating with the sewers?—We have.

Are they trapped?—I do not think they are; they belong to the Commissioners of Pavements mostly.

If it were the opinion that the emanations from your sewers by those gully-holes were prejudicial to the public health, would it be in your power to apply traps without the concurrence of the Paving Commissioners?—I should think it would, but I never knew such a question as that arise.

You never heard complaints of the nature of the emanations from the gully-shoots?—Not from our sewers, or, at least, it occurs so seldom that I do not recollect any instance of the kind.

Do you think your sewers are so safe with respect to their atmosphere that it would be safe for any person to pass any length of time in them?—I cannot say; our workmen very frequently go into them, and we never heard of any accident happening in consequence.

Have you heard of any accident in consequence of the escape from gas-pipes?—Sometimes an occurrence of that kind does take place.

Have there been any explosions?—I think there was a case of that kind, and one of our workmen was injured and taken to the hospital.

It would be important to know what is the character of the emanations from the sewers, that the Commissioners may see whether that is not one of the causes of people not communicating with the sewers?—(*Mr. Alderman Masgrove.*) I think that has not been a cause of their not communicating with the sewer, but that it has arisen from the expense and the limited nature of their interest in the property. I never knew an instance in all my experience of any one refusing to communicate with the sewer by a drain from his house, on the ground of the effluvia.

Have you heard complaints of the effluvia from drains which have been opened?—No.

Is Silk Mill-row in your district?—Yes.

Is not there an open sewer in that locality?—Yes, I know the spot well; and I will take this opportunity of saying that that which has been complained of now has been in existence for upwards of 25 or 30 years, and it is not in so foul a state at the present moment as it was

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formerly. The houses in Silk Mill-row are not inhabited to the extent they were formerly.

Then it is an open sewer?—It is a mill-head receiving the water from the sewer. It is the very mill-head which the Commissioners in my district were desirous of removing several years ago, in order to get rid of the damp, and whereby we might get the 11 feet 6 inches fall, which is so much wanted for all the district. If the Commissioners had had any control over the mill-head, which has been complained of by the coroner, it would have been removed some time ago.

Have the Commissioners turned their attention to covering that brook? —It would be impossible to do so in many parts, I think.

Why?—It is a work which would be attended with such an enormous expense. The powers that would be sought for by a Bill would be to borrow money, in order that the rate might not fall wholly upon the present occupiers of the houses.

Looking to the increasing population in that neighbourbood, do not you think it very essential to the public health that the portion from Hackney-road upwards should be covered over?—It can only be done by the removal of this very dam. In flood times I have known the water run over the bridge, and through the houses in at the back door, and out at the front. Till we could get a sufficient fall in the spot I have been mentioning, it would be impossible to cover over that brook, because in flood times it would blow up.

Why should not it be in an elongated covering, as in the case of the public highways on the metropolitan roads?—It might be done, but the expense would be enormous.

Do not you think it would be a great public convenience if it could be done?—Doubtless, and my impression is if we can get 11 feet 6inches fall the whole of Hackney brook might be covered in, in the partwhich is referred to.

Do you know the extent of it?—Several miles; it runs through marsh lands, and after several days' rain the waters come down from the hills, and completely flood the place.

Supposing your gully shoots were perfectly trapped, would that so affect the atmosphere of the sewers as to be deleterious to the men?—I hardly know how to answer that.

Are you in the habit of making any new sewers through a new district of land?—Yes, upon an application from the owner of the land, that is to say, supposing a large space of eight or ten acres is laid out for building purposes, and the parties produce plans and show that they are intending to make such sewers as come within the regulations of the Commissioners, if they ask us to bring up an outlet of sufficient size to receive the water from those sewers, it would be done at the public expense, but almost all sewers upon a new ground, being so entirely for the benefit of the owner of the new ground, they would be constructed at his expense by the Commissioners, and he would have an outlet brought up to receive the water.

You say you think the expense of sewers to different courts and houses should be paid by a charge on the landlords, why should not it be charged upon the Commission, in order to their assessing the property hereafter?—Assessing the property hereafter would not be sufficient to liquidate the expense in the first instance, and the advantage to be de-

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rived to the landlord would be too great at the public expense. It appears to me that it would be very unfair to charge the public rate with the construction of sewers over 10 or 20 acres of land which is to be laid out in streets and roads for the benefit of the landlord. I think the Commissioners should have power to compel every landlord in laying out ground for building purposes to construct suitable drainage, in the first instance being supplied with the means to take the water away.

In making new sewers do not you raise the money by rates?—Yes, for the public. I cannot bring my mind to think that it would be just to the rate-payers to call upon them to expend 5000*l.* or 10,000*l.* at once, to construct sewers over land for the benefit of the landlord.

Is it necessary to call for the outlay at once?—In the clothworkers' estate with which I am connected, we have the Shepherd and Shepherdess Fields, there are 55 acres. We have lately been letting it upon building leases, and in every case we have called upon the builders to construct the sewers and make the roads at their own expense, under the direction of the Commissioners; the Commissioners have brought up a large sewer to receive the necessary communications. It would have cost the Commissioners 10,000*l.* to construct sewers upon that estate, but the moment the houses are constructed, they may be brought into the rating for the annual expense of repairing and keeping up the sewers and making new outlets. After being built they will be taken under the jurisdiction of the Commissioners, and kept in order and repaired by them, but the first building of the sewers is at the expense of the landowner.

You say it would have cost 10,000*l.*, that, at the annual charge of principal and interest, if spread over 30 years, would be only 591*l.*?—If power were given to the Commissioners to build sewers in such a way as might be required, and to charge landlords with the money, there would be no difficulty.

Do not you think it would be desirable to obtain that power?—Yes.

In this case, the charge of 591*l.* would be distributed among a large number of houses which might be built there?—There could be no objection to that plan.

Is it within your experience that a private builder can build as well as the public builder. If the public administration be well conducted, could not a Commission of Sewers build more cheaply and better than any private builder?—I think we could; all the sewers are built under the direction of the Commissioners by contract; every sewer is built by the Commissioners by public tender.

You have stated that the average of your charge is 2*d.* in the pound?—In some instances not so much; sometimes we have a sixpenny rate upon one level and a ninepenny rate upon another, because the level where the ninepenny rate has been levied requires more expenditure than the level where the sixpenny rate is made.

The Commissioners are led to believe that the expense of a sewer in a street, under the regulation of the Act of Parliament, of not less than 40 feet wide, would be about 8*l.* for a house with 20 feet frontage?—It would depend in some measure upon situation. There are some places where the digging and removal of the soil can be done at very little expense; in other cases it is a very great expense.

Do not you think that if the sewers generally were made under the

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jurisdiction of the Commission, and by them, it would be much more conducive to the public interest?—Probably.

On the same principle that it would be beneficial to the public for the Commissioners to superintend the construction of all sewers, would not it be an advantage to the public if the Commissioners would undertake the building of the house-drains also?—It would be better that all should be under the control of the Commissioners, but the Commissioners must have power to go and build those drains without being considered by law to be trespassers.

Supposing you had that power, do not you think it would be economical to the public, that is to say, the house-drain would be made better and more cheaply than it can be done privately?—I have no doubt of it.

Do not you think that the trouble of doing it, and not knowing where to go, nor the best way of setting about it, is one cause which leads people not to make communications from their houses to the sewers?—I do not think anything would induce people generally to make such communications without compulsory power.

If there were a compulsory power, you are of opinion that the public administration connected with the sewers should execute it?—Yes, for this reason; it would be done so unwillingly by those who were compelled to do it, that it would not be done effectually.

The public administration, whatever it were, would have it in their power to do it better and more cheaply?—I am sure of it.

Do not you think that that power should be coupled also with some real responsibility as to the quality and the expense of the works which might be executed; supposing Commissioners to go on for a series of years constructing sewers at double the necessary cost, or putting in very inefficient work, do not you think that there should be some responsibility attached to their doing so?—There should be responsibility, I think. I may also say, that the power being vested in the Comissioners to construct those drains, they ought to be protected against being called on to make good what injury to the house may be necessary in constructing them, otherwise the landlord would call upon the Commissioners, after the construction is done, to repair his flooring, or to put up his skirting and other matters connected with the interior of the house. I think, where the Commissioners observe a drain is absolutely necessary for the protection of the health of the inhabitants of the house, having constructed the drain, they ought not to be answerable for the reparation of the house.

Supposing it occurs in a district that the outlay appears to have been double or treble for a bad system of sewers, emitting pestilential smells, than would be necessary upon a better system free from such objections, what sort of responsibility do you think ought to be attached to persons who have pursued that system of waste?—It would be difficult to define the sort of responsibility, because the Commissioners, acting under the direction of their surveyor, would necessarily perform the work upon as economical a plan as it could be done, it being done at all times by contract. For instance, we have generally contracts every year for doing certain works, that is to say, 12-inch drains of such materials shall be done at all times and in all places at so much per foot, and done to the satisfaction of the surveyor of the Commissioners. With such regula-

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tions it would be difficult to incur any responsibility in the way suggested.

Supposing those 12-inch drains to be nine times the size which is actually required for the work, or that upon full and competent consideration would have been found necessary to the work, do not you think that the public, or the rate-payers, whose money has been so spent, ought to have some redress?—Supposing it to be so; but it appears to me to be a case not likely to occur. I cannot conceive of a body of Commissioners allowing a surveyor to build a drain so totally at variance with the public advantage. The man would be discharged.

You admit the principle of the responsibility of the Commissioners in employing such a man?—I admit that there should be a responsibility, but it appears to me to be so extreme a case as not to be likely to happen. A person building a drain from a house to communicate with a sewer that shall be nine times as large as necessary appears so strong a case that it seems unlikely to occur.

Mr. Unwin.—Assuming the case that the Commissioners have compelled the man to build a sewer nine times as large as it ought to be, knowing it to be so, I think the present law would reach them.

From the account you have given of the small number of houses communicating with the sewers, must not there be an enormous quantity of cesspools in the district?—A very great number.

(*To Mr. Alderman Musgrove.*) Are you aware what the state of those cesspools is?—I have known cesspools in the Hackney district to be ten, fifteen, or twenty years without being emptied. Since we have constructed so many sewers in the Tower Hamlets, that has contributed in a great measure to relieve the cesspools.

Do you know that to be the case?—I do, and I know that it has deprived a large quantity of our Clapton and Hackney gentry of their wells of water.

If the feculent matter from the cesspools has percolated the soil, is it not probable that it has also got into a great number of wells?—The water does not continue in the sewer; it runs through. The fall is sufficient in the sewers that have been constructed to carry the water and contents entirely away. The water does not remain in the sewer.

Wells and cesspools may have a communication quite iudependently of the sewer?—It is possible.

As both the liquid from the cesspool and the well which is external to the sewer have flowod from the outside into the sewer, does not it follow that the liquid from the cesspools and from the wells may have joined before it got there?—That might depend upon the distance between the wells and the cesspools. A person digging a cesspool to receive the waste water of the house would scarcely dig a well near enough to be at all injured by the contents of the cesspool.

Are you so well acquainted with the situation of the wells and cesspools in relation to each other as to say that it is not likely that they do communicate?—I confess I know of no instance in my own neighbourhood where a complaint has been made arising from the cesspool and the well being placed in the situation your Lordship describes.

Are you not aware that in crowded districts many old wells have been

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given up which were formerly in good repute?—In the city of London, and in crowded districts, undoubtedly.

Have any instances been brought under your notice of injury to the public health by the percolation of the cesspools through the ground, and the saturation of the ground with such matter?—None in the district where I have resided all my life.

Should not you think it must be injurious?—It is possible, but I never heard of an instance.

In crowded and unventilated places, for example?—Yes: in crowded districts I think it is very probable.

Are you aware at all what the general position of the cesspool is with regard to the house—whereabouts it is?—It is placed in different situations for the convenience of drainage. Sometimes the cesspool will be placed near the house, to save the expense of pipes and drainage.

In crowded districts, is not it the case that it is very near, and sometimes under, the house itself?—In crowded districts it must necessarily be so.

And in crowded districts in the Tower Hamlets there are a great many cesspools?—There are.

Are there a great many bakers in the Tower Hamlets?—A great number.

Are you aware whereabouts the bakehouses usually are?—They are generally in the basement storey of the house.

Are they not under the house always?—The oven is under the pavement. The bakehouse would be probably in the place of the front kitchen. The ovens are more frequently under the highway.

Are they not in many instances behind the house?—There are instances.

Whether before or behind the house, in all cases they are underneath the surface of the ground?—They are generally so.

The stuff from those cesspools permeates the soil?—Yes.

Do not you think it likely that it may give out occasionally noxious effluvia?—I think there is no doubt of it, where the cesspool is under the house.

And that in crowded districts you say is frequently the case?—Where sewage is brought up they may have an opportunity of draining into the sewers without the aid of a cesspool. But there are many cases where they have refused to do so, even where they have cesspools under the house.

And that in by far the majority of instances probably?—There are a great many instances I know, where, though there is a sewer directly in front of the house, parties will not make a communication with it, though the cesspool is immediately under the house.

Your district is served by the East London Water Works, is not it?—It is.

What is your opinion as to the Commissioners of Sewers having more control over water companies than they have now?—It think it would be a very desirable thing for the Commissioners of Sewers to have a controlling power over the supply of water. I think the supply of water to courts and alleys and to the poorer classes is not sufficient. I think the supply of water being twice a week only in some cases, and in others only

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once even, it becomes in so impure a state before it is used that it must be most injurious. In what way the power could be obtained by the Commissioners I cannot say; but I am sure that the health of the poorer classes depends in a great measure upon our having greater power over the supply of water.

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Mr. *James Beck.*

You have been surveyor to the Tower Hamlets division for how long?—31 years in January next.

You were examined before the Commissioners of Inquiry into the means of improving the Health of Towns?—I was examined twice.

The Commissioners are desirous of ascertaining the extent of work for street and house and main drainage which remains to be accomplished in your district. Have you any plans in your office upon which you can rely for making an accurate return of the number of streets within the district which have sewers in them?—I think I could obtain that; there is a plan here of the district of the Tower Hamlets (*producing the same*).

Have you sections of all the lines of sewers?—All those which have been put in within the last 15 or 20 years; the cross sections are here, I think.

What is the boundary of your district east and west?—The boundary is the City upon the west side, and on the east side it is the Poplar and Blackwall Marsh. To the north is Tottenham, and the river Thames to the south.

