Discussion.

Mr. BERKLEY, President, said he was sure the members would desire to pass a vote of thanks to the Author for the very complete statement he had rendered, and the valuable information he had given, respecting sewage-farming in Berlin. Mr. Berkley.

Mr. H. A. ROECHLING wished to add a few words to the Paper in reference to the last report of the farms, which he received a few weeks ago. He had carefully perused it, and found that the year 1890–91 did not differ much from the preceding ones, except perhaps that, financially, it had produced better results than former years. The net profit from the farm management pure and simple, including valuation, amounted to £16,699 5*s.* 0*d.*, as against £9,587 for the previous year; this was equal to an excess of 74·18 per cent. Expressed in rate of interest on capital outlay— Mr. Roechling.

	Per cent.				
Osdorf returned . .	0·404	as against a loss in the previous years.			
Gross Beeren „ . .	2·622	„	0·336	per cent.	„
Falkenberg „ . .	3·175	„	3·128	„	„
Malchow „ . .	2·318	„	1·411	„	„
Or all the farms „ . . together	2·854	„	1·162	„	„

The payment necessary to meet the deficiency was equal to a rate of 0·64*d.* in the £, or 5·53*d.* per head of the population, as against 0·89*d.* and 7·51*d.* in the previous year. This confirmed the hope he had expressed, that, with every succeeding year, the profit from the management would increase. Concerning the purification of the sewage on the farms, the same excellent results had been obtained as in former years, with the exception perhaps of Osdorf, where the effluents from the beds had not been up to the usual standard. This was no doubt due to the extensive alterations to the rising- and distributing-mains in connection with the preparation of the new farms Klein Beeren, Sputendorf and Schenkendorf, which prevented a large area from being utilized for irrigation. To test the purity of the effluent, an attempt had been made to cultivate fish in the lake at Malchow, the only supply of which was the effluent from a sewaged area of about 500 acres. Six ponds were made on its eastern bank in the spring of 1890, each with an area of from 700 to 1,000 square-yards, and

Mr. Roechling. various species of fry were put into them. When the ponds were drawn in the autumn of the same year, 1,295 healthy and well-grown specimens in all were found, for which the Authorities had received a prize from the committee of the German Fishing Club. This was an excellent result, and fully confirmed what he had stated in the Paper as to the purity of the effluent water. The sanitary condition on the farms was as good in the year 1890–91 as in previous years, and in no case of illness was it possible to trace it to local influences. No case of typhoid fever was recorded. The homes for convalescents had well maintained their beneficial reputation, and the reports were very satisfactory. The health of the cattle had not been quite so good as previously, but considering the large number kept on the farms the losses had not been heavy. There was yet another item in last year's report to which he should like to draw attention, and that was the expenditure of a further sum of £107,796 on the purchase of more land for irrigation. This was a convincing proof that sewage-farming was an established fact in Berlin, and that the authorities had from year to year to extend the area under irrigation to meet the requirements of a fast-growing population. The record of the farms was one of gradual growth, with several checks during the first years, but since then the objections that had been raised had almost died out, and farmers and landowners surrounding the farms were glad to pay for sewage. The main drainage works could not be carried out fast enough, and the population, having recognized the advantages derived from them, were pressing the city authorities to take the last radial system, system XI, in hand. He had attached to the Paper the great number of thirty-six Tables, and he had to thank the Council for having printed them in full. His only desire in giving this great amount of statistical information had been to afford each member every possible means of forming an independent opinion on the farms, and of judging to what extent the views expressed in the Paper were correct. The sphere of an engineer was an international one, as it was not bounded by the ocean, or by any arbitrary line of demarcation of political power, the forces in nature with which he had to deal being the same throughout the globe. He had thought, therefore, that it might be of some interest to the profession to know what had been done in another part of the world in reference to the solution of one of the most complicated questions, viz., the utilization and purification of sewage. Should he have succeeded in adding to their knowledge on this subject, his humble efforts would have been well repaid.

Mr. JAMES MANSERGH regretted that he had not had time to read this admirable Paper and to digest the thirty-six Tables appended to it. He also regretted that the Paper had been read so soon, because within the next week or ten days he hoped to have an opportunity of examining the farms themselves. There were one or two points he should be glad to see added to the Paper. It did not contain a complete description of the very interesting radial system of sewerage adopted in Berlin, and if the subject was too large for a single Paper, he was quite sure the members would be glad to receive another from the Author dealing with it. It was quite a new departure in the way of sewering towns, and a most interesting one. Mr. Mansergh.

Dr. C. R. DRYSDALE said the subject of purifying the sewage of large cities was one requiring the thoughtful care of all the members of scientific professions. He had had an opportunity at the time of the International Congress in Berlin of inspecting the farms described, and he had taken a great deal of interest in the subject. Considering the population of London, 4,200,000, with a daily sewage-discharge of from 150,000,000 to 200,000,000 gallons, it was absurd that it should be treated by the infantile process of a slight addition of a few chemicals, and then pumped into one of the finest rivers in the world, thereby making the banks of the Thames in the neighbourhood of the sewage outfalls a grievous place of residence. He was quite sure that if those who lived in the west had to reside in the neighbourhood of Woolwich, they would experience a burning feeling of indignation at the way in which they were treated by the pumping of so large a quantity of sewage into the river. The two greatest cities next to London, Paris and Berlin, which had learnt in England all that they knew, had set an example of a much higher state of things in respect to sewage-treatment than London itself now possessed. The authorities of Paris came to London to study the question of sewage-farms. They went to Croydon during the lifetime of Dr. Alfred Carpenter to study the sewage-farms there, and then they returned to set to work in Paris itself. He had visited the Parisian sewage-farms with Mr. Durand Claye. Those farms had convinced them all of the enormous superiority of the effluent to any chemical purification attempted in England. In Paris they had the great advantage of not having anything to pay for what they did because the small proprietors received on their own account the amount of sewage that was wanted. They at first objected very strongly to being poisoned with the sewage, but on ascertaining the enormous produce that Dr. Drysdale.

Dr. Drysdale. could be raised by their neighbours they one by one adopted the system, and now at Genevilliers, near Paris, a splendid set of sewage-farms was at work. The Berlin people went to France and then to England, and they then set to work in their own country, where they had a Government that believed in scientific research, which the English people had not. He had no doubt that they consulted English engineers on the subject. They then laid out their land just as an engineer would lay out the Menai Bridge or the Channel Tunnel. Government supplied the necessary money for the purchase of 19,000 acres near Berlin. The effluent there and also in Paris was so perfect that he had himself drunk it, and could testify that it was as good as any water that could be found. The time had really arrived when the civil engineers of London would have to discuss what should be done with its sewage. It was to his mind a perfect scandal that the London sewage should be treated by the milk and water plan of putting in a small quantity of sulphate of iron and permanganate of potash, which as far as he could understand had not the good effect claimed for it. He looked forward to the time when the members of the Institution would discuss the question more thoroughly than they had yet done. Hitherto it had been left to the chemist of the old Board of Works, and the gentlemen connected with the County Council. The question was far too important a one to be so trusted. With regard to the sanitary part of the question the Berlin farms had not produced a single case of disease that could be traced to the sewage, and the same thing could be said of Croydon, which was one of the healthiest suburbs of London. The Berlin sewage-farms were so perfect in their sanitation that typhoid fever was unknown there. There was a little diphtheria, but diseases connected with sewage contagion were almost absent.

