Discussion.

Mr. Dibdin. Mr. W. J. DIBDIN observed that since his Paper had been printed he had heard some expressions of surprise that he had not entered more into detail; but if he had entered into any great detail the Paper would have been extremely unwieldy. He had been careful to deal with the question on broad principles, and had not thought it necessary to enter into minute details.

Mr. Woods. Mr. E. WOODS, President, in inviting discussion upon the Papers, said there was every reason to believe that there was a very great variety of opinion entertained on the subject, and he hoped that the speakers would compress their remarks as much as possible.

Colonel Jones. Lieut.-Colonel ALFRED S. JONES, V.C., said it appeared to him that the two Papers were of very unequal merit. That by Mr. Crimp was most practical and useful; Mr. Crimp knew exactly what he was about, and had treated his subject in the most practical manner. As to the course of experiments on which he had founded his opinion, that sludge was better than farmyard manure, he thought that it was hardly sufficiently exhaustive to warrant such an opinion; but he might say in support of these views, that he had been using air-dried sludge side by side with farmyard manure, on similar land, for fifteen successive years, without, as a rule, being able to detect any great difference in the resulting crops. Mr. Crimp had stated the cost of the pressing system very fairly and reasonably, but had shown that the expense attending it made it only applicable to rich places in confined situations, where it was an object to have a refinement upon the simple air-drying—a process which, in the open country, 300 or 400 yards from a dwelling-house, he considered to be perfectly safe. If spread out 1 foot in depth the sludge as a rule dried in a reasonable time. Describing the transfer of the sludge from the tank in which it had been precipitated into another tank at Wimbledon, it was stated in the Paper: "The solids, however, quickly subside in the sludge-tank, and the supernatant water is drawn off by means of a sluice at B (Fig. 8), and is conveyed, together with the expressed liquid from the filter-presses, back into the pump-well, where it mixes with the sewage proper." That was perfectly right at Wimbledon, but cases were common in which sewage-tanks were close to a great, wide, dark river into which the storm-water sewage overflowed, and it might be that managers of sewage-works and their subordinates, wishing to stand well with their

boards and with the auditors, who were very careful about expense, might at times find that river preferable to the pump-well. Mr. Crimp added, and all the authorities exclusively concerned in keeping down the charge on the rates would agree with him, "It is important that the water should be thus drawn off, otherwise it must be passed through the presses, subjecting the filter-cloths to undue wear and tear, and also entailing extra labour and expense." Now any manufacturing process that was unremunerative went very much against the grain of human nature, and if a thing was excessively expensive every effort would be made to do as little of it as possible, and it might be thought desirable to keep up the appearance of a beautiful scientific system, and all the while let a good deal of the material go to the river. Mr. Dibdin's Paper was a very theoretical one, and a great contrast to the other. The first theory sought to be established was that London sewage differed very much from the ordinary sewage that engineers were accustomed to deal with in other places. On that subject he should like to quote a few lines from a discussion at the Society of Arts on the 7th of May, 1886: "In the river," referring to the Thames at Barking, "there was an enormous volume of water, which exceeded the sewage to be discharged more than two-hundred fold. . . . One grain per gallon added to the London sewage represented 10 tons of material per day."[1] Now these remarks were made by Dr. Dupré, Mr. Dibdin's coadjutor in experiments on London sewage, by whom they were fully endorsed later on in the same discussion. Colonel Jones believed it was the fact, that each grain of precipitating agent per gallon of sewage would not only cost the price of 10 tons daily of the particular chemical employed, but must throw down more sludge, which had originated the theory, that the less precipitation of London sewage the better, because there would have to be such an enormous amount of sludge disposed of under any of the ordinary processes. He did not say that the theory was invented to meet that state of things, but that appeared to be the dominant idea in the mind of Mr. Dibdin. If the principle were once admitted that the effluent need only be made sufficiently clear to go into a foul river, he thought it would be getting on dangerous ground. That was the theory of the whole of the defence set up by the Metropolitan Board of Works before the recent Royal Commission, that the river was already so foul that the sewage poured into it in its untreated state could not do any harm—a defence only broken down by a personal inspection of the

Colonel Jones.

[1] Journal of the Society of Arts, vol. xxxiv. p. 669.

Colonel Jones. locality by Lord Bramwell and the Commissioners. Another theory set forth in the Paper by Mr. Dibdin was founded on the physiological fact that organic matter diffused in a very large volume of water, and exposed to light and air, became the food of minute organisms; but, of course, these organisms would leave their own excreta and their bodies in the river, or on its bed, in place of the organic matter on which they fed. He thought that Mr. Dibdin had carried that idea (p. 161) a little too far in proposing the cultivation of such animals to feed upon the sewage. The question of the space and time, in which the animals were to eat up the food accumulating at the rate of 150,000,000 gallons a day, was a rather serious consideration, but Mr. Dibdin had passed it over by simply saying, "Retain it for a sufficient period, during which time it should be fully aerated." He would ask if he had calculated how long the food would last the animals and how fast they were to eat it. It would be a very serious thing to have to find tank feeding-room at Barking, or to turn it into the river for them to feed upon, where it must oscillate about for six weeks, either in the form of sewage, organisms, or excreta. Mr. Warington, in his experiments on the nitrification by organisms existing in fertile soil, was quoted in support of this theory, but he was probably the last man in the world to expect organisms to feed without sufficient land or water on which they could have their footing. He would leave the other chemical details for others to refute, but he wished to commend the great clearness with which Mr. Dibdin had demonstrated the evils arising from excess of lime, in setting free by its solvent action organic matter, to produce that nuisance so often complained of as "secondary decomposition" in rivers which had received effluent from lime-precipitation processes. He disapproved of the passage in the Paper (p. 165) referring to the idea of putting permanganic acid into the sewage to deodorize it. It was not a new idea, because Condy's Fluid had long been used. The Author stated, in reference to the argument that the use of sufficient permanganate would be too costly, "This is true, but it only deals with the first stage of an oxidation scheme. The matters in an actual putrescent state in the effluent are the only ones which require immediate destruction, and these are but insignificant in quantity compared with the total organic matter present." Was it to be inferred that all the rest of the organic matter in solution which could not be dealt with by the very minute dose of permanganic acid—all, in fact, but an "insignificant" part—was to be put into the river beyond the reach of any further deodorizing? He also took exception to the statement (p. 168):

Colonel Jones.

"The utilization of the sludge for the raising of low-lying lands is an admirable idea in the concrete. But no one having experience in exposing the wet sludge at all seasons over large areas would suggest that it should be so used in its unpressed state." That was the very thing he had proposed to do in his evidence given before the Royal Commission, by whom it was received with some favour, namely, instead of conveying the sludge by barge from Crossness and Barking, to take it in a sewer, to spread it upon eminently suitable land at Canvey Island, and to deposit upon it common earth, the best disinfectant known, both being deposited from the sewage water itself, in exactly the same way as Nature had deposited large tracts of land at the deltas of rivers for many ages. He had experimented with alternate strata of wet sludge and earth to a total depth of 6 or 7 feet before giving his evidence, and he submitted that that was the most economical plan that could be adopted. He was surprised to find that steamers were advocated by Mr. Dibdin, because he knew that when the idea was originally introduced he had rejected it as absurd; but he supposed that the experience of the immense difficulty of dealing with such an enormous mass of sludge, in the confined and populous area of Barking, had compelled him to fall back upon any expedient however extravagant. With reference to the Table, Appendix I, he should be glad if Mr. Dibdin would explain how in practice it was intended to apply the very minute quantity mentioned in column 7 (p. 172), namely, lime in solution 3·7 grains, and iron sulphate 1 grain. How was that in practice to be applied to the ever-varying quality and volume of the sewage, and how was it to be adjusted so that the average per day or week should be exactly hit off? The Table was a valuable one, because it showed at a glance the enormous expense to which the Metropolitan Board of Works might be put in providing the tanks at Barking and Crossness. The Board had been induced to incur the expense from the idea that the chemicals would only cost £20,805 per annum under column 7; but if it was driven, as it might be, to column 22 (p. 173), the cost would amount to no less than £268,275. He would ask what figure Mr. Dibdin would arrive at for total annual cost when the price of the deodorizing permanganic acid was added to the amount he had mentioned, and also the working charges. He wished freely and thoroughly to give Mr. Dibdin all the credit due to him for his extreme ingenuity in devising a temporary remedy and expedient, by which the Board might evade the fulfilment of the absolute duty imposed upon it by the decree of the Royal Commission.

Mr. Jones. Mr. JOHN JONES as a member of the Metropolitan Board of Works, and therefore a party to the great cost that had been put upon the Metropolis, first in deodorizing, then in precipitating, and finally in making proper tanks for doing the work, observed that within a few days it had made a contract for providing tanks at Barking at a cost of £406,000, and almost an equal number would have to be put into operation on the Crossness side of the River Thames. It had been recommended by Mr. Dibdin that the sludge should be sent to the sea, and to that he strongly objected. The late wet seasons had washed a great deal of the fertility out of the light soils of England, and the country could not afford to throw away any manurial matter. Owing to railways, common roads, waterworks, and extensions of buildings, less land was available for the maintenance of the population than formerly, and there was therefore the more need for cultivation. It was possible to raise from land properly cultivated one-third more produce than was raised on the average of the land in England, but it could only be done by manures; he therefore valued very highly the sludge made in London—indeed, he considered it the safety of the population. He was sorry to hear of the project for sending it all to sea. It was true that the Board had engaged the services of one of the members of the Institution to ascertain the best kind of ship in which to carry the stuff to the ocean, but he wondered that that gentleman went on such an errand, and did not at once discountenance the idea. Sewage when pressed was a valuable manurial product. He held some of it in his hand, sulphate of ammonia produced from the cake, which was commercially profitable. It was of great importance that farmers should know what was actually in the sludge. At present they were ignorant on that point, and would not therefore put themselves to the expense of hauling the material from the stations until experiments had been made, and the Board was willing to make experiments in that direction. Mr. Jones had nothing to do with promoting companies, but he protested against sludge going into the sea instead of being used for manurial purposes. If the farmers would not use it, it could be separated into its constituent elements and made commercially profitable. There was therefore no need to trouble any further about the difficulty of disposing of the thousand tons per day yielded by London.

Mr. Sillar. Mr. WILLIAM C. SILLAR said he had always maintained that no solution of the sewage question ought to be considered perfect until it provided for the agricultural utilization of the product. Was there any one present who believed that there was no agri-

cultural value in sewage? He entirely concurred in the conclusions given in Mr. Crimp's Paper:—"Firstly, that the machine offers a ready solution to the question of the disposal of the huge masses of putrescent mud produced daily in sewage-precipitation works; secondly, that these offensive and useless masses may be quickly converted into a practically inodorous manure; and lastly, that the resulting manure is superior to ordinary farmyard manure." Those conclusions were in striking contrast to the conclusions of Mr. Dibdin, that however in other circumstances, where local conditions were favourable, other systems might be desirable, "it is thus clear that in the case of the Metropolis the conveyance of the sludge to sea is the only available remedy." He entirely differed from that opinion. Instead of being the only available remedy, it was the most disgraceful remedy he had ever heard proposed. The prosperity of every branch of industry depended largely upon agricultural prosperity, and yet Science had been evoked to extract from the land every element of fertility in it: there were manure manufactures where sulphate of ammonia and other stimulants were used more and more, so that the soils day by day were getting exhausted, the result being that landlords and tenants, wealth and poverty, were in antagonism, instead of harmonious co-operation. If people tried the experiment in their own affairs, continually drawing cheques on the bank without paying in deposits, where would they be landed at last? Just where agriculture was being landed by modern civilization. If they went on drawing the sustenance from the land, and recklessly throwing it into the sea, the sooner they gave up agriculture the better. It might be a parsimonious alternative, but it was not true political economy. He was sorry that Mr. Dibdin had arrived at the conclusion mentioned in his Paper, because many persons would follow his advice. He thought the secret of the error was to be found in the statement: "Authorities on either side have differed widely, and it is only in view of the unmistakable results, obtained in the course of many experiments, that the Author ventures to set aside all statements hitherto made upon the subject." When a writer ventured to set aside all previous statements, and all discussions that had taken place, and began at the beginning, he was not surprised that it should appear very clear to him that the only thing to do was to throw the sludge into the sea. There was one important omission in Mr. Dibdin's Paper. The whole treatment of sewage, he said, might be condensed into the use of lime; but, by the addition of lime to manure, the whole of the ammonia was discharged into the air, rendering the manure comparatively worthless for agricultural

Mr. Sillar.

Mr. Sillar. purposes. Why was it that Mr. Dibdin had entirely omitted from his calculations the only precipitation process in England in which lime was not used? When asked to give evidence connected with the Aylesbury sewage-works, Dr. Tidy said: "All my evidence is hearsay, I should like to have it in my power to say that I have seen it. Will you put your works unreservedly into my hands for three months, that I may be able, with my own observation, to ascertain what truth there is in these claims which seem so extraordinary?" That was done, and for three months Professor Dewar and Dr. Tidy took the entire control of the works, and engaged the services of Mr. Ansdell to assist them. The result was that Dr. Tidy and Professor Dewar reported that the percentage of combined nitrogen in the manure was 3·8, where it was perfectly dry, and, when calculated on the manure containing 20 per cent. of moisture, 3 per cent. of available ammonia, and of phosphoric acid, 5 per cent. Now manure with 3 per cent. of ammonia, and 5 per cent. of phosphoric acid was so agriculturally valuable, that there had never been any difficulty in selling it at £3 10*s.* per ton. Mr. Crimp had stated that if 2*s.* 6*d.* per ton could be obtained, it would pay the expense of pressing. To destroy the sludge by putting lime into it, and then to treat it as a totally worthless material, was certainly not an economical method. He would now relate a little of his experience in the matter of drying, which he had gained during a period of twenty years at an expense of about £100,000. The first method adopted was to let the sludge lie upon the ground and dry in the air. During the late wet weather, the roads had themselves been in a state of sludge, yet a day or two of strong east wind sufficed to dry them. It was the same with the sludge under discussion, when chemically treated so as to separate, to a certain extent, the water from the solid part, the air passing over the top vaporized it, and part of it soaked into the ground, and in two or three days it was sufficiently dry to be pulverized. The east wind in March dried it as much as the summer heat. But the expense of picking up the material and turning it over was greater than the expense of putting it through presses. The next plan adopted was to lay out the sludge in shallow pans, and pass hot air over it, but that would not do. Then furnaces were placed under it and it was heated; but the steam rose in clouds, condensed under the roof (for it was covered in), and came back again. The fire underneath roasted part of it, which fell into the fire and made an intolerable odour. The next plan was to try Manlove and Alliott's centrifugal machines, with which very dry cake was obtained; but they were expensive, and

Mr. Sillar.

not always satisfactory. There was no mode of disposing of the tenacious black liquor (which might be used as ink) produced in the process. It became necessary to discard all those methods, simple as they were, because they were impracticable. Presses were then tried. The first press was one that had been used for fining wine by the Pure Wine Company. The diaphragms were made of wood, and they answered very well. An excellent cake was produced; but the wooden plates were always breaking, and the expense was prohibitory. Ultimately iron presses were adopted, which sometimes succeeded and sometimes did not. The sewage had to be pumped with great force into the presses, and as it was very gritty it wore them out. At last it was found that the simplest plan was to let the sewage lie in a closed reservoir attached to the press, and turn the live steam from the boiler into it. There was 60-lb. pressure in the boiler. That pressure was exerted by the press, and it squeezed the cakes admirably, but wishing to improve upon that, steam was discontinued and air pumps were obtained, of which, however, he did not approve, believing that the steam was better and more economical; but that was an engineering question which others could decide better than himself. With regard to the process, the sludge as it came from the city was mixed with a large volume of water, which had to be got rid of. It would not do to put it all through filter-presses. Separation must take place by precipitation, and the bulk of the water got rid of in that way. The sludge at the bottom contained 95 per cent. of water. The second extraction of water was by the filter-presses, which reduced the amount to about 50 per cent. It was not even then available for agriculture; but had to be further dried by heat. When put up in heaps, owing to the nitrogen it contained, it became heated, which dried it to a powder. It might be put through revolving cylinders and artificial heat applied, and although that was an expensive method it was sometimes worth while adopting. The material was then ready for use, but not as pressed cake, for in that form it would not go to the roots of plants. It was so light that if thrown into the air it would not fall immediately upon the ground but would be blown away as impalpable dust, although it still contained from 14 to 20 per cent. of moisture. In that condition it was available for agriculture. Sewage obtained by subsidence alone, however, was not available for agricultural purposes. The excreta of human beings consisted of solid and liquid; the manurial properties of most value were in the liquid, and Liebig considered 8*s.* 7*d.* as the value of excreta, but he gave 8*s.* for the urine

Mr. Sillar. and 7*d.* for the dung of one person. The street-sweepings collected by boys might be put into a garden and have no effect upon it, but urine was of the greatest possible value, and when Mr. Dibdin ignored all the matter in solution in the sewage, he ignored the great bulk of that which was of agricultural value. Mr. Dibdin stated that the processes in question removed such a very small portion of the dissolved matter that they were not worth adopting. Dr. Tidy, however, stated that the A B C process removed 61 per cent. Sewage, therefore, ought not to be destroyed. No chemist would dispute the fact of clay having the power of extracting the valuable part of urine. The experiment could easily be tried. If a handful of clay were put into a bottle of urine and the mixture shaken up and dried to evaporation, and if it were put to the roots of plants its value would soon be ascertained. Dr. Tidy and Professor Dewar in their Report,[1] said, "As to the manurial value of the Native Guano, we are strongly of opinion that this must be judged rather by the practical results of the agriculturist than by presumed theoretical values based on analytical data." Mr. Sillar submitted the Tenth Collection of Testimonials sent to the Native Guano Company by the very men who had purchased the native guano and used it. They had paid 70*s.* a ton for it, and had come again fifteen or sixteen times to repeat their orders, and had declared that they never had a manure equal to it for agricultural purposes. With regard to London, supposing it to produce 200,000 tons of manure a year, that would not be sufficient to manure the county of Kent alone. In the offer made to the Metropolitan Board of Works to treat the sewage of London by the Native Guano Company, the calculation was based upon the estimate of £1 per ton to be obtained for the manure. Would any one suppose that if manure with 3 per cent. of ammonia and 5 per cent. of phosphates could be produced, £1 per ton could not be obtained for it? In that way the agriculturists of the country would obtain for £1 per ton 200,000 tons of manure, for which they were now glad to pay £3 10*s.* per ton.