Will you describe the progress of your works since you were last examined before the Health of Towns Commission?—I did not receive my notice till past 10 o'clock last night, and therefore I have had very little time, and cannot furnish the Commissioners with anything relating to figures except from documents. We have within the last twelve months nearly got rid, and indeed, except 420 feet that will be complete before Christmas, we have altogether got rid of open sewers in the district of the Tower Hamlets, except those which pass through open fields, and a portion in the Hackney Brook Level. All those which are in densely populated neighbourhoods are covered. That amounts altogether to between 10,000 and 11,000 feet.

Do the open sewers which you have at Hackney receive the sewage of any part of the town?—Not in London; they receive the house water about that part, Shacklewell, and Kingsland, and Hackney.

Are there many houses near those open sewers?—In parts there are.

Will you put in a plan, with the sewers which remain open marked upon it?—I will.

Since you were examined before the Health of Towns Commission, have your works at all varied as respects the size of your sewers, or their construction?—At that period we had not any third-sized sewers. We had only two sizes, the first and second. Since then a third size has been introduced.

Are you carrying out sewers of each class?—Yes.

To what sized houses or places do you adapt those sewers?—It depends upon the thoroughfare more than anything else. The third-sized

sewer is applied to the open sewers we have lately covered, running at the backs of houses or through land not thoroughfares. If that sized sewer were introduced in a carriage thoroughfare, the walls would be thickened to 9 inches. If any of those were required where they could be carried a considerable distance and be applied to the drainage of a large neighbourhood, the sewer would be increased in size.

The first sized sewer is 4 feet 6 by 3 feet?—Yes.

With two rims?—Yes, three at the bottom.

At what cost do you get that executed generally?—10*s.* 9*d.*

There is a second-sized sewer of 4 feet by 2 feet 6?—Yes.

What kind of places do you apply that to?—To collateral streets.

To what class do you apply your third size?—Up courts and passages where there are no carriage thoroughfares, and where the traffic is not great.

In a court with a dozen houses upon either side this is the sewer which would be introduced?—Yes.

A sewer of 2 feet 6 by 2 feet 3?—Yes, of half a brick. It is 3 feet 6 by 2 feet 3.

What is the usual expense of that size?—We are now building 2000 feet of that, and the expense of it is under 6*s.* a-foot. If I estimated it I should make it 7*s.* or 8*s.* What they are done for it is impossible to tell.

Is it with concrete at the bottom?—No, it is all cemented.

Do you find many people join on to your newly-built sewers?—Until lately very few. We have instances of 2000 or 3000 feet being carried out, and not half a dozen communications made; but a sewer being put down through a gravelly soil may be very beneficial to houses, without communications being made. The wells are drained, and the water in the cesspools is lowered naturally from the percolation.

Do you allow a portion of the side to be open?—No; but cutting the ground sets it free.

Do you cement it all the way round?—No, the second-sized sewer is never cemented, it is all done with stone lime. The construction of the sewer is of the best material and in the best manner.

Why do you require so large a class of sewer for so small a number of houses?—It is not that the requirement would be equal to that, but it is the custom.

Is it done more for the purpose of communicating with it by men?—That was the object originally, no doubt.

You use that size of sewer in order to put a man down it?—Yes, I reported to that effect. Before it was introduced I gave that as the reason why that should be the smallest sized sewer.

You stated that of the sewers you have already executed there are very few people who join them?—Latterly the numbers have increased greatly. I think at the last Court there were 60 or 70 applications for communications. They have increased considerably lately.

Can you give any return at all of the number of houses which drain into sewers?—I cannot. The clerk can give the Commissioners an account of the petitions. He has them all entered.

Since when have you had this great increase of communication?—I am speaking of the last Court which was held not above a month ago; but they have been increasing for the last year or two.

What was the reason do you consider that the people did not join on

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to your sewers before?—Because of the expense; I do not know any other cause.

Do you charge the whole of the expense upon the owner?—We have no power of compelling him to do it. There is a charge made for the first three feet; that charge is, I think, 17*s.*; that includes the drip-stone.

What size have you been accustomed to require in those cases?—12 inches.

And that size you still adhere to?—Yes.

Supposing it is a house in a court or an alley?—That would make no difference.

At the present time what would be the expense to a person wishing to drain a single house? Would he have to send notice to you?—He first of all applies by petition to the Commissioners for permission to do so. That is referred to me, and if there is nothing irregular in the application, I sign it. It then goes before the Commissioners and leave is granted, and he has an order to do it, before he does it giving notice to the Court that the ground is open so that our contractor may introduce the first three feet, that we may know that the sewer is not injured by the communication. After that he conducts it himself.

The first three feet will be completed for 17*s.*?—As far as that three feet goes. The money paid by the party is not paid to the Commissioners but to the contractor.

Has he any fee to pay?—No, none at all to any one.

Would not he always have notice to give to the Surveyor of Pavements?—If it comes within their jurisdiction. All streets and courts are not so.

And so with respect to any sewers you may lay down?—Yes.

Do not they require to replace the pavement themselves?—Yes; that is required by the Metropolitan Paving Act.

Do not they put their own charge upon that work?—It may be calculated upon; it is 9*d.* and 1*s.* 6*d.* If it is grouted they charge more; that is the invariable charge.

The charges in respect to that are invariable you say?—Yes; I never knew an instance to the contrary.

Have you any survey displaying the courts and alleys in your district which are drained, and those which are under-drained?—No; we are not in the habit of draining courts and alleys. The Commissioners are in the habit of introducing sewers in that situation.

Are water-closets frequent in your district?—No; they are very few; it is a miserable district a great portion of it; in fact the introduction of a drain would be worth the freehold almost in some cases.

In the better class of houses, are water-closets frequent?—I should say not. I think there were very few indeed.

There is no street or court within your district which you can point out as having houses all of which have water-closets, and all of which drain into your sewer?—No.

Have you ever gauged the quantities of water which pass through your sewers when there is no rain, and when there is rain?—No.

You have, and have thought of no system of that kind?—No; nothing at all.

What methods do you use for cleansing out the sewers when there is deposit?—The sewers are opened, and the deposit is taken out and carted away.

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To what extent do you do that now?—At an expense of from five to six hundred pounds a-year; it is rather mixed up with other things; but I do not think it exceeds that.

Of how many loads do you think that sum will imply the removal?—That I can hardly say: some of that refers to cleansing out open sewers.

In some cases, in cleansing open sewers, you throw it on the bank?—Yes, at the wish, in fact, of the party belonging to the land, and there is a different price paid for it.

That is where he wants a run of water to clear his land?—Yes.

Have you much land drainage about you with tiles or otherwise?—Hardly any.

You would confine your statement of the progress in your district to the carrying out or building a greater extent of main sewers?—Yes. A great many other things would be done if the Commissioners had the power; but they have no power to carry out those sanitary measures which they would otherwise do.

What proportion of courts, alleys, and streets within your district remain without sewers?—That I cannot state.

What are the points of improvement which your Commissioners or yourself would aim to seek powers for?—The power to compel parties to pay for sewers that may be necessary. We have many districts where parties have taken the brick earth out of the land; they have reduced the natural level, and, of course, have deprived themselves of the drainage they would else have had. They then come to the Commissioners of Sewers and ask for a sewer, the water not running off. They having first deteriorated the land so much that it was worthless, a sewer being put in would increase the value, and turn it into building ground; it is not a fair thing that the public should be charged in a case of that kind. If the Commissioners had the power to put in sewers, charging the owner of the land with the expense, payable at certain periods, whether it were two, five, ten, or twenty years, would not signify, so that the portion might be spread over a number of years, I think every sanitary measure might be carried out completely, and in the course of a couple of years I have no doubt every thing required could be done. I am sure it could in our district.

Your charges for the drainage of any part of the district are now levied over the whole district?—Yes, in levels.

Have you not portions of your district which have been paying for years sewers-rates, which have had no perceptible benefit from them?—I think not.

If you lay down a main or collateral drain in Shadwell, will that confer upon the Hackney people, who have to contribute to it, any benefit?—They have not to contribute to it, and they never did.

Then your usual practice is to charge by level?—Yes; the Hackney level pays for the works constructed and the work done in it, and its portion of the contingent expenses by itself. Every level, of which there are seven, pays in the same proportion, and the rates on that account are not equal; some are 3*d.*, some 6*d.*, and some 9*d.*, according to the work done, and to be done, and any balance from the rate which may be left in hand. Hackney has never been charged for the construction of any work in Shadwell or Ratcliffe-highway.

Take the case of Hackney level, are there are in Hackney level any

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courts and alleys without any drains?—No doubt about it, in every level there are.

They have been paying sewers'-rates, having had no drainage themselves?—No immediate drainage; they have all drainage, I consider.

Will not they have been paying for collateral drains?—No, they have surface drains into our sewers; there are dozens of houses which are drained into sewers which neither I nor any one else know anything about. There are many places which appear to be deficient in sewers where they have private sewers and drainage of that description, sewers which have been made by the owners of the property.

Have not those parties at the same time contributed to the sewerage of other districts?—Only to their own level. All the surface water has a communication into our sewers, and we are carrying it off for them. Many streets have no immediate connection with the sewer, but they are benefited by it.

What is the amount of benefit in such a case?—I do not think the law of sewers makes any distinction.

The persons living in collateral streets and places undrained will have contributed to the drainage of other collateral streets and places?—Yes, they have paid their proportion to all new works as well as old ones.

From which they cannot have derived any benefit?—No immediate benefit.

What remote benefit do they derive?—The water is carried off the surface.

What is it to them that it is carried off the surface of a street half a mile off?—The water must run into our sewers.

Supposing it is in a part of the district higher up, how would they be benefited by the water running off into a collateral sewer beneath them?—They cannot be flooded if they are above the level of the sewers.

Must not that be the case with a great number of contributors?—It may be so with many, but if it were not for our drainage they would be flooded upon the very surface. The houses in courts generally are two or three roomed houses; they are built almost level with the surface of the court, only raised a step, or going down a step, perhaps. If the surface water were not carried off they would have the water in the houses.

May not that be true of a particular court, and yet not have the slightest effect upon the streets above it?—I do not know how to go into matters of that kind.

Within the level may not it be true that persons may have been paying sewers'-rates for a century for districts which have remained for a century undrained?—In some points of view it may be so. I consider that the sewer rate should be rather like the highway-rate. The highway-rate is made under the Highway Act. A man may not keep carts and horses to go over the road, but he pays the same as the man who does.

Take the case of a district occupied by lessees, having short portions of time to run out, how is that to be paid for?—It should be ascertained according to the different interests they may have in the property.

How would you charge it, supposing the case of a proprietor of a court or block of houses; he wants them drained, how would the drainage be charged?—The sewer would be built by the Commissioners, and charged to him, payable in certain proportions.

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What proportions?—It would be allowed to run over five, six, or ten years.

How many years is it your practice to let it run over?—That is one of the powers which we want; if we had the power we should soon put those matters to rights.

At present, anybody who wants drainage done must pay the whole expense himself?—Not in all cases. If the Commission sees that it is a sewer which may be carried forward for the public benefit and used for other purposes, there is very little difficulty in getting the sewer built. If it is a sewer which is but partially of that character, or which will be certainly more immediately for the benefit of the party applying, it is considered then that he should contribute something towards it, which he does sometimes in the proportion of a third or half, and the Commissioners build that sewer and take it. In other cases, in putting a sewer into a court, with eight or ten houses, where no one can be benefited but the party himself, they consider it hard that the public should pay towards the profit of an individual; the rate he may have been paying is but a trifling rate. I do not think it exceeds 3*d.* in the pound in the year.

Have not you heard complaints in respect of some of the sewers in the streets, that the smells from the sewers and from the drains to them are very offensive?—Very rarely. Our sewers are closed for seven hours; we have sixteen outlets into the Thames, and almost all the water from our sewers, with very little exception, goes into the Thames. For seven hours out of the twelve, we are shut up, the valves discharging 12 or 15 feet below high-water mark, consequently our sewers are mere reservoirs for a certain number of hours. That would argue against the practice of flushing and everything else. We are scoured in that way in the lower part of the district.

You have to remove the deposit, have you not?—Yes.

From those places you have had very little complaint of smells?—No.

But smells must exist?—Of course.

May not the very small number of persons who have hitherto communicated their house drains with the sewers arise from a doubt on their part whether joining is worth while, inasmuch as, in opening into the sewer, they may be only opening a means of conveying effluvia from the sewer into the house?—I think not.

What is the cause of the number being so small?—The expense, I think, more than anything else.

Have you taken any measures to reduce the expense?—No; we have nothing to do with the drains, we do not build them.

Do not you think it would be an improvement if the drainage from the house as well as the main drain, were provided for under one system?—No, I cannot see that. I think the party ought to pay for it. It is a benefit to his property. In our district I think it would be impossible to compel every house to communicate, on account of the expense. On that account I do not hesitate in recommending the Commissioners of Sewers, where there are eight or nine houses and a good sewer to communicate with, to drain the whole of them by one outlet running at the back of those houses, through the gardens for instance.

Do you consider that drainage is an expense if properly conducted,

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or is it that none is seen as it is now conducted?—It must be attended with some cost.

What is the expense of emptying cesspools in your district. Take a common tenement?—From 7*s.* to 10*s.* probably. If the man who does the work is allowed to come to your house and charge, he will charge perhaps four or five times that; but I may safely say that all men who do business of that kind in the Tower Hamlets would think from 10*s.* to 15*s.* ample.

Some of the nightmen say that the average expense may be about 1*l.* a house?—It is not so in the Tower Hamlets.

What would be the average expense of cleansing do you think?—Certainly not exceeding 15*s.*

That might be the fair average, you think?—I think so; that is not allowing the nightman to use his own discretion about it.

How often would you require them to be cleansed in a year?—Perhaps not oftener than once in three, four, or five years.

Can they be properly cleansed in that way?—I think so, taking the houses I am speaking of. The cesspool would not be cleansed oftener than once in three or five years.

Would not that depend upon the percolation?—A great deal must depend upon the percolation; of course where it is sandy or gravelly soil it acts very much upon the cesspool for a time, but after a course of time the pores get stopped, and that ceases.

Your drainage has generally lowered the cesspools you think?—Yes; it has taken the water out of the wells and stopped steam-engines.

Is not that a proof of the extent of percolation?—Yes; in that case there have been springs which have been intercepted.

In the way you speak, the cesspool empties itself by percolating into the substratum and under the foundations of the whole neighbourhood?—Yes; that is, where the communication is free.