Mr. Dibdin. Mr. W. J. DIBDIN understood the subject of discussion was the Sewage-Farms of Berlin, but hitherto discussion had been directed to subjects much nearer home. When the Berlin authorities commenced their Main Drainage scheme they were under considerable difficulty. They were threatened with injunctions, and had to sit still under a great deal of injustice and quietly to work on until the end was attained, letting the end itself show the value of the work done. He thought that was a good example for London to follow, which was much in the same position as the Berlin Main Drainage authorities were a few years ago. It had decided to adopt a certain scheme, which had undergone a certain amount of criticism, and would, no doubt, undergo a great deal

more, and the more it was fairly and honestly criticised the greater would be the satisfaction of those who were concerned with it. But until the works were completed and the whole process had had time for full development he thought it was hardly wise or just or fair that such remarks should be made as those to which they had just listened. The Paper was one which required a considerable amount of study before entering upon any details of criticism. The paramount feature in the question was the peculiar character of the soil to be dealt with. The reason for the success of the Berlin Sewage-Farm was to be found in the character of the soil, which was a sandy one, and totally different from sodden clay. Where sandy soil could be found for sewage irrigation that method was no doubt the best. Ordinary precipitation processes, as he had before had the honour of showing to the Institution, would not remove more than a certain amount of the organic matters in solution. That point had been very hotly contested, but he was very happy to find that the results which he had submitted to the Institution in 1886 had been so entirely confirmed by one of the most elaborate and prolonged researches ever carried on, viz., that of the State Board of Massachusetts. The results there obtained had entirely confirmed the view he had taken, that only a certain portion of the matters in solution could be removed by chemical precipitation, and for that purpose the best substances to be employed were found to be the very foolish and ridiculous substances known as lime and sulphate of iron. He had felt gratified in reading the report of that board that he had some of the most eminent and painstaking personages in his company in preferring to use those materials instead of a large quantity of very expensive materials which could do no more work. It was impossible to criticise the Paper in detail; but the general conclusions of the Author were entirely in accordance with the views which he had himself submitted, and he was glad that the Author had taken the same line. He had concluded his own remarks by saying that there could be no general plan for dealing with sewage, that each place must be dealt with upon its own merits; that they ought not to conclude that because a successful result had been obtained at town A they would necessarily get the same result at town B, one perhaps being on a sandy soil and the other on a water-logged marsh. The Author had said "There can be no general solution of this vexed question, and a great mistake has been made in the past by over-zealous advocates of the one or the other method, each party considering its own remedy to be an unfailing one in every case."

Mr. Dibdin.

Mr. Dibdin. "The question is not so much whether sewage-farming or chemical treatment is theoretically the right way to dispose of town-sewage, but rather whether in a particular case the one method is more likely than the other to give good results, as every case requires to be dealt with on its particular merits." There was one point that ought not to be overlooked in comparing Berlin with London. Berlin had a sewage-farm where land was used to bring about the nitrification and change in the organic matters of the sewage which they could not do by any other means, because they had no river of any size. The Spree was really so small that it would never do to turn the effluent into it in the ordinary condition. London, however, had a river with a flow at the sewage outfalls equal to two hundred times the volume of the sewage, and the effluent discharged into it was perfectly free from suspended matter. With the matters in suspension, plus 20 per cent. of the matters in solution removed, they could depend upon the river to take the place of land in the sewage-farm, while the solid constituents of the sewage were isolated and ready for the use of any persons who might care to take them at their own expense.

Sir Guilford L. Molesworth. Sir GUILFORD L. MOLESWORTH said the question of dealing with the sewage of London by sewage-farms was by no means new. He had been engaged nearly forty years ago by Mr. Maclean in the scheme for passing the sewage of London by Essex to the coast, serving it out as it passed the farms to the different landowners, and reclaiming a portion of land about 30 miles long and 5 or 6 miles broad by the surplus sewage that might reach the coast. He did not know why that plan was not carried out. He believed that the unhealthiness of sewage operations when the liquid was brought out into the open air from sewers had been very much over-rated. In Calcutta the sewage was discharged into a receiving tank from which it was pumped out on to a sewage farm where he had himself seen the operations in progress. The sewage was stirred up by jets of air in the tank and then pumped up. The European official in charge, living as it were in the heart of all the worst unhealthiness, had told him that he and his family had enjoyed excellent health, although the great heat of the climate of Calcutta should have intensified the effects of the miasma arising from the sewage if it were very unwholesome.

Mr. Latham. Mr. BALDWIN LATHAM wished to express his thanks to the Author for his valuable contribution to the literature of sewage-farming, which would hereafter be extremely useful for reference. The views therein expressed entirely accorded with his own. He knew

Mr. Latham.

Berlin well, but that was not the first town in Germany that had carried out a sewage-farm. Long before Berlin was working at the sewage question he had been in communication with the authorities of other towns which had carried out works. What was done in Berlin showed conclusively that sewage could be successfully applied during the whole of the year. The great difficulty he had when he first went to Germany with reference to sewage-disposal was the question of the winter climate. It was long before he could persuade the authorities that sewage in winter possessed a relatively much higher temperature than it did at other periods when the frost was not even manifest. He invited some engineers and others to go to the sewage-outlets of a certain town when the ice upon the river was more than 12 inches thick. They went to the sewer-outlets, but not one was frozen, showing conclusively that the sewage had a high temperature, which adapted it for application to the land in winter. He would not say that sewage-farming was the only mode of dealing with sewage, but there could be no doubt that it was the best mode where land could be got at anything like a reasonable rate, and within a reasonable distance of a town. Under such circumstances it was the most effectual, the simplest, and often the cheapest method that could be adopted. In London they were very unfortunately situated. They had a little magic circle round London called the Metropolitan area, now under the jurisdiction of the London County Council, and outside that area they had numerous sanitary authorities, and the falls of those districts outside of this area were in the direction of London. What had those authorities to do with their sewage? He remembered that some years ago, before the time of the construction of the intercepting sewers of London, a Royal Commission recommended the government of that day to consider the subject of the sewerage of the Metropolis, and advised it to combine not only the metropolis, but all the districts round, in one grand scheme; it was, in his judgment, a fatal mistake that that was not done. London blocked the drainage of a large number of towns in its immediate vicinity, and these towns had a great difficulty in dealing with their sewage. In his opinion, there would be no difficulty in properly utilizing the sewage of London by means of such a scheme as that proposed by Messrs. Maclean and Stileman, or by a similar scheme subsequently proposed by the Essex Reclamation Company. If the sewage were carried away into the sea, there was ample land between London and the sea which could be commanded by gravitation. In that way, they could effectually get rid of the sewage.

Mr. Latham. Mr. Dibdin had advocated the application of minute quantities of chemicals, with a view of getting the best result from the least amount of chemicals. He (Mr. Baldwin Latham) had no hesitation in saying that with forty or fifty days' accumulation of such sewage-effluent in the Thames, in a very hot season, that effluent would be almost as offensive as the sewage itself. He maintained that the present treatment was not a solution to the question which pressed upon London at the present day. No doubt a very large sum of money had been expended upon the works, but he was sure that it would be much more profitably spent in the direction taken by the authorities at Berlin and Paris. In England they almost seemed to have stood still with regard to the question of the purification of sewage. As Dr. Drysdale had said, the French came to England to learn what had been done here. He had had numerous interviews with Mr. Durand Claye and other French engineers on the subject, and he had gone with them to the different sewage-farms established in this country. They had then returned to Paris, and had shown that the best method for the purification of sewage was its application to the land. They discovered on the Paris sewage-farm the nitrifying organism, or, as it had been called, the friendly microbe, a microbe which had the power of converting nitrogenous matter into nitric acid, and, given the proper conditions for its cultivation, it would go on purifying sewage to any extent, and destroying all the noxious matter which was so baneful to life and health. He was glad to see the statement published in the Paper concerning the health of those living on the Berlin sewage-farm. It would be seen, by reference to the Royal Agricultural Society's Journal of 1880, that the judges of the sewage-farms, Mr. Clare Sewell Read, Mr. Thursfield, and himself, were appointed to adjudicate the prizes offered by the City of London for the best managed sewage-farms in the country. One of the things they had to inquire into was the health of the people living upon the sewage-farms, and the statistics brought out the remarkable fact that, of those living upon the farms, a large number of whom were children, during the eleven years the farms, adjudicated upon, had been in operation, the rate of mortality was under 4 per 1,000, showing that in the act of utilizing the waste products, which otherwise were so baneful to life, the process, properly carried out, became of advantage to the public health. Instead of being disadvantageous to the community, from a health point of view, sewage-farms had the advantage of conferring upon the people a blessing which those living in crowded cities seldom or rarely enjoyed. The statistics given by the Author were extremely

valuable, and he was very thankful to him for having brought the subject before the Institution. Mr. Latham.

