Mr. FULTON stated, through the Secretary, that after upwards of an additional year's experience, since writing the Paper, and after a practice of eighteen years in sanitary engineering at Liverpool, and in Dundee, he was fully convinced, that with properly-constructed sewers, no ventilation was requisite. This might seem a startling assertion, but having had a length of not less than 30 miles of main sewers, and nearly as many miles of branch drains, all closely trapped, in use for several years, without a single complaint being made regarding foul emanations from them, was a proof of the correctness of his position. The sewers were kept free of all silt, except sand, by the flow of the ordinary sewage and rainfall, regulated by flushing gates, so that their perfect cleanness, so far as any sewer could be called clean, was insured; or, to put the matter in another form, no putrescent substances were retained in the sewers, or drains, to fill them with deleterious gases, and to poison the inhabitants. Therefore, there did not exist the slightest necessity for the ventilation of such sewers and drains.

Mr. A. BASSETT remarked, through the Secretary, that being well acquainted with the district of Newport, and particularly with a large extent of wharf and other property, on the River Usk, belonging to Lord Tredegar, he had opportunities of forming an opinion on the utility of the drainage scheme executed by Mr. A. Williams, and it afforded him much pleasure to state, that the works had proved to be most satisfactory, both as regarded economy and efficiency. He had never heard of any complaint having been made with reference to the discharge of the drainage water into the River Usk. The large river area, coupled with the rapid flow of the tide, precluded any ill effects arising from this mode of drainage.

Mr. THOS. C. THORBURN (Borough Surveyor, Derby), observed, through the Secretary, that he did not think the drainage works of Dundee would be found to work satisfactorily, without efficient means of ventilation. He was persuaded that the light sewer gases would force themselves through the inlets, or imperfections of the pipe-joints, at the higher levels, which would in most cases be under houses, and therefore would be doubly objectionable in a sanitary point of view. The arrangements for flushing, at Dundee, appeared to be ingenious, but they must involve considerable expense in labour. Such complicated works as town sewers generally were should be arranged on the most simple principle, and be made, as far as possible, self-acting. The flushing of town sewers was absolutely necessary if they were to be kept clean, without resorting to the old method of breaking up the surface of the roads, or sending men up the sewers to clear them by hand. At Derby the whole of the sewers were kept clean by flushing, by penstocks fixed at the river side above the weirs, and by numerous cisterns constructed at the upper end of the collateral and branch sewers, filled with water from the mains of the Waterworks Company. No doubt this involved expense; but, on the other hand, labour was saved, and he believed the public were fully compensated by the more efficient working, and by the sewage being carried completely away from the town to the outlets. In other respects the arrangements for the drainage of Dundee, if carefully carried out, would probably work satisfactorily.

Mr. Williams appeared to have designed the works of drainage at Newport with great discrimination, and if they had been executed with care, they would no doubt act well. He did not, however, entirely agree with the Author in the limit to which he recommended the use of stoneware pipes, for house-drainage, as long experience had convinced him that they might, with advantage and economy, be used for collateral sewers, and for the upper ends of main sewers, where the flow of sewage was small, and adequate means of flushing were provided. He did not, however, recommend the use of stoneware pipes for sewers of any description, without sufficient power for water-flushing being in every case provided, especially where debris was liable to be washed from the streets and roads into the sewers.

Mr. R. Rawlinson said the description of the works at Dundee was clear and full; but there were some remarks which deserved special notice. He would direct attention, in the first place, to the amount of sewage discharged by the outlet sewer, which was stated to measure, in dry weather, 2 feet, and, during storms, 6 feet in depth; and that the velocity of the discharge was in the former case 65 feet per minute, and in the latter 116 feet per minute. He had looked over the calculations, and thought there must be a mistake; unless there was some element which did not appear in the Paper. He believed the velocity would be much higher for the gradient given, and the depth of water in those sewers; at least he had found it to be so in sewers he had constructed.

The principal point, however, to which he wished to call attention was, that although it was stated that the sewers at Dundee had been designed to act entirely without ventilation, and the Author asserted that ventilation was not required; yet, with apparent inconsistency, in another part of the Paper, he had spoken of having trapped certain gullies, to prevent the sewage gases escaping into the streets and houses. Mr. Rawlinson had a large experience in sewer construction, and he contended that it was dangerous to lay down a system of sewers over an entire town, without in the first instance providing, as part of the scheme, for the fullest and freest ventilation, at all parts of a town; but it was generally most necessary at the upper and higher levels. Sewage gases, being lighter than atmospheric air, flowed upwards, while the sewage itself flowed downwards, and as the velocity of the discharge of sewage water downwards would be in proportion to the gradient of the sewer, the flow of sewage gases upwards would also be in proportion to the gradient. Therefore, a town having a naturally steep gradient, required the fullest means of ventilation; and so far from its being easy to sewer such a town, he held, if proper means were not taken to provide for ventilation, the Engineer was liable to leave that town worse than he found it. Within his own knowledge, disease had broken out in well-sewered districts, which was traced to a connection of house drains with unventilated sewers; and in those cases the highest portions of the towns suffered most severely. He thought the authorities at Dundee should not rest satisfied with what had been already done, nor until the work was completed by a proper ventilation of the sewers. Mr. Fulton seemed to infer, that sewers which wanted ventilation had been badly constructed. Mr. Rawlinson, on the contrary, held, that if such sewers were sweet, they must have been badly constructed; and that there were joints and crevices which allowed the gases to escape; because, with a perfectly tight sewer, the gases must make their way to the upper extremity, and have a tendency to find exits into houses through the house drains. The method of cleansing sewers, proposed by Mr. Fulton, was very similar to a system invented by the late Mr. Richard Blades, and used by him at Liverpool; it had also been introduced to the notice of the Metropolitan Board of Works. He thought it right to mention this, because credit ought always to be given to those who had the priority in any useful invention.

