Mr. H. M. BRUNEL gave the lengths of some of the old outfall pipes. The central outfall at the Steyne was 1,760 feet in length. The Brunswick Square outfall did not quite reach low-water mark spring tides; and in 1869, when the agitation for the intercepting sewer led to the plans being prepared, an outfall pipe was being laid at the western extremity of the parish of Brighton, 2,000 feet long. The eastern outfall pipe was 800 feet long, and reached just below low-water mark. The new one put down at Cliftonville in 1869 or 1870 went some way below low water.

The middle piece of the ventilating grate referred to in the Paper could be taken out, and a man could get down comfortably to clean out the catch-pit.

Mr. HAYTER remarked that a short time ago he asked the Inspector in charge of the intercepting sewer whether, since it had been completed and in operation, any mistakes in construction had been detected. The Inspector stated that where the King's Road and Western Street branch sewer joined the intercepting sewer, which it did by a somewhat steep incline, after a shower of rain the road detritus was washed out of the catch-tank and deposited in the intercepting sewer towards the West Pier. That could have been remedied if the catch-tank had been made somewhat larger, as the velocity of the flow would then have been decreased, and the detritus would not have been so easily washed out. There was also a slight tendency to deposit between Roedean and Saltdean, where the flow was checked by the rising of the tide, but the deposit was readily removed by flushing. There had been some slight complaint in one or two quarters as to the ventilation of the sewer, in respect to which the people at Brighton were very particular, and properly so. He believed, however, there was little foundation for the complaint. There were ventilators about every 200 yards. They were at first intended by Sir John Hawkshaw to be at longer intervals; but at the time the Prince of Wales became so alarmingly ill from fever, contracted as some alleged from want of ventilation in a sewer, there was a great outcry everywhere for increased ventilation in sewers, and the distance was reduced to 200 yards. A furnace and chimney, to increase the velocity of the air through a portion of the sewer, were now being erected about 1 mile to the eastward of Kemp Town, and if considered desirable at any time, a fan could be added. The contractors had met with many difficulties. On taking the work materials of all kinds began to rise in price, and the pumping was greater than had been expected. They however completed the contract exceedingly well. The sewage when

entering the sea at the outfall dispersed very readily. Occasionally after northerly winds there was a slight deposit on the shore; but the outfall was far removed from population.

Capt. GALTON asked at what period of the tide the sewage was delivered into the sea; and whether the Brighton Corporation, before adopting the present scheme, had tried the A B C system? It was stated in the Paper that the sewer from the Steyne to Portobello was flushed by admitting water into it at high water, and allowing it to discharge at low water. Was the bottom of the sewer at the point of discharge below low water at ordinary tides, so as to increase its discharging power at and near low water?

Mr. H. M. BRUNEL replied that it would if there was rain to fill the sewer. He also stated, in answer to Capt. Galton, that there was a back valve to prevent the entrance of the sea water.

Mr. HOMERSHAM said he had driven numerous small 'adits,' or tunnels, in the chalk strata below the line of saturation, and in many cases had found no difficulty in shutting out a large portion of the water to relieve pumping, by filling the fissures with dry deal wedges, first rounding the edges of the fissures. It required some manœuvring, for too hard driving would split the chalk. If the water were wanted afterwards the wedges could be taken out. The water did not usually issue through the mass of the chalk, but came out in places, through fissures and small cracks: a large quantity could often be shut out in the way he had mentioned.

Mr. GILBERT REDGRAVE inquired what was the amount of sewage and the quantity of silt that had to be removed daily. In the improved method of constructing sewers it was usual to prepare very capacious chambers on the course of the main sewer. It had been stated, indeed, that the catch-tank at the Steyne was 40 feet long, and that it had to be cleared out daily. If in the course of a main outfall it was necessary to provide for the removal of silt, engineers should study the best position for those chambers and provide ready means of getting at them. They should, if possible, be cleared out on a level, so that the silt would not require to be carried up on the shoulders of the men; and the work should be done at night. It would be interesting to know the proportionate quantity of silt to the whole volume of sewage. No doubt it would vary with the soil, the weather, and other atmospheric circumstances. With regard to the ventilation of the sewer, it had been said that it was proposed to employ furnaces in one of the shafts to draw out the air—a furnace not at

the outfall, but 1½ mile or 2 miles from the lowest point of the sewer. Was it intended that it should draw air only from the higher part of the sewer? If so, what provision would be made to prevent it drawing from the outfall or the penstock chamber? In some sewers, recently constructed, it had been found best to ventilate from the highest point of the sewer; and the question of position, he believed, had never been satisfactorily answered. It would be interesting to have some further explanation on that point. It certainly seemed unusual to employ artificial ventilation at a point midway between the town and the lowest point of the sewer. There was a great difference between the cost of the sewer under the first and under the second contract, and he should be glad to know the reason. It seemed in this case that the cost of the tunnelling had been cheaper than that of the sewer in open work, which was probably due to the easy character of the excavations in the chalk. In other sewage works of which he knew the cost, the tunnelling had averaged a good deal more than the work in open cutting.

Mr. R. W. P. BIRCH asked how often it was found desirable to use special means of flushing, and what quantity of extra water was used. With regard to chimneys too many particulars could not be given. He understood Sir Joseph Bazalgette and other men of eminence reported, in connection with the London sewers a few years ago, that it was quite useless to attempt to ventilate any large system of sewers to one point by artificial means.