Sir DOUGLAS GALTON observed that the radial system of drainage, on the principle of that adopted at Berlin, was proposed for London in 1857 by Messrs. Gotto and Stothert. Those gentlemen would have divided the Metropolis into four areas, and conveyed the sewage to irrigate land to the north-east and north-west, and to the south-east and south-west outside the metropolitan area. But in the face of the residential population which covered all the neighbourhood of London, unobjectionable sites for large tracts of land for sewage irrigation would have been difficult to find. A radial system had been proposed for Florence, where sewage for irrigation was much valued for the highly cultivated land all round the city, and where the river which flowed through the centre would furnish adequate pumping power. But the success of every method of sewage-disposal, including sewage-irrigation, depended on local circumstances, amongst which proper management was of the first importance; without good management any system of sewage-disposal would become dangerous and offensive. There were some facts mentioned by the Author which bore upon that question. The general mortality of the population living on the sewage-farms, viz., 9·75 per 1,000, was very small. On the other hand, whilst the zymotic mortality was very high in the earlier years, in the later years it became very low. The Author had pointed out that the management of the farms improved very much in the series of years under review, and whilst it was difficult to draw conclusions from the short experience of five years, all the evidence, he thought, tended to show that where sewage-farms were carefully managed they were not either unhealthy or offensive. But although so much was said about the spread of enteric or typhoid fever from the dejecta, there was one very remarkable statement by the Author bearing on the subject, viz. that, in 1888–9, whilst a severe outbreak of typhoid fever occurred in the northern and eastern portions of Berlin, no case had occurred upon any of the farms on which the sewage of Berlin was being continually poured. Mr. Baldwin Latham had alluded to the report made by the Referees in 1857 upon the drainage scheme which had since been adopted for the Metropolis. He (Sir Douglas Galton) did not think that the three principal features of that report had been recollected. He would briefly recapitulate them. First, the report suggested that in any scheme for the drainage of London provision should be made for the sewage from adjacent districts, which sewage had proved a source of trouble Sir Douglas Galton.

Sir Douglas Galton.

ever since. Secondly, it provided for the removal by gravitation down to Sea Reach of the whole of the sewage of some two-thirds of the metropolitan area, leaving only one-third to be lifted to a height of 5 feet above Trinity high-water mark into the gravitation-sewers. The plan of the Metropolitan Board, however, only removed, by gravitation to Barking and Erith, the sewage from one-third of the metropolitan area, leaving two-thirds to be lifted, and of the latter one-half had to be pumped a second time. Thirdly, it provided for diluting the sewage at the head of the gravitation-sewer with a very considerable volume of water, so that on its arrival at Sea Reach, the natural changes which would have occurred in this diluted sewage, in its course along a channel 17 miles in length, would have rendered it practically innocuous when mixed with the large volume of water at Sea Reach. The cost of the Referees' scheme, including a capitalized value for the pumping and deodorizing, would have been far smaller than the cost incurred for the present system.

Lieut.-Col. A. S. Jones.

Lieut.-Col. A. S. JONES, V.C., had long been interested in the question of sewage disposal, and had paid attention to the problem in Berlin, having had some correspondence on the subject with Mr. Alexander Aird, who had from time to time furnished him with the German official reports. In the Paper, however, the whole matter was most fully put forward in English measures and English currency, which he considered a great advantage, and he trusted that English Councils would avail themselves of it, as the municipalities of Paris and other large towns in France had done. He thought that too much had been made of the expression, "the radial system." It would be seen on the map that the farms were placed on one line from north-east to south-west, and not on all points of the compass, as the expression would strictly imply. He thought that the engineer and Mr. Marggraff had simply used their common sense in first selecting suitable land wherever they could get it at a reasonable rate; having done this, taking into consideration the area to be sewered, they gravitated the sewage to the centre of a dozen natural basins, from which it could be pumped by one or more rising-mains to the nearest of the selected farms. In so doing they were following, consciously or otherwise, the central principle enunciated very clearly by Mr. Isaac Shone many years ago. Reference had been made to the very sandy soil of the Berlin farms as being an *exceptional* advantage. The fact was that sand was not the best soil for sewage-farming, either for purification purposes or for profit. It had long been known that land and vegetation assisted by nitrifying organisms could purify sewage,

and that properly managed sewage-farms were, as Mr. Baldwin Latham and Sir Douglas Galton had stated, the healthiest localities for animal life. That had been corroborated in every particular by the experience at Berlin. Unfortunately there had been in England a number of sewage-marshes, miscalled sewage-farms, which had been very badly managed; and which had given rise to the idea of the land becoming "sewage-sick" and incapacitated by frost. He thought that the experience of the Craigentiney meadows for nearly a couple of centuries and the very hard winters from time to time in England ought to have dissipated those prejudices, and it was to be hoped that the Berlin experiments, which had been so clearly put forward by the Author, would be more effective. The most important lesson to be derived from the Paper was that the success of the Berlin experiment was due to the intelligent supervision and administration and the careful distribution of sewage over the land which the Germans had adopted, as explained in the Paper. It would be seen in Table XXI that the cost of the officials for administration was put down at £2,116; and the sewage-men £6,989, or £233 per million gallons disposed of: that was simply for the manual labour of distributing the sewage over the ground. Careful attention to cleanliness in every detail was essential to every kind of sewage-disposal. It was nearly everywhere afforded in precipitation work, but as a rule it was denied to sewage-farms. The reason was, that patentees and the persons interested looked after the one, while in the other case the engineer who had laid out the farm, went his way, and it was left to a committee of town tradespeople to look after. The Author had stated that 19,000 acres had been acquired by the municipal authorities of Berlin, but that only 7,824 acres had had sewage applied to them. It appeared from Table XV, that out of that quantity, 2,817 acres were devoted to cereals, and therefore could not be at all times depended on for sewage-disposal. Consequently he (Lieut.-Col. Jones) thought that the quantity of land which the Berlin people could really depend upon for the utilization of 30 million gallons of sewage a day should be reduced to about 5,000 acres; but, he thought, that the area of cereals would be contracted in future, and that dairying would be much extended, in which case he had no doubt that the anticipations of the Author would be justified, and that much larger returns would be obtained for interest on capital and actual rent. With regard to comparisons with London, Berlin might be said to contain one-third of the population, and to have one-third of the ratable value of

Lieut.-Col. A. S. Jones.

Lieut.-Col. A. S. Jones.

London. Five thousand acres effectually disposed of the equivalent of one-sixth of the daily volume of London sewage. The sewage in Berlin, however, was much more concentrated and required more land than that of London. From those data it might be concluded that if London had Mr. Marggraff for Lord Mayor, and a council for the whole of united London, as it no doubt would have in future, the whole of the London sewage would be disposed of upon 30,000 acres in Essex, or perhaps half in Essex and half in the neighbourhood of Woking. His partner and he, in the Canvey Island scheme, professed to have simplified the task by means of 5,000 acres in Canvey Island, which, with its tidal estuary for the effluent, was accepted by Lord Bramwell's Royal Commission as a perfectly satisfactory remedy. He was as convinced as ever that some day that plan would be taken up as the first step towards the proper utilization of London sewage on the adjoining land in Essex.

Dr. Dupré.