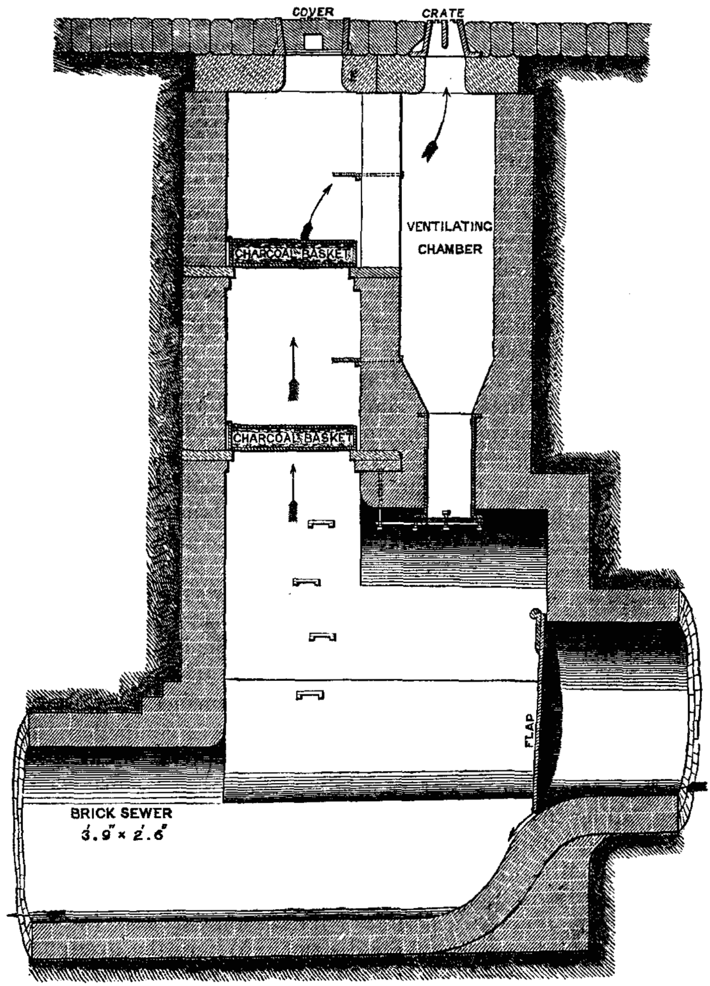
Mr. Alfred Williams had presented an able description of good and useful works executed at Newport, Monmouthshire, where ventilation had been adopted. He did not quite understand what was meant by the remark, that it was not considered advisable to use stoneware pipes as main sewers, but that it was preferable to adopt a sewer of sufficient size for men to traverse. He thought any Engineer in sewering a town, ought to banish from his mind, at once and for ever, the necessity of constructing sewers sufficiently large for a man to pass through, unless those dimensions were required to discharge the sewage flowing into them, and should rather endeavour to design such a form of sewer as would be absolutely certain to discharge the contents derived from the upper extremities and from all the tributaries, and to keep the sewers clean and sweet. He could mention instances, in his own practice, where sewers had been constructed so as to act in the most efficient manner, without incurring the additional cost of making them larger than was necessary, merely for the sake of saying at the conclusion of the work, "that they had a sewer large enough for a man to go through." He could point to dozens of miles of sewers which had been in operation a sufficient length of time to subject them to the severest test, without any instance of failure from choking up, or requiring hand-cleansing. The sections of the Newport sewers (Plate 4) were certainly of the most approved forms, and the bricks employed there were well adapted for the construction of such sewers with economy. Looking at the section, Fig. 8, Plate 4, it appeared that the internal dimensions of that sewer were 4 feet 6 by 3 feet, and that the brickwork of the invert and of the sides consisted of a double ring, 9 inches in thickness, while in the crown there was a single ring only, 6 inches in thickness. He did not know what plan had been followed at Newport, but in his own practice he should have set the two top courses of the thicker part of the work as 'headers,' so as to bond the two lower rings together, and to give a fair start for the single ring. In fact, in every instance where there were two rings of brickwork in the invert and sides, he insisted that there should be two rows of 'headers' at, or about the springing, so as to bond and tie the work together, where the arch commenced. The method of ventilating a sewer at Newport was good as far as it went; but he thought it was imperfect in this respect, that the manhole shaft was not available, without removing the flag which covered it, and thus breaking up the street.

The system of ventilation he had adopted was shown by Fig. 5, page 288. There was a side chamber; but instead of covering the manhole shaft with a flagstone, which was difficult and expensive to remove, when access to the sewer was desired, it was finished with a manhole cover, which formed the street surface, and did not allow air to pass out; so that the sewer gas was compelled to rise through two, or more charcoal screens, or filters, before passing into the side chamber, or ventilating shaft. Any dirt from the street, falling into the ventilating chamber, was caught in an iron box, at the bottom of which there was a slide, so that the dirt could be readily removed whenever necessary.

In a hilly town the whole system of sewage should not be so connected together as to permit of the accumulation of the sewage gases in the higher parts of the district. Where the gradient was steeper than 1 in 200, and a sewer was, say, one mile in length, it should be divided by steps, or falls, and there should be a flap valve upon the upper, or higher discharging end of the sewer; with at least two ventilating grates at that point, so as to insure thorough ventilation.

It was to be remarked, that the systems of sewerage, both at Dundee and at Newport, discharged into rivers. It was frequently necessary to carry the outlet of a sewer to a river, having a low summer level, and a high, or flood level. It was

Fig. 5.



Manhole, Tumbling Bay, and Double Ventilating Arrangement.

neither advisable, nor always practicable, during flood times, to carry the whole of the sewage, if the quantity was considerable, down below the summer level. Figs. 6 and 7 (p. 289) showed the arrangement he had executed at Windsor Castle, where formerly

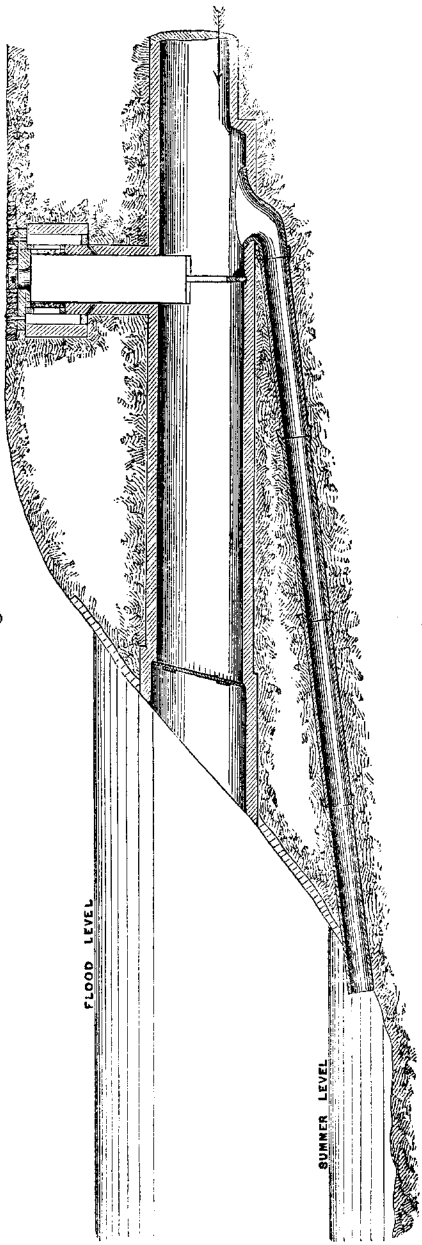


Fig. 6.