Mr. Fowler. Mr. ALFRED M. FOWLER remarked that the observations of Mr. Sillar had reminded him of some experiments that he had been making at the Leeds works, of which he was the Engineer. £10,000 had been spent there in making the experiments based chiefly upon the A B C system, which he believed was similar to that advocated by Mr. Sillar. If all Mr. Sillar's statements were

[1] Report of Dr. C. Meymott Tidy and Professor James Dewar on the A B C sewage process, 1885, p. 6.

Mr. Fowler.

correct, how was it that that transaction had collapsed? The Corporation advertised the matter to the whole world, and had a special chemist to take the cost of each process, but in no case was any practical result shown in the way of making the sewage residuum pay for the cost. At present, after twenty years' trial at Leeds, it had to be given away. After all that had been said by the theorists who were at work at Rochdale, Nottingham, and other towns, and publishing accounts from day to day, how was it that the farmers did not purchase the manure? At Hastings twenty years ago he was told they were paying £3 10*s.* per ton for the A B C manure, but how was it that they did not take it now if there was such great value in it? The result was that after twenty years it had been shown that there was very little value in it, and that it would have to be given away. He thought the Metropolitan Board of Works was going in the right track. The Leeds Works had cost £40,000, the Salford Works, of which he had also prepared the original designs, had cost £100,000. In both towns the precipitating principle had been adopted, but in neither of them was a penny got for the manure. Notwithstanding what might be said, the principle would not be generally adopted unless some better practical results were shown.

Dr. Angell.

Dr. A. ANGELL said that the discussion of the question of the disposal of sewage necessarily involved to a certain extent the kind of materials used, and the method of using them for the production of the sludge. The character of the sludge was of course dependent to a large degree upon the character of the materials used to produce it. The most popular precipitant of the day—popular because easy to obtain and cheap—was lime, and Mr. Dibdin had proposed its employment in the treatment of metropolitan sewage; Dr. Angell was one of those who had the strongest possible objection to lime, which he thought ought to be removed from the list of materials to be used for the chemical treatment of sewage. One of his reasons was that it had a caustic or solvent action on organic matters. It would increase the quantity of organic matter to be dealt with, because it would act even upon the most insoluble portion of it—that which was little more than woody fibre; even paper would feel the caustic and alkaline action of lime. In consequence of its basic properties it liberated foul gases, and added to a considerable extent to the odours about the locality where the treatment took place. Then the production of alkalinity in the effluent was favourable to vibrionic forms of fermentation. Again, it caused ammonia to volatilize from the sludge, and therefore made the sludge of less

Dr. Angell. agricultural value. It should never be forgotten that, if it was intended to put the sludge upon the land, lime could not be continually added to any soil without materially interfering with its agricultural constitution—its property of producing plant-life. He thought, therefore, that the use of lime could not be condemned in too strong terms—it spoiled the effluent, it spoiled the sludge, and, in committing that act of spoliation, it created an intolerable nuisance. He did not know that it was possible to say more, except that the adoption of such methods was an act of chemical vandalism. The greater part of Mr. Dibdin's Paper, as a chemist, he agreed with; but there were certain parts from which he differed. Mr. Dibdin had spoken of alumina as a substance which was a decolorant, and therefore caused the effluents to please the eye. It was something more than a decolorant, because it was impossible to attack colour without breaking up the citadel, and when once the constitution of highly organized matters was broken up, the further oxidation by direct attacks of atmospheric oxygen, or dissolved oxygen, was a comparatively easy task. A laugh went round the room at a philosophical, scientific, and reasonable conception referred to by Mr. Dibdin, in speaking of Dr. Dupré's belief that some day there might be found a method of treating sewage biologically; of course indicating that it might be possible some day to cultivate some form of ferment which could be controlled. But it was hardly safe to laugh at such statements considering the rapid strides that science was making. He believed to a large extent the form of fermentation could be controlled, and therefore the biological action that took place in sewage. If the fermenting organisms were allowed to grow without air, they formed what Pasteur called the vibrionic form of fermentation. The products of that kind of fermentation were the most putrefactive and disgusting to the senses, and serious in regard to health. On the other hand the aerobian or atmospheric forms of life could be caused to grow—those which grew nearer the surface, as Pasteur had taught after the labour of many years. He was quite sure that Mr. Dibdin could never have intended to convey what he appeared to convey by his language in speaking of the danger of agitating sewage and breaking up solid matters. Allowing that that was a danger, it was counterbalanced by the fact that if the sewage was well aerated before, during and after treatment, it would be certain that the microbe life assumed that form which produced the least objectionable by-products. Microbes were undoubtedly swallowed with food; they had plenty of air,

and fermentation was carried on in a wholesome way in the mouth and stomach; but immediately they got into the intestines, where they had no air or oxygen, either the same forms of microscopic life, or those that accompanied them, and could not exist under previous conditions, took the upper hand, and putrefactive fermentation set in. In sewers it could be determined which party of microbes should continue to do its work—whether by thorough aerification, the least objectionable, or whether the lowest possible forms, the putrefactive or the vibrionic. With regard to the action of alumina, he had made experiments to ascertain whether or not sulphate of alumina precipitated in the presence of fresh organic matter would carry down any quantity, and in what kind of combination—whether combined or simply entangled. He had convinced himself that sulphate of alumina precipitated by ammonia in a gelatine solution carried down a large quantity, and it could not be washed away by hot or cold water without leaving behind a compound which was highly carbonaceous. A favourable reference had been made by Mr. Dibdin as to what had been done in Southampton. Dr. Angell would only mention that as a chemist he knew that sewage was being successfully treated there without lime. His own idea of a precipitant would be something of this kind. There must be some particulate material; not only the chemical character of the precipitate, but its physical properties must be studied. It should produce a sludge which it was easy to desiccate by pressure or by other means; very much unlike the quaking sludges made by lime and alumina, but which had such a consistency that farmers could use it, and which, when put upon the fields, the young grass could grow through. Those properties were only to be obtained by making use of some kind of earthy carbonized material, rich in iron and alumina, whose salts should be soluble and available. Then, in order to get reaction, there must be present the sulphates of lime or magnesia, or both. The chemistry of the action of such a substance would be that the lime of the sulphate of lime would react upon the carbonic acid of the alkaline carbonates present, and that constituted a portion of weighting precipitate in the form of carbonate of lime. Liberated, the alkalies would react upon the iron and alumina, and a coagulum would be formed, such as when alumina or iron were used. The iron must be in a ferrous condition, because of the curious reaction that went on in handing over oxygen to oxidizable matters. To be safe the material must be one that had gone through a reducing-action. All carbonized materials had gone through a reducing-action, and therefore it

Dr. Angell.

Dr. Angell. was certain that all the iron was in a ferrous state. This was why he believed that some such substance should entirely displace lime. In using such a material it would be certain there would be no alkalinity, which was so conducive to the after-changes in fermentation taking place in alkaline effluents.

Mr. Bennett. Mr. W. B. G. BENNETT said that if Mr. Dibdin had arrived at the conclusion that the only available way of disposing of London sewage was to cast it into the sea, he hoped that the Metropolitan Board would hesitate before adopting his proposal, because whatever financial value the sewage might have would be lost to the ratepayers of London beyond recovery. He thought that the Author had arrived at some conclusions a little too rapidly, and that, perhaps, was owing to the large quantity of material with which he had felt himself compelled to deal. Granted that there were 3,000 or 4,000 tons of sludge to dispose of, that might indeed appear a large quantity, especially in one place; but if chemists were afraid of moving a few thousand cubic yards of stuff, engineers were not. He would say, "By all means precipitate the sludge, throw a good effluent into the Thames, and hand over the sludge to the engineers to deal with." They would soon find some method of disposing of it, without throwing it away and losing its value to the community. The scheme of Mr. Bailey Denton and Lieut.-Colonel Jones had been mentioned, and that was one example of how the sludge could be disposed of without throwing it away. Mr. Dibdin had proposed to put the sludge or sewage upon a vast area of land, and so reclaim it from the water. Referring to what was done at Southampton, he had also stated that another good plan had been adopted there; and it might not be out of place if Mr. Bennett, as the Engineer of those works, gave a brief description of what was being done there, so as to show that sludge could be disposed of otherwise than by being thrown into the water. He had for the past two years been precipitating the sewage and conveying the resulting sludge from the reservoirs, where it was precipitated, to a place of disposal a mile distant, pneumatically through a sealed main with Shone's ejectors. On the arrival of the sludge at the disposal-works, it was in dry weather mixed with the road-sweepings, and in wet weather with fine ashes from the stoke-holes of a refuse destructor. Up to the present time he had been able to dispose of every ton, so that the works were now paying their way without making the slightest increase in the rates. The power for the transmission of the sludge was obtained from the heat of the burning ashbin contents. The products of combustion passing through the boiler

raised the steam for compressing the air. Mr. Dibdin had further stated that the scheme necessitated the control of the dustbin refuse and road-sweepings by the sewage authority. In the case of Southampton that was a fact, and he thought he could show that it was a very advantageous combination of the two systems of disposal. He thought also that it would be a great improvement if the Metropolitan Board of Works would take the sole control of the ashbin contents and road-sweepings, and put an end to the system of divided responsibility that now appeared to be adopted in London; and also, instead of following the present method of erecting destructors in each district or parish, erect two large destructors, one destructor on each side of the Thames, conveying all the ashbin contents and road-sweepings to the outfall works, and so utilizing them for obtaining some portion of the steam-power for treating the sludge. Mr. Dibdin had stated that one reason against treating the sludge in any other way than throwing it into the sea, was the great expense occasioned in pressing it. Mr. Bennett thought that the ashbin contents could be so burnt that power would be obtained for treating the sludge by pressing it. At Southampton another scheme was being formulated, by which it was proposed to transmit the sludge by a sealed main across the river to an agricultural district on the other side, where a depôt would be established, so that farmers could come and load their carts with sludge, and thus save the expense of carting from the town. No presses were employed; the sludge was simply incorporated with road sweepings and dry ashes by an incorporator. That method turned out the sludge in a state of good portable manure, which was readily bought up by the farmers at 2*s.* 6*d.* per load. This was one way of treating sludge without presses, and thus saving the expense that would be thereby occasioned. About 21 tons of the ashbin contents gave when burnt something like 25-HP.; 4,000 loads, or perhaps more, of the London ashbin contents would certainly give a very great power at the two outfalls, to be utilized for the treatment of London sewage. Mr. Bennett.

Dr. C. MEYMOTT TIDY congratulated Mr. Crimp on his Paper. He did not propose to deal at length with the Paper, which certainly appeared to be a very valuable contribution to the history of sewage-sludge. With two of the conclusions he entirely agreed; first, that the machine offered a ready solution to the question of the disposal of the huge masses of putrescent mud produced daily in sewage-precipitation works; and secondly, that those offensive and useless masses might be quickly converted into a practically Dr. Tidy

Dr. Tidy. inodorous manure. As to the third conclusion, that the resulting manure was superior to ordinary farmyard manure, he offered no opinion. At present he was disposed to regard both sewage and sewage-sludge as materials to be got rid of in the fastest and the easiest possible way. Nature, if let alone, would utilize them. With reference to Mr. Dibdin's Paper, it was said to be one on the subject of sewage-sludge; he ventured to think it was essentially a Paper on sewage treatment. The Paper was a remarkable one, and needed to be read by the light of history. There was a certain Commission appointed some years ago, called Lord Bramwell's Commission, to consider three questions; first, the system under which sewage was discharged into the Thames; secondly, whether any evil effects resulted therefrom; and thirdly, if any evil effects resulted, what preventive or remediable measures should be taken to prevent the nuisance? The second of those questions formed the subject of investigation for forty-five days, between July 1882 and July 1883. It was fair to admit that Dr. Frankland and himself gave evidence as chemists on behalf of the Corporation of London, to prove that a very considerable nuisance existed; Mr. Dibdin, Dr. Dupré, Dr. Odling, and Sir Frederick Abel, being called on the part of the Metropolitan Board of Works, to prove not only that no nuisance existed, but that actually in some cases the river was benefited by the sewage. He would quote two short passages from the evidence of Mr. Dibdin and Dr. Dupré. When asked what all the statistics and facts adduced came to, Mr. Dibdin replied: "It shows at first sight that the river is not polluted with sewage or anything to such an extent as to cause a nuisance, and, independently of chemical analysis, common observation shows the same thing." And again: "The deduction which I draw in the first instance is, that the contamination of the river at that point is immaterial." Dr. Dupré—who was always a little more explicit and lengthy—stated about the facts, "I think they show that the river is quite capable of dealing with the amount of sewage discharged into it, without ever getting generally into a bad condition, and they show also, clearly, that the amount of sewage daily discharged is, upon the average, daily got rid of, otherwise there would be a progressive increase in the pollution which we have not observed, and we have observations after an interval of five years. The sewage outfalls were opened, I think, in 1865; we have the first series of analyses in 1878, and the last in 1883, so that a five years' interval is a very considerable proportion of the whole, and yet they show no progressive increase; on the contrary, as I said, 1883 is slightly the best of

all the years, showing, I think clearly, that the river is quite capable of disposing of the sewage that is discharged into it." In due time the Report of the Royal Commission appeared. He would read from it two extracts stated as the conclusions of the Royal Commissioners: "That in hot and dry weather there is serious nuisance and inconvenience, extending to a considerable distance both below and above the outfalls, from the foul state of the water consequent on the sewage discharge." "It is desirable we should inquire further, what measures can be applied for remedying or preventing the evils and dangers resulting from the sewage discharge." That report was not very satisfactory to the Metropolitan Board of Works, but public opinion was brought to bear upon that body. He ventured to say that if the Board could have left the matter alone it would have done so, but public opinion forced it. Whom should the Board consult to suggest a remedy for the existing state of things? It was scarcely credible, but the very chemists were consulted to cure the evil when they had said that there was no evil, no nuisance, that nothing was wanted. In perfect consistency—for the Metropolitan Board of Works was nothing if not consistent—the Board applied to the very men who had said that the patient was in perfect health to write a prescription to make him better. He had very carefully read the report of those gentlemen. It was not signed by Mr. Dibdin, but he was quite sure that he had given a great deal of attention to the preparation. It was signed by Sir Frederick Abel, Dr. Odling, Dr. Williamson, and Dr. Dupré. He would only quote one short passage from it: "We therefore recommend that the sewage be treated throughout the year with lime and sulphate of iron, in the proportion of 3·7 grains of lime and 1 grain of sulphate of iron to each gallon of sewage; that, whenever it should be found that a fairly clear effluent obtained by that treatment is to any appreciable extent offensive, manganate of soda be added to the effluent in such proportions as are found necessary to deprive it of offensive smell, those proportions to range between ½ grain and 1½ grain, inclusive of the crude commercial manganate, and sulphuric acid in quantity equal to about one-third of the crude manganate." Upon that Report there came, as an apology, Mr. Dibdin's Paper. There was a good deal in the Paper with which he of course agreed; he would not, however, deal with that portion of it, but would refer to one or two details open to question. He would not discuss the question of the quantity of suspended matter in the sewage; that had been fought out over and over again. Mr. Dibdin's statement about