Dr. DUPRÉ had not intended to make any remarks, but the somewhat violent speech of Dr. Drysdale rendered it necessary that he should do so because he desired to take upon his own shoulders some of the blame which had been laid on Mr. Dibdin. The scheme at present in progress in London was first worked out by Mr. Dibdin and himself, and it was then submitted to three other eminent chemists, Sir Frederick Abel, Dr. Odling, and Prof. Williamson. The Paper showed conclusively that the Berlin sewage-farm at any rate was a great success both in regard to the treatment of sewage and, to some extent, financially. But did that fact prove that London sewage-farming would also be successful? He did not think it did. London was now sewered in a certain way; Berlin had been laid out in twelve districts with a view to sewage-farming. The sewage-farms were near at hand, and the land was admirably adapted for sewage treatment. Berlin, therefore, had all the advantages required for sewage-farming. The sewage was fresh, and every one who had dealt with the question of sewage knew that its effective treatment largely depended upon its freshness. Nothing could be done with foul sewage, or at any rate the difficulty of treating it when foul was enormously increased. London, instead of being divided into sixty districts, as it ought to be as compared with Berlin, was divided into two, the entire sewage being discharged at two points, 12 and 14 miles respectively from the centre of London. It had been stated in the Paper that the success of the northern over the southern farms depended chiefly on their comparative proximity to Berlin, the former being 6 miles distant from the city and

the latter 12. The starting points in London would be 12 and 14 miles distant. In the next place there was nowhere near London any suitable or available land for sewage-farms. The conditions, therefore, were reversed; the sewage was necessarily foul, owing to the enormous area from which it was collected, and the land was badly adapted for sewage-farming. It had been said that sewage-farming created no nuisance. That might be the case in Berlin, but it would not be so in London. Beddington sewage-farm had been brought forward as one of the best in England. When Mr. Dibdin and he, after last Tuesday's meeting, were on their return to Sutton on the line which passes through the sewage-farm, and while they were engaged in conversation, not on the subject of sewage, they both suddenly exclaimed, "What is that?" It was a terrible odour coming in at the window as they were passing Beddington sewage-farm. He had noticed that whenever he had passed Beddington sewage-farm on a warm calm evening the smell was exceedingly offensive, and any inhabitant of Sutton going home in the evening would tell the same tale. It might not be injurious to health, but it certainly was very offensive, and he had no doubt that sewage-farms for London would have the same effect. The sewage-farm at Beddington was 1 square-mile in area, but a sewage-farm for London would have to cover about 100 square-miles, and they could imagine what the result would be under a sweltering sun with 50,000 acres of foul sewage. He was afraid that the London scheme was not well understood by many persons. It was based upon some very elaborate experiments by Mr. Dibdin and himself, which had led them to the conclusion, since verified by others, that no chemical scheme that could be adopted would do more than clarify the sewage and remove a small proportion of the soluble matters. They therefore came to the conclusion that the proper plan was to limit the chemicals to the smallest amount which would effect clarification. What advantage would that be? In the first place, there was the enormous advantage of having none of the chemicals used left in the effluent. He was convinced that many of the bad effects observed from effluents were due in a great measure to the excessive amount of chemicals added, which created a further action in the river into which the sewage was discharged. In the second place, this plan saved a great amount of money. In London one grain per gallon added to sewage was equivalent to the use of 12 tons of material a day. Again, one grain of solid matter in the London sewage represented 240 tons of pre-

Dr. Dupré.

Dr. Dupré. cipitated sludge, and 120 tons of settled sludge, which, of course, enormously augmented the cost. It had often been said that the effluent produced was not to be compared with that obtained from a sewage-farm; that was true. He knew no one familiar with the subject who denied that the most effective treatment of sewage was by passing it through land, provided the land was suitable. He maintained, however, that the effluent from the chemical treatment could not be compared with the effluent from a sewage-farm. The river, in fact, was made to do part of the work, and it was able to do it as effectively as and less offensively than a sewage-farm. There was ample reason for that statement. Mr. Baldwin Latham had stated that there would be fifty days' accumulation of sewage in the river. That would be between Crossness and Southend, or seventeen days between Crossness and Gravesend. In a certain measure that was true; that was assuming the sewage to be perfectly unalterable material. It was as true as the fact that one could calculate the coal put into a furnace by the ashes which were collected. He was astonished that Mr. Baldwin Latham should have advanced that point, because he had been obliged materially to modify his earlier ideas. Taking the statement that there was seventeen days' accumulation of sewage between Gravesend and Crossness, analyses made at the time showed that there was not more than about one and a half day's sewage in that section, proving that something like $\frac{9}{10}$ of the entire sewage passing into the river was oxidized between those two points. At that time 150,000,000 gallons of raw sewage were discharged into the river per day. Now the effect of the treatment adopted was to reduce the polluting effect of the raw sewage to about one-fourth of the amount. The volume of sewage at present discharged into the river was about 183,000,000 gallons per day, one-fourth of which was about 46,000,000 gallons. There could be no doubt therefore that the river would do the work effectually, which could dispose of 135,000,000 gallons of raw sewage per day, and that it would deal equally well with the equivalent of 46,000,000 gallons, and would do so with much less nuisance than a sewage-farm. As long as it was supposed that the river did the work by direct oxidation there might be some doubt about it, but they now knew that it did the work, just in the same way as land did, by means of organisms, which could be multiplied indefinitely. He would ask those who objected to the effluent not to go to Barking, but to Southend, and he would ask them to show him at Southend the effluent that came from Barking. He selected Southend because the whole surface of the

river there was not quite equal to 50,000 acres, the area which would be required for a sewage-farm for London. Looked at in another way: the chemical treatment reduced the polluting effect of the raw sewage of 1,000,000 persons to that caused by a population of 250,000, or the treated sewage from 10,000,000 was equal to that of the raw sewage of 2,500,000 persons; rather less than the total population of London when the main outfalls were opened. It had often been said by the opponents of chemical treatment that the enormous amount of manurial value which would be recovered on a sewage-farm was wasted. Was there any reason for such an objection? Suppose the case of a farm on which the whole produce was consumed on the farm and returned to it in the form of manure; such a farm would maintain its fertility for ever. That was not merely speculation; it was exemplified in the case of China for more than a thousand years. It followed that the manure produced in towns should be returned to the land from which that food was obtained. London drew its supply from something like 10,000,000 acres, and all the manurial value should be returned to the 10,000,000 acres. The biggest sewage farm that any man had ever ventured to propose was 50,000 acres. Granting, for the sake of argument, that the fertility of land was increased two-fold, and that 1 per cent. of the total manurial value yielded by London would be saved, was it worth while, in order to get 1 per cent. and still waste 99 per cent., to go to the enormous expense and nuisance of sewage-farming? He maintained that it was not. The problem to be dealt with was to get rid of the sewage effectually without nuisance and injury to health and with a minimum cost to the community. If that was attained it did not matter how it was done, whether by sewage-farming or by throwing the sewage into the river. He went some time ago to Margate, which had been sewered by Mr. Baldwin Latham, and he observed a great outfall-sewer a mile or two long. Did it lead to the sewage-farm? No, but into the sea, and all the valuable manure of Margate was wasted in the sea. He maintained that the great thing was to dispose of sewage without nuisance and at a cheap rate, and that the London scheme would accomplish that object. It had been said that an enormous amount of money was wasted; but in reality the scheme was by far the cheapest. The whole capital outlay of the London sewage works was under £1,000,000, the yearly expense about £130,000, which, in a city like London, was very cheap. Dr. Carpenter had once told him that he estimated the expenses of sewage-farms for London at £25,000,000 sterling.

Dr. Dupré.