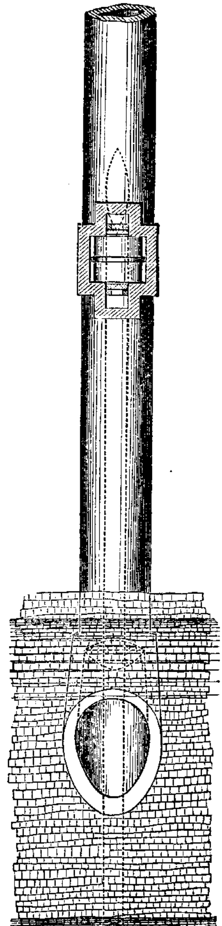


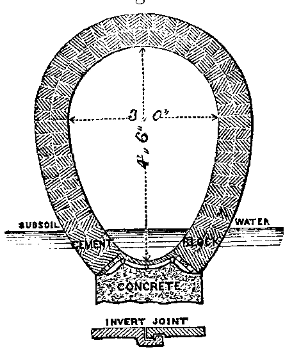
Fig. 7.

Dry Weather River Outlet, at Windsor Castle.

a large brick sewer discharged itself into the Thames, close to the Queen's private walk, and was a source of nuisance. By fixing a cast-iron pipe at the bottom of the sewer, and putting a slight dam in front of the junction, all the ordinary sewage was discharged by the iron pipe below summer level, so that the sewage was never thrown into daylight. The brick sewer above took away all excessive storm waters, and there was no danger of bursting, or other difficulty. He found a sewer 4 feet high and 3 feet wide might be required for flood, or storm waters; but that an iron pipe 12 inches diameter would probably discharge the ordinary flow of sewage for three hundred days out of the year, and when there was anything more than the pipe would take off, it would be in extreme dilution, and the river itself would be in flood, so that there would be a minimum amount of nuisance.

The main outlet sewer at West Ham (Fig. 8) was 4 feet 6 inches in height by 3 feet in width. It had a cast-iron invert, which was laid for about half a mile, at the level of low water of spring tides, and then for $2\frac{1}{2}$ miles with a fall of 3 feet per mile. Of course the outlet was obtained by pumping. The surface of the ground, under which that sewer was laid, varied from 10 feet to 12 feet below high water in the Thames, and the subsoil was so porous, that with a portable engine within 10 feet of the work, the water could not be pumped below the line shown on the section (Fig 8). Consequently, he had to devise an iron invert, which the workmen could put into its place in the trench under water, by feeling only. The arrangement of the joint was such that there was a certainty of the plates falling into place, and each could be raised by the side flanges, and be rammed below with gravel, or clay. Upon this invert plate cement blocks were laid to above the water line, and the other portions of the sewer were built in the ordinary manner. About 3 miles of that sewer had been in use for nearly two years, and there was no difficulty in keeping it clean. The velocity of discharge in that sewer, which had its invert on a level, was higher than that which had been given in the Paper on the Drainage of Dundee, for a depth of 2 feet of water and a gradient of 1 in 400. The velocity was due to the surface gradient, or head. Means of flushing were provided, and the only fall was the grade of the surface.

Fig. 8.



Main Outlet Sewer, West Ham.

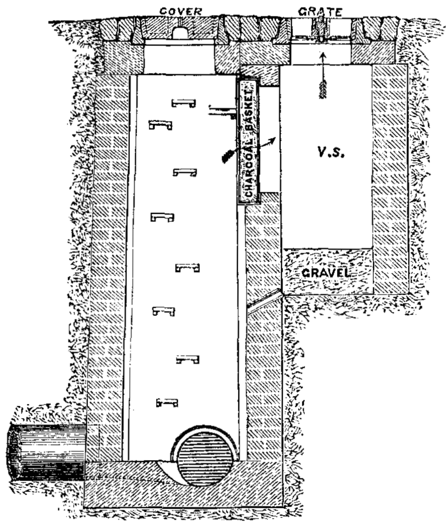
The mode of forming sewer junctions by bent pipes was, he thought, defective. A better plan was at the option of the Engineer, and he had requested Mr. Doulton to send specimens of side junctions, suitable both for 9-inch and for $4\frac{1}{2}$-inch work, which, he explained, formed part of the brick sewer, whatever size it might be; the blocks being built in with the work wherever junctions were anticipated. He also directed attention to an earthenware disc plate, which might be secured either with clay, or cement, and was intended to be put on the openings as the sewer proceeded, to prevent extraneous matters from being introduced. Slate, or flag coverings were neither so cheap, nor so perfect, nor so handy to use. The ordinary invert block afforded great facilities in accelerating the work, and in use, secured the scouring action of a pipe having that diameter, whatever the dimensions of the sewer might be.

The drawing (Plate 5) gave the particulars of various sewers, their forms and sizes, the number of bricks, and of the cost of each section per lineal yard, together with the prices of the various materials. These were not merely assumed figures, but were the actual prices at which sewers had been executed, at Berwick-upon-Tweed, Carlisle, Chorley, Lancaster, and other places. It might be useful for reference, and in every instance it would be seen, that double courses of bonding bricks were put in at, or near the springing, to insure the rings being tied together.

As the question of town sewerage was of daily increasing importance, he had been at some trouble to bring these matters forward, because he wished to give the fullest information in his power; and he thought young Engineers would do well to pay attention to the subject in all its bearings. He had adopted several leading principles, which he would briefly refer to. In the first place every sewer should be laid out in an absolute right line from point to point. He laid stress upon that, because in examining old lines of sewers, he found they invariably took the course of the streets under which they were constructed. To set out a sewer in a straight line surface sight rails were necessary, so as to 'bone' the invert level. The main sewer at Brighton, built within the last ten years, by a former surveyor, under the old Commissioners, was proved on examination to be most irregular both in line and level. This he apprehended must have arisen from the sewer having been built in short lengths, and without sight rails, or any proper levels. Then again at every change either in line, or in gradient, there should be a manhole, or a lamphole, to afford the means of access to the sewer from the surface. At all manholes, and at many of the lampholes, means of ventilation should be provided, such as he had explained. A chamber should be formed at the side of each of these ventilating shafts, to catch detritus from the roads; and the ventilating grate should be over it, and not directly above the crown of the sewer.

Between the side chamber and the shaft, charcoal filters should be fixed, so as to deodorise the foul gases, before passing into the streets. Care must be taken, that ventilating openings should not be direct down into the sewer, as was the case with the great part

Fig. 9.