Mr. HARRISON, President, said that, in considering the drainage of such a town as Brighton, the intercepting sewer formed but a small part of the whole question, because it was quite as essential to ascertain in what manner the sewage was conducted through the town as it was to know what was done with the outfall sewer. Nothing was more treacherous than the fact of a town having a high level like Brighton, leading to the belief that as there were abundant means of fall and drainage everything was satisfactory. The question of ventilation in the town had, in many cases within his own knowledge, been entirely neglected, and the gases had been allowed to accumulate in the higher parts of the town, where, if anywhere, fever was sure to be found. He hoped that attention would be directed to the means taken to ventilate the whole of the upper part of Brighton.

Mr. ABERNETHY remarked that the Paper had been confined chiefly to the construction of the intercepting culvert and outfall at Brighton. Without adverting to the general system of the drainage of that town, he would refer to the general question of the

disposal of sewage in various cities of this country. As a general rule, sewage had been discharged into rivers, and hence their extraordinary state of pollution, from which there appeared to be no remedy, notwithstanding the many Government inquiries and reports on the subject. As Sir Joseph Bazalgette was present, he wished to take the opportunity of expressing an opinion he had long formed, that the half measure of discharging the sewage of the metropolis into the Thames at Crossness would eventually turn out a source of great pollution to the river. The result up to the present time had been that the original clean gravel bed of the river was lined with a deep coating of sewage mud. He had been informed that for some time past the river at that point had been in a normal state; but that did not alter his opinion of the final results to be expected from thus discharging the metropolitan sewage. By the alteration of the river in all probability at that point a state of equilibrium had been established between the forces of the river current and the sectional area of its bed; but he apprehended that the lining of mud over the original gravel bed had been, or was being, prolonged gradually down the river, so that eventually it would become a source of great sanitary annoyance, and to some extent might impede the navigation of the river. He was afraid that the pollution attending the discharge of sewage into rivers was likely to take place also to a certain extent upon the foreshore of many marine watering-places, from the discharge of sewage into the sea within a short distance, generally about low-water mark. He had been recently consulted with regard to the sewage of Ramsgate, and he found that the whole of the sewage of the town was discharged at low-water mark quite close to the Western Pier, the result being that when the foreshore was uncovered the nuisance was exceedingly great. He had ascertained that at certain periods of the tide, and of the discharge, the sewage found its way directly into the harbour, and even beyond the Western Pier, on to the foreshore, which was extensively used as bathing ground. He had some experience as to the value of the deposit derived from sewage. Many years ago, an intercepting culvert had been constructed for the sewage of the city of Aberdeen, which, like Brighton, lay generally on hilly ground above the level of the culvert. The sewage was all discharged at that time at one point in the tidal harbour outside the dock, and had to be removed by dredging. There was an extensive range of sandhills between the city and the sea, and the material raised by dredging had been used in covering the whole of the foreshore within high-water mark with the

deposit from the sewage, converting it into valuable ground for agricultural or general purposes; and he apprehended that if the outlet for the sewage of London had been prolonged as far as Maplin Sands, a large area of waste ground might have been reclaimed for agricultural purposes. This would have been a preliminary step to the ultimate discharge of the sewage water into the sea. He believed a remedy for the present state of things would eventually be found in precipitating the solid constituents of the sewage, and passing the effluent waters into the rivers or into the sea. In the case of the river Thames, he thought that the standard required for effluent water was a great deal too high. He could not imagine that sewage water simply impregnated with ammonia and other salts, and free from solid matter, would cause any injury whatever to the great volume of the water in the river, and certainly it would be innocuous in the sea. Companies had been formed in order to use the deposit for commercial purposes; but they had failed, because they attempted a great deal too much. All that was required was to precipitate the solid constituents, to deodorise the material so precipitated, and to pass the effluent waters into the sea. That was the only way to preserve rivers and foreshores from pollution. A similar intercepting culvert to that at Brighton had been made at Aberdeen, and it was found that during the period when the tidal valve was closed and the sewer had no outlet, the noxious gases generated in the main culvert found their way up the various drains and subsidiary sewers into the higher part of the town; and he apprehended that, with the means of ventilation adopted at Brighton, when the tide was up and the outlet closed, and also when the culvert was flushed with a large body of sea water, the same result would follow. At Aberdeen an attempt had been made to remedy the evil, which to some extent had succeeded, by placing metal valves on the outlets of sewers entering the main culvert. These opened when a slight amount of sewage got behind them; but, as a general rule, they remained closed. No more important question could be brought before the Institution, and he thought that a good subject for discussion would be,—the best means to adopt, in a sanitary point of view, independently of commercial considerations, for the disposal of the sewage of great cities.