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Dr. Tidy. the 27 grains per gallon of dry matter was clearly an error. It was all very well to take the average sewage as containing 27 grains, but Mr. Dibdin had left out storm sewage altogether. A good deal had been learnt about storm sewage and storm overflows in the course of certain enquiries. The treatment recommended for the sewage was 3·7 grains of lime and 1 grain of sulphate of iron per gallon. He would first ask Mr. Dibdin whether the whole of the lime would not be instantly converted into carbonate of lime. He rather suspected that it would. He knew something about the carbonic acid of sewage, and he maintained that, taking ordinary sewage, the whole of the 3·7 grains of lime would be at once used up to form carbonate of lime, this acting simply as a weighting material; as a precipitating element the lime would be rendered absolutely valueless thereby. But he would allow, for the sake of argument, that the action of the lime on the sulphate of iron would be to precipitate ferrous oxide, or, as it was generally called, protoxide of iron. He admitted the value of ferrous oxide as a precipitating agent, and that it combined with the soluble organic matter of sewage to form an insoluble body, a compound of iron and organic matter of a nature not well understood. But admitting that to be the action of the iron, the quantity suggested was practically ridiculous. Taking it as dry sulphate of iron—which was not probable, for it was more likely to contain water than to be anhydrous—the quantity of ferrous oxide precipitated would be actually less that ½ grain per gallon. He had taken the trouble to have the stuff weighed, and he exhibited ½ grain of iron oxide—the amount which was to be added to a gallon of water. Mr. Dibdin had, however, stated that that was not the action of the ferrous oxide at all. The sulphate of iron was not added, he said, to act as a precipitating agent, namely, to combine with the organic matter and then go down as an insoluble precipitate. His explanation, which, having regard to the quantity added, was a remarkable one, was this: "The salt, known as protosulphate of iron, or more generally as 'green vitriol,' affords the ferrous hydrate. This is rapidly converted into the ferric hydrate, by combination with the oxygen dissolved in the water. In this condition it has the remarkable power of parting with the oxygen thus taken up, and of giving it to the sewage matters. Having thus been reduced to the ferrous state, it is again ready to combine with fresh atmospheric oxygen, which it again yields up to the sewage, and, acting as a carrier of the oxygen dissolved in the sewage liquid, becomes an agent for oxidizing the more readily attacked foul matters, within the limits of the quantity

used." Had Mr. Dibdin tried whether, if ½ grain of ferrous oxide was added to a gallon of ordinary sewage, such an action as he described would actually occur? Had Mr. Dibdin any definite proof further that, after the ferric oxide had been formed, it would deliver up its oxygen to the organic matter and become reduced to protoxide again, if present in the proportion of ½ grain of iron oxide per gallon of sewage? Dr. Tidy had tried it, and he left Mr. Dibdin to fight the matter out. Supposing the Fe O to be an active sewage precipitant, Fe_2O_3, the peroxide of iron, was certainly not active. It was quite clear, with regard to the peroxide of iron, that it was not a precipitating agent at all. The statement as to the permanganate business was a most extraordinary story. There was organic matter in the sewage on the one hand, and ferrous oxide on the other. The permanganate was put in; the ferrous oxide had to select between the organic matter and the permanganate. He knew perfectly well that the very first thing that the ferrous oxide would do would be to take the oxygen from the permanganate, and disregard the organic matter. Ferrous oxide was a thing admittedly easily oxidized; it was not so easy to get the oxygen out of ferric oxide. He questioned altogether the extraordinary value attached to this 1 grain of iron sulphate and 3·7 grains of lime. To show that he was not carrying his view of the action of this small quantity of lime and iron salt too far, he would quote a passage from Dr. Dupré's evidence, given before Mr. J. T. Harrison on an Inquiry respecting the Lower Thames Valley Main Sewerage in February 1884. He was asked by Mr. Michael, "Kindly tell us what you understand to be the process which is to be adopted here? *A.* I understand that the sewage itself is all to be treated with a certain proportion of lime.—*Q.* What do you understand further? *A.* Then there is to be added a quantity of lime, not quite 5 grains per gallon, as I understand.—*Q.* Take it from me that there will be a sufficient quantity of lime for the process; do not tie yourself to 5 grains? *A.* It may be sufficient for your process, but in the process you will get a very bad effluent. —*Q.* What do you suppose is to be done next? *A.* After that it is to be run into a solution of alum in certain proportions. I have taken the proportions from your evidence, but I do not know whether it is right.—*Q.* Take it in any way you please, what then? *A.* There is to be some sulphate of iron, and then it is to be allowed a rest of three hours, then it is to be siphoned or drawn off.—*Q.* We will suppose that it is drawn off. What do you say will be the result? *A.* The result will be, I have very little doubt, a very bad effluent." Then in another place he gave this

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Dr. Tidy. evidence:—"*Q.* I am asking you, for the moment, to estimate it at its best? *A.* I think, as far as I understand the process here proposed, it will not produce a good effluent, because the amount of chemicals proposed to be used is much too small.—*Q.* Do you say they ought to be more? *A.* Much more.—*Q.* Would double be enough? *A.* No, double would not be enough.—*Q.* Would three times be enough? *A.* Three times might probably be enough." He would now ask the members to look at Mr. Dibdin's Table, Appendix I, which he himself had studied hard, to see whether the action of this grain of iron was so mysteriously wonderful as had been suggested. The Table represented the "Percentage reduction of oxidizable organic matter in solution by various methods of chemical precipitation." He thought that was a rather bad way of stating the facts, because many persons would have different opinions about the estimation of oxidizable matter. He doubted whether he himself should agree with Mr. Dibdin as to the way in which he had estimated it; indeed, he knew that he should not. The Table was a remarkable one. It was singular to find all the high numbers in the first row. It seemed as if Mr. Dibdin had taken a great deal of care and worked very hard in the first row, and had got good results; for in the last row all the bad results seemed to come in. The first column showed the amount of reduction of organic matter by 3·7 grains of lime. The average reduction was stated to be 11 per cent.; in other words 2·97 per cent. of oxidizable organic matter removed for each grain of lime added. Next came the enormous power of this sulphate of iron. Column 7 showed 3·7 grains of lime and 1 grain of sulphate of iron to have been used, and what was the result? The reduction of organic matter with the 3·7 grains of lime alone was 11 per cent.; with 1 grain of sulphate of iron in addition it proved to be 13 per cent. In other words, whereas each grain of lime had effected a reduction equal to 2·97 per cent. of organic matter, the addition of 1 grain of sulphate of iron had only produced a further reduction of 2 per cent. To show that this was not mere accident, he would take the second column. By adding 5 grains of lime a reduction of the organic matter was obtained amounting to 15 per cent., in other words equal to 3 per cent. for each grain of lime added. In column 10, 5 grains of lime were added and 2 grains of sulphate of iron per gallon, the reduction being now 18 per cent., or a reduction of 1½ grain only of organic matter per grain of sulphate of iron—very much less than the reduction effected by the lime. Again in column 11, 4 grains of sulphate of iron were added, and Mr. Dibdin in this case only obtained 1 per

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cent. reduction of organic matter by the addition of 2 grains of sulphate of iron, equal to ½ grain reduction for 1 grain of sulphate of iron. Had iron, then, proved so wonderfully successful? Undoubtedly no. How about the question of cost? Mr. Dibdin had put down the lime at £1 per ton. Dr. Tidy had taken considerable trouble to ascertain what lime would cost delivered at Crossness. He was informed on the highest authority that lime could be delivered at Crossness and Barking for 12*s.* per ton. Then as to the results of this curious mixture of 3·7 grains of lime and 1 grain of iron sulphate. He had examined some of the samples of the effluent produced by the process of Mr. Dibdin and Dr. Dupré. In the first instance when he sent for them, the Metropolitan Board of Works would not let him have them, but owing to the courtesy of Mr. Dibdin he obtained some samples which he had carefully tested, comparing them with samples of average sewage flowing in the London sewers on the day in question. He was indebted to the courtesy of Mr. W. Haywood, M. Inst. C.E., for the opportunity of making the comparison. He would not at that moment give the numbers, which he would preserve to produce on another occasion; he would simply say that the sewage after treatment by the process in question was as foul as the sewage in the Fleet Sewer. Mr. Dibdin evidently foresaw this difficulty—he foresaw that someone would come forward and say that the samples of sewage treated by his process were filthy in the extreme. There was accordingly a remarkable passage in his Paper which he could only describe as a burst of apologetic eloquence. "Long and disastrous experience has now taught the public that, in the case of drinking-water, nothing is more deceptive than appearances, that often the most cooling, sparkling draught contains the elements of death. Numbers upon numbers of self-sufficient people have succumbed, after having seen their dear ones carried off before them. Who cannot now recall instance upon instance of over-confidence in some long-used source of the daily water-supply, and equal want of confidence in the advice of medical men, resulting in that stern lesson which none can unlearn? If this is so with water, how much more does the case apply to sewage? Hold up a glass of clear liquid poison, declare it to be pure, and thousands will believe the statement; but hold up a glass of pure water with but a small fraction of clean ferruginous clay diffused in it, declare it to be harmless, and how many will turn away with a smile of incredulity? These cases, extreme as they may appear to be, illustrate only too well what may, and indeed what often does, happen, in refer-

Dr. Tidy. ence to sewage effluents, and demonstrate that clearness is no more a sign of purity than is turbidity a sign of foulness." What did that passage mean? If it meant anything it meant, "Take up a glass of sparkling water from many of our wells—things are not what they seem—that sparkling draught contains the elements of death likely at any moment to carry off the dear ones at home. Hold up a glass of my sewage effluent. True, it may smell abominably; true, it may actually be as bad to all appearance as the sewage running in the sewers. Do not believe it; it is as pure as salutaris water." He had spoken warmly on the subject because he felt warmly. He was quite certain that the system upon which thousands of the ratepayers' money was to be wasted would and must prove a failure. As to the treatment of London sewage, there was no real difficulty in it at all; but let not those men be asked to remedy an evil which they had said did not exist. The only difficulty was that the Metropolitan Board of Works had committed itself hopelessly, and did not now like to admit that it had been in the wrong. Its policy, to his mind, had for years past in most matters been one long continuance of muddling inactivity. Before long the authorities would be called upon to account for the course they had taken in the matter of the London sewage, and he felt convinced that the Metropolitan Board of Works had with its own hands, and with its own sewage, written "Ichabod" on the doors of Spring Gardens.

Dr. Dupré. Dr. A. DUPRÉ observed that error died hard, and it was a mischievous error that had been propagated that sewage could be made to pay the community. It had done more to retard the proper treatment of sewage than anything else. He came to England thirty years ago full of the theoretical notions inculcated by Liebig, who then compared England to a vampire sitting on the breast of Europe sucking out its life-blood, and discharging it through its sewers into the sea. He had since become a sadder, and, he hoped, a wiser man, and had come to the conclusion, which he thought most people had reached, that sewage was a nuisance to be got rid of, irrespective of expense or any idea of making a profit out of it. Liebig himself in after years came to the conclusion that there was something in the sewage system adopted by England which rendered it impossible to make it of any agricultural use. There was no doubt a great deal of valuable material in sewage, but the difficulty was how to get at it. Many rivers in Europe carried gold, but if a man could earn a penny a day on something else it would not pay him to get gold out of a river. He had calculated that the silver in the sea-water that passed by Southend every year

would be worth £36,500,000. All the gold in California and Australia was as nothing compared with the unlimited stream of silver that passed the coast. But who ever dreamt of getting silver out of sea-water? It did not pay. In like manner Englishmen had adopted for good or evil—he sometimes thought for evil—the water-carriage of sewage, which probably would not be altered in the lifetime of any one present; and the idea, therefore, of making sewage pay must be given up. He did not say that there might not be some places where the sewage might be made to pay, but in the great majority of cases it was mere folly to think of making money out of it. Lieut.-Colonel Jones had raised a laugh against him in regard to his suggestion about treating sewage with organisms. He had, however, conclusively proved that by taking London sewage, or any sewage either by itself, or added to river-water, and sterilizing so as to kill life, no change took place, and it could be kept for weeks without the slightest alteration. By adding some organisms the organic matter in the sewage disappeared rapidly. For years a discussion had been carried on between Dr. Tidy and Dr. Frankland. Dr. Tidy had stated, "Add sewage to river-water, there being 20 volumes of water and 1 volume of sewage; watch it, and you will see that although it comes in a foul black stream it alters almost yard by yard, and in a short time it disappears." And his idea was that it disappeared by direct oxidation. Dr. Frankland, on the other hand, contended that no river in England was long enough to produce that result. Both were right, and both were wrong. Both forgot, or did not realize, that the action was due to organisms in the water. The whole question was one of a sufficiency of these organisms. With a sufficient number of organisms in the polluted water, and plenty of air, the sewage could be dealt with in the easiest and most perfect manner. If the aeration of rivers could be kept to a proper point, say 30 or 40 per cent., no nuisance need be feared from sewage. The organisms to which he referred might be sneered at, but they were among the most powerful agents in the world. With regard to Dr. Tidy's quotations from evidence given by him, he could only say that he would now repeat the same evidence without the slightest alteration, except in one point in which he was mistaken. Any one who had had experience in sewage-treatment knew that the rate at which the precipitate subsided varied considerably with the nature of the sewage, it varied apparently also with the bulk treated. Unfortunately he had been experimenting at the time with sewage that required a longer treatment than many others. He had however lived

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Dr. Dupré. and learned, and he now admitted that, as a rule, the time for precipitation need not be longer than four hours. As to the effluent produced, he held that any chemist or scientific man, who was consulted by an authority or a private individual, was bound to give the best advice of which he was capable. He was not bound, because he happened to have some hobby, to run his clients into an expense of hundreds of thousands of pounds, when he believed that all the necessary result might be obtained with a much smaller outlay. It would, he hoped, be clear to every one that the character of the sewage effluent must depend upon the place where it had to be discharged. What might be a nuisance in one room in a house might be no nuisance in another; what might be a nuisance in the dining-room would be no nuisance in the stable. The sewage effluent to which his evidence related was to be discharged near Kew Gardens, into a part of the river which was so shallow that it could occasionally be crossed on foot, and where it was a pleasure resort for Londoners, where thousands of pleasure-boats passed every year, not to say every week, and these would have been obliged to go through the sewage-effluent itself. Was that not a place where the sewage effluent ought to be something specially good? No man in his senses would recommend a sewage effluent, treated by 3 grains of lime and 1 grain of sulphate of iron, to be discharged into a part of the river, where he might have to take his pleasure-boat through the sewage-stream itself. Dr. Tidy moreover omitted to mention that the effluent to be discharged at Crossness would, whenever necessary, be deodorized by manganate of soda and sulphuric acid; the effluent near Kew was not deodorized. This effluent was to be produced by a certain amount of lime, iron, and alumina. At the very time when Dr. Tidy gave his evidence before the Committee of the House of Commons, stating that the sewage-effluent would be purer than the river in which it was to be discharged near Kew, Dr. Dupré obtained some samples of effluent produced by exactly the same process, and it was as foul, probably, as the sewage in the Fleet Sewer was on the day when Dr. Tidy examined it for the purpose of comparison, except that it contained little or no suspended matter. This was the second time he had, in the presence of Dr. Tidy, explained the apparent discrepancy between his evidence and his recommendation, he hoped he should not have to do it a third time. He now came to the essential question of sewage-precipitation. According to his experience, it mattered very little what precipitants were used. As Mr. Dibdin had pointed out, a more or less

clear effluent might be obtained; but fairly examining the amount of organic matter remaining in the solution, it mattered very little whether 50 or 10 grains of lime were added, or whether alumina or iron was added or not. The essential effect was that matters in suspension were precipitated. One point mentioned in Mr. Dibdin's Paper might to some extent reconcile conflicting statements, the fact that the stronger the sewage the greater the proportionate amount of organic matter that could be removed. In London the sewage to be dealt with was certainly somewhat diluted, and whether much or little precipitant was used within practical limits, it had very little effect upon the effluent. He wished to speak with the highest respect of the Royal Commission, and any one finding that the conclusions arrived at by such a Commission confirmed his own might well be pleased at such a result; but a dozen Royal Commissions would not make him alter his own convictions if he had arrived at them from a fair study of the subject. When he gave his evidence before that Commission there was little or no nuisance in the river, and although hundreds of persons were before the Commission, no instance was given in which any injurious effect had been produced by the pollution of the river, by any one who had visited it. He had suggested that if the Metropolitan Board of Works would organize a series of excursions down the river, so as to let the public see the actual state of things, he was quite sure that the outcry then raised by persons, who wished to treat the sewage, would have been overwhelmed by the outcry of the public at the idea of spending millions for removing so small a nuisance as had existed before 1883. Since then there had been two remarkably dry and warm summers, when no doubt the river was not in a condition in which it ought to be, at any rate for a short time in the year. That was a new experience, and of course any reasonable man would learn by experience, and he was now ready to admit that something must be done to purify the river. The question was what was to be done? It must be enough to remedy the evil complained of, but no more. It was easy for the Metropolitan Board of Works, or those who advised it, to recommend schemes at an expense of hundreds of thousands or millions; the expense did not come out of the pockets of the Metropolitan Board of Works nor of those who advised it, but if 3·7 grains of lime and 1 grain of sulphate of iron, supplemented when necessary by deodorization, sufficed, what was the use of adding more? When Mr. Sillar was speaking of spending £100,000 in experiments, Dr. Dupré felt tempted to ask him how much of that money came out of the pockets of the ratepayers, where the

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Dr. Dupré. A B C process had been tried and had failed. With regard to Dr. Tidy and this A B C process, he possessed a report signed by Dr. Tidy and Professor Dewar, two very able men, who knew perfectly well what they were about, and he deliberately said that that report, dated April 1885, was not worth the paper on which it was written. Here was a Paper dealing with the A B C process, which somehow or other always cropped up when Dr. Tidy spoke about sewage. He had read the Paper and endeavoured to get some information from it, but notwithstanding every effort he had failed to grasp its meaning. A series of experiments had been devised for the purpose of finding out how much organic matter in solution the A B C process removed, and he found that the effluent, after treatment, on an average contained a little more organic matter than it did before. In an answer given at the Society of Arts,[1] Professor Dewar stated, and, he admitted, stated fairly, that part of that was appearance—that they had added so much salts to the sewage that what was put down as organic matter was really water. But he asked any reasonable man what was the value of a Paper which was prepared for the purpose of settling a given question, and which after settling the point had to explain it away. Either there was more organic matter in the effluent or there was not; or the whole series of experiments was not worth the time it had occupied. He had tried to find out how much of the A B C mixture was used. For as every grain per gallon added to the London sewage was equal to 10 tons a day, when 50 or 100 grains were added it became a serious matter. The average cost per ton would be £1 to £2, or more. The only statement that he had found was, that in one series the precipitating-agent used was not much more than one-third of the total sludge obtained. He should have thought that a chemist would at least say it was not much more than one-half of the amount of suspended matter in the sewage. It was perhaps thought better to put it down at one-third the total sludge. Whether that total sludge was dry or not he did not know. In the other case, the third series, they reported that the relation between sludge and precipitant was not quite so favourable; the total amount of sludge obtained being less than in the former case, owing to the small amount of sewage. In the second series, the amount of sewage was something like 540,000 gallons with 59·9 grains of suspended matter per gallon; the total amount would therefore be 32,000,000 grains. That was the sludge where the precipitant was not much more than one-third. In the case which

[1] Journal of the Society of Arts, vol. xxxiv. p. 670.

was supposed not to be quite so favourable, the total amount of sludge produced being less than the other, the amount of sewage was 358,000 gallons, with as much as 234 grains of suspended matter per gallon, the total suspended matter being 84,000,000 grains. Yet they asserted that the effluent was always almost absolutely clear. What became of the 50,000,000 grains that disappeared in the process? Lastly, Mr. Sillar had stated that the A B C works were placed in the hands of Professor Dewar and Dr. Tidy for three months. Their record was for three days, a little over 3 per cent. He should very much like to see the remaining 97 per cent. He had not provided himself with extracts from the evidence, but he believed that Dr. Tidy stated before the Royal Commission that an effluent might be produced at Crossness, and be discharged into the river at any state of the tide. The Metropolitan Board of Works was now undertaking to build tanks for precipitating. The Board was not at all wedded to the particular process that had been mentioned, and whether the A B C process, or iron, or alumina, were used, the tanks were as ready for the one as for the other. Meanwhile, however, the process to be adopted was far the cheapest that had been recommended, and the Metropolis would be saved such a sum every year as that, supposing it to be necessary some years hence to make an alteration, the ratepayers would in the meantime have saved more than the outlay that might then be necessary. Dr. Dupré.