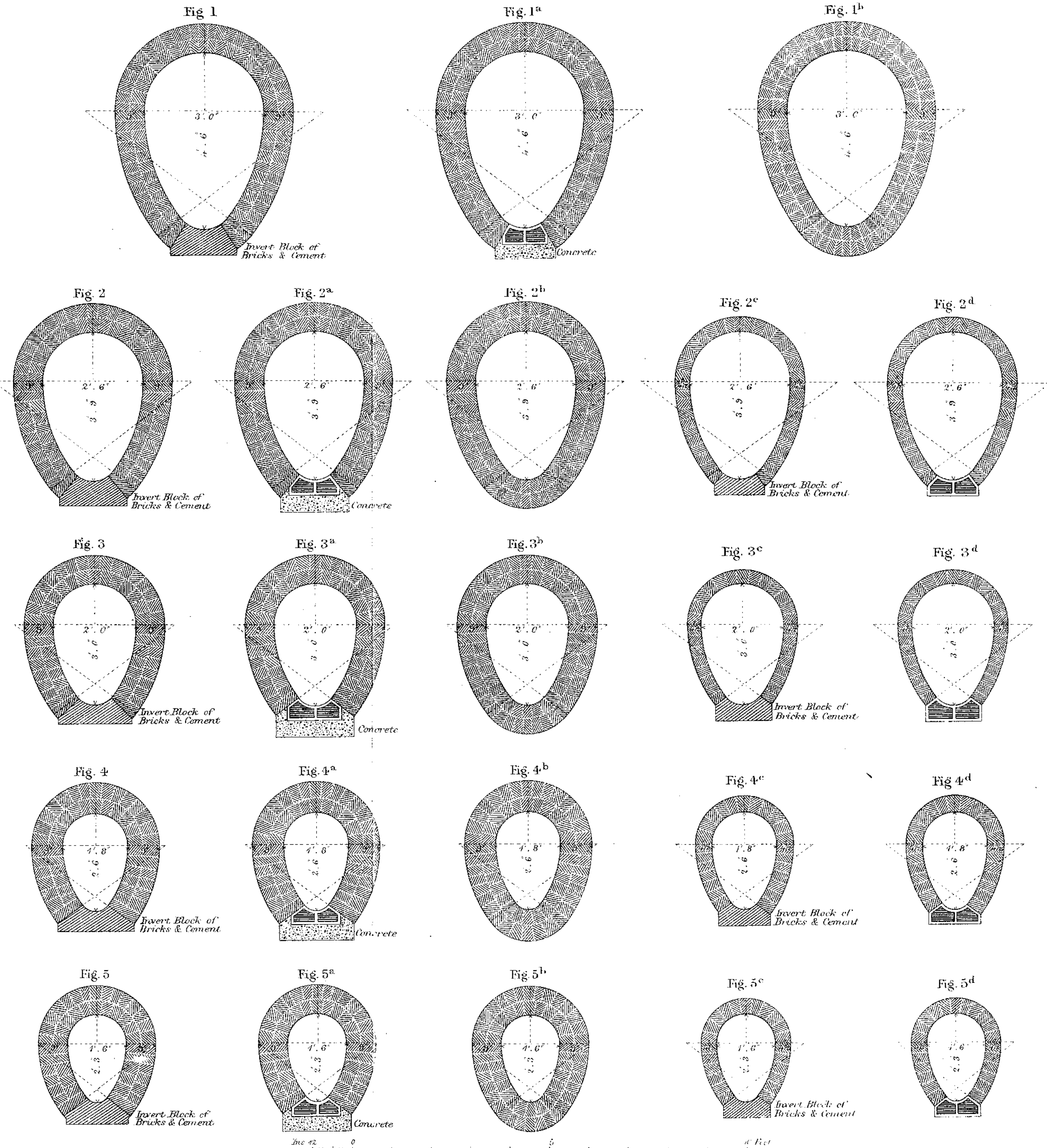


Manhole and Ventilating Shaft.

of the sewers of the Metropolis, where shafts were carried up direct from the crown of the sewer, and the ventilating grate was put directly above it, thus admitting foul gases into the streets without deodorisation, and allowing stones and mud from the macadamized roads to fall into the sewer below, and to form an obstruction upon the invert, which was a cause of great mischief. The sooner this state of things was remedied, the better it would be for the Metropolitan drainage. It was impossible to carry out the grand scheme of intercepting drainage beneficially, if the tributaries were left in an imperfect condition. He ventured to mention his views on this subject, as he thought the first effect of the operation of the intercepting sewers would be, that water would be abstracted from the sewers which were now diluted with it; the washings of macadamized roads, which formed a good disinfecting material, would be taken away with the flood water, and in the intermediate districts, where there were great lengths of foul tributary sewers, there would be deposits of putrid matters; and with the ventilating grates opening directly into the streets, one of the first effects, during a hot and dry summer, would be to raise

SECTIONS OF BRICK SEWERS.

		No. of Bricks Pr lin. yard. excl. of Invert.	Cost Pr lin. yd.
Figs. 1, 1ª, 1ᵇ. Area 10.40 Sq. Ft.	Fig. 1	388	1 . 18 . 10
	Fig. 1ª	384	1 . 19 . 2
	Fig. 1ᵇ	432	1 . 17 . 3
Figs. 2, 2ª, 2ᵇ, 2ᶜ, 2ᵈ. Area 7.20 Sq. Ft.	Fig. 2	336	1 . 15 . 3
	Fig. 2ª	336	1 . 15 . 9
	Fig. 2ᵇ	384	1 . 13 . 10
	Fig. 2ᶜ	156	1 . 5 . 3
	Fig. 2ᵈ	156	1 . 5 . 9
Figs. 3, 3ª, 3ᵇ, 3ᶜ, 3ᵈ. Area 4.60 Sq. Ft.	Fig. 3	256	1 . 10 . 2
	Fig. 3ª	256	1 . 10 . 8
	Fig. 3ᵇ	304	1 . 8 . 8
	Fig. 3ᶜ	116	1 . 2 . 1
	Fig. 3ᵈ	116	1 . 2 . 7
Figs. 4, 4ª, 4ᵇ, 4ᶜ, 4ᵈ. Area 3.20 Sq. Ft.	Fig. 4	216	1 . 7 . 6
	Fig. 4ª	216	1 . 8 . 0
	Fig. 4ᵇ	256	1 . 5 . 7
	Fig. 4ᶜ	100	1 . 0 . 9
	Fig. 4ᵈ	100	1 . 1 . 3
Figs. 5, 5ª, 5ᵇ, 5ᶜ, 5ᵈ. Area 2.60 Sq. Ft.	Fig. 5	208	1 . 6 . 9
	Fig. 5ª	208	1 . 7 . 3
	Fig. 5ᵇ	248	1 . 4 . 11
	Fig. 5ᶜ	92	0 . 19 . 11
	Fig. 5ᵈ	92	1 . 0 . 5



Bricks 30/- per 1000. Mortar 1/2 per 100 Bricks.
Bricksetting 1/2 per 100 Bricks. Excavation 1/8 per Cubic Yard.