Did you adopt in the Tower Hamlets any precautions at all respecting the cholera when it appeared before?—Not by making sewers. I could detail to the Commissioners what did take place during that period. We had been in the habit of cleansing sewers in the Tower Hamlets by contract once in three years. The contractor generally took the first two years of his contract to cleanse the sewers. In consequence of the cholera and the number of Boards of Health, parties who had puddles in front of their doors thought it a good opportunity to get rid of them. The table of the Commissioners was groaning with applications for the purpose. Instead of 20 or 30 men being put on to cleanse the place, there were 120 men; and that which would have takeu two or three years to do, was done in the cours of three or four months. During the whole of that time there was not a man of those 120 men that was in the least injured, or who suffered in any way in his health. In one place, however, we were putting in 4000 feet of the largest sewers; more pure and beautiful water than was running in that excavation I never saw. There were men there who were working as bricklayers, five of those bricklayers were taken ill, and three died of the cholera; while those who were cleansing the sewers entirely escaped. I was in conversation with Dr. Farr after that, and he said, "Do you not know the reason? your men were all enveloped in ammonia, nothing could hurt them."

According to that theory the whole district would be safe if the whole district were enveloped in ammonia?—The fact I know to be that none of those men were injured.

Supposing the cholera to re-appear, should you alter your mode of dealing with it?—I do not think we could. One thing is very essential in my opinion, and that is an excess of water. I think if plenty of water were applied, the surface drainage in courts and alleys is of more consequence than anything else. If there is a great run of water there is cleanliness, but it is a very difficult thing to introduce anything of that kind in such neighbourhoods.

Has the system of man-holes to the sewers been adopted?—Yes; we have man-holes to all of them.

On the whole, if the cholera re-appeared, you do not think there is anything more that you could do?—I do not think there is anything as regards the sewers. I was in houses where people were ill for two hours quite unconsciously when the cholera first appeared at Limehouse.

Were those men who were cleansing the sewers young men?—No; some of them had been at work 20 or 25 years.

Is it your opinion that, in however filthy a condition a sewer may be, it is not injurious to health?—I cannot venture to say that; but I am quite certain that masses of water upon the surface, or where there is decomposing vegetable matter, which is a vast deal more injurious to health, would engender disease; but I do not think anything like the evil arises from the sewers which has been talked of. In Surrey, I think, they met with the same circumstances we met with.

The conclusion you state was the general conclusion of all parties connected with sewers?—Yes.

And you are convinced that if left to themselves they would act upon it?—Yes.

It was the general opinion among the officers?—Yes.

Can you give the Commissioners any idea of the expense of draining courts?—It must depend upon circumstances; the court may be ten feet wide, or twenty feet wide.

Have you made any estimate of the expense of draining courts and alleys?—No.

As to private drains you have made no estimate?—No.

Nor does it enter into your calculations for the future?—No.

Nor any adaptation of the supplies of water?—No.

What measure, so far as you know, do the Commissioners contemplate, or what additions to their power do they desire?—The main thing, I think, with regard to sanitary measures, would be the power to compel parties to drain their property, not that the Commissioners should be put to the expense of laying in two or three thousand feet of sewers and no one communicate with them.

Would you appoint any scale of expense?—The expense must depend upon circumstances.

Has it been calculated what it would be done for if done by the Sewers' Commission, as compared with the ordinary rates of expenditure by individuals themselves?—I should expect it would be done for less money by the Commissioners; and I am sure that it would be done infinitely better. I do not think it should be done by the parties.

With respect to a survey, have you levels of your whole district

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taken?—No; we have longitudinal sections of the sewers built within a few years past. Those were sections made before the work was carried out.

Supposing you wanted a block of houses drained in some part, how could you tell that it would join on with any future system of drainage?—All I could do is to take the situation of our sewer, and likewise the situation of property beyond it. By that I can ascertain the probability of its being carried further.

You drain to your nearest outfall in fact?—Yes; If I found there was a fall in the land one way or the other, I should take care that the sewer was taken to the lowest possible level.

Have you ever mooted the subject of getting a general survey to a fixed datum line to the Commissioners?—No.

Nor have they to you?—No.

It has not entered into the consideration of the Commission?—No; we have a very large plan.

When was that made?—In 1833.

You cannot tell what levels were taken?—No levels were taken.

You do not know how far it is to be trusted or not?—No.

Is Bethnal-green in your district?—Yes.

Do you know anything of Lamb's-fields?—Yes.

Have not you had frequent representations as to the want of drainage in that particular district?—Not frequent. The sewer is now almost completed up to the spot in consequence of representations from Dr. Southwood Smith.

Is not there a great population all round Lamb's-fields?—We are now putting in a sewer along Three Court-lane up to the end of the street leading on to Lamb's-fields, to afford an opportunity to the proprietor to communicate, if he thinks proper, that is in consequence of a letter which the Commissioners received. They immediately took up the matter and did what they thought right. The work would be very much for the benefit of the neighbourhood.

Has not that private property paid sewers'-rates for a length of time?—No; they are all new houses. We are now cutting off all the drains from the old property which used to communicate with Lamb's-fields; the sewer will now intersect the water which used to go into Lamb's-fields, and we shall carry it off another way. Lamb's-fields is one of the fields I referred to where the making of the sewer would be simply for the benefit of the owner of the property.

You are aware that there was a large space there, which was constantly covered with water?—Yes; about one-fiftieth part of what was represented; where thousands were spoken of, it measured hundreds. It was under the arches of the Eastern Counties Railway.

Are you aware of any particular frequency of disease which was prevalent in the street branching off from it?—I went there, in consequence of what was said, by the direction of the Commissioners. It is not part of my duty to go into houses for the purpose of inquiring into that, but in consequence of what was stated I went to ascertain as to the number of cases of fever; and I inquired at most of the houses along the line about this stagnant water, and I did not find any case which had taken place lately. Some of them they gave me went back two years. I found nothing but four or five cases of scarletina.

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In what month was it that you made that examination?—About the middle of this year; I think about June or July. It was in consequence of a letter which appeared in the newspaper, and which was sent likewise to our Commissioners. At this time the sewer is being carried up so as to take the water from those old properties, and entirely cut off the water which goes to Lamb's-fields; the water under the railway will be absorbed, and it will be like other ground.

You could not hear of much disease in the neighbourhood?—Not in the course of the inquiries I made. I was accompanied by one of the inspectors and the sluice-keeper, and, I suppose, we went into a dozen houses, or more. I reported it to the Commissioners afterwards. There has likewise been a complaint by Mr. Baker, the Coroner, as to Silk Mill-row, at Homerton, but that is a case where the Commissioners have no power.

Is Hackney within your district?—Yes.

Shoreditch?—No.

Bethnal Green?—Yes.

Is Stepney?—Yes; and Mile End Old Town.

Is Limehouse in your district?—Part of Limehouse is in our district. There are two levels, Lower Limehouse and Upper Limehouse.

The Registrar-General of Hackney reports the number of deaths from epidemics to the total number of deaths of gentry in Hackney, to be 9 per cent.; of the tradesmen, 9 per cent.; and of undescribed persons, 20 per cent. Of Stepney it is reported the deaths of the gentry are 4 per cent.; of the tradesmen, 17 per cent.; of artizans, 21 per cent.; and of undescribed persons, 21 per cent.: those are deaths from epidemics. It is also reported from Bethnal Green, that 8 per cent. of gentry, 22 per cent. of tradesmen, and 27 per cent. of artizans, die of epidemic diseases, and those epidemics, typhus, and that is ascribed more or less to bad drainage?—I cannot pretend to go against medical opinion, but in those cases, the poorer the locality, the greater the per centage of typhus. Bethnal Green is in that situation. Hackney is a very healthy district. The per centage is less there than at Bethnal Green, where the people are starving; and if the gentry were reduced by want of food, bad lodging, and bad clothing, to the same situation as those people are, the state of things would be reversed.

You consider Hackney a healthy district?—It is so considered.

It stands thus: the average age of deaths of gentry, 47 years; tradesmen, 29; artizans, 27; and persons undescribed, 25. Every tradesman who lives in the Hackney district, according to this return, loses ten years of his life, and every operative twelve?—So it appears by that return.

Has the state of the Burr-street district been much altered since the cholera appeared in respect of drainage?—Some little alteration has been made by the Dock Company, but there has not been much alteration; no district can be better drained than that. There are sewers in the streets.

Here is the account given of it—"What is the condition of the houses in the district inhabited by the labouring classes?—Very bad. It was the practice to pump the water out of the cellars which had got up into the houses by infiltration from the river, or more frequently by flowing in through the house-drains from the sewers when the tides forced back the

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water into the house. The stench from the water pumped out from the cellars was often intolerable—so much so, that I was accustomed to go out of the way to avoid it. Were cesspools general?—Yes. They percolated the substratum?—Of course. And the river water percolating through the substratum, carried with it the matter from these cesspools?—Of course, and the river itself there was very impure; a large sewer discharged itself into the river nearly opposite to Tower-street." Then he is asked—"What were the means adopted in your district to improve its cleanliness?—Cleaning the drains and the surface of the streets. Were any means taken to remove the filth?—Yes, but this was done unskilfully, and under the influence of great alarm. They opened the drains and cleansed them out; they also opened cesspools, and placed the contents in heaps on the surface, where they were allowed to remain and accumulate for the convenience of cartage. This matter was highly offensive when first placed on the surface, and produced in some cases an intolerable stench, so that I thought at the time the very means taken to lessen the disease tended to increase the evil." You say that your men employed in that way received no injury?—No; but we did not cleanse the drains and gulley-holes—those are parochial matters. The refuse from the sewers when opened was carted away as soon as possible; it was no longer upon the surface than a sufficient time to be got into carts and carried off.

What do the men do with the matter taken from the sewers in your district; do they sell it?—No; they are very glad to give it away, and give 6*d.* a load to any one to take it; there is no more virtue in it than in so much sand. The manure I consider is taken into the Thames.

How do nightmen dispose of the night soil?—They take it into the country.

Do you know what they sell it at?—I do not.

Have you had any applications for sewer-water in any way in your neighbourhood?—No.

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No. 30. Wm. Baker, Jun., Esq.

William Baker, Jun., Esq.

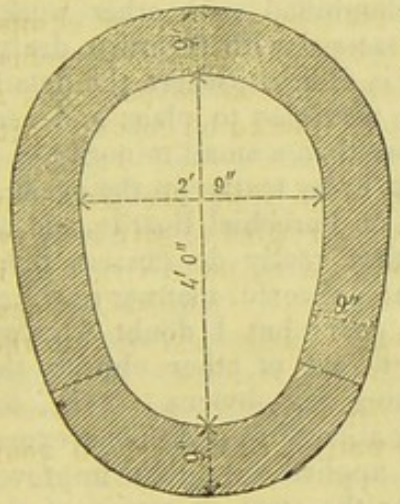
You are clerk to the Commissioners of Sewers for Poplar Marsh?—Yes.

Since your last examination what has been the progress of the Commission? what works have been executed? Describe them—I mentioned in my last examination, in 1843, that this district, originally a mere marsh, was in a state of transition; and that the establishment of numerous factories would probably lead to an increase in the number of dwellings, principally for the labouring classes. That expectation has been realized to some extent, and particularly along the line of the western branch of the Ferry-road, and its immediate vicinity. That branch traverses the marsh in a direction nearly from north to south, and was fenced on either side by open marsh ditches, and it occurred to the Commissioners to be highly expedient to form a covered sewer down the centre of that road, to receive the drainage of the new buildings, supersede the open ditches, and place the sewage of the level on a basis

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more conformable to its altered character and growing importance as a manufacturing district. A sewer to extend about one mile and a half in length has been accordingly commenced. The first branch of this work extends half a mile in length, and has been completed at a cost of 1012*l.*, including a branch down Alfred-street. A good fall has been obtained, and by the introduction of water from the inlets on the west side of the marsh the sewer can be readily scoured out, and the periodical cost of cleansing thereby rendered very moderate. A very extensive work has been for some time in progress under the direction of Mr. William Cubitt, who is enclosing the foreland and constructing a new river wall from the ferry house, nearly opposite Greenwich, to the Folly House, a distance of about a mile, by which means several acres of land, formerly merely osier beds, will be rendered available for the erection of factories and other buildings.

Have you a cross section of the new sewer you have referred to?—Yes, I now produce one.



What was the rate of charge?—33*s.* 6*d.* per yard, including excavation and making good the road.

What extent of land or houses will be drained by this sewer?—By that portion which is at present executed nearly 200 houses already existing, most of them newly built, and some factories may be drained.

Have you made any alteration in system?—We have adopted a new mode of forming communications with sewers by means of drain tiles. The tiles form a drain of 9 inches in diameter, and are in two pieces, one overlapping the other. I produce a specimen.

What is your charge to the owner of the house for laying on house-drains?—The charge has hitherto been 9*s.* 6*d.*, to include the cost of the tiles and the labour attending the connecting them with the sewer, and setting in cement. The work is executed by a builder who contracts for that purpose with the Commissioners; but a reduction of the charge is contemplated, and other builders are about to be employed accordingly, on trial, under the direction of our surveyors.

When you formed your sewer, what proportion of persons availed themselves of it?—Nearly one-fourth. We gave notice to parties at the time of the formation of the sewer, and invited them to communicate then; when the ground being excavated and the works in progress, the communication could have been made more conveniently, and at less expense; but the comparatively small number of persons who have availed themselves of the advantage offered, shows that something more than the influence of mere persuasion and example is needed to secure to the individuals themselves, and the public who pay for it, the full benefit of the new sewer.

Have you had any complaint from the vestry or parochial authorities as to the state of the sewerage, or any suggestions for its improvement?—No.

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Supposing the power were given to the vestry, by representation or otherwise, would the science of drainage be improved?—I think not.

State your reasons?—If the power were given to the vestry by representation, it is probable that the election would be confined to such resident rate-payers as have filled the parochial offices, to the entire exclusion of the landowners and proprietors of the larger establishments; not from the unpopularity of the latter, but from the circumstance of their not being in the habit of attending the vestry meetings, and not making the same interest with the rate-payers to secure their return. It would virtually be a transfer of power from the owners to the occupying tenants and persons of short interests; and I cannot think that that would be a wise measure which should exclude such a very important class. If the power were given to the vestry to act *directly*, and not by representation, it would then, I think, be manifest, that such a numerous body would be incompetent to deal with administrative details. The business of a Court of Sewers is unfitted for the discussion of popular assemblies, and will be the more unfit as it increases in the science demanded, and more especially if combined with other works. Even in the present state of knowledge possessed with regard to drainage, and uncombined with other works, it is difficult, where the details are so infinite, and such constant reference necessary to plans and sections to elucidate every question, to get more than a small minority of a Board to follow, with the requisite attention, every matter in the agenda. I have had some experience of the conduct of Parochial Boards, and no one estimates the good qualities which they really do possess more highly than I do, for instance, the willing and cheerful manner in which they tax themselves for the support of the poor; but I doubt whether the same liberality would be evinced in favour of other objects, the urgency of which is less immediately pressing and obvious. Take, for instance, the small amount of salary usually allowed to parish surveyors, and the sparingness with which money is applied to public improvements. How much better, for example, was the state of repair of the New-road, St. Pancras, when formerly under the care of the Metropolis Roads Commission, than of late, under parochial management.