Dr. Dupré. The Berlin sewage-farm had taken twenty years to attain its great perfection. It was undoubtedly admirably managed and was a deserved success. The present London scheme was not yet completed, and he would ask every one to give it at least a few years' trial, that it might have an opportunity of showing what it could accomplish. But even if London should ultimately outgrow the present scheme, the remedy, he ventured to predict, would not be found in sewage-farming, but rather in taking the sewage entirely out of the estuary of the Thames.

Mr. Denton. Mr. EARDLEY BAILEY DENTON said that although he admitted that England owed a great deal to her German neighbours, and would even confess that, if Englishmen were imbued with the pluck and determination of the Germans, London would be in a very different position as regards the disposal of its sewage to what it was; nevertheless, as a sanitary engineer, he would like to make one or two statements to show that England was not altogether behind Germany, and that there were some things mentioned in the Paper as carried out at Berlin, which England would do well not to imitate. There was first the system of under-drainage. He wished especially to refer to this point, because he thought it had escaped the observation of many of those present, and because he had noticed that, in the last few years, there had been an inclination in England to follow suit upon Germany, and to adopt, to the detriment of sanitary science, a defect which would be regretted sooner or later at Berlin. He referred to shallow under-drainage. The Author had stated, "The drainage is executed in what is commonly known as the parallel system, in contradistinction to the herring-bone principle; the feeders, mostly 2-inch pipes, pass downhill, parallel with the slope, at distances varying from 16 to 33 feet apart. They empty into a master-drain at the bottom of the slope, which in turn discharges into the effluent-ditch. The average depth of the feeders below the surface is from 3 to 4 feet." In his opinion, this principle must prove most detrimental to sewage-farming, and, whatever success the Berlin sewage-farm had obtained in the past, would, he believed, if that system were continued, be to a great extent jeopardised in the future. If the under-drains laid to discharge the effluent-water, which had originally been sewage when applied to the surface, but which having passed through the soil should now be pure, were shallow, say 3 or 4 feet deep, they would not achieve their object, and the effluent must in time become impure. In a varied experience he had not found reason to depart from what had been impressed

upon him in his boyhood by those who knew far better than himself, namely, that with every square-yard of surface 2 cubic-yards of aerated and filtering material were necessary in order that the foul liquid might pass out after filtration in a pure condition. In this way our rivers might be preserved unpolluted, but not otherwise. He wished to emphasize this point because within the last six months, three towns in England, which he need not name, had, within his own professional experience, caused pollution to the streams into which their effluent-water was discharged, simply because the under-drainage system of their sewage-farms was shallow, as at Berlin. Not only did he maintain that failure must ensue if shallow under-drainage were adopted, but he contended that it was in other ways detrimental to the true interests of a town not to have deep and efficient under-drainage, for, in addition to the effluent being impure, inferior crops were grown. Better crops were produced in the case of deep under-drainage, because the temperature of the soil was improved, the water-level in it having been lowered, and aeration secured—an all-important matter in cultivation. He did not hesitate to say that if, at Berlin, instead of 3 feet the under-drainage had been 6 feet deep, the crops all round would have been far better, and this would have amply repaid for the extra expense involved by the increased depth. Another cause for probable failure at Berlin was that the branch under-drains were pipes of ridiculously small diameter—viz., 2 inches. It was obvious that such small pipes, laid at a depth of only 3 feet from the surface, were much more likely to become choked up, and thus entail a heavy outlay in maintenance than larger pipes of 4 or 6 inches diameter laid at a depth of 6 feet from the surface. It was, therefore, not to be wondered at, to use the words of the Author, that "much trouble was caused by the choking up of drains, and a considerable amount of money had to be expended in making good the drainage." In the speaker's opinion, those responsible for this description of under-drainage were really wanting in rudimentary knowledge, for, instead of laying the pipes with perfectly open joints, they had puddled round the ends of each pipe and even surrounded the joints in some instances with layers of cement. He trusted that this had never been done on any sewage-farm in England. Summarizing matters, he considered that the under-drainage of the farm had been evidently undertaken by persons who were novices at the work, and they had obtained most imperfect results at great cost. Another important error committed was the practice of continuously piling water over these shallow under-drains. This was

Mr. Denton.

Mr. Denton. of course done because they had such intense frosts in Germany that in the winter they could not manipulate the sewage. As far as his experience went, he could substantiate what Colonel Jones had said, that with frosts in England they could manage the distribution of sewage perfectly well upon land without any such extraordinary means as that described, which merely courted failure, because, if it were followed, the necessary aeration of the soil could not be secured. The pluck of the Berliners in tackling a big question was doubtless to be admired, but they had erred in the above two most important details, without which, in his opinion, successful sewage-farming was an impossibility. He also desired to state that with efficient under-drainage half the area of land would have secured better results than those now obtained, with the additional certainty of permanent success. This was a most important point when the sewage of London came to be considered.

Mr. Cooper. Mr. C. H. Cooper said the Author had stated: "In irrigating the plots the sludge goes on to the land with the sewage, except that where grass plots are sewaged, the sludge is now intercepted in shallow catch-pits, as it was found that the coating of sludge on the plots interfered with the growth of the grass." That was an interference well known in the case of sewage-farms; one point bearing on it was the length of time the sewage was allowed to run on to the plots, and the period of rest given to the plots. These periods not only bore a relation to the damage of the crops, but also to the purity of the effluent. These catch-pits appeared to him to be a very rude way of intercepting sludge. The sludge in the pits was exposed to the sun until it dried; it was then dug out and sold to the farmers. A much better way of intercepting sludge would be by the use of tanks; it could then be pressed into cakes. A still better, and more efficient method was to pass the sewage through tanks with roughing-filters. That plan had been at work at Wimbledon since 1876, on the high-level sewer, where the sewage of between three thousand five hundred and four thousand persons passed through a roughing-filter, having an area of 132 square yards, the filtering material being about 8 inches of rough burnt ballast and brick rubbish. During the nine warmer months of 1889, the sewage passed through the filter was cleaned over an area of 2½ acres, and that close to four cottages, the number of persons per acre treated being about one thousand four hundred. Had the sewage been chemically treated, no doubt a much larger area of land would be required to cleanse it. In the case of chemically-treated sewage, the effluent from the tanks seemed to

Mr. Cooper.