R. RAWLINSON, DELᵀ

KELL BROS LITHO CASTLE ST HOLBORN

the rate of mortality. The Registrar-General would find it out, and record it in his Reports on the State of the Metropolis, unless some prompt precautions were taken, as it would be a serious evil to abstract the flood water which now diluted the foul matters in the sewers, unless provision was made to counteract such effect.

His reason for laying out sewers in right lines, was because he had found in practice, that to insist upon straight lines of sewers, and an absolutely true gradient, was more than equivalent to putting an inspector on the work. He would defy a contractor to scamp work if it was required to be true in line, both vertically and horizontally. Practically he never allowed the curves of junction to exceed $22\frac{1}{2}$ degrees.

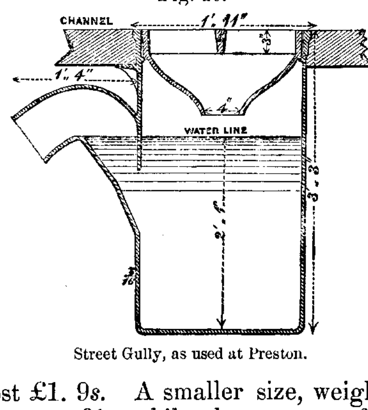
Sewers of unequal dimensions should never be level at the inverts. It was safer, as a rule, that they should be even at the crown,—that the tributary drain should have an extreme fall at its junction with the main sewer. The fact of one sewer being made larger than another, implied that the former would have more work to do; and if the sewers were joined with level inverts, the large sewer would dam back the sewage in the smaller tributary, and prevent its being flushed out. He had found that where pipe drains were brought into a sewer with level inverts, the pipes became rapidly choked up, as the sewer water was dammed back for one-half, or two-thirds of their diameter, and sediment which had poured into them had no opportunity of getting out. But if the invert was raised above the ordinary flow of the main sewer, the solid ingredients might be diluted, and be flushed out, without still-water lying in the tributary drain. A tributary sewer would be better with less gradient and a free delivery. Sewers might be made to discharge large weights of material which had passed through the gullies. As an illustration of this he might instance the Birmingham sewers. The amount of sediment at the outlets of those sewers was not less than 500 tons per week, or 25,000 tons per annum, which was almost equivalent to the weight of the metal put upon the roads, as Birmingham was macadamized throughout all the streets, and there were only very few paved channels. Whenever there was a heavy fall of rain, large quantities of the ground-up materials of the roads were carried into the sewers, which passed through them, and collected at the outlets.

At Carlisle, the main sewer had a fall of 1 in 700, for a length of a mile and a quarter; it was liable to be flooded frequently in the course of a year, and at times the freshets and floods rose 18 feet, or 20 feet above the level of the invert, and 10 feet, or 12 feet above the surface of the ground where the sewer was built. That sewer had been in operation for six, or seven years, without requiring any outlay for hand-cleansing, and without any extreme power for flushing, but simply by due attention being paid to the arrangements at the manholes. At every manhole there was a groove in the brickwork to receive a stop plank, by which the sewers could be flushed out in sections, either by accumulated sewage, or by the admission of water from the Waterworks.

The question of fouling of rivers, by allowing undiluted sewage to pass into the nearest available water courses, was a matter of serious importance. It was a practice which the legislature should be called upon to put a stop to; but in saying this, he hoped that advocates would not arise for the abolition of the system of sewerage, because certain rivers had been fouled, and injuries done, for which apparently there had been no remedy up to a certain time. That which was of the greatest value in the consideration of this question was that greatest blessing to any community,—healthy human life. Modern civilization had been the means of massing populations together in towns: a town population could not exist and enjoy good health without some efficient, constant, and unceasing system of removing all the soil refuse from the midst of that mass of human beings. Schemes had been propounded for the sanitary inspection of water-closets, and house-to-house visitations; and various plans had been devised, to save what was conceived to be a valuable manure, in a form other than its being passed away in water. But his experience led him to the conclusion—that the cheapest element to remove soil refuse was water, and that the readiest method of doing it was by a proper system of sewers. It was quite possible that this could be done without committing any injury whatever; because chemistry could be brought to their aid. If it was not worth while commercially to pump the fluids and the solids, for the purpose of appropriating them to agricultural uses, then the solid matters should be removed by deposition and filtration, and the liquids should be deodorised, before being discharged into the rivers and water courses. In the year 1859, the River Thames, within the Metropolis, became a foul stinking stream, and the rivers in the vicinity of Manchester were foul beyond the powers of language to describe. That was also the state of some of the rivers in the manufacturing and thickly populated districts of the West Riding of Yorkshire. It must not, however, be thought, that because these evils existed, the sewers were in fault. They were only imperfect appliances at present, but were still a great improvement on the old cesspool system. He believed they were on the eve of a satisfactory solution of this problem. The land, beyond all question, was the place to which the soil refuse should go, and if the authorities of a town could not dispose of it at a profit, so as to obtain a return for their outlay, they ought to be compelled to incur the necessary expenditure, for carrying it to some place, whence it could be beneficially applied, without creating a nuisance, and pay the necessary cost.

Mr. J. Newton contended that no system was perfect which permitted accumulations in the sewers; for if the velocity of the flowing sewage was insufficient to prevent the deposit of sand, grit, or other insoluble substances, such matters ought not to be allowed to enter the sewers, and by suitable gully traps and cesspits this might be easily accomplished. At Dundee, the main outlet sewer had a fall of 1 in 400 only, whereas some of the other mains had gradients varying from 1 in 600 to 1 in 700. As the scouring power was in proportion to the velocity, and the velocity, with like gradients, was in proportion to the amount of flow, this outlet might, with advantage, have been made much flatter than 1 in 400, and the fall, thus economised, have been used for augmenting the fall of the subsidiary mains. The gradient and the section of a sewer at the invert ought to be carefully adjusted to the probable average flow of sewage through it; and when this was done, it would very rarely be found that silting occurred, or even that flushing was necessary. In regard to street gullies, he directed attention to one entirely of cast iron which he had adopted (Fig. 10). It weighed 4 cwt. 2 qrs. 14 lbs., and, at six shillings and three-

Fig. 10.