To what description of administrative body, then, do you consider that the local management in reference to drainage may most safely be confided?—There can be no doubt that, under judicious superintendence, great public benefit may result from a comprehensive measure of sanitary reform. The success of the movement must mainly depend on its being carried out by persons of education, intelligence, and experience in the dispatch of business, and free from contracted notions on subjects of finance. The proposition contained in the Health of Towns Bill of last Session, that one-third of the governing body should be Commissioners appointed by the Crown, appears to have been founded on a just appreciation of the importance of retaining the services of part, at least, of the old body of Commissioners of Sewers, or persons of their class. Those who are practically acquainted with the various minute details of the business of Courts of Sewers, which can only be impressed on the memory by local knowledge and association, can well understand the value of that consecutive and traditional information which such Commissioners have the opportunity of acquiring, and the power to communicate. The proposed retention by the Crown of the power of

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nomination to this limited extent, seems to imply a doubt whether, under the elective principle, the persons most qualified by previous habits and experience, such as some of the old Commissioners, would be returned. Many of that class, indeed, who have regularly attended the Court of Sewers for a long series of years, would most certainly shrink from undergoing the ordeal of a public election, and the ground would thus be left clear for others less qualified, but who, in their turn, would acquire knowledge and experience, and ultimately become useful; but, in the mean time, how are the pressing exigencies of the sanitary movement to be satisfied? In some of the Poor Law Unions there have not been wanting symptoms of jealousy between the elected and the ex-officio Guardians; at all events, the success of that arrangement does not appear to have been sufficiently decisive to encourage the repetition of the experiment. On the whole, in my humble judgment, there does not seem any just ground why the Crown Commissioners should not be intrusted, for a further term of years, with the duty of carrying into effect those additional powers for the public benefit which they have by their chairman and officers for several years past urged on the attention of successive Parliamentary Committees and Commissions of Inquiry.

Do you consider that the superintendence of paving, and of the supply of water and gas, may be advantageously combined with that of the draining?—Gas-works have for some time been established in that part of our district called the Isle of Dogs; and the East London Water Company have recently laid down their mains there, having contrived to overcome the obstacles which presented themselves in consequence of the southern part of the marsh being insulated by the formation of the West India Docks, and what was formerly called the City Canal. The supply of water and gas may be readily provided for by empowering those who have charge of the draining to contract on moderate terms with the water and gas companies; and great advantage would result to the poorer classes from rendering the supply of water cheaper and more abundant; but in our district we have an ample supply for all purposes of drainage. But whatever may be the constitution of the governing body, I am of opinion that the attempt to combine the paving and drainage would signally fail, and go far to neutralize any benefit to be derived from the increased powers with respect to sewage.

What are the grounds of that opinion?—It was formerly considered that the ends of efficiency, particularly in matters of detail, were best promoted by a judicious subdivision of labour; but that doctrine seems in danger of being lost sight of in the rage for consolidation. The questions connected with paving, particularly in the suburbs of London, require exact local knowledge, and much discrimination in dealing with them, and may well continue to engage the attention of a separate Board, and a consolidation of Paving Boards may be very desirable. If all streets and roads were to be deemed public property, were all in an equally advanced state, and there were an inexhaustible supply of stone, it would be easy to generalize and introduce a very desirable uniformity, by paving them all on the same principle, and much discussion might thereby be saved. But every day new private roads and streets are being formed; some wholly, and others partially, dedicated to the public; some have foot pavements, others are merely gravelled and with a stone kerb; almost all are in a state of transition. It is difficult

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enough to raise money for these purposes by rates under present circumstances; if combined with other objects and a more liberal expenditure, the difficulty will probably be increased; and in balancing between the contending claims of drainage and paving, there is too much reason to fear that the operations of the Board would be contracted, the paving and drainage would alike suffer, and the important object of a vigorous and liberal administration for the removal of nuisances and the promotion of the public health greatly discouraged. The combination suggested is presumed to rest on the supposed convenience of having these different services provided for under one establishment, and one governing body, so that the various operations might be carried on simultaneously, and the ground disturbed once only instead of twice or thrice. But assuming drainage to be of paramount importance, if the authorities were to wait until there were a concurrence of favourable circumstances, such as the paving, water-pipes, and drainage in a particular locality, all requiring attention at the same moment, or even the pavement and drainage only, it would seem that procrastination rather than increased vigour and efficiency would be the result. The Board would be perplexed with the pros and cons where a multitude of different objects were to be kept in view and reconciled. The combination may answer in the city of London, where the streets are all formed and paved, but in our district the case would be different.

You are clerk to a Board distinguished by the peculiarity of having laid down a stoneway; what was the original cost, and what the annual cost?—I am acting clerk *pro tempore* to the Commercial-road Trust. The original cost for a single line of stoneway extending from the West India Docks to Whitechapel, a distance of two miles, was nearly 22,000*l*., and portions of it have been repaired since its formation, about 18 years ago, at an expense amounting to about 2388*l*.

Has the experience been such, that if you were to begin *de novo* you would adopt the stoneway?—I think it probable that we should, if we could maintain the same rate of tolls; but the system does not appear to be one likely to be generally extended.

Why not?—Because a stoneway is so expensive as to be only adapted for roads, where there is traffic with heavy goods sufficiently extensive to remunerate for the outlay. In very narrow thoroughfares, where only one carriage can pass at a time, it may be advantageously laid down, but generally in other thoroughfares it will not answer, as there is no holding ground for the horses' feet unless the carriage keeps in the exact tract.

What is the advantage gained in respect of ease of draught?—I will hand in a copy of a memorandum, of the result of certain experiments made on the first opening of a portion of the stoneway. It must be recollected, however, that the benefit resulting from ease of draught is to a great extent neutralized by the necessity of employing increased power to convey the load from the end of the stoneway to its destination.

"GENTLEMEN, *Limehouse, 12th March*, 1829.

"I BEG to report the results of the experiments made this day, upon the stone tramway now forming on the Commercial-road, before you, accompanied by the chairman and deputy-chairman of the West India Dock Company, and Mr. Colville, one of the directors.

"The experiments were made upon the space between the West India Dock-gate and

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the first turnpike upon the Commercial-road with a very good *town* waggon belonging to Messrs. Smith and Sons' distillery, and a stone truck belonging to Messrs. Freeman. The dust had been swept off the tramway in the morning.

"The distance is 550 feet, of which 250 feet, nearest the dock-gate, rises 1 foot, or 1 in 250; and the other 300 feet rises about 2½ feet, or 1 in 116.

"The whole rise in the 550 feet is 3½ feet, or 1 in 155.

"The gravity of 1 ton upon the lower length is therefore 2240 lbs., divided by 250, or nearly 9 lbs.

"Upon the upper length it is . . . . . 2240 lbs.
divided by 116, which is equal to. . . . . 19⅓ lbs.

"And the average of gravity upon the whole length is 2240 lbs. divided by 155, or 14½ lbs.

"*Experiment 1st.*—The general average resistance of 4 tons gross (viz., waggon 1 ton 16 cwt., and goods 2 tons 4 cwt.), as ascertained by your chairman and Mr. Colville, by means of a spring weighing-machine, was 127 lbs.

"From which if we deduct the gravity of 4 tons, or 19⅓ lbs., multiplied by 4, say 77 lbs.

"There is left for the friction of 4 tons 50 lbs., which gives for the friction of 1 ton 12½ lbs., or $\frac{1}{180}$ of the whole weight moved.

"This friction is not more than upon the best constructed edge railway. I consider that the greater size of our wheels, and there being no *flanch*, compensate for the roughness of the stones (from their being newly laid) as compared with an iron railway.

Experiment 2nd.—A pony 12½ hands high, weight 4½ cwt., drew upon the upper part in your presence, and afterwards upon the lower part in your and the directors' presence, 6 *tons* (gross). I was not aware that the difference of inclination of the two parts was so great, or he should have gone over the upper length again; he had done it more than once before.

"Taking, therefore, the upper part, or the rise of 1 in 116, the
pony's exertion was gravity . . . . . 19⅓ lbs.
Multiplied by 6 tons, or . . . . . 116 lbs.
Friction 12½ lbs., multiplied by 6 tons, or . . . . . 75 lbs.

Making together . . . . . 191 lbs.

and 191 lbs. divided by 12½ lbs. (the friction of 1 ton), gives 15 tons.

"The pony's work, therefore, was equal to 15 tons drawn upon a level road.

"*Experiment 3rd.*—The waggon (loaded as in preceding experiment), being turned round, and started by the pony's exertion, ran down the whole length to the dock gates with increasing velocity (the pony not drawing it), and for a distance off the tramway before it could be stopped, consequently the average fall of 1 in 155 exceeded the resistance by friction.

Experiment 4th.—A powerful horse (weight 14 cwt.), drew 12 tons gross (the waggon and truck loaded) from the West India Dock-gate to the turnpike at the rate of 4 miles per hour.

"Taking, then, the upper length, or a rise of 1 in 116, we have:—
Gravity 12 times, 19⅓ lbs., or . . . . . 232 lbs.
Friction 12 times, 12½ lbs., or . . . . . 150 lbs.

Making together . . . . . 382 lbs.

And 382 lbs. divided by 12½ gives 30½ tons.

"The horse's work was therefore the same as if he had been drawing 30½ tons upon a level.

"The full average work of a horse per day is 150 lbs. moved 20 miles.

"Consequently the *pony* was exerting *one-fourth* more than the average work of one horse through the day, and the *horse* was doing the work of *two and a-half* horses.

"The horse appeared to go easily, but the exertion was of course too great to be continued for any considerable time so as to form a basis for general calculation.

"Upon the whole I think the conclusion is, that if the road were level the work of a London draught-horse upon the tramway would be 10 *tons* (gross), but as the Commercial-road rises towards London, a deduction must be made from this for *gravity*, the amount of which depends upon the inclination of the road, and is common to all kinds of roads and railways.

"Therefore, taking all things into consideration, I am of opinion that *six tons* (gross)

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from the Docks to Whitechapel, and a greater weight from Whitechapel to the Docks, may be considered a proper load for one horse on the tramway.

"I am, Gentlemen, very obediently, yours,

(Signed) JAS. WALKER.

"*To Chas. H. Turner, Esq., Chairman, and the Trustees of the Commercial-road.*"

Have iron tramways been suggested as worth a trial?—Iron has been laid down to a very limited extent on our road by way of experiment. It is more lasting than stone, but the first cost is considerably greater. The case of the Commercial-road may be taken as an illustration of some of the difficulties which would occur in the event of a general scheme for paving being adopted. This road was made at a vast expense by a body of proprietors at the time of the formation of the West India Docks, to complete the communication between the Docks and the city of London; and the capital embarked therein on the faith of Parliament is as much entitled to protection as that embarked in the Docks themselves. This road has been held to constitute an exceptional case, and been specially exempted from the operation of General Turnpike Act. It would be manifestly unfair to transfer the management of the pavement, which it is the interest alike of the road trust and the commercial community to maintain in the highest state of efficiency, to a foreign body; such, for instance, as the parishes which it traverses, and which derive little or no direct profit from the extensive traffic which passes before their doors on its way to the City, and no adequate inducement to maintain the road in any better state than the other roads throughout the parishes.

Is it the practice under your Commission to make a general sewers'-rate, or distinct rates for portions of your district, and have you any observations to make thereon?—We have adhered to the ancient practice in our district of making a general rate, it being originally a marsh of one uniform level. I think it of the highest importance, that when a district shall be formed under competent authority, and after due consideration, all who fall within the limits should be deemed liable in law to contribute to the common fund. The promotion of the general health of the district is an object of common interest to all within it, and the petty subdivisions which exist under some Commissions is unfavourable to comprehensive schemes of improvement, and deprives the governing body of that unity of sentiment which is essential to harmonious action. By way of illustration, it may be stated that in some of the Poor Law Unions, where parishes have been previously inclined to a separation, the circumstance of their acquiring property in common, such as an union workhouse, has proved to be a bond of union, while the separate interests of parishes, under the law of settlement have been frequently regretted by members of Boards of Guardians, as being an obstacle to a perfect amalgamation. The same principle of distribution of charges would enable us to carry out other public improvements at a cost per head so moderate as to be scarcely felt; for instance, how desirable it would be to secure for the labouring classes a few acres of land in the Isle of Dogs as a cricket-ground, or place of healthful exercise.

What extent of area have you in your district?—There are between 700 and 800 acres, and the district is about 5 miles in circumference.