Dr. TIDY desired to say that neither directly nor indirectly were Professor Dewar or he in any way concerned with the Native Guano Company. Dr. Tidy.

Mr. H. MAUDSLAY said that the general tendency of the discussion had been rather to find fault in regard to the chemistry of the question, than to deal with the subject of sludge and its disposal. He desired to say a few words on the latter subject, because he thought that a material had been discovered which had produced a very good and marked result, namely, porous carbon, which he believed to be a lignite, and he had been informed that there was a large field of it at Bovey Tracey and Newton Abbott. It was that material mixed in certain proportions which had produced so favourable a result at Southampton, where all the sludge had been disposed of at a small advantage, which was certainly much better than throwing it into the sea. Certain combinations of the material had the effect of deodorizing and purifying the effluent of sewage to such an extent, that he and others had drunk the water proceeding from it. He wished to refer to the results of the dredging of a portion of Malta Harbour. Mr. Maudslay.

Mr. Maudslay. The material dredged out came from salt water, and the authorities being afraid that it might produce a very bad result, adopted the plan suggested in Mr. Dibdin's Paper, namely, that of taking the material out in barges to a certain distance and emptying it into the sea. The plan, which might be supposed to be very ingenious, succeeded so far; the flotation of the barges was sufficient, the speed attained was satisfactory, and the result was what the engineers who carried out the scheme determined that it should be. The process was therefore considered a success, but there was a loss of the sludge which would have been beneficial to vegetation in an island composed of rock. If it had been left in certain cavities upon the surface of the ground, the salt would, by the action of the rain and sun, have been deposited and the sludge probably purified to such an extent as to make it useful on the island. A century or so before, the authorities on the island had paid for earth to be brought from Sicily for the purpose of supporting vegetation upon the island. The island wanted earth, manure, and material for increased vegetation, and yet the very thing that it wanted was thrown into the sea. With a natural chemical agent which would produce the desired effect in purifying sewage, as there now was in porous carbon, surely it might as well be used for that purpose, instead of throwing the London sludge into the sea as if it were valueless. If those who had the power would only try it for London, they would probably obtain the same beneficial result as had been obtained at Southampton. There was a large area in Devonshire in which the material was found; there was a railway within a very short distance of it, by which it was taken away in bags to Southampton. The sludge could be utilized by any machine that might be preferred by the engineer having charge of the works. At Southampton the sludge was not offensive.

Mr. Strachan. Mr. G. R. STRACHAN stated that he had been at Southampton, and had seen the process adopted there in its every-day work. It was misleading to members to state that all the sludge made at Southampton was sold, because out of a population of sixty-three thousand, the sewage of only fourteen thousand persons was treated. Southampton was so situated that it could get for its rough dust 1*s.* 6*d.* a load, whereas in London 9*d.*, 1*s.*, and in some cases 2*s.* 3*d.*, had to be paid to get rid of it. When the sludge was mixed with the dust, horse-droppings from the streets, and all the other manure obtainable from the town, it was saleable. From what he saw, he did not think that the sludge from the porous-carbon process was either better or worse than sludge from any

other process that was efficient. It had, moreover, the smell of ordinary sludge. He had been at Southampton on a cold day, and the sludge then certainly had that smell distinctly. It had been stated that burning the sludge was a good method of getting rid of it, and that a good mode of burning it was to utilize the dust for that purpose. At Chelsea, where the dust was purely domestic, it being insisted that all trade refuse should be kept out of it, last year he kept accurate records of the quantity, and it might be taken from him that 4 cwt. of dust per year in London was given by each inhabitant. It was stated in Mr. Crimp's Paper, that in an efficient chemical process, 10 cwt. per head per year of wet sludge containing 90 per cent. of moisture was obtained, so that 2 cwt. of dried sludge would contain 50 per cent. of moisture. He would ask those gentlemen who said that the dust of a town was sufficient to burn the sludge of the town, whether they seriously asserted that 4 cwt. of dust was sufficient to burn 2 cwt. of sludge, when one-half of that sludge was water? He should be glad if Mr. Jones, of Ealing, would state the exact quantity of sewage treated there chemically, the quantity of sludge, wet or dry, that he obtained from the sewage works, and the quantity of dust; and whether he did, as a matter of fact, burn all the sludge that came from his process? If that could be done at Ealing, it could be done elsewhere. No general statement that it was done at Ealing or at Southampton ought to be sufficient, but the exact facts of the case should be stated.

Mr. Strachan.

Mr. CHARLES JONES said it was not necessary to discuss the quantity of dust. He would simply state that he dealt with the sludge of a population of twenty thousand persons. It was not necessary that he should use dust. He had burnt tons of sludge pure and simple without the admixture of dust. Sludge consisted almost entirely of carbonaceous material. The question had been a burning one with him for many years. The experiments of the late General Scott were carried out by him, and his experiments with sewage-cement arose from the experiments which Mr. Jones was making. When the Association of Municipal and Sanitary Engineers, of which he was the Honorary Secretary, met at Leeds, in 1880, he saw for the first time the destructor in full work, and he there recognized the fact that it could deal not only with the house-refuse difficulty, but also with the sludge difficulty; in the next season he obtained from his Board permission to erect a four-cell destructor, and from that time the whole thing had been a success. He had been asked whether he burnt all the sludge? He would only reply that if a farmer

Mr. Jones.

Mr. Jones. wanted 50 tons of sludge he was at liberty to take it. What he did actually burn was the sludge of twenty thousand persons. He believed, however, that the refuse from the houses was sufficient to burn the material of the sewage-sludge which came in contact with the works of any one town. In 1884, seeing a notice in the papers, that the Metropolitan Board of Works was going to try to burn sludge, he wrote to the Chairman, and recommended him, instead of carrying out the experiment with a kiln that was not efficient, to go to Ealing, and see what was being done there as a matter of every-day work. He had heard that an attempt had been made in this direction, but did not succeed. The works at Ealing were open to all who chose to visit them when they were in operation. When there was no material to burn, the fires were sometimes banked up for a week, and then of course it would be useless to visit the place. In the last report of the Metropolitan Board of Works, p. 8, after referring to the suggestions of the Commission in reference to the various modes of dealing with sludge, it was stated: "The process of burning the pressed sludge has been tried in various ways, and the conclusion arrived at is, that whilst this method of disposing of the material presents little difficulty, the expense of carrying it on without nuisance would be so great as to be prohibitory." That statement was entirely fallacious, because there was not the slightest necessity for any nuisance. The gases thrown off were highly combustible. He burned the gases from the sewage of twenty thousand persons at a cost of 1*s.* 6*d.* per day. He procured breeze from the gas-works close at hand, for which he paid 1*s.* 6*d.* per chaldron. He used a muffle-furnace for the destruction of the gases, all the gases and smoke passing through it, and in this furnace, or fume cremator, as it was called, he used about a chaldron a day. The actual cost, however, was practically less than nothing. With the destructor he formerly got a pressure of 20 lbs. per square inch of steam using the destructor with a boiler attached for precipitating, pumping, and so on; but now he obtained a pressure of 40 lbs., so that he gained 20 lbs. by the combustion of the gases, and the small amount of breeze used in the cremator, and there was no smell whatever. The furnace stood in the midst of a suburban district. When he first used the destructor there was some smell, but since the gases had been burnt at this small expense he was able to get rid of all the sludge without difficulty. Formerly farmers used to snap their fingers at him when he had 500 or 600 tons that he could not get rid of, and one winter it had cost him between £300 and £400 to remove it. That had

put him upon his mettle, and now he was able to destroy the sludge without difficulty. Sewage-sludge was a thing to be got rid of. It would never do as a money-making material, except upon the Stock Exchange. He ought not, however, to omit stating that he got back 25 per cent. of the sludge in the form of a very hard clinker, which was valuable to grind for sand, for concrete, for wall-making, and it was also useful as a substitute for York stone. He was now laying it down in the district; it was quite equal to any Victoria stone, and at a cost of only 3*s.* per superficial yard. Mr. Jones.

Mr. JAMES MANSERGH, while he dissented from the depreciatory remarks of Lieut.-Colonel Jones on Mr. Dibdin's Paper, quite agreed with his commendation of the Paper of Mr. Crimp, and of his work at Wimbledon. He had witnessed personally the very thoughtful and careful manner in which Mr. Crimp had dealt with the sewage at Wimbledon since it had been under his charge. He had, in fact, brought what used to be a ghastly failure, ending in serious litigation, to a conspicuous success, and he deserved great credit for it. Mr. Crimp's remarks on the construction and working of filter-presses showed that he had taken great pains to utilize the machine to the fullest possible extent, and in the most economical manner. Where the effluent was to be passed over land, it might suffice to run the liquid expressed from the sludge back to the tanks for a second treatment, as was done at Wimbledon; but his experience led him to believe that, where land was not available, this liquid would probably need special treatment in another way. The details of cost of working the presses, and the experiments on the manurial value of the sludge-cake as compared with farmyard manure and superphosphate, were most useful, and it was to be hoped Mr. Crimp would continue to accumulate such facts and communicate them, whether they turned out in the future to corroborate his present opinions or not. The use of filter-presses had undoubtedly diminished the trouble in dealing with sewage in many inland towns. The accumulation of unpressed sludge had for years been the great incubus of many sewage-works; it had now happily been got rid of at Wimbledon. At Chiswick, also, which a short time ago was in litigation, presses had been erected under Mr. Strachan's advice, and he had been informed by the Surveyor that the stuff was now readily taken by the market-gardeners, who grew considerable crops by its aid. At Coventry 4,000 or 5,000 tons a year were disposed of, and 1*s.* a ton was received for it, with the exception of a small quantity that was handed over to the Corporation Mr. Mansergh.

Mr. Mansergh. tenants. So far the use of sewage-presses had no doubt been a great advantage. He would now make a few remarks on Mr. Dibdin's Paper. Mr. Dibdin had stated (p. 156) that it would be desirable that the sewage should be deodorized on its way from the houses into the main sewers. There were one or two kinds of apparatus by which that had been done fairly successfully, and in many houses of a good class it might be possible, but to expect it to be done universally was quite out of the question. The Metropolitan Board during last summer had erected sheds at the heads of many of the principal sewers, from which he believed there had been passed a quantity of manganate of soda into the sewers, with a view of deodorizing their contents on their way to the outfall. If not premature it would be very interesting if Mr. Dibdin could give some information as to the results of those experiments. If deodorization at the very earliest stage could be thus effected, no doubt the advantages pointed out by Mr. Dibdin would be obtained, and a trouble constantly pressing upon local authorities and their officers would be mitigated, that was, the offence produced under certain conditions by surface ventilators. This was a growing difficulty, in consequence of changes taking place in other directions. These changes were: first the making of watertight sewers and the diminution of the water let in from wet subsoil; and secondly, the isolation of house-drains from the mains by intercepting chambers, and the consequent loss of numbers of more or less effective ventilators. Mr. Dibdin had raised the question of the superiority of iron to alumina as a precipitating agent, and he hoped that the chemists would thrash out this point before the end of the discussion. Alumina had always been regarded as one of the sheet-anchors of precipitation-methods. Mr. Dibdin had also raised the question of nitrification. Mr. Mansergh agreed with Dr. Dupré that it was hardly justifiable to ridicule his remarks upon that point. Five years ago Dr. Tidy, in a discussion on Mr. Folkard's Paper, raised a laugh by asking, in his inimitable manner, Where were the germs?[1] Since that time germs had come to the front very much indeed; and in connection with the examination of the London waters, Dr. Tidy was now well immersed in bacteriological research. At Burton-on-Trent, where he was now dealing with the sewage of the town on a farm of 500 acres, some interesting experiments were being made, with a view of obtaining nitrification, which, under the circumstances of the soil and the sewage, was a very difficult thing to accomplish. With the

[1] Minutes of Proceedings Inst. C.E. vol. lxviii. p. 79.

assistance of Dr. Ashby, of Grantham, and Mr. Arthur Marshall, Assoc. M. Inst. C.E., who were working enthusiastically on the experiments, he had been encouraging the growth of those micro-organisms. These creatures disliked very much to "stew in their own juice." In carrying on their function, they manufactured nitric acid, but they could not live and continue to do their work in it; they had, therefore, to be supplied with a base, and this was being given them by putting upon the land a certain quantity of carbonate of lime. They had made experiments on a small scale, and were now dealing with a plot of 8 acres, from which they could collect the effluent for analysis, and the results had been, so far, encouraging. Nitrification had been started and nuisance diminished. He agreed with Mr. Dibdin that the antiseptic treatment of sewage was a mistake. At Carlisle, where Mr. McKie and he had carried out the first sewage-farm in England twenty-seven years ago, carbolic acid had been introduced into the sewage, which was, no doubt, an undesirable thing to do. Mr. Sillar's earnest and energetic speeches on the A B C process were always interesting, but he thought it was high time that the mystery of that system should be in some way cleared up. The Native Guano Company could, no doubt, and did produce an exceedingly good effluent, but it had been always astonishing to him that while it had had the chance of making experiments at Leeds, Leamington, Hastings, Crossness, and other places, a capital of £200,000 invested, valued at one time on the Stock Exchange at £1,000,000, it had now in 1887 only Aylesbury to show. The Company had always contended that it made a manure readily saleable at £3 10*s.* per ton, with a profit of £2 a ton. Surely, if that were really the case, every town in England would be adopting the process. Mr. Sillar had pointed out that the value of the A B C sludge was due to the fact that no lime was used in the process. Was this the true explanation of the apparent enormous difference in value between this sludge and other sludges? It was high time the mystery was cleared up. The report of Professor Dewar and Dr. Tidy did not appear to explain it. If the pretensions of the A B C Company could be substantiated, it had undoubtedly been hardly dealt with in the past, and deserved, for its dogged perseverance, greater success in the future. Mr. Mansergh had some years ago made, on behalf of a sanitary authority, what he considered a businesslike proposal to this company, which, if its assurances were reliable, would have resulted in a profitable undertaking being entrusted to it, with the chance of others to follow; but it had been rejected, and this had prevented him

Mr. Mansergh.