Street Gully, as used at Preston.

pence a cwt., cost £1. 9*s*. A smaller size, weighing 3 cwt. 1 qr., cost at the same rate, £1; whilst the expense of fixing, or of removal did not exceed two shillings each. The efficiency, cheapness, and durability of this form of gully had induced him to use it exclusively, and during the last five years, he had fixed upwards of sixteen hundred of them in the borough of Preston.

There was still a diversity of opinion amongst Engineers, as to the proper size of sewers. His own experience showed, that in purely urban districts a rainfall of 1 inch in half-an-hour ought to be provided for. Thus, on the 29th of July, 1857, he registered at Preston $\frac{3}{4}$ of an inch of rain in thirty-five minutes, and on the 8th of October, 1861, nearly the same depth in thirty minutes. On the latter occasion an egg-shaped brick sewer, 4 feet 9 inches high by 3 feet 2 inches wide and 300 yards in length, with a fall of 1 in 156, carried away this water from a closely built and densely populated district containing 117 acres. In another part of the town, which was also built upon and which contained 85 acres, a sewer 3 feet 6 inches high by 2 feet 4 inches wide, with a fall of 1 in 75, carried off these storms, without causing any damage, or without the water rising in the cellars, which were generally from 1 foot to 2 feet above the soffit of the arches. In both cases, however, the sewers were under pressure, as on the first occasion the water rose 18 inches, and in the other case 1 foot in the manhole shafts. These examples showed, that the sewers of Preston were not too large, and as most of the tributary mains ran nearly full on these occasions, and had never proved insufficient, they indicated the sizes required generally under similar circumstances. Almost all the rainfall, in the districts alluded to, flowed direct into the sewers, every house being drained, and but few receptacles existing for retaining the water. The sewers were constructed in straight lines, or on easy curves, and all branch drains were connected with the mains at angles of 45°. In ordinary town districts, calculating upon a maximum fall of rain of one inch in half-an-hour, and that it all passed directly into the sewers, he believed the following proportions would prevent silting, if the district was thickly populated, and the house drains were connected with the sewers:—

Diameter of Sewer.	Inclination.	Drainage Area.
Inches.		Sq. Ft.
6	1 in 50	200
9	1 in 100	400
12	1 in 150	650
15	1 in 200	1000
18	1 in 250	1400
21	1 in 300	1800

In intercepting sewers, where the ordinary flow was greater, and in large mains, an ordinary velocity of 1 foot per second would be amply sufficient to scour the invert, without any artificial flushing. As a general rule, he preferred the egg-shaped section for sewers, but where the inclination was such, that the velocity of the flowing sewage would not allow of silting, the circular form was preferable, because its discharging power was greater, when the flow was a maximum, and the cost of construction was less.

The form and construction of the brick sewers at Newport appeared to have been well considered; but there were many places in which a smaller tube than 14 inches in diameter would have sufficed. In such cases a 6-inch, or a 9-inch pipe would have effected a considerable saving in expense; in fact, at least one half might have been saved, and the efficiency of the system would have been improved. Although the advantages of good sewers, both in a moral and physical point of view, were undoubted, it was desirable not to be too sanguine in anticipations as to the results. Mr. Williams stated, that the mortality of Newport had been reduced from 30 per 1,000, in 1850, previous to the adoption of the Public Health Act, to less than 20 per 1,000 in 1860 and 1861. On reference to the Registrar Generals' Report he found that in—

1851,	the mortality	was	23·1	per 1000.
1852,	,,	,,	25·5	,,
1853,	,,	,,	22·6	,,
1854,	,,	,,	26·2	,,
1855,	,,	,,	25·2	,,
1856,	,,	,,	26·4	,,
1857,	,,	,,	23·3	,,
1858,	,,	,,	33·3	,,
1859,	,,	,,	24·1	,,
	Average	. .	25·5	,,

Mr. Williams might, therefore, with equal accuracy and reason, have said it was reduced from 22·6 per 1,000 in 1853, to less than 20 per 1,000 in 1860 and 1861. The mortality of a district was influenced by so many causes, and fluctuated so much, that conclusions should not be drawn from a short period of time: nevertheless he was satisfied that much good must necessarily arise from such works.

Mr. W. Merry remarked, that some of the observations which had been made reminded him of the dogma of twelve, or fourteen years ago, that certain specific rules might be laid down to apply to every town in the United Kingdom. He dissented from that doctrine, and he regretted to find that such notions should still be entertained; because experience had shown that every town must be dealt with on its own merits. It was necessary to take the local circumstances into consideration, as there might be a variety of peculiarities appertaining to one town which did not exist in another. There were general principles which should be discussed before entering into the details. In the first place, with reference to the drainage of provincial towns,—it was said that the work was done at less cost than in the metropolis. The great point, in the system adopted at Dundee, appeared to be, that a length of 30 miles of sewers had been in use for years, without provision having been made for ventilation, and that no complaint was made of nuisance. It should at the same time have been stated how many houses in that borough had water-closets, what number of these drained into the sewers, and what proportion had 'middins.' He believed it would be found, that not more than one-third of the filth of the town got into the sewers. He had visited several large provincial towns which were drained upon this system, at probably one-half the cost of similar works in the metropolis, and he found that there were only water-closets in the first-class houses,—the houses of the middle and lower classes having 'middins,' the contents of which were removed periodically by the dust contractors, and were used upon the land. In such cases there was plenty of room in the rear of the houses for ventilation; but that system would not answer for London. This was further evident, by reference to the quality of the sewage, which in London might be compared to treacle in consistency, whilst in the country it was simply dirty water. At Paddington, which was considered an aristocratic part of London, there were about 800 acres of land on which there were 10,000 houses and 80,000 inhabitants, or an average of 100 to the acre. In other parts of London there were from 1,500 to 2,000 persons per acre. Recently plots of land at Paddington were covered with six-roomed houses; and on one estate, called Hall Park, containing an area of 3 acres, 235 six-roomed houses had been erected, with a water-closet to each house, the population amounting to 2,649 inhabitants. The sewers there, had a gradient of 1 in 480, and yet they required flushing, notwithstanding it had been stated that 1 in 600 was self-cleansing. Before arriving at conclusions on this subject, it was necessary to know the number of houses, the number of the inhabitants, the amount of the water supply, and whether each house was furnished with a water-closet which drained into the sewers.