Supposing an enlargement of that area to be considered desirable, in

what direction do you consider that your district could best be extended? —There are some peculiarities in our district: First, we have river walls to maintain, extending all round our level, except on the north; Secondly, we have the High-street Sewer, as it is termed, being south of Poplar High-street, with which it runs parallel, and constituting the northern boundary of our district, being the edge or margin of the ancient marsh. North of that sewer the ground immediately rises a few feet to such a height as not to be exposed to any danger of inundation, if the marsh were submerged by the river walls giving way. This higher land drains into the High-street sewer, and consequently derives a direct benefit from our works, particularly the outlet into the Thames at Blackwall, but not being locally situate within the limits of our Commission, nor benfited by the maintenance of our walls, and the owners and occupiers of land on either side of the sewer having been bound "*ratione tenuræ*," or by prescription, to cleanse the particular sewer in question, they were, by a decision of the Court of Queen's Bench, between 20 and 30 years ago, exempted from liability to pay our sewers'-rates, it being held that the performance of that work, the cleansing of the sewer, had been accepted by the Commission as an equivalent for the benefit received, and in lieu of rates. In progress of time that benefit has been extended northwards, by the gradual continuation of old drains, so that owners and occupiers of property in the East India Dock-road, and its vicinity (within the Tower Hamlets Sewers Commission), are deriving direct benefit from works maintained at the expense of our level, to which it cannot be pretended that they contribute, either directly or indirectly, neither are they rated under the Tower Hamlets Commission, which, I believe, has no works in that direction eastward of North-street. Again, the very ground of exemption claimed for the higher lands nearest the High-street sewer may be said to have failed, inasmuch as the owners and occupiers have of late years ceased altogether to perform the service on which they relied for such exemption. The West India Dock Company, being owners to the southward, were quite willing to continue to cleanse their one-half of the sewer; but in consequence of the impossibility of getting the work performed simultaneously by the numerous inhabitants of Poplar High-street, liable for the other half on the northern side, the cleansing has, in point of fact been executed by the parish authorities, and thus the level, either in the shape of parochial or sewers'-rates, sustains the double burthen of repairing the outlet and cleansing the sewer, while the parties principally benefited escape the contribution to the sewers'-rate. The extension of the district northwards, and the enforcing contributions from all who derive direct benefit from the works of the Commission, would be at once an appropriate remedy for this injustice, and the means for securing to the East India Dock-road and its vicinity a still more ample participation in the benefits to be derived from our sewers and outlet. The next peculiarity in our district is that since the formation of the Blackwall railway it receives a portion of the drainage of the small level adjoining to ours to the eastward, called the "Bromley-marsh Level," but without being able to receive rates in respect thereof. That level (although in Middlesex) is included in the Essex Commission, and the Courts of Sewers are held at Ilford. It contains 202 acres, and is bounded on the east by the river Lea, and on the south by the river Thames. Being a

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marsh with comparatively few buildings, and with river walls to maintain, it is a district very similar in character to ours, and the two have comparatively very little in common with the neighbouring Tower Hamlets Sewers Commission. It is submitted, therefore, that they might with great propriety be included in the same metropolitan district, whatever it may be that may ultimately be determined on for this part of the suburbs of London. By a singular chance it already happens that the respective offices of marsh-bailiff and surveyor for the Poplar and Bromley levels are held at the present moment by the same identical individuals. On the whole, I am strongly of opinion (and in which I am confirmed by that of our surveyors, who are also civil engineers and of high standing) that instead of merging the Poplar and Bromley Commissions in that for the Tower Hamlets, which is already quite sufficiently extensive for the proper dispatch of its large and increasing business, it would be more for the public interest to constitute a new eastern district, to include the Poplar and Bromley levels and a small portion of the Tower Hamlets district, viz., to comprise the parishes of Poplar, Bromley, and Bow, the two latter of which are not at present rated under the Tower Hamlets Commission (except to a very limited extent), and the small portion of the parish of Limehouse at present within the limits of the Poplar Commission. The district so constituted would be co-extensive with the Poplar Poor Law Union, with the addition of the small part of Limehouse just referred to. It would contain about 2200 acres, would be about 12 miles in circumference, bounded on three of its sides by the river Thames and the river Lea, distinguished by general uniformity of character, and attended with this advantage that the drainage from the northern portion of it, as well as the southern, would be discharged into the river Thames four miles lower down the stream than by the outlet of the Tower Hamlet sewers. It is all likely to be built upon, and will, eventually, become a populous district. I produce a rough sketch or plan, with the levels distinguished by different colours, showing the proposed additions.

Your father is one of the coroners for Middlesex. In a letter which he has recently addressed to Lord Morpeth, he has strongly recommended that power should be conferred for borrowing money for the purposes of sewage to be repaid by instalments, have you at all considered the subject?—In my examination under the Commission of Inquiry in 1843, I urged that power should be given to borrow money on the credit of the rates, and to extend the repayment over a series of years. Also that great benefit would result if power were given to effect an equitable adjustment between owners and tenants, of the proportions in which they were to contribute to the expense of new works according to their interests. Subsequent experience and reflection have confirmed that impression. We frequently hear of obstacles being interposed to drainage, by the tenant contending that he has too short an interest, and the owner urging that his interest is too remote. If a large owner, he is frequently embarrassed by the consideration of the cases of his numerous tenants, whose terms are of various duration, and no ready mode of apportioning the charge between them and himself presenting itself, combined with the difficulty of procuring the money, the work is left unexecuted. The fairest and most practical course which I have heard suggested is, to permit money to be advanced

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to be repaid by equal instalments of principal and interest, extending over a period of 30 years, the work being in the nature of a permanent improvement to be deemed as worth 30 years' purchase, the tenant with a 10 years' or other term to pay for the period of his occupancy, the remainder to be paid by the reversioner, the charge to be levied from the tenant, except where houses are let as weekly tenements, in which case it should be primarily levied from the owner. As the tenant always pays in the shape of rent for permanent improvements, such an arrangement would, of course, be no hardship to him. It would work beneficially both for landlord and tenant, and eventually tend to the advantage of all classes of the community.

You have given the Commissioners in the former part of your evidence some remarks upon the consolidation of various Boards for the purpose of carrying out both paving and sewage. The Commissioners understood you to think that some consolidation of the Paving Boards might advantageously take place?—Yes.

What advantage do you suppose would be derived from the consolidation of the Paving Boards?—The ordinary advantage in all consolidations is, that of the reduction of unnecessary establishments, and of bringing together a class of persons who would be more efficient. It would be more worth while for good men to come and join a large administrative Commission.

Do you mean by "good men" officers employed at a higher salary, or the Commissioners themselves?—The Commissioners themselves.

Do you think a better class of men would stand for election in those cases?—Yes, I should think so.

By "Paving Boards" you mean bodies who are elected in certain districts?—Yes.

You have also stated that you do not think both the sewage and paving could be very well consolidated under the same Commission, because it requires a good deal of local knowledge, and because it might lead to procrastination. Who do the Paving Boards derive their knowledge of the circumstances of their divisions from generally?—At present, the Paving Commissioners are all locally resident, and they know the district from their own observations.

They derive their principal knowledge and advice, do not they, from their surveyor?—I should doubt it. In the small divisions they have, they frequently judge for themselves. They have sometimes a very incompetent surveyor.

In all those matters it requires a certain degree of scientific attainments, does it not, to carry out works under a Paving Board?—Works are infinitely better done, of course, where science is brought to bear upon them.

They are matters which would be infinitely better done if people of scientific qualifications were employed upon them?—I understand in some instances there are several separate Paving Commissions in one parish. I cannot think it desirable that they should continue to exist; consolidation would be clearly beneficial there.

Supposing competent persons were employed, would not they give the Commission of Sewers every local knowledge which the Paving Boards could possibly obtain?—I think not. I think the parties would be still different; that is to say, the parties who are now members of our Poplar

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Sewers' Commission are very different from those who constitute the body of trustees of the parishes. Our Commissioners are now owners of property, and connected with large establishments who do not reside there, but who live at the west end of the town, and in all parts; though they come down to attend the meetings of the Commissioners of Sewers, I doubt whether they would be elected at all to superintend matters of pavement.

The question did not at all imply the necessity of election. Do not you think a Commission could be appointed which could perfectly well take both the sewerage and the paving under one management, and obtain all requisite local knowledge by the employment of competent surveyors?—My impression is, that in the circumstances you describe, you would not get a Board of that kind.

Are not the surveyors competent to obtain local knowledge. The questions connected with marshes and river walls are so minute that the local knowledge which our own Commissioners possess is exceedingly valuable. If strangers were introduced, or even persons living in Poplar High-street, they would not know matters which are of great importance, and which occur in reference to those marshes. It has not been their business; they have no connexion with those fields or marshes themselves.

Why should not those Commissioners who meet with respect to the sewers do the paving business at the same time?—I think a Board can attend to a great amount of detail, but if you throw too much upon them, it will fail altogether. We have two barristers, three London bankers, three or four county magistrates, and people of that class upon our Board. They would embrace a great amount of detail, but if you overpower them with business, they would decline.

Is it not a complaint with respect to existing Boards of Sewers, that the Boards are encumbered with a mass of detail business, approvals, for instance, of plans of drains, all of which would be much better dispatched upon the responsibility of a paid and competent engineer. Have not you observed in your own Board that much business has come before them which a surveyor would dispatch much better?—I certainly think so; but I do not contemplate that any surveyor would ever be allowed to act very extensively, except under the direction and supervision of the Board.

Do not the defects of the existing plans of drainage, and the incompetency of the surveys, occasion a great deal of occupation of the time of your Boards?—Not from my experience; it may be so in other districts, but not in our district. We have an admirable plan of our own level, which has been made within the last 20 or 30 years, by Messrs. Walker and Burgess, on a very large scale.

Why should not business connected with the paving be done at the same meeting of the Board?—I think you would be obliged to have separate Committees. Suppose you combine the two together, you would be obliged to appoint a paving Committee and a draining Committee.

Why should not they do as is done in the city of London?—The streets in the city are all formed and paved.

Are not your plans complete?—No, they are not; at this moment we have a plan of three streets across a marsh; there is no such question in he city of London.

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Such matters would arise periodically as the business is increased; the question refers to your present position?—For paving in the city there may be a very large quantity of stones, and there may be a contract with a paviour; it is very easy to direct a particular street to be paved, but in our district they are in a state of transition, the roads are only partially formed.—You would not merely order them to be paved, but there would be a question whether those streets should be gravelled, or in what particular way it should be done.

If an application is made for paving, you must go to the Paving Board, must not you?—Yes.

If it is necessary to take up a street for the purpose of a sewer, you must apply to the Paving Board?—In our district we have no paved streets, or but very few.

Then you have no Paving Commissioners at all?—There are trustees in the parish of Poplar, but it is not paved. I do not believe they have more than two or three paved streets in the district.

Who has the control of the roads in the case of a sewer being made?—The trustees of the parish of Poplar, under an Act of Parliament, have the general control of the roads in that district.

Must not the Commissioners of Sewers, if they want to open any of those sewers, apply to the trustees for leave to do so?—A notice would be necessary.

Would not it be a convenience to parties who wanted to make sewers, to have to deal with one party only instead of with two?—It would be easier for a person to apply to one Board than it would to two, but that amounts to very little, in my judgment.

How often do the Commissioners meet for the dispatch of business?—We have about three Courts a-year, and special Courts, when required upon any emergency.

It does not appear, therefore, that the amount of business is very heavy that they transact at the present moment?—Because a great portion of it is done by the officers, under the direction of the chairman, and reported at the next Court.

What, in your opinion, prevents the business being done by the officers exactly in the same manner for the paving as it is for the sewerage?—I think such a system, if very extensively carried out, both with respect to paving and drainage, would not be permanently satisfactory to the public. The local authorities would not be content to leave matters so much to the paid officers.

You alluded in some of your answers to the circumstance that the open ditches are cleaned out periodically—what are those periods?—I am not prepared to speak precisely to the time; when they appear to require it, we give notice. I think they keep constantly doing something towards it, so as not to let it accumulate too much.

How often do you clean out the ditches in the marshes opposite Mr. Stock's house?—They have men constantly at work; they do not allow it to accumulate too much.

Have not you seen it very offensive there?—I have stated in my evidence that in consequence of the difficulty of getting all the inhabitants of Poplar High-street to perform the work simultaneously, it has been done by the parish authorities at the expense of the parish.

What work is it that the parishes have done?—The trustees of Poplar

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have cleansed the High-street sewer, in consequence of the impossibilit of getting the occupiers in High-street to perform the work simultaneously.

Out of what fund have they done it?—Out of their parochial fund, the highway-rate.

Were not the Commissioners of Sewers called upon to do it?—No. I have explained that individuals under an ancient prescription, or *ratione tenuræ*, were bound to cleanse the sewer, and the performance of that particular work was held by the Court of Queen's Bench a ground of exemption from the sewers'-rate.

What water company serves Poplar?—The East London Water Works Company.

Are you aware how often they supply the courts and alleys?—I am not able to speak to that.

What parish is it that cleanses the place to which you refer?—The parish of All Saints', Poplar.

Is not a great deal of goods carried by the Blackwall Railway which formerly used to go by the Commercial-road?—Yes.

Is not that the reason why the toll there should be reduced?—I do not consider that because they appear to be exposed to a severe competition that that can be a good ground why the tolls which the trustees of the road receive should be still further diminished.

Is not it a ground that the toll should be taken off almost, if there is no longer a running way upon it?—A very small proportion of the goods goes by railway; it is large in amount, but relatively it is not great.

There is not so much wear and tear upon the road, and consequently it would appear they should not charge so high a toll?—I should say that the diminution of the wear and tear consequent upon the quantity of goods carried upon the Blackwall Railway would not constitute any appreciable amount.

You stated that one evil which might result from the consolidation of various authorities which had to do with works under the road might be procrastination, because they would be waiting till several operations could be simultaneously commenced. Do not you think, if the Commission were composed of men of business, they could make their arrangements without waiting too long; at all events, do not you think those arrangements more likely to be made for the benefit of the public than when the authority for lifting the road is confided to the hands of various bodies?—I think if the district were small, one body could superintend the whole. I think a body might superintend all the affairs of one or more parishes, and attend to the drainage and everything; but I do not think one body could superintend the paving and draining in the Tower Hamlets Commission and the Poplar Sewers Commission combined.

Do you think that if those authorities, namely, the Paving Board and the Commission of Sewers, were consolidated, it would in fact really lead to any procrastination?—I think it would if the district were large: if it were small, it would not do so.

One reason for supposing that is, that you think too large a district might be overwhelmed with business?—Yes.

Supposing the Commissioners not to be overwhelmed with business, you probably think the larger the district the better?—I would not

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say the larger the district the better. That must be a matter of grave and careful consideration on the part of the body on whom the responsibility of forming the district devolves by law.

If proper plans and surveys are arranged, looking to the joining of one sewer to another, to the finding a proper outfall, to the stating what sized drain should be put in, what sort of pavement is necessary, and at what time the pavements had better be lifted, will not it follow that the larger the district, provided they are capable of executing the business, the better the work will be done for the public, and at a small expense?—I think with a small district like my own, the paving and drainage might be combined with perfect efficiency, but if you take as extensive an area as the Tower Hamlet Sewers and the Poplar Sewers, I am of opinion that one Board could not attend to the duties of both paving and draining with satisfaction to the most intelligent part of the public.

Would not that depend upon the manner in which the work was done?—Having had some experience myself in the management of local business, I think the details would be too onerous for the Board.

It must of course depend upon whether they were too onerous or not?—Whether they would be so or not must be a matter of opinion at present.

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C. A. Smith, Esq.

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C. A. Smith, Esq.

Are you clerk to the magistrates of the Greenwich district?—I am.

And also clerk to the Sewers Commission?—I am.

The boundaries of that Commission are the Kent and Surrey district on the one side?—Yes; on the west side.

And the head of the Ravensbourne is another boundary, and Lombard's wall is the boundary on the east?—Yes.

Is that the eastern boundary of the parish of Greenwich?—It is.

And upon the other side is the river?—Exactly.

Is the parish of Greenwich only within your Commission, or are Lee and Lewisham also within it?—They are: at least portions of those parishes.

What is the amount of acreage actually drained within your Commission?—It is difficult to say exactly, because the line is so uneven, no plan having, to my knowledge, been taken, or at least, not being in existence, it would be impossible to say exactly the number of acres drained.

From not having any plans of the general levels, you do not know what level you are draining into?—No.

Nor how much you have to provide for?—No.

Have you any survey of the district?—Not of the entire district, but of a portion of it.