Mr. Mansergh. making further approaches. He had no prejudice whatever against either the company or the process, and would like very much to be satisfied on this crucial question of the intrinsic value of the manure. With regard to the very entertaining speech of Dr. Tidy, it ought to be clearly understood that the learned Doctor did not object to the system which the Metropolitan Board was intending to carry out at the two outfalls. Dr. Tidy agreed with the idea that the sewage should not be taken further down the river; but should be treated at Barking and Crossness. The whole of his objection, as he understood, was to the intended use of 3·7 grains of lime and a single grain of iron to a gallon. If 20 grains of lime were used, as suggested in Dr. Tidy's evidence before Lord Bramwell's Commission, the impending doom of the Metropolitan Board might possibly be delayed. No doubt, to any one experienced in the chemical treatment of sewage, these figures of Mr. Dibdin's were startling figures, and if he proved, in actual working on a large scale at Barking, that he could produce a sufficiently good effluent with these quantities he would deserve infinite credit. With regard to the decision of the Metropolitan Board as to the treatment of the London sewage, he would say that it met with his approval, in principle certainly. During the preparation of the evidence for the arbitration between the Metropolitan Board and the Thames Conservators, known as the "Mud Case," and for the inquiry by Lord Bramwell's Commission, he had frequently gone down the river, and he was bound to say that he never noticed any serious nuisance at either of the outfalls. Strangers might go there for years without knowing that sewage was being discharged at those points. In such years, however, as 1884, when in a hot summer very little land-water was coming over Teddington weir, and when the temperature of the water near the outfalls became abnormally high, the state of things was enormously changed. Then the putrescible mud accumulated on the submerged banks by deposition from the untreated sewage was floated up to the surface, by the evolution of gases, in great patches, and was there broken up by the winds, currents, and traffic, until the river became a black foul-smelling stream throughout a length of several miles above and below the outfalls. Such a state of things showed that the original intentions of the Metropolitan Board, as submitted to Parliament thirty years ago, ought to have been carried into effect; that was to say, the suspended solids ought from the first to have been removed prior to the discharge of the sewage into the river. If this had been done, in his opinion neither the great mud fight nor Lord Bramwell's inquiry would

ever have taken place. And now, if the Board would take out the solids by some effective precipitation process, the sewage might, he believed, be discharged harmlessly at Barking and Crossness at any state of the tide. As to the disposal of the sludge, the Metropolitan Board was, he thought, carrying out pretty closely the suggestions of the Royal Commission. It might seem a clumsy mode to take all this material down by steamer 10 miles out to sea; but it would be most difficult to treat it anywhere nearer. Of course, it would seem more desirable to an engineer, if it had to be taken to sea, that it should go in some pipe or conduit; but he believed it would be difficult to find any place upon the coast where untreated sewage could be discharged, and where it would be at all times carried away by the currents without doing harm by creating a nuisance. If it were taken 10 miles out to sea, the fishes would certainly dispose of it most effectually. Although he was in no sense the apologist of the Metropolitan Board, he agreed with Mr. Dibdin that the principle of its present proceedings (without expressing any opinion on the details) was in accord with the suggestions of the recent Commission. In their 3rd conclusion, the Royal Commissioners said:—"We are of opinion that some process of deposition or precipitation should be used, to separate the solid from the liquid portions of the sewage." In the 4th, "Such a process may be conveniently and speedily applied at the two present main outfalls." In the 5th, "The solid matter deposited as sludge can be applied to the raising of low-lying lands, or burned, or dug into land, or carried away to sea." So far the Metropolitan Board appeared to be carrying out those suggestions. The Commissioners went on to say, in No. 7, "The liquid portions of the sewage remaining after the precipitation of the solids, may, as a preliminary and temporary measure, be suffered to escape into the river." In conclusion, No. 10, they said: "But we believe that the liquid so separated would not be sufficiently free from noxious matters to allow of its being discharged at the present outfalls as a permanent measure. It would require further purification, and this, according to the present state of knowledge, can only be done effectually by its application to land." The exact meaning of this conclusion was not easy to make out. It appeared to be incomplete without some reference to time, or to population, or increasing quantity of sewage, and seemed to have been added as a sort of saving clause out of excess of caution. In that respect also, the Metropolitan Board was carrying out the suggestions of the Commission.

Mr. Mansergh.

Mr. R. W. PEREGRINE BIRCH knew that Dr. Tidy had disputed

Mr. Birch.

Mr. Birch. some of the conclusions arrived at by Mr. Dibdin, but it should be borne in mind that the information, given by Mr. Dibdin to the Metropolitan Board of Works, had been supported by Sir Frederick Abel, Dr. Odling, Dr. Dupré, and Professor Williamson. Although he was not prepared to admit that precipitation was either the right thing or the cheapest that the Metropolitan Board could undertake, he wanted to learn all he could about precipitation, and he welcomed the information given by Mr. Dibdin on precipitation and the relative merits of precipitation processes. Mr. Birch then exhibited in a diagrammatic form the results given by Mr. Dibdin in Appendix I to his Paper. The lesson which, he thought, was to be gained from the diagram and from Mr. Dibdin's Paper generally, was, that there was more difference between the sensitiveness of two sewages, even two London sewages, to any chemical treatment whatever, than there was between the effect of one chemical treatment and of another upon any specimen of sewage, although the different treatments might vary in cost from £13,000 to £9,000,000 a year. It would be seen that while samples 20 and 21 only yielded an average of 10 per cent. to all the twenty-four different treatments, and sample 6 yielded as much as 36 per cent. on an average to each of the twenty-four treatments, no such difference was to be found between the average effect of any two treatments upon all the samples. The results were not due to any chance or any mistake in the analysis. Looking, for example, at sample 6, it would be seen that it had yielded liberally to all chemical treatments alike; No. 10 had also yielded constantly to all of them, and sample 1 had been a very good one all the way through. There were, no doubt, exceptions to the rule, and he thought that they were very suggestive; possibly Mr. Dibdin had found the results so varying that he had hesitated to build up any theory from these facts; but notwithstanding, Mr. Birch hoped that he would give all the facts bearing upon the twenty-three samples and their treatment, as to the character of the sewage taken, the age of the sewage, the strength, the temperature, and the time of taking the sample, also how long the sewage was kept before the experiment was made upon it. It was clear from the experiment on the solution of mutton, that the strength of the sewage had some bearing upon the susceptibility to chemical treatment; but the figures showed that there was some much more complex element than the simple strength of the sewage in dissolved matters, for while he increased the strength of the mutton solution from 0·1 per cent. to 20 per cent., or two hundred fold, he only increased

the sensitiveness to chemical treatment from 56 to 90, or some 60 per cent. He would ask whether the twenty-three samples had been previously filtered, or whether they contained at the time of treatment all their suspended matter. If they contained the suspended matter he thought that possibly the amount of it might have affected the action of the chemicals on the dissolved matter. A second diagram which Mr. Birch had prepared from the same Table exhibited the relative effect of different chemicals on the suspended matter, as well as on the dissolved matter. Mr. Dibdin's figures only referred to the dissolved matter; and the comparison between the yielding of the dissolved matter to the various reagents did not give a fair comparison of the merits of the precipitant. While sample 7 yielded 13 per cent. of its dissolved organic matter at a cost of £20,000 a year, and the last sample but one yielded 31 per cent. of dissolved organic matter at a cost of £800,000, both of them would take out practically all the suspended organic matter contained in the sewage; and, if to the amount of dissolved matter taken out were added the 14 grains of suspended matter, which was removed, instead of the two precipitants being in merit as 13 to 31, they would be as 83 to 101, the difference not being worth the cost. Mr. Birch.

Mr. BALDWIN LATHAM could not allow the opportunity to pass without saying a few words upon the two Papers. With reference to the first Paper, it had, he thought, always been a question in dispute how much solid matter London sewage really contained. Ever since the great mud inquiry, the Metropolitan Board of Works had been endeavouring to show that London sewage contained a very small amount of suspended matter, and Mr. Dibdin had pointed out that it only contained 27 grains of such matter per gallon. This was at the rate of 0·1 lb. per head daily, while the suspended matter in ordinary sewage was not less than 3½ oz. per head daily; and taking the results given in Mr. Crimp's Paper, was very much more than this latter amount in the case of Wimbledon. By reference to Sir Joseph Bazalgette's report, and also the report by Mr. Keates, in January, 1873, relative to the experimental operations of the Native Guano Company at Crossness, where upwards of 11,672,000 gallons of sewage were treated, it would be seen that on the south side of London the sewage contained 57½ grains per gallon of suspended matter. It was a notorious fact with reference to the sewage of the south of London that it was more dilute than that in the north. The figures of the Metropolitan Board and of the Royal Commission on Metropolitan Sewage Discharge showed that the Mr. Latham.

Mr. Latham. proportion was 50 on the south and 30 on the north. If, therefore, a few years ago there were 57 grains of suspended matter in the south, he could not conceive how it was that there were only 27 grains in the north. The suspended matter was not at all difficult to deal with; but the proportion of chemicals now proposed to be introduced for the treatment of sewage was certainly a novelty in all places in which such precipitation had been attempted to be carried out. He knew from personal experience that to put 3·7 grains of lime and 1 grain of sulphate of iron into the ordinary sewage of a town, especially a manufacturing town, would have no effect whatever upon it. He could not imagine how it would be possible to produce an effluent fit to discharge into the Thames with such an amount of chemicals. It would be only throwing the chemicals away. After that process the sewage was to be treated occasionally with 1 grain of a material containing a large amount of oxygen, namely, manganate of soda. Accepting the volume given in Mr. Dibdin's Paper, when it was going to be treated at that rate, 10 tons would be applied daily to the sewage. What were the conditions under which the sewage was now discharged into the Thames? On the average, taking 30 cubic feet per minute as the quantity of river-water discharged over Teddington Lock for each square mile in the course of the year, a little over 45½ tons of oxygen were every day poured into the river at its upper end, and the sea-water, on the average of the year, would bring in more oxygen than the upland water as far up as Erith. Now it had been shown that at no period had that oxygen been sufficient to make the river pure, so that fish could live in it. Ever since the Metropolitan sewage had been turned into the river fish-boats came up no higher than Gravesend, being gradually driven down as the sewerage works extended. From the time when the first outfalls were opened it had never been possible to bring live fish to London. For miles the river was devoid of any sign of fish life. In exceedingly low-water periods, as in 1884, to which Mr. Mansergh had referred, the volume of water passing into the river at Teddington was reduced to about 10 cubic feet for each square mile, and at that rate 15 tons of oxygen were poured every day over Teddington Lock; but in such a period a proportionately larger amount of oxygen was brought in with the sea-water which was then in considerable volume in the river. And what was the state of the river? Why, the whole river about Woolwich, and below the outfalls, down to Erith, was one seething mass of putrefied matter. If 40 tons of oxygen were now daily passed into the river in the way men-

tioned, and it did not produce an oxidizing and purifying effect, how was it likely that 10 tons of that particular salt would effect the object? It would be simply waste to spend a large sum of money upon that most expensive salt, and to use it in the proportions mentioned. With reference to the materials which could be employed for precipitating, the list referred to contained nothing like the number which had been introduced from time to time, and with which he himself had personal acquaintance, for the treatment of sewage; in fact, there was hardly an earthy salt which had not been patented and attempted to be used, either by itself or in combination with other earthy salts, for treating sewage. The experiments made by the late Professor Way during the inquiry of the Royal Commission on Metropolitan Sewage Discharge, showed that one of the simplest processes of precipitation had not been tried at all. The river at high water contained an enormous quantity of chloride of magnesium, which was an excellent precipitating agent in conjunction with lime, so that if a little water were let into the tanks at high tide, all that would be needed would be to apply the lime in sufficient quantity, and there would be no necessity for any other precipitating agent. In that way there would be an enormous deposit of sludge, as the magnesium salts produced a much larger deposit and a much more satisfactory effluent than the lime alone. He did not quite agree with Dr. Tidy in his remarks with reference to the iron. Iron was a more expensive salt than lime, and, according to the experiments, it did not remove such a large amount of oxidizable matter; but in all probability iron would remove matters that lime would not. Iron had a power of combining with dissolved organic matter in water which lime did not possess. The particular matter which lime would not act upon iron might, and so produce good results; but in order to get those results larger quantities of iron were necessary than were proposed in this case. At Northampton iron salts were used in the proportion of $4\frac{1}{2}$ grains per gallon to 15 or 16 grains of lime, with the result that the river was as foul after treatment as before. The sewage at the outfall works was made to appear clear, and the river seemed to be inoffensive; but after it had flowed a short distance it began to turn, and was soon as black as ink—one putrefying mass. Iron was an antiseptic, and pickled the sewage, and consequently was not the best means of treating sewage. Lime was not such an antiseptic; it tended to destroy; it had some effect in clarifying, but the effluent often underwent decomposition. He had a town under his care where the water left the tank clear as

Mr. Latham.

Mr. Latham. crystal, but after running through ditches about a mile before getting into the river, it was quite black. The authorities were now abandoning that process, and were going to put the sewage upon the land. Every known earthy and mineral salt had been utilized, even the most expensive, and all certainly produced in their way good effects; but in order to get complete purification some better method was necessary than the mere treatment with a very minute quantity of a salt giving off oxygen. Land, even of limited area, combined with a precipitating-process, was the best plan that could be adopted; and where land in sufficient quantity could be obtained, it was undoubtedly the simplest and cheapest method. Mr. Crimp's Paper was one of extreme value, giving some very important statistics with reference to the treatment of sludge; and he quite concurred in the remarks of Mr. Mansergh as to the success of the works at Wimbledon. The question was one which ought to occupy the attention of engineers. It was strange that down to the present time it should cost so much to press sludge. Some other method might be introduced by which the water could be got rid of, for the problem was simply that of pumping 1,200 gallons of water 200 feet high, and which operation now cost from 2*s*. to 3*s*. He had used the method of applying air in what was called the monte-jus apparatus, and also direct pumping. His own view was that direct pumping was far the most economical, and he had had a set of sludge-pumps at work some years pumping into a filter-press at the tanneries at Nantwich. These pumps had two sets of suction-valves and two sets of delivery-valves arranged one set before the other. If there should be any clogging, the chances were that both valves would not clog. They drew the sludge horizontally 80 or 90 feet, then the suction dipped down to the bottom of the tank, and it was thrown back again through the delivery-pipe a similar distance, and passed through the filter-presses. The reason for adopting this plan was to enable the sludge-pumps to be put in the existing engine-house. That plan had worked quite satisfactorily. If the pumps would work under such a condition as that, and give a duty of about 40 per cent. of the power applied, it was much better than using the air where only one-sixth of the duty could be got out of it, or 16 per cent., as shown in Mr. Crimp's experiment. The filter-press seemed to be looked upon as quite a modern device, but it was nothing of the kind. It was used thirty years ago at the Leicester Sewage Works, by the late Mr. Thomas Wicksteed, M. Inst. C.E., who then adopted one of the best methods ever devised. Instead of using air or pumping direct into the

press, he erected a stand pipe and pumped the sludge into it, and from that he produced what was called "Leicester bricks." The Leicester Company spent £50,000 upon the works, but they turned out a great financial failure, and ultimately came into the possession of the Corporation of Leicester without charge. Another device that Mr. Wicksteed introduced had been very largely used for other purposes—a centrifugal drying-machine, which had been adopted in washing-factories. It was originally produced for the purpose of separating the water from sludge. Seeing that the filter-press had been revived, it was a question whether or not some form of that centrifugal machine might not be more economical to get rid of the small quantity of water in the sludge at a less cost than at present. If engineers would direct their attention to that point he was quite certain, considering the small amount of work to be done, that the plan was feasible, and, that in future, sludge in a compact form could be produced at far less cost than at present. Mr. Latham.

Mr. J. C. MELLISS observed that he had spent many years in personally conducting practical experiments with reference to the chemical treatment of sewage, and he had tried a large variety of chemical precipitants, the outcome of which was that he had found that lime of itself did not produce good results, that sulphate of alumina produced much better results, and that the addition of some salt of iron produced the best results. He agreed with Mr. Baldwin Latham that perfect purification could not be got by chemical treatment, but that to raise the standard of purity to any high extent further steps must be taken. The filtration of the effluent water, after chemical treatment, through land, seemed to him to be the best course to pursue. As to whether land treatment simply was better than chemical treatment combined with land filtration, he rather differed from Mr. Baldwin Latham. He thought if the two were taken together, in a large number of cases they would not be found to be more expensive, and the results would be better. He had himself tried the proportion of 3·7 grains of lime, and 1 grain of iron per gallon, not upon London sewage, but upon sewage which would compare very favourably with it, namely, domestic sewage, where the town was fully provided with water-closets, where there were no manufactories, and where the sewage was about 50 gallons per head, and he found that they afforded no useful result whatever. Mr. Melliss.

Sir ROBERT RAWLINSON, C.B., said that as far as he knew no chemical ever used was a purifier, nor was it the best clarifier. Whenever precipitation was attempted and carried out, he knew of Sir Robert Rawlinson.