Mr. RAWLINSON stated that Professor Way, who had analysed many different sewage waters from all parts of the country, found the analyses as nearly alike as possible. It was a mistake to speak of London alone as being a water-closeted town. At Alnwick, with 7,000 inhabitants, there was not a house without a water-closet. There was no necessity to provide duplicate sewers for surface flood water, in a system of sewers in provincial towns. The special features of every town should be studied, and the works be laid out with due regard to local peculiarities. Rules for sewers in the metropolis, or at Preston, or elsewhere, would not apply, except under similar conditions. In the town of Alnwick, having an area of 2,000 acres, the outlet sewer was 18 inches in diameter, with a fall of 1 in 400. It had been in use for ten years, although all the down spouts, yard grids, and street gullies communicated direct with the pipe sewers. Alnwick Castle, with several acres of area, was sewered by a 12-inch pipe, and that effectively. The town of Worksop was sewered by a 15-inch pipe outlet. In each case the flood water of heavy rain flowed over the surface, as it did before any sewers were made.

Mr. J. Grant remarked that, the main sewers on the south side of the River Thames were all provided with ventilating shafts and side catch pits, each capable of holding about a cubic yard of matter, which prevented stones and mud from entering the sewers. Between each ventilating shaft and catch pit there was a semicircular opening, all the openings being of the same diameter throughout, to admit of frames filled with charcoal, or other deodorising material being afterwards fitted; and through these frames of charcoal the foul gases would have to pass, before being allowed to enter the atmosphere. In confirmation of the statement, as to the advantage of a supplementary pipe outlet to discharge at low water, he mentioned that he had carried out a similar arrangement, at Battersea, eight, or ten years ago, and subsequently at four, or five other outlets of the main sewers on the south side of the River Thames. He laid large iron pipes to below low-water mark, having flaps, or penstocks, to prevent the tide from entering at high water. This plan had been adopted at London Bridge, and at Waterloo Bridge, as well as at other places. He concurred in the opinion that, in laying out a system of sewers, every town must be dealt with according to the local circumstances and the peculiar features of the case. The character of the outlet, the rate of inclination, and the nature of the surface of the ground, the rate and the amount of the rainfall, the number of houses draining into the sewers, the extent of the population, and other things, all required consideration.

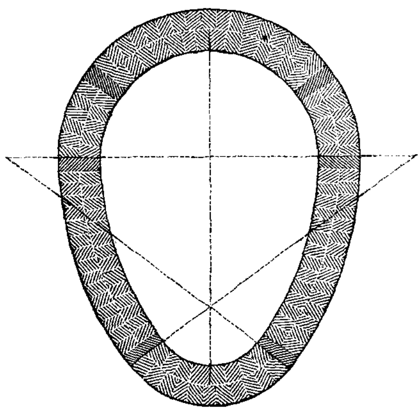
With reference to the question of cleansing sewers, he thought that the method adopted at Dundee was complicated and expensive; and that the plan pursued in the metropolis, which he had first practised at Richmond, was simpler and cheaper. In the pipe, or sewer a flap valve was fixed, which could be kept closed until a head of water accumulated. By this means the water could be backed up to any height that might be fixed upon; and when the valve was opened, the rush of water would clear away any deposit, including macadamized matter and stones.

Mr. Rawlinson inquired whether the system of ventilation alluded to had been adopted at the west-end of London.

Mr. Grant replied, that he believed it was likely to be adopted. It was simple, and effectually prevented stones and road mud from getting into the sewers.

Mr. Cockburn Curtis said, that the extension of the main sewerage works of the city of New York afforded an instance of the application to a particular case of the results arrived at, after a calm consideration of all the facts and arguments which had been recorded on either side, in the numerous blue books which had been published in England during the Administrative Contest popularly known as the 'Small Pipe' and 'Back Drainage' Controversy. In extending the sewerage of New York, the section adopted for nearly all the main sewers was similar to that shown in Fig. 11. As it appeared to be a well-established fact, that the

Fig. 11.



Section of Sewer adopted by the Croton Aqueduct Department.

maximum amount of rain which had fallen upon Manhattan Island, upon which New York was situated, had never exceeded one inch in an hour, the capacity of the sewers was adjusted to provide for that amount of flood water, in addition to the prospective maximum house sewerage flow of the several districts proposed to be drained. The material adopted was brick laid in cement, and the inner bottom of the sewer was plastered with cement, to make a uniform surface for about a foot in vertical height, or the lower courses were laid dry, according to the necessities of the locality. In keying the crown of the arch, no headers were allowed to be used, except when bricks were furnished of a particular shape, made expressly for that purpose. In all other cases, the inner and outer courses of stretchers were carried over separately, and each was keyed with slate, after the arch was turned. The streets in the modern part of New York were laid down in straight lines, and the main sewers were laid down as nearly as possible in the middle of the streets, but with confluent junctions, having radii suitable to the peculiar circumstances of each locality. Receiving basins for the road detritus, with trapped culverts for passing the surplus water into the sewer, were fixed at the corners of the streets, or in other suitable positions. These receiving basins were from time to time cleared out by manual labour. In most cases there was a good natural fall. Each length of sewer was laid down from end to end, on an uniform gradient. In almost all instances it was found, that these arrangements were sufficient to keep the sewers free from any permanent deposit.

As regarded the example which had been adduced, of a sewer constructed with a dead level bottom, Mr. Curtis considered generally, that such a mode of construction was objectionable, on account of its decreasing the hydraulic mean depth at the outfall, where it was most needed. In most similar cases an easy gradient would be preferable, as affording a greater sectional area at the outlet for the passage of the sewage, or the flood waters, and as occasioning less danger of regurgitation. He did not think the question of priority of invention could be entertained, in reference to the mechanical cleansing of sewers, inasmuch as similar systems had been used for cleansing out the supply and discharge sluices of the tanks in India, probably for the last thousand years.