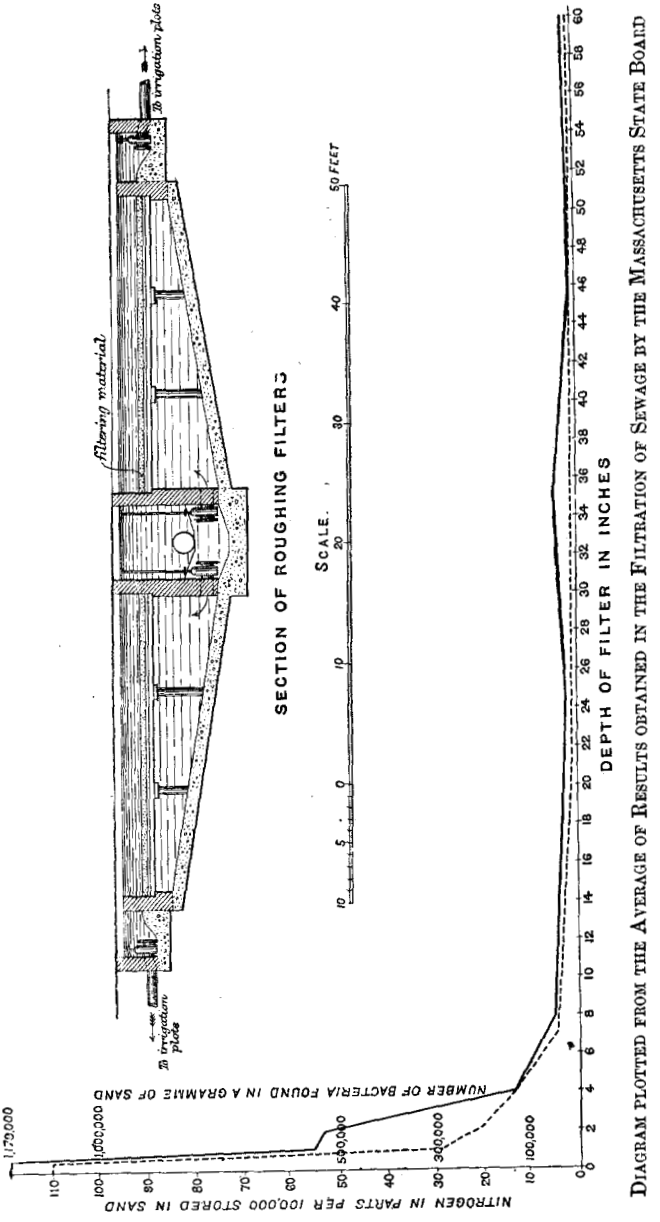

DIAGRAM PLOTTED FROM THE AVERAGE OF RESULTS OBTAINED IN THE FILTRATION OF SEWAGE BY THE MASSACHUSETTS STATE BOARD

Mr. Cooper. be pickled, if he might use the expression, and it was much harder to remove the matters that remained in it by land than it would have been had the sludge been removed in a mechanical way, such as was done in a filter. In a great many works sewage was first cleansed by chemicals and was afterwards passed over land. It would be more economically cleansed were the same sewage passed through roughing-filters and then passed on to the land. The International Purification Company had clearly shown the work that could be done by filters. Their filters were certainly very practical, the sewage was partly cleansed before passing on to the filters, and the filters themselves were cleansed every day. In the case of filters experimented upon by the Massachusetts State Board, the sewage was allowed to run on to the filters without being cleansed. For his own part, he did not believe in the great superiority of polarite. The work of cleansing sewage seemed to be done on the surface. To illustrate this he had plotted a diagram from the returns of the State Board of Massachusetts, on which a full line represented the number of microbes per gram of sand; these amounted to more than one million one hundred thousand in the first $\frac{1}{4}$ inch; whereas, between one and five inches they dropped to a little over one hundred thousand, showing that by far the greatest number was contained in the surface. The dotted line showed the amount of nitrogen per one hundred thousand parts stored in the filter. Within the first $\frac{1}{4}$ inch of surface there were more than one hundred parts, whereas between $\frac{1}{2}$ inch and 1 inch there were only twenty-seven. The line appeared to drop, until it came to almost nothing, at a depth of 60 inches; showing clearly that the work was done on the surface. At the Wimbledon farm they found, when the present manager, Mr. J. Snook, took charge, that the effluent running off was quite as bad as the sewage which came on. What was done was to puddle up the drains and stop the sewage from running down to them. Since this work had been carried out, the greater part of the sewage, at least 90 per cent., ran over the surface and did not enter the drains, the result being one of the best effluents obtained in England.

Mr. Lewis. Mr. W. B. Lewis wished to draw attention to two figures obtained from the Paper, which were very interesting to all who were thinking what was to be done in London. In the first place, it appeared that at Berlin they had 11,000 acres of land, of which a total had been prepared for sewage of about 8,000 acres. The quantity of sewage in Berlin might be roughly taken at about one-fifth of that of London; if, therefore, they had the same sandy

soil to deal with, they would want in London, as compared with the 11,000 acres in Berlin, 55,000 acres, or, as compared with the prepared land, 40,000 acres. It would be difficult, as well as expensive, to get so much land near London. The other figure that he wanted to notice was that the loss on the farm in 1890 was £3 14*s.* per million gallons of sewage dealt with. Taking the London sewage at 156,800,000 gallons daily, or 57,232 million gallons annually, then at £3 14*s.*, the loss would work out to nearly £212,000 per annum, which was a very serious thing to face. He had been unable to ascertain the cost of the present system. Dr. Dupré stated that it was £130,000. Certainly £212,000 per annum was a good deal to pay, but there was no reason to suppose that it could be done at anything like the same price in London, because the land was not so suitable, and it was necessary to start 14 or 15 miles off. These facts seemed to him to point to the wisdom of patiently waiting, and seeing the result of what was being done. Some of his friends who had lately been to Barking had told him that the improvement in the condition of the river there was very noticeable, that vegetation was growing where it had ceased before, and that they felt very hopeful that the effluent was not doing mischief. Looking at the matter, practically, he thought they ought to hesitate very much before condemning, without fairly trying it, an experiment which promised to be much more economical than any sewage-farm could possibly be.

Mr. Lewis.

Sir ROBERT RAWLINSON said that town-sewage might be applied to almost any class of land in existence, but not always with the same advantages. He agreed with a previous speaker in some things, as that they must be very careful in what they did with any land in tampering with under-drainage. He knew of heavy clay land, that had a good surface-slope, which was under-drained and ruined for sewage-irrigation, and the drains had to be taken out. Again, the character of land had necessarily to do with the character of the crop. They could irrigate sea-sand, and they could irrigate the heaviest clay and every class of land betwixt the two; but it should always be remembered that the effect they got from sewage would be from the surface, and not from any great depth that the sewage might be supposed to penetrate in open gravel soil or on sea-sand. He had special experiments made with regard to the celebrated Craigentiney meadows near Edinburgh, of which so much had been said. Some of those meadows, which were common sea-sand, had received sewage more than a century, and at six inches in depth below the surface they

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showed no stain or taint. He had heard remarks about land being made sick with sewage, or being corrupted with it so as to be dangerous and unwholesome. There was no evidence that one acre of that land at Edinburgh had either been sickened or in any respect made dangerous to health by the gross manner in which the most corrupt sewage had been floated over it. It was a very remarkable fact that, though in the vicinity of those meadows there had been complaints of smell, there had been no established complaints of an excess of sickness. The men who lived and worked upon them with their families did not suffer. They had heard, in some cases from chemists, that land was corrupted by floating human excreta in a coarse manner upon it, carrying out from the human bowels the ova of tape-worm and other pests which inflicted human and animal bodies. In Edinburgh, where the coarsest form of sewage had been applied for so long a time, no evidence had been obtained from hospital practice that there had been any excessive danger caused by these pests in the course of irrigation that had been carried on there. Then with regard to sewage-farms and sewage-experiments in London, one could hardly conceive of a new process which had not been taken up and tried and pushed forward in some way. The chemical process, the precipitating process, the filtering process, and the combination of chemicals with filtering, had all been tried. The result of his experience, and of all the knowledge he had gained, having served upon two Royal Commissions appointed for the special purpose of investigating the sewage question, was that the crude sewage in its simple form, without tampering with it by chemicals was the best form for the land, and would produce the best results, if applied judiciously in proper dilution, in proper quantities, and at proper times. There had, however, been some most wonderful quackery with regard to sewage treatment by chemicals. They had been told, and attempts had been made to thrust it upon them from time to time, that the deposited matter from sewage treated by precipitation could be manufactured into a portable manure worth from £3 to £3 10*s.* per ton. He did not believe one word of it. Yet that process was carried on up to the present time. When a town had sewage to deal with, a great deal depended upon its relative position in determining what it could do and what it should do. Many towns were so situated that they were not in a position to be able to carry out broad-irrigation; the land about them was either too low or too high, or too much occupied by manufacturers to enable them to use it. Then they had to resort