Sir Robert Rawlinson.

no place where the annual cost was less than £2,000 for each million gallons of sewage treated per day. As to the disinfection of excreta, the late Dr. Parkes carried out some exhaustive experiments at Netley for the Army Sanitary Committee—so persistently as to have seriously affected his health—and he came to the conclusion that to disinfect with any advantage a cubic foot of excreta would cost in the best chemicals as much money as clearly to put it out of the field to disinfect on a large scale on the score of expense. Whatever the Metropolitan Board of Works expected to accomplish by the methods it was now adopting, the result must be similar to what had occurred over and over again, namely, failure to purify the sewage, as whatever money might be spent in applying chemicals in precipitating and abstracting sludge, if the effluent was turned into the Thames it would again putrefy, and the river would not be purified, as proved on other streams where the experiment had been tried. As to the use of perchloride of iron as a disinfectant, when that had been carried out on a considerable scale, and where a comparatively clarified and pure-looking effluent had been turned into a small stream in hot weather, the water had been of such a character that where milch cows had been permitted to go into the fields, and get access to it, the milk had been spoiled. As to sewage-irrigation, it was now being carried out on a large scale both in Paris and in Berlin, and he believed that if proper conduits were constructed for London, and the sewage applied in its freshest state to a sufficient area of land, it would need no chemical treatment whatever—no precipitating process, because the crude sewage as it came from the Metropolis might be floated on to the land in the open country without causing a nuisance, as had been done at Bradford, Nottingham, Birmingham, Croydon, Doncaster, and several other towns. As to precipitating sludge from the Metropolitan sewage and barging the same to sea, could the Board be really serious? There were at least some 200,000,000 gallons of sewage per day—probably on an average more. But take 200,000,000, and 5 tons of silt and sludge in each million gallons. This would give 1,000 tons of sludge per day, 365,000 tons per annum. Did the Board seriously propose to barge this volume and weight of sludge down the Thames and to sea, a distance of 50 miles; an amount of 7,000 tons per week? If so, how many barges would be required, and what would the working cost? And all for what? Not to purify the Thames, as the effluent would foul the river in summer; not to purify the sites of Barking and Crossness, as these would be far fouler than ever; they would, in fact, be

intolerable in summer. On the other hand, deal with the sewage as at Berlin and at Paris, and at a number of places in England, as at Birmingham, Nottingham, Bedford, Croydon, and Doncaster, and there would be least cost to the ratepayers of London, and an enormous benefit conferred on the country. Sewage-conduits might be made from the existing stations at Barking and Crossness, through agricultural districts, for 20 or 30 miles in length, from which conduits crude sewage might be distributed to land on both sides as required by farmers, paying 5*s.* for each 100 tons, some 40,000 or 50,000 acres of land being easily within reach of the conduits and the sewage. If a farmer took 100 tons per acre in spring he would, at a cost of 5*s.*, double his hay crop; and, for a second dressing in the autumn at 5*s.*, he would double his aftermath. This would be the simplest and easiest mode of distributing sewage, and 10*s.* per annum per acre to increase the produce of the land four-fold in these bad times would be an advantage. But sewage could be used to grow other crops besides hay and autumn grass. Sir Robert Rawlinson.

Mr. G. B. JERRAM stated that he had succeeded at Waltham-stow in getting good results. The authorities had been in litigation with their neighbours below for the last ten years, but by the aid of new machinery, and the altered way of dealing with the sewage, they had given satisfaction, and during the last eight or nine months had been complimented on the results achieved. The sludge was used as at Birmingham, and was dug into the ground. The produce of thirty-six thousand inhabitants was placed on 1 fresh acre of land every month; it became dried in a month or so, and the crops produced were very good. There were 36 acres of land, so that in three years' time it would be necessary to come back to the original acre on which to put the sludge. The difficulty was with the black sludge formed at the bottom of the stream; when the weather became hot the black mud putrefied again and became offensive. That had produced the wretched state of the Lee and of the Thames. It was more apparent where the volume of water in the stream was nearly equal to the volume of sewage which flowed into it. To get a certain result, in the mixture of two compounds, it was necessary to know exactly the quantities that had to be adapted to each other. The quantity of sewage varied at different times of the day, being much larger in the morning than at night, and the difficulty was to apply the exact amount of chemicals to the varying quantity. It was in consequence of not doing this that the black sludge appeared at the bottom of the streams. In the morning the sewage, which Mr. Jerram.

Mr. Jerram. was of course of a very light nature, was treated with a certain amount of chemicals, the attendant putting on what he thought was requisite, the consequence being that the effluent was highly charged with chemicals. He had proved by experiment that an effluent highly charged with chemicals acted on the organic matter in the stream, precipitating it as black mud at the bottom. At another time, perhaps, the sewage would not be treated with the requisite quantity of chemicals, and the effluent would be highly charged with sewage. Then again, when the requisite quantity of chemicals was added, the sewage that had been discharged an hour or two before was precipitated, and sludge was formed at the bottom of the stream. He had visited nearly all the towns in England where sewage was treated chemically, and had found that that was the result. By using automatic machinery, whereby the volume of sewage itself regulated the inflow of the requisite amount of chemicals, it was possible, to a very large extent, to minimize the effect to which he had referred. Both by day and by night the requisite quantity of chemicals could be added according to the flow of the sewage. It was in consequence of adopting that system that he had obtained such good results, and he thought that if more attention were paid to the mechanical arrangements for mixing the chemicals with sewage far better results would be secured. Let the chemists say what the proper proportions were, and engineers could provide the mechanical means for mixing them. He had seen and noted another machine for dealing with sludge in precipitating-tanks, namely the Astrop machine. He had seen several experiments in which sludge was taken direct from the tanks and passed through a certain number of vacuum rollers, by which the water was extracted, and in the space of four hours the sludge was in a state of dry powder.

Dr. Edmunds. Dr. JAMES EDMUNDS, Medical Officer of Health for St. James's, Westminster, said that he would offer only a few remarks upon those chemical and biological questions which had not yet been exhausted. The proposal, to put protosulphate of iron and permanganate together into sewage, he could only characterize as an astounding one. The protoxide of iron would instantly denude the permanganate of its spare oxygen, and become sesquioxide. The lime would at once combine with the carbonic acid of the sewage, and be precipitated as chalk. The chief result of these chemicals would thus be to load the sludge with inert sesquioxide of iron and inert chalk, while loading the effluent with the inert residue of the permanganate salt. The use of lime in larger quantity, as an effective precipitant, would spoil the sludge by

Dr Edmunds

dissipating its ammonia and by making the sludge-cake putrescent; it would spoil the effluent by making it alkaline, and it would create an intolerable nuisance by defiling the atmosphere with ammoniacal emanations. Mr. Dibdin's Paper, he thought, was one of which that gentleman would not be proud in future years, its chief merit having been to serve as a point of departure for this valuable and instructive debate. One point on which he was obliged to differ from Dr. Tidy's admirable critique was in reference to the use of iron. He did not doubt that, in the curious oxygen-carrying power of iron there was a power which, if properly applied, might be made to continuously and automatically oxidize the organic refuse in sewage. In living animal blood, this most remarkable oxygen-carrying power of the iron was the mainspring of all animal life. Blue London clay was coloured by ferrous sulphide, which, on exposure to the air, turned yellow by absorbing oxygen; yet this yellow clay, if left in contact with organic matter, was reduced again by deoxidation, and a blue halo thus caused would be seen in yellow clay wherever a fossil was imbedded in it. The action thus described, however, was not to be got by mixing a protosalt of iron with a permanganate. It was only to be got by the use of a persalt of iron, and the sesquichloride would be the cheapest and most effective. This should be used, not with lime, but with a cheap aluminium chloride, which was the best basis for a precipitating process. Previously to the addition of these salts, however, there might sometimes be added, in alkaline sewage, as much magnesian salt as would precipitate the ammonia and phosphoric acid as basic phosphate. Dr. Dupré had attacked the Native Guano Company's process although, as he understood, he had never even visited Aylesbury in order to see and study the process. Dr. Edmunds, in his own studies of the sewage question, had applied to the Native Guano Company for permission to visit those works; that permission had been at once granted, and the Manager attended and showed him everything. He himself had learned much there, and he recommended every one who would see what precipitation could do, to write for permission to inspect those works. At Aylesbury there would be seen a torrent of foul sewage running into the works at one end, and a bright clear effluent running out at the other, while a valuable manure was made out of the sludge and its precipitants, and the whole process was free from nuisance. He observed from the newspapers that the Corporation of Kingston and the Improvement Commissioners of Surbiton, after prolonged consideration of all existing schemes, had combined and signed a con-

Dr. Edmunds. tract with the Native Guano Company to relieve them of their sewage at a poundage upon their rates. He believed that, as to safety and efficiency, the native guano process was the best at present before the public, and, if it could be carried out at any reasonable price, he was convinced that Kingston and Surbiton had done wisely to get rid of the responsibility. The precipitation process depended entirely upon skilled and efficient management, and could be done best by a responsible company. The description which had been given of sewage was most imperfect. As to the mineral and dissolved matters of sewage, their treatment was a mere matter of scavengering. Then this should be made quite clear, namely, that all matters in solution were free from infectiveness and from all danger of multiplication after the manner of living germinal matter. But as to the suspended organic matters, in them there were germinal particles which, under suitable conditions, had infinite capacity for multiplication, and which, when imbibed in drinking-water, were the means of propagating all the great intestinal epidemics. In the district of St. James', now under his charge as Health Officer, there was, some years since, in Broad Street, Golden Square, a pump, the water from which contained 107 grains of solid matter to the gallon, including 11¼ grains of chlorine and a large quantity of nitrates and organic matter. Practically this water was sewage and street slop, merely filtered through some 30 feet of gravel and fine sand which lay there upon the London clay, yet it was in great request as drinking-water and was regularly fetched from long distances. People who had acquired a taste for it could never relish any other drinking-water, and it was universally regarded as "splendid spring-water." Now this water was drunk by a whole neighbourhood for years, and never did anybody harm. But, at the end of August 1854, a choleraic attack occurred in the house abutting upon this pump. The evacuations of the patient went into an old rotten brick drain which passed by the wall of the well, and it was afterwards demonstrated that the drainage of this house had for many years contributed to give that body and flavour which had brought this water into so much request. Shortly after those choleraic excreta had passed into that well, over five hundred fatal attacks of cholera occurred within 250 yards of its pump in a period of ten days. This incident illustrated what was the main point to be kept in view in the treatment of sewage—*i.e.* the destruction of those pathogenic germinal particles which, when they got into waters charged with organic matter, found food on which they multiplied and produced cholera, typhoid, dysentery, or, under a certain

temperature, yellow fever—the four great intestinal epidemics which were propagated chiefly through drinking-water. Now to pour into the Thames an effluent merely superficially deodorized, as proposed in Mr. Dibdin's Paper, would assuredly be followed by that poisoning of the river which had been predicted by Sir Robert Rawlinson. It had been said, again, that these germs could only be dealt with by means of other microbes which would devour them much as a ferret might suck out the contents of an egg, and so prevent its growing into a chicken. But he denied altogether that this was the only, or even the best, way in which these germs could be destroyed. Not only might an egg be killed by setting a ferret to suck its contents out, but also by boiling it, or by poisoning it, or by breaking it up. He believed that these pathogenic germs were best dealt with by a good precipitation process; that in this way they could be entangled, coagulated and carried down into a sludge, in which they could safely and easily be desiccated, and then be carried out on to the land. They would there undergo decay, just like dead eggs, and be safely got rid of, while at the same time they would fertilize the land. But towns must be made to realize that, whatever be the cost, they would have to dispose of their sewage, and to dispose of it without poisoning their neighbours. Dr. Edmunds.

Mr. W. SHELFORD wished to call attention to the fact that Mr. Dibdin had advocated the use of a very small quantity of chemicals as precipitants. That had been pointed out by him as very desirable, if not necessary, on other grounds, in a Paper, eleven years ago, "The Treatment of Sewage by Precipitation."[1] It was satisfactory to find that chemists, for reasons of their own, had come to the same conclusion, and also that they had adopted the use of solutions, as at Buxton, Wimbledon, and other places. It was obvious that in that way a large quantity of inert matter was excluded from the sewage, and that the sludge was thereby diminished, and if the chemical effect was increased the advantage was very great. Mr. Baldwin Latham had alluded to the quantity of suspended matter in the sewage, as stated by Mr. Dibdin, namely 27 grains per gallon, which he thought was very small. Mr. Shelford was of the same opinion. In 1871–2 he constructed the works at Crossness for the Native Guano Company, working the A B C process, where a sum of £25,000 was spent, and one of the great difficulties was to get a true sample of Metropolitan sewage. The company was to take for experimental Mr. Shelford.

[1] Minutes of Proceedings Inst. C.E. vol. xlv. p. 144.

Mr. Shelford. purposes 500,000 gallons per day, and the point at which he proceeded to tap the sewage was a culvert, into which the whole of it was raised by pumps, and was kept in a state of agitation. In those works 11,672,000 gallons were treated, and Mr. Keates, the chemist of the Metropolitan Board, reported in 1873 that the difference between the dry precipitants and the dry manure derived from the sewage was 61 tons, or 82 grains per gallon, which Mr. Shelford believed fairly represented the suspended matter contained in the sewage. That was also confirmed by his experience at Battersea on a large 5-foot main sewer, where, from experiments continued for some time, it was found that the suspended matter was about that quantity. But when it was remembered that a gallon of sewage amounted to 70,000 grains it was easy to see how difficult it was to obtain a correct average of the quantity of suspended matter. It would be interesting if Mr. Dibdin could say where, how, and when he obtained the samples which gave such a remarkably low average. Some years ago there was a considerable difference of opinion on the sewage question compared with that prevailing at the present time. From 1869 to 1876 the idea presented itself to many minds that sewage was a valuable commercial commodity, and concessions of sewage were asked for, and obtained in some cases, from corporations, on terms which must have been ruinous to the concessionnaires, if the undertakings were ever carried out. Again, in 1868 or 1869, Mr. Sillar obtained a patent for the A B C process, the speciality of which was the purification of sewage by the use of blood; and it was said by Mr. Sillar, and others, that the discovery was due to his reading in the Scriptures the words "almost all things are by the law purged with blood." In 1871 Mr. Baldwin Latham, speaking on irrigation, said that the Croydon Sewage Farm Company paid 15 per cent. dividend, and carried 15 per cent. forward to the next account, making a total profit of 30 per cent. on the capital.[1] In 1876, in the discussion on his Paper on "The Treatment of Sewage by Precipitation," Sir Joseph Bazalgette said that precipitation processes were palliatives, but not cures; and in the following year, in an exhaustive Paper on "The Sewage Question," [2] Mr. Norman Bazalgette condemned chemical treatment on account of its inability to deal permanently with sewage on a practical scale. That was the position from ten to seventeen years ago; but at present it was very different. The value of sewage was depreciated; in fact, it might

[1] Minutes of Proceedings Inst. C.E. vol. xxxii. p. 399.
[2] *Ibid.*, vol. xlviii. p. 105.

be said that its depreciation was as great as its former appreciation; possibly a medium course might be safest, and might turn out to be the right one. Mr. Sillar, in the present discussion, never mentioned blood. Recently, Dr. A. Carpenter, of Croydon, defending irrigation, had stated in another place, "There may be no actual profit to the farmer .... but the production of the food must be a benefit to the country."[1] With regard to the Metropolis, the Metropolitan Board of Works had decided upon adopting the "palliative," as it was called by Sir Joseph Bazalgette, and had entered into a contract to the amount of more than £400,000 to carry out precipitation or chemical treatment upon a practical scale, or at all events upon such an extensive scale as would make the outfalls permanent precipitation works for a long time. He only mentioned those facts to show that the satisfactory solution of the sewage question was almost as far off as ever, and that engineers could not afford to give too confident opinions until they came within a measurable distance of such a solution. With regard to the progress by engineers in the disposal of sewage-sludge, he believed that during the last ten years there had been practically none whatever, except in the improvement of the presses. He had seen those at work at Wimbledon, and they were certainly working very satisfactorily. They produced a sludge-cake which contained 50 per cent. of moisture, and reduced the volume of sludge $\frac{4}{5}$ths. That was no doubt a great advantage in places like Wimbledon, and many others; constituting, in short, the difference between success and failure, but it was no solution of the sewage question. Mr. Crimp had said that, "If, however, sewage-sludge is to take and retain its place as a manure of superior class, in order to save carriage and render it more suitable for application to land, it is necessary to go further than treat it in a filter-press. The sludge-cake should be dried and pulverized, and as its quality must vary with the occurrence of storms, which bring quantities of mineral detritus into the settling-tanks, every endeavour should be made to turn out a manure of uniform quality, either by fortifying weak samples or by thorough admixture of the mass." No doubt that was true. Sludge-cake could not compare with stable manure. At some stables which he had built at Deptford for three hundred horses, the contract price for the manure, which was the best price that could be got, was 2*s.* 9*d.* per ton. Mr. Crimp had shown that he had reduced the cost of the production of sludge-cake to 2*s.* 6*d.* per ton; but seeing that it had to contend against prejudice, and to

Mr. Shelford.

[1] Journal of the Society of Arts, vol. xxxv. p. 222.

Mr. Shelford. compete with farmyard manure, which was abundant and efficient, it was not likely that it would ever attain to any great success. The conversion of sludge into portable manure worth £4 per ton in the market—the lowest price at which artificial manure was saleable—was a serious and difficult matter. A full description might be seen in Mr. Norman Bazalgette's Paper of the different processes that had been tried up to ten years ago.[1] As to the Metropolis, Mr. Shelford approached the subject with an intimate knowledge of the question. He had constructed the works for the Native Guano Company; and like other engineers he had been connected with the arbitration between the Metropolitan Board of Works and the Thames Conservancy; with that knowledge he ventured to say that, unsatisfactory as it was in principle, and from many points of view, he thought that the proposal to ship the sludge to sea was the readiest way of getting out of the difficulty at the present time.