Mr. LOVEGROVE said, what appeared to be the most remarkable circumstance about the two Papers was, that in one case brick sewers seemed to have been mainly adopted, whilst in the other tubular drains, or pipes, had been more largely employed; but as no drainage areas had been given, the relative merits of the two systems could not be compared. At Dundee, the sewerage had been laid out, so as to avoid the necessity of purchasing water from a public Company. To accomplish this, the sewers had been constructed at such relative depths, as to admit of the sewage being turned from one channel into another, and this, doubtless, caused the gradients to be kept as low as 1 in 600 and 1 in 700, which would favour a deposition of silt. Then there was the expense of shafts at every forty yards, and the application of mechanical arrangements for the purpose of cleansing. It was a question, whether it would not have been better and more economical, to have paid the Water Company for a proper supply of water, and have depended upon that for the scouring power, rather than to have reduced the gradients sufficiently to enable the water to be turned from one channel to another. With a series of sewers constructed on rising ground at different levels, it was easy to intercept the sewage at various points, and to make use of the several sewage currents as a scouring power. If, however, the land was level, and the sewers were about the same relative vertical height, the intercepting sewers must be nearly on a dead level, thus reducing the scouring power of the system to a minimum. He thought, that if a greater fall had been given to the sewers at Dundee, and an occasional supply of water had been obtained from the Water Company, the expense would have been less than that incurred in the original construction on this plan. There must be nearly a thousand shafts, solely for the purpose of removing the deposit, and their cost could not be calculated at less than £5,000 or £6,000; added to which the expense of manual labour would have been decreased by 50 or 60 per cent. if the other plan had been adopted. The form of street-gully was also objectionable, as it would allow of large quantities of road detritus entering the sewers. The cess-pit below the grating was about 10 inches in depth, and would contain about one cubic foot. When the cess-pit was filled, and while water passed through the hanging flap-valve, the sediment would escape into the sewer. Such a cess-pit, he thought, was not large enough for protection against the intrusion of road detritus. There were certain principles which should be observed in the construction of gullies. They should be so made as to prevent road detritus from entering the sewers, and to arrest the escape of noxious effluvia, while at the same time they should provide for the admission of a downward current of air, to aid in the ventilation of the sewer. With untrapped and imperfect gullies this downward current existed, but they also permitted the foul air to escape through the same channel. The gullies in Preston were an instance of this, as unless there was a sufficient quantity of water there could be no trap, for as soon as the water was evaporated below the syphon dip, the gully was no longer trapped, and the sewer was in direct communication with the outer air. The same state of things existed in Derby and in Leicester. He had noticed many instances, in those towns, where the water had evaporated below the syphon dip, and where a direct current of foul air escaped from the sewers, through those defective gullies. In many cases these gullies were placed within two, or three yards of the windows and doors of the dwelling-houses. With reference to the direction of the air passing through sewers, it had been asserted, in the course of the discussion, that the more powerful the current of water passing along a sewer, the more powerful would be the current of air in the contrary direction; while in one of the blue books issued by the General Board of Health, it was stated, that there was always a flow of air in the direction of the sewage current. He had tried some experiments as to the direction and temperature of the air in sewers, but he had not found any relation between the flow of the water and the direction of the air. The latter was sometimes with, and sometimes against, the sewage flow, and did not appear to be governed either by the velocity, the temperature, or the direction of the sewage; but to be determined by the various points of ingress and egress, and by the number of gullies and ventilating shafts.

Mr. Lovegrove then directed attention to a model of a vertical inspection shaft designed to facilitate the cleansing and ventilation of small sewers, and described its principal effects with regard to ventilation. Also a form of gully trap combining the three principles before adverted to; to prevent the escape of noxious effluvia from the sewers, to protect the sewers from the entrance of road detritus, and to aid in the ventilation of the sewers, by providing for the admission of air, as a downward current. These subjects he proposed to bring more prominently before the Institution on a future occasion.

Mr. Williams said, in reply upon the discussion, the principal objection to the Newport works had been, that he had carried brick sewers too far, and that a saving would have been effected by using pipes. He thought by referring to the prices given on Plate 4, it would be seen, that there would have been little saving by adopting pipe drains in any part. The smallest brick sewers, 14 inches in diameter, were built at a depth of 10 feet, at a cost of 7*s.* 7*d.* per lineal yard, including the junction pipes for the house drains; and according to his estimate and experience a pipe drain 12 inches in diameter would have cost that sum, or rather more. The only other prices that had been given, were those relating to the works at Dundee, where the average cost was—brick sewers 33*s.*, and tubular drains 13*s.* per lineal yard; whilst he had constructed sewers large enough for a man to traverse at 11*s.* per lineal yard, and these with radiating bricks, specially made for the purpose, samples of which were shown. He thought that a sewer of those dimensions would be preferred to a pipe drain, through which a man could not pass.

With regard to what had been said, as to the rate of mortality, he might state, that the average of several years before 1850 was 30·3 per 1,000. He had taken the figures very carefully from the returns of the registrar of Newport, inasmuch as at the time he had no opportunity of obtaining the Registrar-General's Report; and probably there was some difference in the boundaries of the districts over which the averages had been taken. But, in confirmation, he read a letter from Mr. W. Downing Evans, the Registrar of Newport, dated the 13th of February, 1863, which said, "the number of deaths I registered last quarter was 128, chiefly from diseases of the respiratory organs; there was not one case of fever. The mortality of Newport became much reduced immediately upon the formation of the drainage, and I estimate it to be now 22 per 1,000."

Further, in the Report, for the last three months of 1862, of Dr. Davies, the Medical Officer of Health for the borough, it was said, "not one death has been recorded from continued fever, which is a most remarkable immunity among so large a population, and is, no doubt, chiefly to be attributed to our excellent and thorough system of drainage."

Mr. HAWKSHAW, President, concurred in the opinions which had been expressed, as to the necessity for the thorough ventilation of sewers. The fact seemed to be overlooked, that a sewer was an inverted receiver, and could not with safety be hermetically sealed. If the gases were not allowed to go out into the streets, they must pass into the houses. Those who constructed sewers should be bound to provide frequent inlets and outlets, at given distances. He believed the best way to render sewer gases innocuous was by a large admixture of atmospheric air. He agreed, that not only must the gases be let out, but air should also be admitted into sewers; he did not, however, quite concur in the suggestion as to charcoal filters, through which gases had to escape, not because he did not wish the gases to be purified, but because in proportion to the extent to which that plan was adopted, would the ingress of atmospheric air into the sewer be obstructed. He believed, that if the sewers of London had ventilating shafts at every 100 yards, by which air could have entrance and exit, the metropolis would be in a much better and healthier state; and when he heard of sewers being constructed wholly without ventilation, he felt thankful he did not live where such plans were adopted. With reference to the sample of earthenware invert for sewers, having at one time filled the office of a Metropolitan Commissioner of Sewers, he had paid some attention to the subject, and he believed that this plan of invert was a mistake. It was well known, that the bottoms of the sewers were subject to the greatest wear, and the inverts, to which he referred, had a thickness of only an inch. It was along the invert that the grit and other triturating matters passed, and it formed the pathway for the men, who used their shovels upon it, when cleansing the sewers, and an invert, only one inch in thickness, was the weakest and worst thing that could be applied.

With regard to the fouling of rivers, no doubt by vastly increasing the local burdens upon trade and manufacture, means might be provided for depositing the heavy matters, and for deodorising and disinfecting the fluid portions of sewage; but such nuisances were, to some extent, the penalty incurred for concentrating the population in dense masses, and it was hopeless to expect, that the rivers in the neighbourhood of large manufacturing towns could ever be restored to their former state of purity.