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to chemical treatment to clarify, as far as they could, the effluent-water before it passed into the river. But in no case was that clarified sewage pure; it had seven-eighths of the salts of sewage in it (all the dissolved impurities) when it was as clear as the clearest water which could be obtained from the best filter, and, if passed into a shallow brook or a small river, it would in summer ferment and become putrid and offensive. With regard to London, he might say that he had had to pay especial attention to the sewage question. He knew the history of it from the beginning of the first Metropolitan Board of Works down to the present time. Parliament had laid down the rule to the Metropolitan Board that they should be bound to purify the Thames, but the only method of purifying the Thames, or any other river, was by keeping the sewage out of it. Had the Thames been purified? Certainly not. Was it purified now? Certainly not. By a small modicum of chemicals mixed with vast masses of crude sewage, some of the richest sewage produced in the world by precipitation was supposed to be brought about. And then the effluent, which they called "clarified," was passed direct into the river, and the precipitated matter was said to be barged out 50 miles to sea. What was that precipitated matter? From 90 to 95 per cent. of it was water. Was that wisdom? It would flow anywhere if they would permit it to do so; but they had bought barges at a cost of £30,000 each to take it 50 miles out to sea. He was told the other day that during the foggy weather they took the opportunity, when nobody could see them, to drop their load half-way down the river. He thought they did wisely; and if they had dropped it there or somewhere else all the time instead of going the full distance, they would do very little harm. They would pollute the river, of course. The Thames, however, was polluted from two causes, and he was bound to say that, humanly speaking, it never would be purified. The present gross and shameful pollution could be abated by the construction of sewage-outfall works from Barking to the sea, and by no other means. London stood upon 117 square miles of land, on the two sides of the river. It had a population of upwards of five millions—approaching six. It had about eight hundred thousand houses, all of which were water-closeted. London was the only great city in the world which was thoroughly water-closeted, and it used about 200,000,000 gallons of water per day, and passed this volume, plus tributary river-water, spring-water, and rain-water, to the river. All the lower part of London was water-logged with sewage, which meant that the low intercepting-sewers were far too small for the work they had to do;

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and the Metropolitan Board, finding that out, kept increasing the overflows into the river until more than a moiety of the whole of the low-level sewage during heavy rain went into the river at those storm-overflow outlets. He did not blame the first engineers. They had a task set them, when they had to drain London with no experience to guide them. Again, when they began their work, London had not half its present population. But the engineers made one mistake; they did not take and cultivate the valley lines by making intercepting-sewers especially for interception, and not for sewage at all. For instance, the Fleet river was a sewer. There ought not to be one atom of sewage passed into it. The other springs and small streams in London which went down to the Thames were also polluted by having overflows from the main-sewers to relieve them during heavy storms. The question was, What should be done with London as it existed? He said—and he said it unflinchingly—that there was only one process by which London was to be dealt with as Parliament wished and legislated for, and which, as the last Sewage Commission reported, ought to be adopted, viz., some process of combining the sewage by an outlet-conduit, sending it down bodily to the Maplin Sands in one volume, and dealing with it in patches by broad-irrigation where any means could be found. There was a distance of 46 miles between the northern outfall and the Maplin Sands. On that 46 miles, if the conduit was carried out, there was an area of from 1 to 2 miles of poor land on both sides over which sewage might be distributed with enormous advantage, because arrangements could be made by which so much and no more should pass on to so many given acres; no more than the land could utilize without causing a nuisance. There in broad-irrigation they might have perfect aeration, filtration, and purification of the sewage. If they put 1,000,000 or 100,000,000 gallons of sewage over a certain area of land which the land could deal with in summer, $\frac{9}{10}$ths of the water of that volume would pass off into the atmosphere purified by evaporation. In some of the farms he knew in England, during the summer months there was no effluent. The whole volume of the water of the sewage that went on to the surface was dealt with at the surface, and the water never got down into, or away from the land, but was either taken up by vegetation or passed away in evaporation. Where such crops as Italian rye-grass were grown, the evaporating power of the plants was very great. It took 200 lbs. of water evaporated to deposit 1 lb. of woody fibre of any kind, whether of grass or oak. Therefore, if they could weigh their crops of rye-grass, growing as rapidly as they did, they were evaporating

at that rate—for every 1 lb. of woody fibre which they might find, they were passing into the atmosphere 200 lbs. of water, which was as pure as chemists could distil it. At the Maplin Sands reclamation might be made, which would give them from 10,000 to 12,000 acres. That land could be warped by sewage in the first instance, deposition allowed to take place in the sewage, and the top or clarified water could be passed off into the sea at low water with the ebb tide, and do no harm. The sewage on the line of the conduit could either be used or not. The great necessity was to open the door into the sea, and then deal with what they had in the conduit in the best possible manner. He supposed it was disrespectful to speak of statesmen as not being wise, but those, whoever they were, who abolished the Coal and Wine Dues were not, in his opinion, wise statesmen. Why abolish the Coal Dues? London was not a manufacturing town, and the less means were taken to promote manufactures, or to cause a necessity for bringing extra coals to London, the worse it was for the population. If he could by any persuasion re-enact the Coal and Wine Dues, he would do it to-morrow, and then they would have a sum of money at command, which no individual in London would feel the worse for, that would more than pay the interest on the capital sum needed to make the conduits from the north of London out to the Maplin Sands. Nature had arranged things for us in the very best possible way that one could wish. Sewage should always pass from any population to the north and east. They had but little moist air coming from those quarters. For nine months out of twelve the flow was south and west, and that was a moist atmosphere, the north and east being a dry atmosphere. A circumstance had come to his knowledge many years ago, when he held inquiries in Birmingham and in Wolverhampton. When he saw the results of the death-rate, he could not quite account for certain differences. Wolverhampton had been visited once or twice most severely with cholera, and with typhoid fever to a large extent. Birmingham, on the other hand, never had cholera, and yet the water-supply of Birmingham, during the cholera period, was about as bad as any human being could imagine. It was drawn from the River Tame, which rose near Bilston, where cholera raged fearfully, and was taken into a large open reservoir, and nothing was done to it but to allow it to settle, and it was then pumped in that form to supply about one-third of the population of Birmingham. The only difference he could find in those two towns to lead him to any possible conclusion was that the sewage of Birmingham, what there was of it, went to

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Sir Robert Rawlinson. the north and east, while the sewage of Wolverhampton went to the south and west, and stagnated in the ditches and swamps on those sides. He by no means said that that difference in the outflow of the sewage caused the difference in the disease in the two towns. He only gave it as a fact, that though the two towns were situated on similar subsoil—New Red Sandstone—and stood at about the same elevation—500 feet above the sea—yet there was no cholera in Birmingham, while a fierce epidemic raged in Wolverhampton. Then with regard to the metropolitan outfall. London drew all the idle scamps in the three kingdoms into it during any time of distress. Men were now appealing to the Lord Mayor and to various societies to find them work, and the Socialists were demanding to have work found for them. Now, if the northern outfall were carried out to sea, and the London County Council acquired 2,000 or 3,000 acres of land for the undertaking, they might tell these very eager gentlemen to work, and work for wages. They could be sent down there and have spade-work, as the cotton-famine men had in their district. In Lancashire at that time there were some forty thousand men receiving relief of one kind or another from the rates and charities before local works were begun. Those works were, however, somewhat complicated, because, having the management in his hands, he would not permit any useless works to be taken up. Lancashire at that time was very backward in everything connected with road-formation, street improvement and sewering, and money was provided by Government so as to enable work to be found for distressed men. But out of £1,500,000 advanced he could only find that £600,000 could be spent upon unskilled labour. The distressed men, however, had encouragement to go to work. They had a suit of working-clothes provided for them, and if they worked in wet they had a pair of waterproof-boots. Every one of those forty thousand men, who were living upon the rates and charity, had work offered to him, but no more than six or seven thousand ever went near the work. The remaining portion vanished and left the district, and they (the local officials) neither knew nor cared where they went. He believed the same thing would occur in London. If one hundred thousand men were clamouring for employment, and spade-labour could be offered to them, not ten thousand would go to work.