Sir Joseph Bazalgette said the Paper was one of peculiar interest, opening up as it did the large question of how to dispose of the sewage of towns. He might call it the "vexed" question, because he was quite sure that a variety of opinions would be expressed concerning it. It was always more easy to speak of a

Paper when one differed from the Author's views, and he now found himself in the difficulty of agreeing very much with the general features of the scheme propounded in the Paper, which were in accordance with what he had carried out in London, at Weston-super-Mare, and at St. Leonards; with what he was now carrying out at Torquay, and had obtained an Act of Parliament for last year for West Kent, and also with what he had recommended for many other places. The principle of simply diverting the cause of mischief to a locality where it could do no mischief was one which, he believed, had been attended with considerable success. He was surprised to hear it stated that in consequence of the drainage of London, a large accumulation of mud had taken place in the river at the outfalls, and that there was a prospect of it impeding the navigation. He had never before heard such views expressed by any member of the Institution. He would ask whence the facts were gathered on which these conclusions were grounded. Since the metropolitan outfalls were first opened, he had had soundings taken in their neighbourhood, and he found that there was, at the present moment, less accumulation of mud there than there had been before the outfalls were established. The question was raised some time ago, when it was proposed to carry the sewage of London to the Maplin Sands. The company formed for that purpose failed to raise sufficient funds, and an effort had been made to put pressure upon the Metropolitan Board of Works to induce them to carry out the scheme. The cry was then raised that the Thames was silting up. Mr. Rawlinson was on that occasion appointed a commissioner to investigate the matter, and after a patient hearing of all that could be stated on both sides, he came to the conclusion that there were no solid grounds for the complaint. It was, however, determined that if an accumulation should take place, it should be incumbent upon the Metropolitan Board of Works to dredge, if called upon to do so by the Conservators of the Thames. Notwithstanding that arrangement, they had never been called upon to dredge that portion of the river. His soundings agreed with those of the Thames Conservators, although the conclusions at which they arrived differed, and it appeared that while during two years there had been an accumulation, during the next two or three years there had been a large decrease. Any one who would observe what was going on in the Thames would discover that the accumulations in the river were governed by much larger forces than those to which Mr. Abernethy had alluded.

He thought the mode of disposing of sewage adopted in London

and in seaport towns—that of intercepting sewers, as far as possible by gravitation, with an outfall at a point where no nuisance could be created—had been successful. It had been said, and would no doubt be repeated, that, in forming such outfalls, an article of great value was thrown away, while guano was being imported at a cost of £10 per ton. No doubt sewage was an article from which one would expect a return; but for various reasons it was exceedingly difficult to turn it to profitable account. First there was what might be termed "the water difficulty," while it was of the greatest advantage to towns to have an ample water supply to carry off the sewage, that ample supply formed one of the great difficulties of dealing with it at its outfall. Then there was "the land difficulty." In the neighbourhood of large towns land could only be obtained at a large cost. Those two difficulties stood in the way of what otherwise might be a most successful mode not only of purifying sewage but also of applying it to profitable account, namely, by means of irrigation; and it had been mainly on account of these and of the necessity for purifying that any profit from sewage irrigation had so rarely been realised. Croydon would no doubt be instanced as a case in which the system had been profitably applied. He might say at once that in all cases where the sewage was properly applied to land of sufficient quantity it would be purified; but there were many instances in which that could not be done. When Mr. Marriage, the tenant, worked the farm at Croydon, he paid the Corporation 30*s.* an acre for it, but the Corporation were paying £10 an acre, so that while he had been making a profit they were making a loss; and when the Corporation afterwards took to the farm themselves, they continued it at a loss. It was only in some few exceptional cases, where land well suited for the reception of sewage could be obtained under sufficiently favourable conditions, and where the sewage could be applied by gravitation (it generally had to be pumped from the lowest point to be drained on to the land), that it could be made to give a profitable return. The land difficulty had been attempted to be met by reducing the quantity of land, and by substituting for broad irrigation intermittent downward filtration. This was introduced by an experiment of Dr. Frankland, and was first tried at Merthyr Tydvil, where it was proposed, instead of applying the sewage from one hundred people to an acre, to apply the sewage of one thousand people. In some instances it had been proposed to go to the extent of three thousand. At Merthyr Tydvil, however, the conditions were very favourable. There was a bed of gravel 50 feet deep, with

a porous soil, and the sewage could be applied by gravitation, there being an abundant fall. The result was that the system had been a success; but the Engineer stated that he would not permanently apply more than the sewage of five hundred persons to an acre under those favourable circumstances. The plan was to divide the farms into three portions: one-third had the sewage poured upon it for a year, the other two-thirds remaining at rest. When the land was once charged with the sewage it had two years to recover itself. The one-third was again divided into thirds, each third having sewage poured upon it for eight hours, during which the other two-thirds remained at rest; the object being that the sewage might filter through the land, and that the air might pass through, so that it might be oxidised and purified. That, no doubt, was a very efficacious mode; but if on the average the sewage of a thousand people to the acre was applied, it was in reality for the time being applying the sewage of nine thousand persons to the acre. The scheme was, at the present moment, a popular one, but it was in great danger of being carried to an injurious excess. In the case of a clay soil, or where it was difficult to obtain broad acres of land without a large expenditure of money, it was very easy to say, "We will have recourse to intermittent downward filtration;" but he believed that the hobby was now being ridden so far that, unless it was checked, it would lead to very disastrous results. With regard to the water difficulty, it had been proposed to meet it by the use of all kinds of chemical agents to produce precipitation and to allow the water to pass off in a pure condition. No doubt most members had seen upon the table in a committee-room or a lecture-room some of those processes tried, and apparently with great success; but what had been the practical result? The lime process was tried at Leicester twenty-five years ago, and it proved a gigantic failure; first, because it was exceedingly costly; and secondly, because the more lime put into the sewage the more deposit was produced, and the deposit being valueless, it was extremely difficult to get rid of it. Then there was the phosphate sewage process, the A B C process, and a variety of other methods of disposing of sewage. Most of them had been tried by companies, and although the shares had gone up for a time, the bubbles had burst; and he knew of no case at the present moment that could be referred to, in which these processes were being carried out except as a palliative, and then at such a cost that the tendency was always to shirk the process of purification as much as possible. The sewage of Birmingham was now being utilised by the lime process under