What do you call a survey?—A correct plan and section of the ground.

What portion of your district has been surveyed?—Only about 500 acres at the east end of the level coming up to the eastern boundary.

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By whom was that survey made?—The oldest plan is of the year 1745. It was made by the surveyor at the time, Mr. Skynner. It was taken for the Commission.

Greenwich is the only town in the district?—It is the only town. Deptford adjoins, but is not within the limits of the district.

Is Greenwich completely drained and sewered?—It is not at all.

Who is your surveyor?—The surveyor of the sewer is Mr. Richard Smirke Martyr.

If there are no sewers it is of no use having a surveyor?—He is surveyor for that portion of the level which I have described as having been drained.

That is surface drainage?—Yes; and also with a view to prevent the irruption of the tidal waters by the maintenance of the river banks.

Is much of the land there below high-water mark?—It is; a considerable portion of the town of Greenwich is below high-water mark.

Who pays the expenses of the surface drainage?—It is paid for by the owners of the land in the East Greenwich level, that portion to which the survey I have referred to applies.

Those owners pay the general expenses of the whole Commission?—They do; there is no other fund.

Can you state what your rates are; how much in the pound each year?—The rate for the current year is 1*s.* 2*d.* in the pound.

Have you a rate every year?—Yes; once in the year only.

Would that give a fair notion of the average rate, 1*s.* 2*d.* in the pound?—No; it is less this year than it has been for many years; in the last 13 years the rates have been as high as 3*s.* 6*d.* in the pound, and this 1*s.* 2*d.* is the lowest rate that has been made.

What is the inclination of the land as regards the river, does it drop towards or from the river?—It falls inland from the banks of the river generally.

Therefore you have great difficulty in getting outlets for the drainage?—Yes.

Have you ever considered the expediency of pumping at all, or is your drainage of 500 acres only on so small a scale that you have not thought it necessary to enter into that consideration?—I have never heard that that has been suggested.

But you find a great difficulty with regard to the outfall?—We do.

Are any of the cesspools required to be built water-tight?—No; they become to a certain extent water-tight, from constant use, from the multiplication of cesspools in a particular locality, they act one upon the other, and in wet weather there is an oozing from the cesspools, and they become to a certain extent water-tight, and overflow.

Does that cause the gravel to bind?—It fills up the instertices of the gravel, and prevents its oozing through.

Into what outlets do they overflow?—Into the channels and kennels of the street.

Are there drains leading thim into any kennel?—No.

Will you explain to the Commission how they overflow?—Through the premises of the parties.

Are the cesspools level with the street?—Many of them are.

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Not in the basement story?—The lower part may be to the extent of the basement story, but the top part will be level with the street.

The river overflows there?—Yes, at high tide.

That is the reason the cesspools are not carried to a greater depth?—Yes; that is the difficulty in the way of carrying them to a greater depth.

What is the amount of rental in your district upon which you have power to make a rate?—The present rental is 6965*l.*

Does that include Greenwich?—Only the part I have referred to, there is no rate whatever upon the town.

Where is the expenditure of 1*s.* 2*d.* in the pound made?—Upon the 500 acres, for the surface drainage, to keep the common sewers of that part clear, and also to maintain the banks of the river.

A large portion must be expended upon the banks of the river?—Yes; it is principally expended upon the banks of the river.

No system of town sewerage, as you have already stated, has been laid down?—None whatever.

Are the inhabitants in the habit of pumping matter from their cesspools into the streets?—They are.

Where does it go to?—It goes into the street-kennels, and then into the river; it runs on the surface.

Do you know anything of the state of those parts of Lee and Lewisham which are comprised in your district; have they any sewerage?—None whatever; nothing but surface drainage.

Where does the Ravensbourne run into the river?—At Deptford Creek.

That is employed as the principal sewer for Lee and Lewisham?—Yes.

Have any complaints been made to you of the state of the sewerage in Lewisham?—There have been recently complaints made.

Have any steps been taken to remedy it?—There is a Special Court convened for the 30th of this month, for the purpose of examining into the complaint, and seeing what can be done to remedy it.

What assessment do you make upon Greenwich?—None whatever, except upon that portion of Greenwich to which I have referred.

The east part of Greenwich?—Yes. I may perhaps be allowed to say, that the Commission exists under an old Act of Henry VIII., and the rate that has been made has always been employed for the purpose of keeping up the banks of the river, preventing the irruption of the tidal waters, and providing for the surface drainage of this part of Greenwich, and no local Act having been obtained by the Commissioners, they have no adequate powers to carry out a system of house-drainage.

Have you ever made an application to Parliament for powers to carry out a system of house-drainage in Greenwich?—No, the matter has been under the consideration of the Commissioners from time to time, but it has not reached the point of their carrying out a system of drainage; the expense is the serious difficulty.

Was not the town of Greenwich seriously visited with cholera?—It was; the lower part principally.

The cholera was remarkably prevalent there?—Yes.

And chiefly confined to that part?—Yes.

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Are there in Greenwich a great many small tenements?—Yes, a good many.

Whom are they inhabited by?—By the watermen to a great extent, and people connected with the factories in the neighbourhood, and small shopkeepers.

Your whole district is greatly increasing in buildings?—Very much so.

Of what sort; of the smaller or middle class, or larger?—Not perhaps of the higher class, but of the small class and middling class of houses.

Would it not be of great importance for such a district as that, not only for the relief of the present population, but for the accommodation of the future population, that the drainage should be as early as possible systematized?—Yes, I think so decidedly.

A great increased value would be given to tenements in consequence of that?—No doubt of it.

You are no doubt aware also of the great improvements in regard to drainage that are going on in some parts of the adjacent county of Kent, for instance?—Yes.

And the land in and about Greenwich would also be benefited by the adoption of a general system of drainage which would facilitate an early extension of those improvements in land drainage which have been carried on in some parts of Kent?—I am not sufficiently acquainted with the system of land drainage to speak to that point. I would only say with reference to that point, that the immediate neighbourhood that I am speaking of, of the district of our Commission in the parish of Greenwich, is of a nature that I doubt whether that system of land drainage is likely to be applied usefully there; for this reason it is very limited in extent, and it is almost daily being converted into building land; it is therefore absorbing that species of land to which land drainage can be applied.

You are, however, well aware of the great importance that a good survey would be for that purpose?—No doubt it is very important.

Would it not be highly beneficial to your district to define your boundaries which are now perfectly undefined, and with a view to prepare for future improvement, that you should have a survey on the best possible system?—There is no question of it.

Therefore, if any general survey be determined upon for the metropolis at large, it is highly important for such a suburb as yours, in order to lay the foundation for a good drainage?—Certainly.

And it is also important that you should have practically carried out a good system of drainage founded upon that survey?—No doubt of it.

Are you likely to get such a survey as a separate operation for yourself?—I have great doubt about it.

At all events, whatever skill is brought to bear upon the service of drainage, or upon the carrying of it out in the metropolis, it would be of importance to the improvement to the property as well as the health of your district that you should be comprehended within that limit?—Certainly.

Do you happen to know, from your general knowledge of the district adjoining that comprised within the Commission of Greenwich,

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whether there is any improvement on your condition in the Gravesend level?—The next principal town to ours to the eastward is the town of Woolwich, and I think I may say that there is no system of house-drainage there any more than there is in our parish; but it is not of so much importance there, because the high land comes precipitantly upon the river. There is not any extent of low marshy ground between the river and the high ground at Woolwich.

From neither the parish nor any of the persons resident in it have you had any plan of drainage proposed?—None whatever. A few years ago there was a company attempted to be formed for the purpose of sewering the town of Greenwich, and notices were given for an Act of Parliament to be applied for; but it came to nothing: the Act was not applied for; it was intended to be a private joint-stock matter, and it failed; it was not proceeded with.

Did your Commission entertain it, or did they oppose it?—It never came before them in such a shape as to enable them to give an opinion upon it; it was merely a project; the parties went no further than the advertisements for the application to Parliament.

Is not the sewerage at the back of Greenwich Hill, where it runs into the Ravensbourne river, in a very bad state?—Very bad; there is one place particularly, where there has been an excavation of chalk; it is called Loats Pits, and from the excavation carrying the level lower than the level of the adjoining ground, and being a very large excavation, which is now turned into building ground, the water from the houses drains into those pits and becomes stagnant, and is very offensive, and it has been very frequently complained of.

Is that near Penn's manufactory?—Not very far from it, on the left hand side nearer Lewisham.

The inhabitants there are of a very low description, are they not?—They are; the Vicar of Lewisham, the Honourable and Reverend Mr. Legge, has frequently made complaints of it, and has attended our meetings, with a view to get something done, but he has never been able to get anything done, from want of power in the Commission to do anything.

It appears, upon reference to the returns from the Greenwich district, that the number of deaths from epidemics, at times, has been between 300 and 400 a-year. From your knowledge of the state of the district, are you surprised that a considerable number of deaths from epidemics has taken place there?—I am not at all surprised, from the state of the lower part of the town, with respect to drainage.

And also looking at the state of Lewisham and the other districts?—Exactly.

At present, unless provision be made, and on some comprehensive scale, an extension of buildings within that district will carry with it an extension of evils?—Quite so; it is very important that any measure of that kind should be adopted before any increase of buildings goes on which will render it more difficult.

And the sooner those measures are adopted the more economical they will be?—No doubt of it.

Your district is unencumbered with any old defective works, and therefore, in a state to enable you to begin any new works, except as regards the removals of the cesspools?—Yes; I have not mentioned

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that there is a cesspool connected with Greenwich Hospital, but that is solely for that building and for certain houses connected with the estate.

That discharges into the Thames?—Yes.

Is it from any particular circumstances that the Commission are about to take into consideration the want of sewerage in Greenwich; is it from any application having been made?—From the general complaint that has been made by parties of the bad state of the town and the want of sewerage, and the Commissioners of Sewers considering themselves the only body that could take the matter into consideration, have determined to do so. The complaint from Lewisham that has been made by a gentleman of the name of Johnson, is in reference to a stream which communicates with the Ravensbourne, called the Quaggs River. Mr. Johnson and some of his neighbours have made complaint to the Commissioners frequently upon the subject, and recently a complaint has been made which is now to be taken into consideration.

That is Mr. Cuthbert Johnson?—Yes.

Is he a gentleman who has cultivated scientific agriculture, and has paid great attention to agriculture generally?—I was not aware of that.

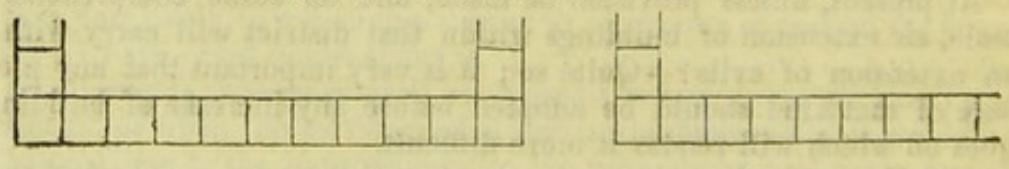
No. 32.

Colonel Hall, R.E.

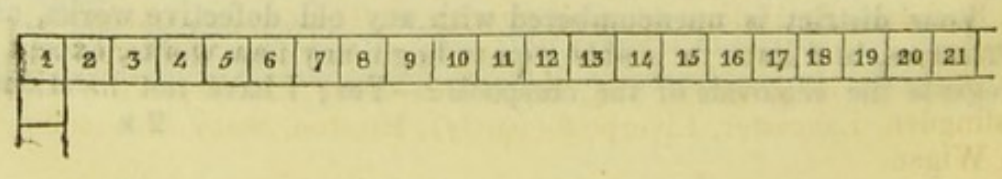
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The Commissioners, being desirous of ascertaining what may be done for the prevention of waste, and to place works of drainage on a safe footing, and to afford means of facilitating the immediate extension of efficient drainage, are desirous of ascertaining how soon a survey on a general plan could be constructed on a sufficient outline to enable works to be carried on with safety. With that view they have requested you to examine the maps and surveys in the possession of the several Sewers' Commissioners, to determine how far any of them and what might be used in aid of any general plan. Have you made this examination?—I have examined such plans as were shown to me at each of the offices.

Will you describe the sort of materials shown to you at each of the offices? Do this as fully as practicable.—At the office of the Holborn and Finsbury Division of Sewers I was shown a block plan on a scale of 10 chains to the inch. This plan does not show the yards, gardens, outbuildings, &c., in rear of the houses. It is a plan of the streets, but not drawn to scale as regards the width of each street. I was also shown district plans on a larger scale than the general plan, on which the division of the houses are marked and numbered thus—



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At each of the other offices, viz., in Greek-street, Soho, Abingdon-street Westminster, Guildhall City, Lawrence Pountney-lane, Great Alie-street Goodman's-fields, and Tooley-street, the same description of plans were shown to me. In the office in Tooley-street there is a survey of Camberwell district on a scale of 3 chains to 1 inch, and one of Rotherhithe district on a scale of 200 feet to an inch, and these plans are more in detail than any of those shown to me at the other offices.

Will you state to the Commissioners the judgment you have formed upon these several plans?—In my opinion they are plans not based upon points trigonometrically fixed; and that, in the event of a general survey of the metropolis being determined upon, they would be of no use.

It appears to be important for the sanitary improvement of the metropolis that such a work as a general survey should be commenced with the least possible delay, not only for the general object, but that every class of buildings, operations, and the employment of workmen should have every practicable facility. In the event of the general survey being determined upon, would it not be practicable to complete those portions of the suburbs where new works are carrying on prior to the execution of the old and denser parts of the metropolis?—The survey of any district, or portions of district, can be taken up without reference to the execution of the survey of the older and denser parts of the metropolis.

Within what time do you consider could anything be got ready in the suburbs from the date of commencement, with any force employed that you may consider most desirable?—Presuming that the necessary funds are forthcoming, impressions in outline of sheets of a skeleton map, drawn and engraved on the scale of 60 inches to a mile, containing about 153 acres each, may be in the hands of the Commissioners for working purposes, though not thoroughly finished, in from six to eight months after the order is given for their preparation.

The Commissioners presume that the expense of the survey of the metropolis would be defrayed out of the annual vote when it came to its turn. What will be the proportionate expense for the metropolis out of that vote?—There is no order existing at the present time showing it to be the intention of the Government to survey the south of England again.

Is there any portion of the work of the Ordnance survey now in progress which would be of immediate importance for the construction of railways?—Yes, the counties of Lancaster, York, Wigtoun, and Kirkcudbright.