Dr. Thudichum. Dr. J. THUDICHUM regretted that the actual points at issue had not been discussed. The subject before the Institution was whether the process, as described by Mr. Dibdin, was a good process for solving a question which had engaged the attention of the engineers and chemists of the Metropolis for many years. Having had the opportunity of inspecting the works at Crossness, and also of inspecting the River Thames at various periods, and having studied the question of the treatment by pressure of the sludge precipitated by chemical means in various towns in England, and at various periods, he, as a sanitarian and as a tax-payer, had come to the conclusion that this was a highly practical and very useful process, and he rejoiced to hear that the precipitation process was going to be adopted by the Metropolitan Board of Works. Nothing could be more simple than to put into a gallon of sewage 3·7 grains of caustic lime in solution and 1 grain of ferrous sulphate, whereby a clearance was produced of a very satisfactory nature. No doubt in warm weather a secondary process might be necessary to make the effluent less objectionable than it would otherwise be, namely, the addition of a quantity of permanganate of soda, that remarkable agent which was first introduced to the notice of sanitarians thirty years ago by Mr. Condy. Dr. Tidy had stated that Mr. Dibdin had made such a remarkable mistake as to say that a ton of lime cost £1, whereas he knew from unquestionable authority that it only cost 12*s*. That statement had no doubt arisen from the fact that Dr. Tidy

[1] Minutes of Proceedings Inst. C.E. vol. xlviii. p. 105.

had mistaken a cubic yard for a ton. Another statement had been made by Dr. Edmunds, to the effect that the addition of permanganate to the liquid treated with lime and iron would quickly lay hold of the sub-oxide of iron, and thus lose the oxygen. He had forgotten that before the permanganate was put in, the iron was out again. It was strange that two gentlemen should suppose that the Chemist of the Metropolitan Board of Works could be found napping in that way. He congratulated the Metropolitan Board of Works on having come to the resolution to which he had referred. The cost was not unreasonable. The Thames would be purified, and there would be no difficulty in carrying out the process; the deposition of sludge on the shores of the Thames would cease, the material would be taken out to sea, and there would be an end of the existing troubles for a long time to come. Dr. Thudichum.

Mr. G. E. EACHUS said he wished to fill up a gap that had been left in Mr. Crimp's Paper, by giving the quantity of lime used at Edmonton per 1,000 gallons when the Hillé process was adopted. It was from 7 to 9 gallons per grain of lime, $1\frac{1}{2}$ grain of chloride of magnesium, and $\frac{1}{16}$ grain of carbonated creosote. The quantity of sludge was rather more than $\frac{1}{2}$ cubic yard daily per thousand inhabitants. The total quantity in the year carted was about 4,000 cubic yards, and the cost of the carriage and spreading of the sludge was about 1*s.* a cubic yard. With reference to Mr. Dibdin's Paper, he was inclined to think that a chemical, which could be placed practically in the closet for disinfecting the sewage, would be of material assistance in removing the nuisance. The only question was, whether that chemical would not be such as to cause a deposit in the sewers. He also agreed with Mr. Dibdin in thinking that aeration, both in the sewers and afterwards for the effluent, was a most important matter. With reference to sludge disposal, he could not agree with Mr. Crimp in looking so favourably on sludge-presses. In certain cases, no doubt a sludge-press was a last remedy; but under ordinary circumstances he thought that it laboured under the great disadvantage, that it squeezed out a liquid which was a black and foul one, and produced a manure which was of no value. The dry manure was certainly reduced to a minimum quantity, and consequently the cost of cartage was reduced *pro tanto;* but he had heard of no means by which the black, foul liquid could be got rid of. The last remedy was, that it was run back into the sewer to go through the tanks, and so on in a circle. That seemed to be a very weak point in the pressing of Mr. Eachus.

Mr. Eachus. sludge. He had always had in mind the difficulty of getting rid of sludge when he built the tanks at Edmonton, and he kept them well above the ground so that the invert of the tanks might be 2 or 3 feet above ground level; the sludge could then be run out through the bottom of the tank through a stone-ware pipe. For some years that was done, the sludge being run on to the adjoining land and there allowed to dry. That sludge accumulated to a very great extent, and there was a considerable expense in cartage. At 4,000 cubic yards a year the amount was about £200 for carting it on to the farm and ploughing it into the land. Having kept the tanks at a certain level and finding that the pipe under the tanks was always clear, that the sludge never stopped there (there was always a certain amount of liquid when the sludge was emptied from the tanks), it had occurred to him that the expense might be saved by continuing the pipes and running the sludge on to the low-lying land; and this was accomplished at a cost of only £200 or £300. He had also found an advantage in distributing the sludge in different parts of the farm, and not merely ploughing it into the low-lying parts. In order to do that, he had connected the sludge-disposal pipes with the distributing pipes, which took the effluent water after it left the tanks, and by putting a little head on he could run the sludge to almost any part of the farm. With reference to the disposal of the sludge and its utilization, it appeared to him that, according to the chemicals used, the sludge must have more or less value for different crops. It was not only desirable, as Mr. Dibdin had said, to work so that different organisms which were beneficial might be generated, and certain other organisms which were injurious might be destroyed or burned up, but also to look to the vegetable organisms that required different kinds of food. Dried sludge was unsuitable as food for vegetables. As to London sewage, he could not agree with Mr. Dibdin. He did not like the idea of chemical sewage works on such an enormous scale. He would much rather have the sewage pumped from the present works, so as to command all the land, which was now good for next to nothing, along the valley, and he thought that if the Metropolitan Board was to advertise for such land, it might get 20,000 or 30,000 acres at a very low rate. The sewage could then be pumped on to the higher part of it, and allowed to run away to sea in open carriers, so as to give it plenty of aeration; and if no profit could be made out of the crops, it would at least cover the cost of the purchase of the land and increase the market produce. At Edmonton, since the chemical process had been given

up, the expenses had been more than covered. Even last year, when the crops generally were so bad, under the management of the farm-bailiff very fair prices had been obtained for the standing crops, ranging from £6 to £16 an acre. Mr. Eachus.

Mr. A. GILES, M.P., said he should be sorry to think with Mr. Shelford that sewage-disposal had not made much progress in the last few years. In 1884 he was Chairman of a Committee of the House of Commons, before which the Lower Thames Valley Main Sewage Scheme came, and after examining what had been done at Chiswick, and taking a good deal of evidence upon the subject, the Committee came to the conclusion that the scheme, as then proposed, to concentrate the sewage of all the districts above Richmond somewhere about the Soap-works at Barnes, would lead to intolerable nuisance. The scheme created such an opposition in the neighbourhood, that the Committee, after having heard everything that could be said in favour of it, and without waiting for what the opponents said against it, came to the unanimous decision that it would not work. Since that time, only three years ago, those districts which were to have been comprised in one huge scheme had adopted their own methods of draining, some of which, he believed, were worked very satisfactorily. It was said at the time that, by the use of chemicals, the effluent thrown into the Thames at Chiswick was perfectly inodorous, but several bottles of it were brought into the Committee-room, which, as soon as they were opened, emitted such a fume that they had to be removed. He did not think that there need be the same difficulty with proper chemicals in small districts, and he could vouch for the fact that at Southampton, where the drainage was mixed with certain chemicals, and ejectors were used, when the sludge was thrown into a pit and mixed with cinders and soil there appeared to be no nuisance. But it was different in a small place like Southampton, where there was a demand for the refuse and sludge, from what it would be in a place like the Metropolis, with four millions of inhabitants. He confessed that he thought the problem was not yet solved, and he considered it not at all improbable that, before it was solved, the mode suggested by Mr. Dibdin, of taking the sewage of so large a population into the sea, would prove the cheapest and the best remedy. Mr. Giles.

Dr. T. STEVENSON recognized in Mr. Dibdin's Paper an effort to solve the sewage question, so far as it concerned the Metropolis; but he should be glad if, before it was applied to London, it could be applied, not on a very small, but on an extensive scale, under some other conditions. The great difficulty would be, not the preparation Dr. Stevenson.

Dr. Stevenson. of an effluent which under ordinary conditions, when cast into a stream, would give rise to little or no nuisance, but an effluent which when accumulated in immense quantities in a relatively small quantity of fresh water, would again enter into putrescence in hot weather, before it had become sufficiently oxidized or exposed to such fresh influences, like the lower vegetable and other organisms, as would convert it into inorganic constituents, or into the tissues of animal and vegetable life. But he recognized that Mr. Dibdin had placed on an experimental basis what had only been dimly perceived before with regard to the economical use of chemicals; for he had shown, what had been ascertained before by practical experience without any explanation, that the use of a minimum quantity of lime in solution would effect as much in the way of precipitation as a much larger quantity, if simply mechanically mixed, or only partially dissolved. At Bradford, for instance, the conclusion had been arrived at empirically, that, using about 15 grains of lime to the gallon, it must first of all be mixed in the proportion of 90 grains of lime to the gallon, and be well worked up again and again, to get the most effective results. That was what Mr. Dibdin had found: 90 grains being about the maximum solubility of lime in water. Mr. Dibdin had put that experience on a more scientific basis, and shown that in solution lime was greatly more effective than when mechanically suspended or only partially dissolved. With regard to the use of iron, he recognized fully as a chemist that in a ferrous or proto condition it was an effective carrier of oxygen, taking this from the air and handing it over to the sewage, again to take another portion from the air; but he had ascertained, by the examination of sewage-effluents that had been treated with lime in conjunction with other materials, that for a long time the effluent water did retain in solution, when well limed, a certain quantity of iron in a proto condition. Of course there was always this disadvantage with regard to the use of iron, that it created a sentimental grievance—that it blackened the mud banks. The chemist, however, recognized in that a beneficial influence, whereas those who simply looked at black matter as almost necessarily offensive, regarded it from a different point of view. As to the disposal of the sludge, there was much to be learned; although the filter-press was a very efficient engine for removing sludge and converting it into a portable condition, where it could be applied to land or burnt, or disposed of without nuisance, it must also be recognized that if sludge-presses were to be used all over the kingdom, the material would become much

more costly, and that this method of disposing of the sludge was an expensive one. In all such cases there was the great difficulty of the disposal of the pressed liquid, which was always highly concentrated. It contained organic constituents and nitrogenous constituents, necessarily putrescent under certain conditions, and there was a further difficulty to contend with, that lime had to be used, and when it was used in large excess it had a highly solvent action. Any one who had examined, as he had done, the effluent from the Wimbledon Works would recognize it as a saturated solution of lime, and the difficulty was to get rid of that lime. His own opinion was that the most effective means of getting rid of the effluent was to dilute it with clear water and apply it to the land, instead of, according to the general plan, turning it back again into the main sewage to be again treated *da capo*. He thought that the latter course often created great obstacles to the further clarification of the sewage. Mr. Crimp, however, had informed him that he had not found that difficulty, but Dr. Stevenson knew that it had in other cases proved very serious. Although a chemist, he looked with much interest on the question of carrying sludge to sea, and if it could be carried to a sufficient distance, and done economically, he saw no reason why it might not be effected without nuisance. If engineers could accomplish that result a great step would be taken towards solving the sewage question for the Metropolis. Dr. Stevenson.

Mr. FREDERICK JAMES LLOYD said it had been stated in Mr. Crimp's Paper that manure made from sewage-sludge was superior to ordinary farmyard manure. He wished, as an agricultural chemist, to raise a protest against any such statement, and he felt certain he was expressing a view which would be held by every farmer in the country in asserting that no such manure could be made from sewage-sludge. Considering the fact that farmyard manure was made upon the farm, and that the sewage-sludge manure had to be carried to the farm, the expense of carriage alone outweighed any beneficial effect that the latter might have. Sewage-sludge contained from 1 to 2 per cent. of a phosphate of some kind and a certain amount of nitrogen. It was not known that the phosphate was phosphate of lime; even if it were, a manure could be bought containing 25 per cent. of phosphate for £2 10*s*., and superphosphate was twice as valuable as any phosphate that could be present in sewage-sludge. Nitrogen also could be obtained by the farmer for agricultural purposes in a form twenty-five times more concentrated than in a similar Mr. Lloyd.

Mr. Lloyd. quantity of sewage-sludge, and at a price varying from £10 to £12 per ton. It was known that the nitrogen in sulphate of ammonia, or in nitrate of soda, was available for plants; it was not known that the nitrogen of sewage-sludge was available, and considering that its compound had resisted the decomposition of the sewage, and the decomposing action of lime, it might be confidently assumed that it was in a very stable form, and would not readily decompose and yield its nitrogen to the plant. He thought, therefore, that on all sides sewage-sludge might be considered as practically useless to the farmer, because it cost too much for him to apply it. But it might be useful to make a sewage-sludge in the treatment of sewage, and if the effluent water was to be used for irrigation purposes, he thought a little more attention ought to be paid to the nature of the chemicals which got into that effluent water. If the effluent was to be applied to plants, it was wrong to put into it a substance which was injurious to their growth. All the tillage operations of farming had in view the oxidizing of substances in the soil, while plants would not grow in any soil which was either alkaline or acid. Sulphate of iron, if used in excess as a precipitant, passed into the effluent water; being acid, it was one of the most injurious compounds to the plant that could be applied. There were many acres of land in Ireland where nothing could be grown, because of the sulphate of iron present in the soil, and it took years of cultivation, and a large quantity of lime, to bring that sulphate of iron into such a form that it was no longer injurious. With regard to the subject of precipitation; in studying the changes which took place in silage, he had found that the decomposition was at times very similar to the decomposition that went on in sewage. Part of the substance was continually decomposing, part of it appeared to be very slowly acted upon; and in the process of decomposition substances were formed which would combine with any metallic hydrate to produce a precipitate of a very stable nature, and all those compounds were more or less nitrogenous. If further decomposition followed those compounds were broken up into others, which were not precipitable by metallic hydrates; the conditions of precipitation were a neutral solution or liquid and some compound which would readily precipitate the metallic hydrate. Copper sulphate, iron sulphate, and alumina sulphate would easily give precipitates with this organic matter; they were flocculent, and would carry down any substances in the liquid that were not in solution. He thought, therefore, that much that had been said, with regard

to the large quantity of chemicals necessary, pointed to the fact that the action of the chemicals had not been studied; inasmuch as the most minute quantity of metallic hydrate was sufficient to combine with the organic compounds and to precipitate them. Much more of the chemical might be put into the liquid, and more of the metallic hydrate might be precipitated by using an alkaline substance like caustic lime, but not any more organic matter in combination would be brought down. If the advocates of the utilization of sewage studied the question more from a scientific point of view, instead of endeavouring to bolster up patents or to make farmers believe that they could produce a manure which was of great value, they would find that only a small quantity of precipitating agent was necessary to purify sewage, and was preferable whether they used the sewage-sludge or the effluent upon the farm. Mr. Lloyd.

Sir JOHN COODE, K.C.M.G., observed that he should like to correct a little misapprehension into which Mr. Giles had inadvertently fallen. He appeared to be under the impression that the suggestion of taking sludge to the sea was one that had emanated from Mr. Dibdin. As a member of the late Royal Commission on Metropolitan Sewage Discharge, he wished to call attention to the fact that the disposal of the sewage by taking it to sea was one of the recommendations of the Commission. He had reason to think that in some quarters there existed an impression that, in making that recommendation, the Royal Commission was taking up a rather "big" question, but he was not of that opinion. Accepting Mr. Dibdin's figures as correct, that it was necessary to deal with 3,000 tons of sludge per day, that was not a very large quantity. It only amounted to 1,095,000 tons annually, which was by no means large. If reference was made to what had been done by the River Tyne Commissioners, it would be found that, in the course of the twenty-five years ending December 1886, they had taken to sea 77,109,749 tons, or more than 3,000,000 tons yearly, which was three times the quantity that would have to be dealt with in the case of the Metropolitan sewage. In one year alone, 1865, they dredged and took to sea, 18 or 20 miles distant, no less a quantity than 5,250,000 tons. In the face of those facts, it could not be fairly said that the proposal made by the Royal Commission was by any means an extravagant one. Sir John Coode.

Major LAMOROCK FLOWER remarked, that the main point of Mr. Dibdin's Paper was that the disposal of London sewage should be regarded as an exceptional case, and that the volume being so Major Flower.