the able direction of Mr. Hawksley, Past-President Inst. C.E., and it was being carried out as well as it possibly could be; but he thought Mr. Hawksley himself would admit that it was only a palliative, and that it was not such a process as could be applied to most towns. The system required large open deposit reservoirs, the sewage being pumped by troughs on to the land, then spread over the land and left to dry and afterwards dug into the ground. If such a mode were adopted for places like Brighton, Bournemouth, Torquay, and St. Leonards, those towns would soon be deserted by their visitors and would be utterly ruined. It had also been proposed to do away altogether with water-carrying and to revert to earth closets, to adopt the Liernur system and various 'midden' systems. He ventured to say that, whatever difficulties there might be in disposing of sewage when mixed with large volumes of water, such was the feeling of this country that the people would never revert to systems like those he had mentioned. Such processes might answer under certain circumstances. The earth system, for instance, might do very well in the country, where a gentleman had his own ground and his own servants to carry away the refuse, but it would never do to have carts going through the streets of a town, carrying dry earth, and men going through the houses with pails to carry up the fresh earth and to remove the refuse. People would rather grapple with the difficulty of disposing of sewage mixed with water than revert to such a state of things. The earth system, moreover, would not do away with the expense of constructing sewers, because the washings from sinks, and other offal of that kind, would have to be carried away underground, so that sewers would still be a necessity. Not wishing to occupy the time by reviewing many other processes which had been proposed, and all of which had engaged his earnest attention—for he had looked forward to the time when what might still be called the sewage difficulty would be surmounted—he came back to the conclusion that sewage must, for the present, be regarded as an enemy to be got rid of, and not as a friend to be courted and turned to account. Each of those processes might, under certain circumstances, be adopted with advantage; and it was for the engineer to consider which was the best. In some cases, as in many inland towns, it had been difficult to obtain an outfall, and in such cases the principle of combination was very advantageous. It was a principle which he had recommended for the towns in the valley of the Thames above London. There was a large number of small towns which could not go to the expense of carrying sewage to a great distance where a suitable outfall could

be found, but if they would unite together, what was impossible for one would become possible for the whole. The difficulty in such a case was not an engineering one, but it was the difficulty of inducing the different authorities to combine for their general good. One of the advantages of combination was a great economy in construction. If a sewer of 1 foot in diameter was required for the drainage of one town, a sewer of 3 feet diameter would suffice for the drainage of ten such towns, because the area was as the square of the diameter, and the velocity was much greater in a large sewer than in a smaller one. The excavation for a sewer 1 foot in diameter was the same as the excavation for a sewer of 3 feet in diameter, and the only difference in cost was in the size of the sewer itself. If by increased volume increased velocity was obtained the fall might be saved, and in that way there would be a saving of pumping. Again, instead of having a variety of pumping stations for each town, if they all combined together the staff required for one station would do for half a dozen. In regard to sewage, as in regard to other matters, there was strength in combination, by which things otherwise impossible might be accomplished.

Mr. Monson remarked that the question now to be considered was, whether it was expedient to adopt large outfall sewers. He did not propose to go into the various processes for dealing with sewage; he would confine his remarks entirely to the Paper, but he would endeavour to make his observations apply to large intercepting outfall sewers generally. The Author of the Paper had brought out boldly the difficulties of pumping, the extraordinary depth of cutting, and the method of overcoming water from the chalk. He had, however, abstained from stating the objects of the work, and the benefits which the people of Brighton had derived from so stupendous an undertaking. If a longitudinal section had been included in the drawings the faults of the system would have been at once apparent. The work was called the Brighton Intercepting and Outfall Sewers, and the object in view was to remove the sewage from the town in such a way as not to be offensive either to sight or smell, and to improve the health of the place. He learned that the range of the tide was 22 feet, that the invert at Hove was 21·6 feet above low water, and that the point of outfall was exactly at low water, so that the sewage was never entirely discharged; also that six flushers were employed, showing that there must be a large amount of sludge deposited: it followed that putrefaction was always going on, and a large quantity of sewage gas was constantly being given off.

Again, the sewage for a good part of the day was blocked in by the tide; the sewage therefore headed up, and there being no current at all, sludge was freely deposited. The sewer thus became, not a channel for sewage, but an elongated cesspool—a manure tank, which during a storm and high tide might be filled from end to end. The whole of the sewer was covered, ventilators were put in, but their united area was small compared with the volume of putrefying sewage. What took place? The tide rose, the sewage could not escape, it headed up further and further, and the sludge was deposited thicker and faster. Again, sewage gas was constantly forming, and the space for it being contracted by the rise of the sewage, it became more and more concentrated, and was at length forced into the houses of the unsuspecting inhabitants. It thus failed in its chief object, to improve the health of the place. He believed the resident medical men considered the scheme the reverse of satisfactory. Then with regard to the sewage, the insoluble portions were not removed, but were discharged at dead low water. It followed as a matter of course that this would come in with the tide, and be cast upon the shore; and besides, the salt water would precipitate a large quantity of the soluble elements of the sewage. He believed the sewer was constructed at too low a level. A main sewer ought always to be self-acting and self-cleansing, and this should have been so laid that the sewage could be continuously discharged from it even at high water. The drainage of the lower part of the town ought to have been separately dealt with, and carried along shore, the old sewers being utilised to discharge the surface water. The sewage being thus reduced in quantity, a smaller sewer would have sufficed, which would have reduced the expense. As regarded treatment, the insoluble portions ought to be removed from the sewage before it was discharged. To do this it should be received into a tank and treated with lime, there being no better method than that which had been so well conceived and so ably carried out at Birmingham by Mr. Hawksley, Past-President Inst. C.E. Such an arrangement would have met the circumstances of the case most admirably. The work under discussion did not appear to be an outfall sewer at all. The character of sewage seemed to have been left out of account. The arrangements were such as might be made for carrying off clean water, but were most improper for disposing of sewage. Putrefaction and noxious gases had been entirely ignored, and sludge was not taken into account. The only idea of disposal seemed to be, "Throw it into the sea, and disregard all future consequences." The work