Can you furnish the names of the towns in Great Britain that would come under the Ordnance survey during the next twelvemonths?—Sheffield is now being surveyed; and plans of the following towns are being prepared, on the scale of 60 inches to a mile, viz., Accrington, Ashton-under-Lyne and Staley Bridge, Bingley, Bolton, Bradford, Burnley, Colne, Fleetwood, Halifax, Heywood, Huddersfield, Leeds, Manchester and Salford, Middleton, Newton, Oldham, Ormskirk, Prescot, Rochdale, St Helens, Skipton, Stockport, Todmorden, Ulverstone, Warrington, and York; and the engraving of the plans of the following towns is in progress, viz., Blackburn, Bury, Chorley, Clitheroe, Haslingden, Lancaster, Liverpool (partly), Preston, Selby, Wakefield, and Wigan.

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Captain W. Yolland, R.E.

Captain W. Yolland, R.E.

How long did the survey of Southampton, which you have exhibited to the Commissioners, occupy?—It occupied 21 months, and it is drawn on the scale of 60 inches to a mile.

How large was the staff employed upon it?—It was principally done in the process of instructing a number of military men for the general survey of the country. The actual work which the Commissioners have before them was performed almost entirely by four persons.

You do not mean the triangulation?—No; the drawing only.

What number of people do you calculate it would take to survey the town of Southampton in 21 months?—Ten or twelve persons.

Can you at all state what the expense would be?—The cost of this work was about 8*s.* per acre, taking it altogether.

What number of acres are there?—Close upon 3000 acres.

What proportion of it was laid down in building?—About one-eighth part.

Supposing you proceed to survey a large number of acres laid out in buildings only, would it be much more laborious?—It entirely depends upon the nature of the survey that is wanted.

Is such a survey as this absolutely necessary for the purposes of drainage and sewerage?—I do not apprehend there can be the slightest doubt upon the subject.

By that answer do you mean that so accurate a survey as this, both in mapping and surveying, is necessary?—I think so.

Have you calculated what the expense of a survey of a town, per acre, without any country district, would be?—Estimates have been given in to that effect.

The necessity of such a map would be more applicable to towns, probably, than to the country?—Very much more so. I imagine that in all questions of improving drainage or sewerage, or any public works, it is necessary to have the whole of the district under your view at once. The Index Map of Southampton now produced, which is drawn on a scale of six inches to a mile, exhibits at one view the whole of the district shown on the large scale maps; and, when schemes of improvement are sketched out on this index, it will be easy to refer to the particular sheets of the large maps through which the schemes pass, for every portion of the details.

Would the survey of houses take very much more time?—Very much more time.

You have heard and read descriptions of the requirements for sewers; would not it be possible to make skeleton plans to facilitate that work, and get out the levels with greatly increased rapidity?—No question of it.

Can you judge the proportionate rate of time?—One-fourth of the time.

Which would give the altitudes?—Which would give the altitudes of the streets and along the roads, but not the plan of the rears of the houses, the gardens, enclosures, &c.

Would that be sufficient to enable an engineer to judge where a drain should be carried up?—It would.

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Have you any means of judging of the difference of expense between the Ordnance Survey and surveys taken by private individuals?—I am not aware, at present, of the existence of any surveys executed by any civil surveyors whatever, that can compete in quality of execution or accuracy with such a survey as now produced. Such surveys may exist; but I have never seen any of them.

Can you say that, not only with reference to anything you have seen in England, but anything you have seen abroad?—The establishment at Southampton has been visited by many foreign officers; and I have been informed by them that there is nothing in foreign countries either in the mode of execution or in quality comparable with the system or with the works which are carried on at Southampton.

Do the cadastre plans take in any towns upon a large scale?—Nothing of the kind.

Do you know whether the scales in use in Germany for the registration of property can compare with this?—The Bavarians have a very large scale, but not so large as this.

Therefore there being nothing like it in execution that you are aware of, you cannot compare the relative expense; but cannot you compare the expense of wages or remuneration to persons employed on the Ordnance survey with the rates of remuneration to persons conducting surveys either for corporations or for private individuals or public companies?—I can compare the rates of the wages of labour given to persons employed on the Ordnance Survey with the rates which have tempted them to quit the Ordnance Survey for employment upon other works. I beg to hand in a Return in which all the names are purposely omitted, showing the rates of pay of 21 persons employed on the Ordnance Survey, the nature of the duties they performed, and the rates of remuneration; with the duties and rates of pay of these persons on railway surveys. Also the rates of pay at which many of them rejoined the Ordnance Survey.

[*The same was delivered in, and is as follows.*—*See p.* 421.]

What per centage does that vary from yours above or below?—From 500 to 1000 per cent. above the rates in the Ordnance Survey.

Have you any instances of persons employed on the Ordnance Survey being taken by corporations into their employ?—At the present moment the corporation of Liverpool, who are engaged in carrying out sanitary measures for the town of Liverpool, have abstracted a number of assistants from the Ordnance Survey that will answer the purpose of carrying on this very necessary work at rates of pay varying from 500 to 700 per cent. over that which they received on the Ordnance Surveys; and this, after having been furnished by the Ordnance Survey Department, almost at a nominal price, with a skeleton plan of the town of Liverpool on this scale, with some altitudes inserted at the corners of streets.

How do you account for the corporation of Liverpool desiring to have an additional and accurate survey, they having already those outlines which are sufficient for all purposes of drainage?—I imagine it is to project their schemes.

The Commissioners are anxious to ascertain what it would cost to survey the metropolis sufficiently for the purpose of drainage and sewerage; therefore it was that the question was asked, why the Liverpool people should be anxious to have a more complete survey

RETURN of ASSISTANTS who left the ORDNANCE MAP OFFICE for RAILWAY EMPLOYMENT, in the Autum of 1845.

	Rates of Daily Pay on the Ordnance Survey, when they resigned, and their Qualifications, &c.		Rates of Remuneration and Employment on Railway Surveys.		Remarks.
	s.	*d.*			
A	2	11	A good computer, intelligent and useful, but was not employed as a surveyor or draftsman on the Survey.	21*s.* per diem, and expenses, and an additional allowance of 21*s.* per mile for each mile surveyed.	Employed two months surveying and plotting plans and sections.	Rejoined at 2*s.* p diem.
B	3	3	Ditto	Ditto	Employed two months surveying and plotting plans.	
C	3	3	Ditto	Ditto	Ditto	Rejoined at 2*s.* p diem.
D	2	8	A smart useful lad at computations, but wholly unacquainted with the other duties of the Survey.	Ditto	Ditto	Applied lately f re-employme on the Survey.
E	2	11	A good computer, employed also constructing diagrams of triangulation and plotting plans. Very intelligent and generally useful.	10*l.* 10*s.* . . . . per mile for surveys and plans. 5*l.* 5*s.* . . . . . per mile for levels and sections. Employed only two months.		Rejoined at 2*s.* 6 per diem.
F	5	0	A good writer and computer, but unaccustomed to survey or draw plans.	Ditto	Ditto.	
G	3	0	Employed surveying, drawing, and examining plans on the ground; also making diagrams of triangulation.	1*l.* 11*s.* 6*d.* per diem, and expenses.	Surveying, levelling, &c.	Applied lately f re-employme on the Survey
H	6	0	A good writer and careful computer, and experienced at the various field and office duties of the Survey.	1*l.* 1*s.* per diem for 12 months.	Ditto.	
I	4	9	A good draftsman. Employed also for some time in the field. Very intelligent and useful.	10*s.* per diem . . . for office duties, and 21*s.* per diem . . . for field duties for 12 months.		
J	5	9	A good computer. Very intelligent and useful, and capable of drawing plans.	Ditto	Ditto.	
K	3	0	A neat writer, careful and attentive. Principally employed constructing diagrams of triangulation.	4*l.* per week, and expenses.	Office duties.	
L	2	8	Ditto	10*s.* per diem . . .	In a lithography office.	
M	2	8	Ditto	Ditto	Ditto.	
N	2	8	A neat penman, principally employed tracing and computing.	Ditto	Ditto.	
O	1	4	A smart lad, but principally employed at computations, and knew nothing practically of surveying or drawihg.	4*l.* per week in field, with expenses, and 1*l.* 10*s.* when in office	Employed for five months, principally at tracing, and other office duties.	Rejoined at 1*s.* p diem.
P	4	3	A good mathematician, but had not been employed either as a surveyor, leveller, or draftsman on the Survey.	Agreed for 1*l.* 1*s.* per diem for 12 months; But subsequently made another arrangement for	as a surveyor, &c. . levels and sections, at 5*l.* 5*s.* per mile.	Rejoined at 4*s.* p diem.
Q	3	4	A good computer, highly intelligent and useful, but not employed surveying or drawing.	4*l.* 4*s.* per week, and expenses for 12 months.	Surveying, &c.	
R	3	6	Ditto	1*l.* 11*s.* 6*d.* per diem .	Ditto for two months.	Rejoined at 2*s.* per diem, a again resigne
S	2	10	A fair computer, good writer, and tolerably intelligent, but practically unacquainted with surveying and plan drawing.	2*l.* 2*s.* per diem . .	Ditto	Rejoined at 2*s.* diem.
T	3	6	A quick computer, active and intelligent, but unacquainted practically with surveying and drawing.	1*l.* 1*s.* per diem, and expenses.	Miscellaneous field office duties, for two months.	Application for employment the Survey fused.
U	4	3	A careful computer, and pains-taking useful man, but wholly unacquainted with the general duties of the Survey.	1*l.* 1*s.* per diem, and expenses.	Surveying and chaining with levellers, for two months.	Rejoined at 3*s.* diem.

1. In addition to the above, one civil assistant, who is still employed, and whose pay amounts to 4*l.* 18*s.* a week, received an offer of rail employment at 50*l.* per week. Subsequently he could have obtained from ten to twenty guineas per diem, near the close of the t allowed to deposit plans.
2. One non-commissioned officer of Sappers, still serving, received an offer of 5*l.* 5*s.* per diem, and from another engineer an offer of 3 per annum for two years.
3. Another non-commissioned officer, who purchased his discharge, and whose pay amounted to 3*s.* 9*d.* per diem, received employme 2*l.* 2*s.* per diem, exclusive of his expenses.
4. Another, under similar circumstances, obtained employment at 5*l.* 5*s.* a-week for 12 months; and,
5. A private, who purchased his discharge, and whose instruments were supplied to him, agreed for levels at the rate of 3*l.* 3*s.* a mile.

Altogether, 25 military men obtained their discharges, and 271 civil assistants left the Survey to accept of railway employment in 1845, beginning of 1846.

than is necessary for those purposes?—All I stated, as having been given to the Liverpool corporation, were skeleton plans not embracing every alley and every court.

The Liverpool corporation own a great deal of property in Liverpool, do they not?—I do not know.

Except in the case of Liverpool, in what year or years was it that those enormous rates of pay were given in order to abstract persons from the Ordnance employment?—In 1845.

At what rate have railway engineers and surveyors obtained copies of your plans?—Copies of plans drawn upon a 6-inch scale have been supplied at the rate of 10*s.* per mile.

What have they charged to Companies?—We have memorand in our office stating that the charges made to Companies have varied from 30*l.* to 80*l.* per mile.

In the detail of this Southampton plan, which you have prepared, do you show the gully-holes?—Everything upon the surface of the ground is shown on the plan.

Do you show the different classes of inhabitants?—It has not been done, but it would be perfectly possible to do it, as it is simply a question of enumeration.

Supposing it should be wanted to complete some of the suburban districts, for instance the Westminster district, so as to keep workmen employed, within what period of time do you think it would be possible to get out a skeleton plan to enable a portion of them to go on with safety?—I have no doubt portions may be given in from six to eight months. Of course dependent upon the extent required will be the number of persons employed, and the possibility of getting the work done within a reasonable period of time. The sheets of the Large Scale Map are of uniform size, 3 feet by 2 feet, and contain rather more than 153 acres. I should mention that London would occupy, if a radious of eight miles be taken, about 900 sheets.

How many sheets have you for the county of Lancashire which is already done?—Lancashire contains 120 sheets, upon the 6-inch scale.

How many sheets are there for Manchester itself, on the large scale?—I do not recollect. Liverpool contains 50 sheets; Yorkshire contains about 300 sheets on the 6-inch scale.

The Ordnance Survey has been carried throughout the country upon a vote from the Consolidated Fund?—Yes; regular funds voted annually by Parliament.

The parts you are completing are those which have no survey at all?—Quite so.

They have been completed upon an enlarged scale?—A recent decision has been taken upon that subject—it has been determined to complete the six northern counties of England and the whole of Scotland upon the 6-inch scale.

Upon what scale is Dublin?—Six inches to a mile, and sixty inches to a mile.

What is the additional expenditure which has been incurred for the part of England which has already been done above what would have been the rate if it had been completed upon the original scale of the rest of England?—My impression is that it exceeds 200,000*l.*

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LONDON CITY MISSION.

Rev. John Garwood.

SIR, 20, *Red Lion Square, London, November*, 22, 1847.

A CORRECT map of London on a larger scale than at present exists, and somewhat more extended in its boundaries, would undoubtedly be a great boon to us in our operations. As it is, on occupying any district, we are obliged, as a preliminary, to employ an individual to make a map of it, which occupies time and incurs expense. The existing maps do not show the parts of the metropolis in which the poor are chiefly congregated, and which it is an object to visit. And for want of such a map we are able very imperfectly to show benevolent individuals the parts of London which still require their sympathy and efforts. I might state, in illustration of the importance of this matter to us, that a map of the borough of Marylebone was some years since, on its being made a borough, published on a large scale. It is, of course, of less value now on account of the extensive additions which have since taken place in the buildings, especially in the parishes of St. Pancras and Paddington. But with these imperfections we have yet found it so valuable, that our Marylebone and Paddington auxiliary have recently incurred the expense of 23*l.* in reprinting 150 copies of the parishes of Marylebone and Paddington, with slight additions to mark the improvements, and they represent to us that they have found the expense much more than repaid to them by the exhibition which such a map gave to their subscribers of the large portion of these parishes in which a poor population was congregated —a portion much larger than most of them would have supposed, if not thus represented. The sympathies of the more respectable inhabitants have thus been called forth towards their poorer neighbours in a manner which would not otherwise have been the case. And I have no doubt this will still more be manifested in a short time, when the map is more seen and known.

I ought, however, to state, though no doubt the Commissioners are well aware of the circumstance, that the want of a good map of the metropolis is a small desideratum as compared with the want of those arrangements in the poor districts which would promote the cleanliness, health, and physical comforts of the inhabitants. In illustration of such evils, I take the liberty to enclose our magizine for the present month, and to direct attention to the article on the district of St. Giles.