Mr. Roechling. Mr. H. A. ROECHLING, in reply, remarked he would have great pleasure in acting upon Mr. Mansergh's suggestion, should his time permit of it. Mr. Bailey Denton seemed to think that the under-drainage of the Berlin farms was much at fault—the feeders being too small, and their depths too shallow; and he stated that

"the effluent must under all circumstances be impure." The feeders were 2 inches in diameter at their upper ends, and they increased in size as they proceeded downhill; and he could not see any use in making these pipes larger than they need be, considering the work they were called upon to do. He did not doubt that the feeders on the Berlin farms were all calculated to do their work properly. It was a well-known fact that, with a given gradient and a given quantity to be carried away, a small pipe kept itself cleaner than a large one. It was a very natural proceeding to place a band of puddled loam round the joints to prevent the passage of fine sand into the drain-pipes, for sand, when present in the subsoil, was easily washed into the pipes, especially where, owing to their great depths, the pressure of the water on them was considerable. To lay drains with open joints under willow beds was absolutely useless, as the roots of the willows would soon get into the pipes and block them up; in such a case it was necessary to protect the joint, as for instance, by a shell of cement. It was wrong to suppose that the sewage-tanks were frequently called into requisition, as such was not the case. Their area amounted to about $\frac{1}{20}$th part of that of the prepared land, and they only came into use when everything else had failed. If the sewage had been piled up in them for any length of time, how could they have retained on the average as much as 95 per cent. of the organic ammonia? The question of deep *versus* shallow under-drainage was an important one, and he much regretted that Mr. Denton had not supplied facts and figures in support of his statement that a deep under-drainage was calculated to lead to better results in the case of the land, the crops, and the effluent, than a shallow one. If the opinion that the greatest amount of purification by nitrification was effected near the surface of the land, which was now generally held, was correct, what was the use of burying the drains under 6 feet of soil? In the absence of convincing proofs, it was impossible to follow Mr. Denton to his conclusions. On the contrary, they were bound to admit that an under-drainage of between 3 and 4 feet only, had, in the case of the Berlin farms, produced an effluent which was excellent in every respect. With reference to the size of the fields, it could not be denied that large fields, between 20 and 30 acres in extent, had, in the matter of the cultivation of the soil, certain advantages over small ones; but it was equally certain that a small field could be more systematically and rationally sewaged than a large one; and as, in sewage-farming, the purification of the sewage was the first object to be aimed at, the size of the fields should be regulated

Mr. Roechling.

Mr. Roechling. accordingly. He had seen sewage-farms with large and unwieldy fields, which betrayed at a glance the utter absence of a rational or methodical system of sewaging, and he was of opinion that large fields increased the difficulties of management to a considerable extent, especially where, owing to the small volume of the stream, it was absolutely necessary that the effluent should be perfectly purified before it was discharged into it.

No doubt, as Mr. Cooper had said, the manner in which the suspended matters in the sewage were intercepted in shallow catch-pits on the Berlin farms was a crude one, but he was afraid that the remedy he proposed would, in the case of the Berlin farms, prove very expensive; and the advantages gained would in no way be commensurate with the expenditure. Mr. Cooper forgot that, on the Berlin farms, they had not merely one or two outlets, as in the case of Wimbledon, but 74 at Osdorf, 46 at Gross Beeren, 86 at Falkenberg, and 72 at Malchow, or a total of 278 on the four original sewage-farms. It would be seen, therefore, that to construct roughing-filters after the Wimbledon pattern, at 278 points, would require a large outlay, and the advantages derived thus over the crude catch-pit method would in no way warrant such an expense. The catch-pits answered their purposes very well, and having sufficient land at their disposal, the authorities had adopted that method as combining efficiency with practically no extra expenditure. Mr. Cooper had plotted a diagram, showing some results obtained by the Massachusetts State Board of Health on their experimental filter, No. 1. These experiments were made to ascertain whether a filter was an absolute barrier to the passage of the germs contained in the sewage. It was found that, although this filter retained a great number of bacteria, which number was greatest in the first quarter of an inch from the surface, and then rapidly decreased towards 60 inches in depth, it did allow some of these micro-organisms to pass through it and into the effluent. It did not necessarily follow from the report that all these bacteria were nitrifying organisms. It was perfectly correct, as Col. Jones had stated, that "the most important lesson to be derived from the Paper was, that the success of the Berlin experiment was due to intelligent supervision and administration, and careful distribution of sewage over the land." This was doubtless a point upon which great stress must be laid. Bearing in mind the experience with English sewage-farms, it was a very natural thing to recommend the Berlin authorities to give up cereals and to pay more attention to dairy-farming. He was afraid, however, the Berlin authorities would tell them that

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they had at the outset followed the English practice, and had only given it up when they found it did not pay them. As long as the area under sewage-treatment was comparatively small, the farm products were easily disposed of; as both qualitatively and quantitatively they appeared to be all that could be desired. To enumerate the list of roots and green vegetables grown on the farms in the first few years would be a heavy task; it must suffice to say that hardly any kind of vegetable was omitted that was at all likely to find purchasers. But, when the size of the farms increased, difficulties arose in the cultivation of so many kinds of crops and in their sale, and at last this method of market-garden farming had to be given up. The results obtained by the sale of milk were of a similar nature. Now, only such products were cultivated as could command a ready sale to the merchant, such as provender, corn, &c. He was of opinion that it was a mistake to say that the system of radial drainage had been chosen solely with a view to sewage-farming. There were many reasons that induced the city authorities to adopt this system, apart from the consideration of the ultimate disposal of the sewage. It was further a misapprehension to assume that, in the case of the Berlin farms, the sewage was perfectly fresh when it reached the land. He had stated in his Paper that it took the sewage twelve hours to traverse the distance from the pumping-station to the stand-pipe on the Gross Beeren farm; and, if to this were added three hours for traversing the sewers in the town and for passing from the stand-pipe to the sundry outlets on the farm, they had a total of fifteen hours in all. Such sewage could not be called fresh, and he had seen it both at the pumping-station, where it had a greyish tint, and on the Gross Beeren farm, where it issued from the pipes inky black in colour, showing that it had undergone putrefactive changes. He had made inquiries as to whether any special difficulties had been experienced at Gross Beeren in the purification of the sewage, but he had been informed that such was not the case. It was quite correct to say that the greater success of the northern farms was due to their being much nearer to Berlin than the southern ones; but this had reference solely to the financial success, and had nothing whatever to do with their success from a sanitary point of view; as he had stated in the Paper, there was practically no difference between the various farms with respect to the degree of purification attained on them. As to the smells from a sewage-farm, his experience on the Berlin farms on one of the hottest days of the year, and under a sweltering sun, led him to the

Roechling. conclusion that there need practically be no smell from a well-managed farm.

He was very much obliged to Mr. Dibdin and to Dr. Dupré for the part they had taken in the discussion, as he had never before had an opportunity of listening to so lucid an explanation of the new process adopted for the metropolis. He might remark that the process of nitrification in various soils had been attentively studied, and was now fairly well understood, whereas it would be wrong to say that the question of the self-purifying powers of our rivers and streams was fully elucidated. On the contrary, it would be more correct to say, that the investigation of this most important matter was yet in an elementary stage. Mr. Percy F. Frankland had stated, in the abstract of a paper read by him at the last International Congress of Hygiene, that "Unanimity (of opinion) only exists with regard to self-purification by sedimentation, a process which can never guarantee the absence of danger, whilst of the removal of dissolved organic matter to any large extent there is no evidence at all." Mr. Dibdin and Dr. Dupré had based the success of their treatment upon what he should like to call the digestive powers of the river in respect to the removal of 80 per cent. of the dissolved organic pollution, and he trusted that these powers would prove equal to their expectation. The purifying powers of the Thames had been sadly overtaxed in the past, and it was imperative that this high-road of civilization should be no longer defiled by the filth of London.

In conclusion, he had to thank the gentlemen who had joined in the discussion for the favourable view they had taken of his Paper. The question of sewage-disposal was a very important one; and he thought that a knowledge of what had been done in other towns could not fail to be of interest to those who were seeking a solution of the problem.