was a failure in a sanitary point of view—an elongated cesspool of the worst kind, generating sewage gas to an enormous extent, which, having no means of escape, was offensive to smell and injurious to health. It was a failure as regarded the removal of the sewage from sight, for it came back with the tide. It was a failure in an engineering point of view, being constructed at a wrong level, and being much too costly. It was altogether an example of what to avoid.

MR. AIRD said he had thought, as one of the contractors for carrying out the work at Brighton, that he and his firm had been associated with an engineering undertaking which would have obtained credit for every one concerned in it, and of which they might justly feel proud. He still entertained that opinion, notwithstanding the severe strictures of the last speaker. Having had a great deal to do with sewage work, he could conceive nothing better than the outfall system adopted at Brighton. The engineering arrangements had been considered as carefully as possible, and he thought the same thing could be said with regard to the construction; so that Brighton might fairly take credit for being in as good a position as regarded its general sewage arrangements as any town in the country. With reference to the cost, the members should not take the figures given as an accurate criterion. Not that Mr. Gamble was incorrect in his statements, but it was pretty generally known that the actual cost of the work was largely in excess both of the estimate and of the money paid under the contract. His firm was unfortunate enough to lose £40,000 in carrying out the work. He mentioned that circumstance in order that it might be taken into account in any similar undertaking, and also as bearing upon the remarks made by Mr. Redgrave on the comparative cost of the work in the tunnel and in the open cutting. It had been an error in judgment to take the work at the price named. It was brought about by the desire, which most contractors felt, to complete works of great interest which they thought might add to their reputation, and which they took a considerable amount of pleasure in following up. But the cost was enormously increased by the extraordinary rise in the price of fuel and materials generally, and more than all by the great difficulties in dealing with the water. The quantity of water previously estimated was nothing in comparison with that with which they had to deal. There were one or two points in which he now thought they were wrong in the course pursued. First with reference to the pipe under the 7-feet sewer. It was found necessary in carrying out the works to put the pipe under the

sewer with the view of bringing water to the pumps, and unfortunately the contract threw upon the contractors the responsibility of finding any pipes that might be necessary for temporarily draining the works. That which read as a small matter in the contract turned out to be a very serious one, inasmuch as it necessitated a line of pipes between 5 and 6 miles in length continuously under the sewer, laid at a very great depth, where there was a large amount of water to be dealt with. Under the circumstances, instead of using earthenware pipes, he believed it would have been true economy if they had used iron pipes throughout the whole length. It was difficult at all times to make the joints of the earthenware pipes sound, and he believed that they pumped an enormous quantity of water more than they ought to have done. He also thought that an error in judgment had been committed in not dealing with the question of water supply for the machinery, and laying down piping 6 or 7 miles in length to supply fresh water. They endeavoured, without success, to make some arrangements with the inhabitants along the line so as to divide the expense. The negotiations took up a considerable time, but ended in nothing towards facilitating the object in view. Having regard to the pumping at the end of the work being very large, it was in reality a great misfortune, inasmuch as all the boilers had to be fed with brackish water, except that which was taken by water-carts. The pumps broke down many times in consequence, and a bad effect had been produced upon the engines sent to do the work. The last point to which he would refer was the position of the sumps. In that respect, too, a mistake had been made. They commenced by sinking them in the valleys, saving in that way a depth of about 60 feet in the excavation for the shafts, and some expense in lifting the material from them; but later on, when it was found that there was so much water to contend with, they sank several shafts in the high ground, where the water was much less than in the valleys. He believed that the work would have been carried out at less cost if in the first instance the shafts had been sunk in the high ground, so as to have the sumps there, and the work carried across the valleys with great rapidity. The ventilation, he thought, might be better provided for by pipes at such points as might be thought most convenient with regard to levels, those pipes being carried at several points either to high ground, or by the side of, or, if necessary, through houses which might be bought for the purpose.