While such evils exist, the efforts of societies like our own, to promote the moral and religious benefit of the working classes, must be greatly impeded and prevented. If more could be done for the improvement of the condition of the districts in which the poor reside, and of their residences, we should undoubtedly anticipate more fruits from our endeavours. But while the poor live as in St. Giles's, decency, morality, and religion are no less set at defiance than health, economy and comfort.

I may further state, that through the neglect of attention to the sanitary condition of the poor districts, our Society are very great losers, by means of the constant loss of service which they sustain in the failure of the health of their missionaries. Although we admit none, except between the ages of 23 and 45, and after careful examination by

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medical men, and although as soon as they are at all ill, they are allowed to lay by, have the best medical attention gratuitously afforded to them by the Society, and receive the privilege of going into the country to houses provided for the purpose, and although, further, they have a fortnight's holiday every year, even if well, and are allowed not to reside in the very close parts, yet with all these advantages, and although they have many of them previously been born and bred in poor districts, and accustomed to hard and trying labour, a considerable number of them are continually laid aside, and very many who promised best have to give up altogether in a few years. Indeed, I may say, very few of our missionaries, with all these advantages, can stand many years' work on the really bad districts of London, although 36 hours' visiting each week is all which is required of them. I consider that we sustain as much loss of life and health in prosecuting missionary work in London as those Societies do the object of which is to send missionaries to foreign parts, many of which are notoriously unhealthy. And I cannot but consider that this is a reproach to the metropolis of our country. There are some districts respecting which we almost feel sometimes a question. whether we ought to expose the health and life of men by placing them on them; and there are other districts on which missionary after missionary has broken down, when located there, while even in a large number of our districts, the energy, strength, and vigour of our missionaries become impaired by their constant exposure to impure air. I beg also to enclose a magazine of our Society for August, 1845, in which is a statement of the condition of the lodging-houses of the metropolis.

I have to apologize for the length of these remarks, but I trust they will not be considered as irrelevant to the objects of the Commission.

I am, Sir,

Your obedient humble servant,

Henry Austin, Esq. JOHN GARWOOD, *Secretary.*

P.S.—Should a further illustration or two be desired of the crowded state of some parts of London, and of the evils which result from the same, I enclose an extract, on 1st, a court in Marylebone; and 2nd, Charles-street, Drury-lane. I am only afraid of burdening you with too much to peruse.

J. G.

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J. Billing, Esq.

No. 35. J. Billing, Esq.

You were engaged in the preparation of plans for the sanitary improvement of Reading, were you not?—Yes.

In Reading there were many old courts and alleys, were there not?—Yes.

You have seen courts and alleys in London, have you not?—Yes.

What was the comparative sanitary condition of the courts and alleys in Reading occupied by the working-classes?—In respect to the drainage, paving, cleansing and ventilation, and the supply of water, many of them were as bad as those in London.

Did you not, for the purpose of laying down a plan for the sanitary improvement of that town, visit several towns where works for carrying

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out sanitary improvements had been effected?—Yes. I visited the Holborn and Finsbury division of sewers, and Eton, and Southampton, Birmingham, and Derby, for works of drainage; for water-works, the places of constant supply, Nottingham, Ashton-under-Lyne, and Oldham. I did not visit Preston, but I got every information in respect to it.

In respect to drainage, the works of all the towns you mention were on the intermittent supply of water were they not? and the principle of cleansing the sewers at intervals by flushing? and with brick sewers large enough for men to go up them to cleanse them?—Yes; that was the general principle of construction.

None of them had got tubular sewers for the collateral streets?—None.

What did you propose for the courts and alleys?—Tubular earthenware drainage.

Of what size?—Ten inches in diameter.

Of what construction and size the house-drains?—All of them tubular drains, six inches in diameter at the entrance to the sewers; but with collateral branches of four inches in diameter.

On what data did you propose 6-inch house-drains?—I adopted the recent London practice of using 6-inch tubular house-drains. I had used 6-inch tubular drains in houses, and found them work far better than the 9-inch brick barrel drains, or the common brick drains. These were always more or less choked up, whilst the smaller tubular drains were always clear.

From subsequent observation, would you not say that a 4-inch tubular drain for such a class of houses would work still better than the 6-inch drains?—Yes, I should.

You proposed the entire removal of cesspools from these courts and alleys, as well as from every house in the town, the introduction of a constant supply of water, the substitution of a water-closet apparatus, and the complete house and court drainage. Will you describe the nature of the works you proposed to lay down for the courts and alleys, and the average expense per house, supposing that each house paid only for its own particular works?—I proposed to form the drains for the houses in all courts and alleys with 4-inch earthenware pipes; in some cases two or more houses would branch together, each 4-inch pipe to have a trap at its junction with the main drain of 10 inches diameter. The water-closets would have had the common earthenware syphon pan, or with the syphon portion of the pan, as contructed at Ashton, with solid blocks. Thus, Fig. 1:

Fig. 1.

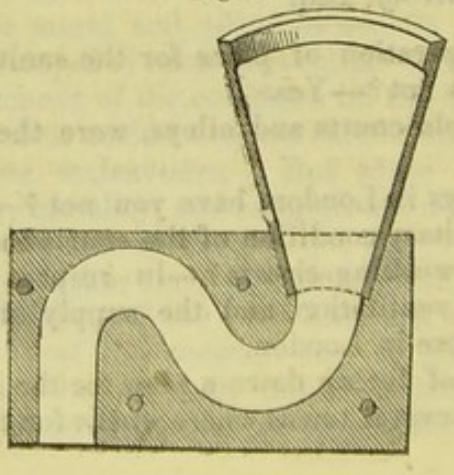
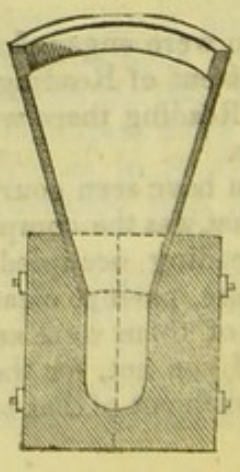


Fig. 2.



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Fig. 2, represents the end of the two blocks, fixed together with small iron screw bolts. The present cesspools to be entirely removed. The water supply to the courts was proposed to be effected by a 1¼-inch lead pipe, with branches to each house and water-closet of half an inch in diameter.

The following is a table of the expenses which would have fallen upon the houses in courts and alleys supposing the main sewer to have been constructed opposite to the entrance of the court:—

First Outlay per Tenement.		Annual Instalment for Repayment in 30 Years.	Annual Interest Commuted at 5 per Cent. charged as Rent on Tenant, and Annual Rent of Water.	Weekly Charges to the Tenant as increased Rent.
	£. s. d.	£. s. d.	£. s. d.	£. s. d.
5805 feet Drains in Courts at 2*s.* 6*d.* per foot=725*l.* 12*s.* 6*d.* ÷885 Houses	0 16 3	0 0 6	0 0 6	0 0 0¼
30 feet 4 Pipe Drain at 7*d.*= 17*s.* 6*d.* Trap 2*s.* 6*d.* . .	1 0 0	0 0 8	0 0 7¼	0 0 0¼
Water closet, Pan, Trap, 10*s.*; expenses of covering or emptying Cesspools, 10*s.* . . .	1 0 0	0 0 8	0 0 7¼	0 0 0¼
Annual rent of Water, which included the contribution to the original expense and maintenance of the Water-works .	. .	. .	0 5 0	0 0 1¼
Total . . £	2 16 3	0 1 10	0 6 9	0 0 2

Had you satisfactory contracts for the execution of the drainage of the courts at these prices?—Yes, I had obtained the contracts.

In respect to soil-pan apparatus, what was the most simple which you found had been introduced into successful use?—The above mode I consider the most simple and best adapted to the purpose required.

Was this apparatus in use by persons of the labouring classes?—Yes it was.

What was the report of its use?—Perfectly satisfactory.

Then, practically, the presumptions that persons of the labouring classes would wilfully stop them up, that children would, from mischief, throw things down, and the like apprehensions, proved to be groundless?—Yes, entirely so.

For what sum did you estimate the removal of cesspools?—To empty the cesspools (the contents of which the agriculturists at Reading would remove gratis), to cover them securely with brickwork in cement; to fix the soil-pan, connect it with the drain, and a self-acting Lambert's stop-cock for the supply of water, 1*l.* 5*s.*

What did you observe in those houses where a constant supply of water had been carried?—An increase of cleanliness certainly, and more comfort.

In respect to the supply of water, you may have seen it stated by some engineers of London water-works, that the constant supply would require larger and more expensive pipes; what did you find practically to be the fact?—Decidedly the reverse.

Will you give examples?—I found that in Nottingham, Ashton

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and Oldham, all the pipes are much smaller than the sizes used on the intermittent system, and this is the case at Preston also, where 50,000 inhabitants, and many factories, are supplied by a 14-inch main. There are also 80 cottages supplied by a 1-inch pipe; with ½-inch pipes branching to each house. It is common in all the towns above mentioned to supply branches to several houses by a 1-inch pipe.

It appears that the landlord's expense for carrying water into each of those 80 cottages was 24*l.*, or 6*s.* per cottage; were you satisfied that the work might have been done for that?—Yes, I had estimated the expense of a supply to similar houses in Reading at the same price. In many of the cottages we should have run the inch pipe along the foot of the wall at the backs, with short branches entering into the houses. The piping used was ½-inch lead pipe, which, in quantities, was to be had at 3*d.* per foot. The Preston taps, which are admirable things, cost 2*s.* each. There was one tap and a sink-stone to every house, besides a supply of water to the soil-pan, or water-closets, with one of Lambert's self-acting stop-cocks.

Did you not find it advantageous in respect to economy, to drain the houses at the back instead of through the fronts?—Yes, for I found that made a very great difference in the outlay.

It has been stated by some engineers of the London water-works, that not only would larger pipes and more expensive apparatus be necessary, but proportionately larger supplies of water for the system of the constant supply; how did you find the practical experience in that respect?—I found that the quantity of water now used in those places is, without exception, much less then when the intermittent system was in operation. At Preston the average supply per house, exclusive of factories, is fifty gallons per day.

Did you find earthenware pipes in use, and course of introduction anywhere for the distribution of water?—Yes, at Ashton.

That is to say, under the constant system of supply at a pressure of 150 feet, was it not?—Yes.

Will you describe the material and the sizes of the pipes?—The pipes were of a common coarse fire-clay; 3 inches in diameter, and three-quarters of an inch thick, with sockets jointed with Roman cement. From these there were ½-inch pipes for the house supply.

The mode of jointing the iron pipes in London is with tow and tar, and lead run in, and then hammered down; now inasmuch as it has been presumed that the earthen pipes would not bear the hammering down of the lead, it has been stated that earthen pipes could never be jointed, to be used as substitutes for iron pipes; what was your observation on the jointing?—Roman cement is exclusively used at Preston for jointing pipes of every size and description, and it stands perfectly well under the constant pressure before stated. About 10 miles of pipes, varying from 3 inches to 14 inches in diameter, have been laid 13 years, and not one joint has failed. The pipes are bored and turned to fit; the cement is wetted with warm water, and is laid thinly round, or painted on the espigot end of the pipe, and into the fawcet end, the pipes are then driven gently in, and the joint is made. The engineer of those works says, "It makes a perfect joint, and the pipes never move," and "he has not heard any objection made to this method." The joints formed of tow and lead are not only less secure,

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but also immensely more expensive than those formed as at Preston For example,—the cost of laying 60 yards of 4-inch pipe at Preston, including labour and materials to joints, boring and turning the pipes, opening and filling in ground, and taking up and relaying the paving, is 2*l.* 9*s.* 3*d.*; to execute the same work in the London manner would amount to 6*l.*, being an excess in the expenditure of nearly 250 per cent.

Are you satisfied that earthenware pipes would resist the weight of the column of water proposed to be used for sanitary purposes?—To test the strength of earthenware pipes, I have made some experiments upon the stone-ware and the common red-ware pipes which are used for house-drains. The following table shows the pressure per square inch at which the several pipes burst:—

No. of Experiment.	Stone Ware.		Common Red Ware.		Lbs. pressure per square inch at bursting.	Equal to a column of Water in feet altitude.
	Inside Diameter.	Thickness of Material.	Inside Diameter.	Thickness of Material.		
	In.					
1	15	$\frac{11}{16}$ of 1	..	..	46	92
2	9	$\frac{10}{16}$ of 1	..	..	107	214
3	$6\frac{1}{2}$	$\frac{11}{16}$ of 1	..	..	160	320
4	..	..	$6\frac{3}{4}$	$\frac{6}{16}$ of 1	35	70
5	..	..	$4\frac{3}{4}$	$\frac{8}{16}$ of 1	77	154
6	..	..	$3\frac{3}{4}$	$\frac{6}{16}$ of 1	97	194
7	$2\frac{1}{2}$	$\frac{5}{16}$ of 1	..	..	80	160
8	2	$\frac{6}{16}$ of 1	..	..	not burst at 160	320

From these results upon pipes irregularly made, of very unequal thickness, too thin for the purpose, and with the material insufficiently prepared, it is evident, that by proportioning the thickness to the diameter, earthenware pipes may be formed to resist the weight of a column of water of any required altitude. The strength would be greatly increased if they were made by a machine, and of a more regular thickness than those which were tested by these experiments. Each experiment consisted of two pipes jointed with common Roman cement of good quality. None of the joints failed.

Architects and engineers, and others who have been informed of the strength of earthenware pipes against internal pressure, have nevertheless expressed doubts of the capacity of such economical materials to resist external pressure. Have you met with any facts to justify such a conclusion?—Sufficient evidence of their strength to bear external pressure has been afforded already by their use as drains.

You are aware that earthen pipes have crossed highways of traffic; have you heard of any breakage amongst them?—I have seen large quantities of 4-inch, 6-inch, and 9 inch pipes laid down in highways used for various traffic, and I have never heard of any breakage. I imagine that at a sufficient depth to be protected from the action of frost, they would also be secure from all other kinds of injury.

From your own observation of these facts, should you hesitate to use a distributary apparatus of earthenware pipes entirely for the water

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supply for such a town or such a district as Reading?—I should have no hesitation in doing so.

The chief advantages that arise from the use of earthenware pipes for distribution are stated to be freedom from oxidation, by the water, which has sometimes a pernicious action upon metals; greater coolness and freshness; the fire-brick or earthenware being a less rapid conductor of heat, less liability to freeze, and reduced expense?—Those advantages I conceive, would be obtained; the reduction of expense by our present modes of manufacture would exceed one-half of the cost of iron pipes, but with improved methods of manufacture, and a supply suited to the nature of the demand, a saving of two-thirds of the present outlay for iron pipes might be effected, and thus the expense of laying down the various distributing pipes for the water supply of towns may be safely calculated as capable of reduction in this particular to the extent of 65 or 70 per cent.

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