Mr. Philip C. Lockwood remarked that, having been Borough Surveyor for Brighton for seventeen or eighteen years, he had had

some opportunity of watching the progress of the sewage and drainage of the town. When he first went to Brighton there was a trunk in the centre of the town opposite the central valley, to carry the sewage to low-water mark, but being a structure 10 feet in height, made of wood, and subject to the action of the waves, it leaked very much, and the sewage was really delivered immediately on the shore, and was very offensive. When he was appointed surveyor he proposed to obviate the evil by putting in a pipe, which would extend beyond low-water mark, with an overflow for storm water. Opinions were adverse to any expenditure of money, and it was difficult to get a vote for the purpose. A 12-inch pipe was, however, put down to low water, which proved so successful that he was afterwards enabled, being supported by the opinion of Mr. Hawksley, to induce the Corporation to lay a still longer pipe, 3 feet in diameter and 1,760 feet in length, and another 2,000 feet long at the western district, extending 1,500 feet beyond low-water mark. He believed that no pipes of that kind had been laid elsewhere. The lowest depth of water at those points was from 8 feet to 16 feet, so that at all times the mouth of the pipe would be at that depth below the surface, and the sewage would be delivered into a current of from 2 to 3 miles an hour. He fully appreciated the comprehensive way in which the matter had been dealt with by Sir John Hawkshaw, and he also admired the care and ability displayed by Mr. Gamble; at the same time he felt that perhaps, in a sanitary point of view, they were not better off than they had been with the outfall pipes previously laid. The sewage was delivered by the pipes moment by moment into a current, and disposed of before it could reach the shore. With a south-west wind it might at times reach the shore; but before it could do so it would be so oxidised by the air and the water as to be practically harmless, which indeed he had found it to be by his own personal observations. There was, however, to be seen when it rained a yellow patch of water, which gave alarm to the visitors when they were told what it was. Unfortunately, Brighton and Hove, although practically one town, were under separate systems of local government, and at the western boundary of Brighton, where it joined Hove, there was at the time referred to an outfall which only went to low-water mark, and which was a serious cause of offence, the sewage being delivered at a point where there was but a small quantity of water, just at the edge of the tide. When sewage was delivered in sufficiently deep water there was really no offence at all, although occasionally particles of sewage matter not soluble might

be seen by persons swimming or rowing, which of course was not desirable. He believed a mistake had been made in taking the outfall immediately opposite the centre of the town. He quite endorsed the sentiment of Sir Joseph Bazalgette, that sewage was to be regarded as an enemy to be driven out in the most peremptory manner. It should be removed in the shortest way; and the shortest or nearest way of disposing of it was to take it out straight from the valley with the best possible hydraulic inclination. The discharging power of the present outfall sewer was about 8,000 cubic feet per minute. The three pipes previously used discharged about 10,000 cubic feet per minute, the gradient being much sharper, the intercepting sewer producing a velocity of about 209 feet per minute under the most favourable circumstances, whilst the pipes, owing to their superior hydraulic inclination, gave a velocity of 580 feet per minute, and they had the advantage of discharging into deep water. They had been in use for nearly ten years, and during the whole of that time they required no attention whatever. They still served to receive the storm overflow from the new sewers. The flattest gradient in the old sewers was 1 in 218, and the sewage was taken entirely to sea. By the present system about ten loads of silt were lifted from the catch-pits every week. A short time before the present project was started, he carefully examined the mouth of the principal outfall pipe, and he found that the bed at the bottom of the sea was perfectly clean. The outfall scoured for itself a clean place, and there was no sand around it—nothing but white chalk, which could be seen from a boat when the water was clear. There were nuisances existing, as would always be the case, from seaweed and other matters, and to a certain extent the shore might be affected, though he had not been able himself to detect that it was affected by the sewage. The examination had been most carefully made both in-shore and with the assistance of diving apparatus in deeper water, and numerous samples of the sand and water likely to be affected were submitted to chemical examination. Certainly it was not desirable to have the outfall at the point to which it was at first taken, and it was perhaps better that the sewage should be taken 4 miles away. But it was not entirely disposed of: the flat sewer was still there although underground, the ventilators were in the high road of the principal drive, and some of them were placed near the centre of the town. There was certainly a prejudice against them. In the late frosty weather the steam from the ventilators could be seen coming up in the middle of the street. Nor ought the evaporating surface of the sewer to be lost

sight of. Multiplying the length of the sewer by the diameter, the evaporating surface covered with sewage or sewage deposit was about 250,000 feet, a very large surface, constantly throwing off sewer gas, which must be discharged somewhere, and no doubt the tendency was for it to be driven up the tributary sewers. That might prove a source of danger. He had, therefore, proposed, and Sir John Hawkshaw had concurred in it, to put a tidal valve at a place called 1A, about 750 yards east of the toll-gate, halfway between Brighton and Rottingdean; an ordinary wooden tidal valve, with an iron frame, which would open for the sewage and shut out any air coming from Portobello. A length of 2½ miles of the eastern end would thus be cut off, and this was, no doubt, the worst part, because being tide-locked there was a great tendency for sludge to be deposited. When the sea was up the sewer was tide-locked, and when down it was subject to draughts; and for that reason he had proposed to put in the valve. It was also proposed to build at that point a shaft 100 feet high, in close proximity to, and in connection with, an existing shaft there, the top of which at the surface of the ground was already 100 feet above the sewer, so that the total height would be 200 feet. This would act as a powerful ventilator, and it was part of the design to fix a small steam-engine, and an exhausting fan at the foot of the upper shaft and in connection with the lower one. Provision was also made to apply a furnace experimentally. That spot had been chosen because it was at a distance from any inhabited houses. Mr. Aird had suggested the desirability of putting in pipes and getting houses through which to carry ventilators; but it was extremely difficult to obtain sites for such a purpose. Not only the owners of the houses, but the whole neighbourhood would object. He hoped the time would come when a shaft would be placed at the eastern extremity of the sewer. He desired to bear his testimony to the admirable manner in which the work had been carried out by the Messrs. Aird, notwithstanding the many difficulties with which they had to contend. They had been the contractors for laying the central outfall pipe, in regard to which they displayed similar perseverance. A length of 1,500 feet of the pipes was below the lowest low-water mark. The pipes were put together with lead joints, and floated out in lengths of from 150 feet to 300 feet, the joints at the end of each section being made with wooden wedges, and the whole secured by screw piles. They were perfectly tight, and delivered the sewage admirably. He was still inclined to think that, for a town situated like Brighton, the system of pipe outfalls taken into deep water was a good one,

but, unfortunately, in this instance they were placed within sight where they were subject to prejudice. If they had been taken a mile from the town, and well out to sea, he believed they would have suited extremely well.

Mr. GRANT said it had occurred to him that it might have been possible to combine the system recommended by Mr. Hawksley of extending the outlet pipes into the sea, with that adopted by Sir John Hawkshaw. He thought it might have been advantageous to use the old outfalls for carrying off the surface water as far as possible. It was of course very difficult to carry off separately every drop of surface water, but a large amount might have been taken into the sea by means of the old outfalls. Had this been done, much of the deposit, consisting of flints and sand, road metal and mud, which now found its way into the deep sewer, would have been kept out of it, and the expense which it entailed would have been saved. He would also suggest, with great deference, after the consideration given to the subject by Sir John Hawkshaw, that the sewer might have been improved by giving it less fall, say 2 feet instead of 3 feet per mile, and keeping the outfall 7 feet higher. The difference of discharge could easily have been made up by the slight increase of about 6 inches in diameter; and by raising the outfall it could have been kept clear about four hours out of the twelve. That opinion was based upon what might be observed of the two outfalls of the metropolitan drainage, at Barking and at Crossness. The three culverts forming the outfall sewer from Abbey Mills to Barking were kept on a high level, and had at all times a clear discharge into the reservoir. With regard to the sewer on the opposite side, it was exceedingly difficult to keep the lower length of 3 miles of it clear; as soon as it was cleansed it began to get foul again, because the outlet was periodically checked—the sewage flowed down into ponded-up deep water, so that there was a great tendency to deposit, with which it was difficult to deal. With reference to flushing, it was suggested in the Paper, that for the upper part of the sewer it might be necessary to get water from a company. It would be easy, however, to get sufficient water for flushing by fixing one or more penstocks or movable dams, to collect the drainage water behind them, and to let it off when required. These would be useful when it was necessary to examine or cleanse any section of the sewer, or to connect new drains or branch sewers. They would, however, cost much more than if they had been put in during the progress of the work. It appeared that the brickwork was estimated, and to a considerable extent carried out, at a

thickness of 9 inches, which he thought too little. With that thickness there could be but one collar joint, and there was great difficulty in keeping the water outside the culvert from getting into it. Reference had been made to 13½-inch work, which should as a rule be actually 14-inch; the difference being made up by two thick collar joints. He had seen some of the bricks used for this work; two of the kind mentioned in the Paper were very hard, and of one he had used a large number. The plan adopted in the main sewers of London of putting Staffordshire blue bricks in the invert was a good one, and quite justified the slight additional expense. Flushing had a great tendency to wear out the invert if a hard brick was not used. In London, also, there were chemical works discharging matters into the sewer that affected the brickwork; so that a strong brick like the Staffordshire blue was preferable on that account. Many years ago, wherever the ground was wet, an attempt was made to get over the difficulty by using brick blocks; but for the last fifteen years he had given up their use because it was an essential point to previously drain the trench thoroughly. A good foundation of concrete was made, and on this the brickwork was laid as securely and as dry as if above ground, every brick being properly jointed, which could not be done with brick blocks. With a straight joint it was impossible to bond in the work properly, and if there was water round the culvert, it was sure to get in at those large ill-jointed places. It appeared that radial bricks had been thought of, but not used. Twenty-five years ago he had specified radial bricks, but, fortunately, did not get them. He did not think they were of much use. They were more costly than the others by 25 per cent.; and if one face were injured the brick was of no use for any other purpose. In the next place, the joints, though thicker at the back, were as good, with cement, as the thinner joint of the radial brick, or even better. The method stated by the Author, of laying out the curves in the tunnel, was ingenious, and no doubt answered well. There were, however, simpler modes than that which Mr. Gamble had described. As a record of work done, the Paper was a useful one; and he only wished that it had dealt more with the principles of drainage, so as to afford room for a good debate upon the general subject of the sewerage and drainage of towns.

Mr. HANVEY observed that the question of outfall sewers upon the shore at Dover had been a vexed one for the last twenty years. A bay was formed by the Shakespeare Cliff, and the Admiralty Pier, with Archley Fort almost in the centre, where the outlet

pipe, 2 feet 6 inches in diameter, discharged. The result was that for a considerable period there was slack water, a quantity of sludge was deposited, and flocculent matter was seen floating about. This passed on towards the pier, and remained there until a north-easter, or some other powerful agent, carried it away. Efforts had been made for many years to get rid of the nuisance. Some persons thought the best mode would be to lay a pipe to the end of the Admiralty Pier, while others considered the pipes should be extended into a depth of 7 fathoms. He had himself made experiments with corks, at different times of the tide, which in about a quarter of an hour returned to the bathing machines on the Marine Parade. He also put in some corks in front of Archley Fort, and in about the same time they were on shore. There was a south-west breeze for about nine months in the year, which carried any floating matter in towards the shore. In quiet seasons the matter suspended in the water was precipitated, with what result might be easily imagined. He devised a scheme of carrying out the sewage by an intercepting sewer from Archley Fort to the end of the Shakespeare Cliff, and there discharging it. Mr. Harrison, the Government Inspector, came down and approved of the method; but the people were not satisfied. Sir John Hawkshaw was then called in, who also approved of the scheme of carrying the sewage to the west of the Shakespeare Cliff; but the people would do nothing until Government compelled them. With regard to ventilation, he believed that the greater the number of openings the better. He disapproved of ventilating by pipes through houses, or by shafts at intervals; the friction upon the pipes would altogether prevent their efficiency. There should be as many openings as possible; and, in order to prevent their being offensive, charcoal filters should be employed. The great thing was to take care that there was no internal communication with the private drainage. He should be glad to know the quantity of water pumped at Brighton, and the cost. At Dover about 50,000 gallons an hour were pumped without exhausting the adits, and they were only 220 yards long.

Mr. Haywood asked whether much spring water leaked into the intercepting sewer at Brighton.

Mr. Hayter in replying, in the absence of Sir John Hawkshaw and Mr. Gamble, said he would confine himself to answering the questions that had been asked. With regard to the A B C process, it had not been tried at Brighton. Some samples of the sewage had been sent to the Phosphate Sewage Company who worked the

process, but they said it was too diluted to be dealt with. The level of the sewer, at the extreme end of the outfall pipes, was at zero, or low-water ordinary spring tides, and the sewer rose 2 feet to the penstock, which was situated a short distance from the pipes; so that at low-water spring tides the sewer was entirely emptied, and at low-water neap tides nearly so. Mr. Homersham had stated that in tunnelling through chalk he had experienced no difficulty in shutting out a large quantity of water without pumping, filling the fissures with dry deal wedges. That method had been tried at Brighton, also thrusting cement bags into the fissures, and other expedients, but none of them would answer. The chalk was of a very friable character, and as soon as a fissure was stopped by a wedge or by cement bags, the water appeared in half-a-dozen other places. The only way of dealing with the water was to convey it away as it appeared by the pipes laid under the invert of the sewer, and pump it out. The quantity of sewage amounted to somewhat under 25 gallons per head of the population in twenty-four hours. In the daytime, when there was no rain, the ordinary depth of sewage was 12 inches, and the maximum velocity 84 feet per minute, or nearly 1 mile an hour. At night the flow was about 6 inches deep at the Chain Pier, and 10 inches at Portobello. The reservoir capacity of the sewer was sufficient to contain a rainfall of about $\frac{1}{5}$ inch during the comparatively short period when there was little or no discharge. The storm overflows had been in operation six times since the sewage was admitted in May 1874—that was to say, three times in 1874, and three times in 1875. On one of these occasions (the 4th of October, 1874) the rainfall had been 1·39 inch in twenty-four hours, of which 0·6 inch fell between nine and half-past ten in the morning. The quantity of silt removed from the catch-pits varied from six loads to twenty-one loads per week, the total quantity in seventy-five weeks (from July 1874 to December 1875) having been seven hundred and forty loads, or a little less than ten loads per week on the average. A load was little more than 1 cubic yard. The silt from the catch-pits was removed at night. Respecting the arrangements for flushing the inlet from the sea at the Steyne, the sea water was admitted at spring tides for four or five days in succession. Besides this, the upper end of the sewer was flushed by penning back the sewage by a sluice, but fresh water from the waterworks was now used, and by this means the upper end of the sewer was flushed twice a week, or oftener if there was no rain.

The area of the grate of the furnace now being erected, 1 mile

to the eastward of Kemp Town, was to be 20 square feet, the height of the chimney 100 feet, and the area of the top of the chimney 10 square feet. A valve would be introduced in the sewer to shut out the gases from the lower end. The site was selected because the Sewers Board had land there, and the spot was distant from houses, there being, in fact, no house within view, and because it was generally suitable. At one time there had been considerable leakage into the sewer, but before the sewage was let in, the joints from which water flowed were scraped out, caulked with yarn and tallow, and stopped with Portland cement. This plan had answered, and there was now but little leakage. It had been stated that, in a sanitary point of view, Brighton was no better off with the intercepting sewer than formerly. Before the new work had been determined upon, Sir John Hawkshaw told the Brighton authorities that sewage delivered into the ocean, from 1,500 to 2,000 feet from the shore, was not likely to be productive of disease or to be objectionable, diluted as it must be with a large volume of sea water. But that was not the only question. The specific gravity of sewage being less than that of sea water, the sewage rose to the surface; and even at the old central outfall at the Steyne, which was 1,760 feet from the shore and farther to seaward than any of the others, the stream of sewage was plainly visible from the shore, and to those who went in boats and came near the point of discharge the effluvium was unpleasantly evident. Moreover, the very appearance of large sewage pipes inspired feelings of disgust. Influenced by these considerations, the Brighton authorities determined, after protracted discussions and investigations, to discharge the sewage at a distance from the town, and the result proved that they had arrived at a right conclusion.

Mr. G. R. STEPHENSON, Vice-President, remarked that Mr. Gamble ought to be highly gratified at the reception of his Paper, and at the discussion which had followed it. He was rather surprised, however, that one point had not been fully brought before the Institution. He was not satisfied as to the way in which the gas emanating from the sewers had been dealt with.