Major Flower. vast, and its condition so varying, ordinary modes of sewage treatment could hardly be said to apply to the case; that it was, in fact, impossible to do more than roughly treat it chemically, and then throw the residue away or take it out to sea, and hope to see the last of it. Hope had often told a flattering tale. He thought the idea wasteful and extravagant. More than ten years ago he suggested that sewage-sludge should be used for filling up low-lying land, putting its value at the lowest possible amount. He referred to this in his evidence before the Royal Commission on Metropolitan Sewage Discharge, and he adhered to it now. He fully admitted the vastness of the question for London and all its difficulties. He was certain that ultimately the outfalls must be taken lower down the river, and the Canvey Island scheme of Lieut.-Colonel Jones and Mr. Bailey Denton seemed to point to a final and satisfactory solution of the question. He would be the more pleased if this idea were carried out, as it would provide an outlet for the Lee Valley sewer, in which he was interested with Sir Joseph Bazalgette, and Messrs. Law and Chatterton, MM. Inst. C.E., and the requirements of the residential districts of the Lee Valley would before long make the construction of that sewer a necessity. Not long ago the Metropolitan Board of Works took pains to make out a case that there was no nuisance at the outfalls; perhaps this contention was right scientifically. The noses of the public, however, seemed to point to a reverse conclusion, and it became desirable to appease the popular indignation. He should have liked to have heard Mr. Dibdin give the results of the various modes which were supposed to have been tried at the outfalls, rather than merely his own views on the effect of certain specified chemicals; his excellent Paper would have been increased in value; perhaps he would favour the members with the missing information in his reply. Admitting, for the purpose of argument, that the nuisance at the outfalls only existed in sentimental objection, it appeared to him that it would have been true wisdom on the part of the Board of Works, instead of deciding to spend a large sum of money in new works at the present outfalls, to have boldly grappled with the question, and to have decided on carrying the sewage lower down the river, thus finally settling the matter, and to have at once applied efficient chemicals in the existing tanks as a temporary measure. Mr. Dibdin had said (p. 165) that in order to destroy smell sanitarians were limited to practically only two materials, "chloride of lime and permanganic acid," and he said nothing as to the effect of sulphurous acid in the direction wanted. He could speak with great satisfaction of the effect of treating sewage with

Hanson's black ash waste, a well-known preparation from the refuse of alkali works. He mentioned this in his evidence before the Royal Commission on Metropolitan Sewage Discharge, and if he had then known as much as he now did of its properties and effects, he would have spoken more decidedly about it. It had been used with singularly satisfactory results in the lower parts of the River Lee. Mr. Dibdin had mentioned a fact which Major Flower had often noted, "clearness is no more a sign of purity than is turbidity a sign of foulness." Now, the appearance of the effluent from treatment of sewage by black ash waste was not that of "a good effluent," but its effect upon the river and the bed and banks was remarkable. This was due to chemical changes, to which he would not allude; he would deal with the subject only from the point of view of a practical man accustomed to observe sewage-effluents almost daily for many years. He had recently been informed by a chemical friend that the effect of treating sewage by lime and black ash waste was, that while the objectionable micro-organisms were entirely destroyed by it, much vitality was given to harmless bacteria, which lived by eating up the organic matter, a fact which would be interesting to Dr. Dupré. Mr. Dibdin stated (p. 162) that he had "not the slightest doubt, but that the future treatment of sewage will be a combined chemical and biological one, as suggested elsewhere by Dr. Dupré." Hanson's black ash waste seemed to point to a realization of that idea; the material was the carrier of sulphurous acid. Mr. Dibdin had only given the estimated cost "for chemicals"; the same course was followed by Mr. Hanson in his evidence before the Royal Commission.[1] The cost would be about equal to that mentioned by Mr. Dibdin, column 12, Appendix I, p. 172. Mr. Dibdin had put it at £54,750 per annum; Mr. Hanson at about £50,000 per annum. Of course, those estimates were founded on details which might be modified. In considering the question of "the disposal of the sludge," he thought it was universally admitted that filter-presses seemed to afford the most available way of reducing the moisture. Again, the case was an exceptional one, and even admitting the value of Johnson and Co.'s presses or Clark's radial press, the "cake" must be disposed of somehow. Mr. Dibdin had stated (p. 168) "the furnace appears to be looming in the distance as the ultimate destination of the unwholesome matter." Doubtless, if it were possible to control the dust-bin refuse and road-sweepings, the destructor furnace, as applied so well at Southampton and at

Major Flower.

[1] Royal Commission on Metropolitan Sewage Discharge, vol. ii. p. 10.

Major Flower. Ealing, was to be commended. But the case at Barking and at Crossness was exceptional. A series of experiments had recently been carried out at Leyton and on Leyton sludge at Cardiff, having for their object to endeavour to prove that it was possible to burn sewage-sludge without offence and with a profit. He could only quote details of results as given him by an eminent firm of coke-makers. It was proposed by them to treat sewage-cake by "a combination of coking of coal and incineration of sludge-cake." After the fire was started the volatile gases given off in the drying of the cake supplied the carbon wanting in the cake to complete the incineration and to deodorize the offensive gases. The firm stated that "the ammonia escaping during the preliminary drying of the sludge-cake can be collected very economically." Also, that by this process "the coke itself pays the coal and working expenses, and so the cost of incineration per ton of ash does not exceed 6*d*." Thus far for the final disposal of the sludge; but then there was the large cost of the pressing, which was put both by Mr. Dibdin, and by Mr. Santo Crimp, at 2*s*. 6*d*. per ton, irrespective of depreciation and interest on the original outlay; it appeared, however, that half the cost was due to the lime considered to be necessary to be used in the sludge previous to pressing, and to the wear and tear of the cloths at present employed. As to the first item, the aforesaid firm stated confidently that by burning the sludge-cake at high temperature, caustic lime could be produced from the cake itself, which might be used for the pressing, and the cost be much reduced. As to cloths, it was hoped that by the result of a new mode of manufacture, the cost might also be much reduced, and it was believed that a cake might be made at 1*s*. 6*d*. a ton instead of 2*s*. 6*d*. From these figures it might be roughly calculated that 800 tons of sludge per day might be pressed and incinerated for about £30,000 a year. The ash would be of some value, and doubtless would do good on cold clay lands, such as the clay in the Weald of Kent, or upon chalk soils, or as a base for making artificial manures. On p. 167 Mr. Dibdin dismissed the subject very summarily, but with perfect justice and sound argument. "If an inventor has a process by means of which he can more than repay the cost of working expenses, doubtless he will pursue the usual course adopted by business men, and, after obtaining the sludge for nothing and paying working expenses, put a handsome sum in his pocket." "He either fears his fate too much, or his deserts are small, who fails to put it to the touch." Major Flower was informed that there were business men ready to put this matter "to the touch," and relieve the Metropolitan Board of

Works of this part of its heavy task. He did not think the position should be given up as hopeless. Major Flower.

Mr. W. J. DIBDIN, in reply upon the discussion, observed that Colonel Jones's first objection was to his Paper being too theoretical. That was a curious criticism, as the whole Paper contained only one proposition not founded on ascertained facts, and that one was a logical deduction from known data. Colonel Jones was of opinion that the fact of 10 tons of chemicals being required daily to supply each gallon of sewage with 1 grain, originated a theory which the Author had never propounded, viz., that the fewer matters taken from the sewage the better. Nowhere could such an idea be found shadowed in any part of the Paper or elsewhere. As many persons seemed to be unaware of the vast quantity of sewage to be dealt with in the case of the Metropolis, he mentioned this simple arithmetical fact in his evidence before the Royal Commission on Metropolitan Sewage Discharge, merely as a useful mental guide in working out results stated in grains per gallon. Its value was well shown by the fact that, if but 1 grain of precipitating matter were added to each gallon of sewage in excess of the quantity actually required, no less than 100 tons of sludge, of 90 per cent. moisture, would have to be disposed of daily by reason of that seemingly unimportant quantity. Thus: 1 grain per gallon was equal to 10 tons daily or 100 tons of 90 per cent. moisture. Colonel Jones's want of appreciation of biological facts was well shown in his remarks on this question. He evidently did not seem to be aware that permanganic acid had not been used previously to any extent in the treatment of sewage because of the expense, and that its adoption now was solely due to the fact that this difficulty had been overcome by the Author's manufacturing operations. Colonel Jones stated that placing the sludge on land to dry was the very thing he proposed to the Royal Commission. Mr. Dibdin did not read his proposal thus, but that he intended to mix a large quantity of earth with the sewage, allow that to settle with the suspended matters, and so accumulate a bed of well-manured soil under flowing water. This was a very different thing to placing wet sludge on the ground and allowing it to lie and putrefy until it dried up. It was true that if circumstances were different; if pressing could be accomplished at a low rate; if farmers would take away the pressed cake, and so on through a variety of ifs, he should prefer not to take the sludge to sea. But where a practical difficulty had to be overcome, practical measures must be adopted. Colonel Jones was wrong in stating that the Author Mr. Dibdin.

Mr. Dibdin. at any time considered the carriage of the sludge to sea absurd. Other systems might have appeared more desirable, but a wise man looked to the possible. He seemed frightened, too, at the possibility of regulating the application of the chemicals to the ever-varying flow of sewage. That was a mere mechanical detail of which engineers of the present day did not require to be informed by a chemist. It would be sufficient to say that this point had received the attention of the proper persons. He further contemplated the possibility of an expense for chemicals for the treatment of the Metropolitan sewage of £268,275 per annum. Why did he not at once contemplate the sum given in column 25, Appendix I, viz., nearly £10,000,000 per annum? The addition of permanganic acid to the effluent during the summer months would involve some £15,000 beyond the £20,805 in column 7. The total cost of the process proposed by Mr. Dibdin, including working expenses and interest on capital, was estimated at £118,000 per annum, as against double, and more than double that sum, which would be involved by the cheapest plan otherwise proposed. Mr. John Jones complained that the country could not afford to throw away any manurial matter. If the country required sewage-sludge the country would take it, especially when it could have it for nothing, but the country would not and did not take it, and it had to be got rid of somehow. After over 3,000 tons had been given away during the past twelve months at Crossness, there was now more than that quantity of sludge lying ready for removal, and only small quantities were being taken away, mainly at the instigation of members and friends of the Metropolitan Board of Works, who were doing all in their power to induce farmers to utilize it. Mr. Jones thought that if farmers would not have it, then the sludge could be made commercially profitable by separating it into its constituent elements. Very good; let manufacturers take it. Where would they find another industry in which the raw material was given to them for nothing? Mr. Sillar asked "Was there any one present who believed that there was no agricultural value in sewage?" He was immediately answered by Mr. Fowler, than whom no one was better able to judge, having at last given up the problem after twenty years' hard work spent in vainly trying to induce the country to adopt Mr. Sillar's views. If Mr. Sillar chose to consider a system which received the full endorsement of the Royal Commission "disgraceful," he was, of course, entitled to his opinion. Mr. Sillar was sorry that the Author had arrived at his conclusion, because many farmers would follow his advice. On p. 168, however, it was expressly stated, that

"Beyond doubt the wants of farmers should be most carefully considered. So long as they remove the sludge from the works, so long should sufficient be pressed to meet their demands." Further evidence of the one-sided manner in which Mr. Sillar had read the Paper was to be found in his next remark as to the Author setting aside all statements hitherto made on the subject. Mr. Sillar applied this to the utilization of the sludge, whereas on turning to p. 158 it would be seen that this remark applied to a totally different question, viz., the partial removal of the dissolved impurities. The Author submitted that the wisdom of starting on an entirely new basis was clearly proved by the results of the special experiments made on this point, as the light thus thrown on the subject was of great help in reconciling the seemingly contradictory results hitherto obtained. Mr. Sillar objected that the only precipitation process in England in which lime was not used had been entirely overlooked by him. Now the A B C process consisted of the use of sulphate of alumina, with a little blood and some charcoal and clay. The Table in Appendix I showed results obtained by the use of alumina, and also of animal charcoal, and proved that while no advantage was to be derived from the use of these substances in the place of lime and iron when properly applied, their cost was far greater. Furthermore, the recent Royal Commission on Metropolitan Sewage Discharge in their second and final Report, p. lviii., stated, with reference to the process of the Native Guano Company: "There appears no evidence of its superiority to others in the resulting effluent. . . . . The fact that, although it has been before the public for sixteen years, and has been tried in many places, it is only now adopted in one small town, does not speak in its favour." Again, "That several processes appear to be fairly effective, but that there has been no evidence to satisfy us of the marked superiority of any one in particular." Mr. Sillar quoted a Report by Dr. Tidy and Professor Dewar on the treatment of the Aylesbury sewage, and implied that a similar result would follow in the case of the London sewage. Here, again, Mr. Sillar showed that he had not grasped the contents of the Paper thoroughly. On p. 159 the Author stated "that no practical process of chemical precipitation is capable of removing more than a limited quantity of the oxidizable organic matters in solution in London sewage." And on the same page, "The second portion of the Table gives some results, which will explain the remarkable differences of opinion expressed, by various authorities, as to the percentage reduction of dissolved solids by various processes, when acting on sewage of a different character to that

Mr. Dibdin.

Mr. Dibdin. of London. The sewage used for this purpose was obtained from other sources, and was evidently of such a character, that the oxidizable dissolved solids were readily precipitated by even a small quantity of lime in solution, viz., 5·0 grains per gallon, no less than 52 per cent. being removed. The addition of an iron salt to the limed sewage effected a further reduction of from 9 to 17 per cent., or, in the latter case, a total reduction of the dissolved oxidizable matters of 69 per cent.," and he then referred to the further experiments in corroboration of these results. He had purposely refrained from criticising results obtained by patent processes at isolated places. Mr. Sillar considered that the manurial value of the sludge was neutralized by the addition of lime. Now, what was the character of the manure produced by the Native Guano Company at Crossness in 1872? On p. 11 of the Reports by Sir Joseph Bazalgette and the late Mr. Keates on that company's experimental operations at Crossness, an analysis of the manure so obtained was given, from which it would be seen that only 0·48 per cent. of phosphoric acid was present in the London-derived sewage-manure of the Native Guano Company, while the ammonia was only 0·36 per cent. On turning to his Paper, it would be seen that the pressed sewage-sludge obtained at Crossness by his process contained actually more organic matter and ammonia, and about half as much again phosphoric acid as the celebrated Native Guano Company's London-derived production. The following were the two analyses side by side for comparison,

	Native Guano Company's manure as made at Crossness in 1872.	Pressed Cake at present produced at Crossness.
	Per cent.	Per cent.
Water	26·45	58·06
Organic matter	16·16	16·69
Alkaline salts	0·36	—
Carbonate of lime and magnesia	2·62	7·94
Phosphoric acid	0·48	0·66
Alumina and oxide iron	15·42	4·36
Insoluble siliceous matter	38·51	—
Free lime	—	2·45
Silica	—	8·08
Alkalies and loss	—	1·76
	100·00	100·00
Total nitrogen in the organic matter, calculated as ammonia	0·929	1·060

so that the effect of the lime used by the Author, and objected to by Mr. Sillar, could be at once seen. Dr. Angell seemed to be

under a wrong impression as to his objection to unnecessary agitation in the sewers. The idea intended to be conveyed was that prevention was better than cure. The contrivance of Mr. Baldwin Latham, for straining off the larger solid matters, was far better than breaking them up and afterwards removing portions from the liquid by precipitation. In all other respects he would aerate by all means, and to the greatest extent possible. He admitted that sulphate of alumina removed some matters in solution, but the question was, to what extent? Mr. Bennett seemed not to be aware that an eminent engineer was attached to the staff of the Metropolitan Board of Works, and that the Author was by no means solely responsible for the recommendation to take the sludge to sea. So far as he was concerned the engineers might have all the sludge, as he thought that few chemists would care to interfere with them in the matter. Chemists had tried their best to utilize the foul matter for years past, and were now compelled to admit that they could do but little with it. He had already stated that the Southampton scheme was an admirable one where it could be carried out, and in such cases he would recommend it for adoption, but the circumstances of the Metropolis were so different, that it would be very doubtful if all the authorities interested in the matter would work together to bring about the desired result. The present need was to dispose of a nuisance, and not to wait until more elaborate plans could be got into working order. The scheme was not peculiar to Southampton, although it had been recently brought into prominence in connection with that town. Dr. Tidy's criticisms might be divided into twelve parts, namely: 1st. That Mr. Dibdin, with others, was entirely discredited in matters of fact, as the evidence given by him, and them, before the Royal Commission on Metropolitan Sewage Discharge, was not subsequently borne out by experience under different circumstances; 2nd. A refusal to discuss the question of the quantity of suspended matter in the London sewage; 3rd. An attempted ridicule of the quantity of lime and iron proposed for the treatment of the London sewage; 4th. The implied doubt as to the change of the iron from the ferric to the ferrous state; 5th. A mixture of facts as to the action of the iron and permanganate; 6th. Quotation from Dr. Dupré's evidence in a case totally different to that of the Metropolitan outfalls; 7th. A criticism of the Table, Appendix I; 8th. The cost of the lime; 9th. A statement as to an alleged refusal of the Metropolitan Board to let him have samples of sewage; 10th. A comparison of the effluent from Crossness with sewage taken from the Fleet Sewer; 11th. A misrepresentation of his objection

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Mr. Dibdin. to claptrap statement that because a clear effluent could be produced it must therefore be pure; 12th. Dr. Tidy's certainty that the ratepayers' money was about to be wasted. Dr. Tidy's first, second, sixth, and ninth points were not in any way connected with the subject-matter of the Paper, Mr. Dibdin would therefore deal with them before considering those points more immediately in connection with the subject before the Institution. Dr. Tidy, with many others, had overlooked the fact that from the time the evidence was given before the Royal Commission, the atmospheric conditions had entirely altered. The evidence of the witnesses on behalf of the Metropolitan Board of Works was prepared previously and up to the spring of 1883. On looking at the returns of the Registrar-General for the years 1877 to 1886 it would be seen that the rainfall at Greenwich was as followed:—

	Total Rainfall.	Rainfall during June, July, and August.
	Inches.	Inches.
1876	23·93	3·91
1877	27·41	5·84
1878	28·55	10·26
1879	31·65	13·18
1880	29·07	6·74
1881	25·44	7·80
1882	25·16	6·04
1883	21·98	4·13
1884	17·76	4·65
1885	23·05	3·49
1886	24·10	4·05

In 1885 a depth of 10·16 inches, and in 1886 of 9·25 inches fell in the months of September, October, November, and December. From these returns it would be seen that the circumstances were entirely different after the date of the evidence—a fact which Dr. Tidy failed to take into account. Surely even he would admit that, given from 50 to 300 per cent. more rainfall, a different condition of the river was to be expected. It was generally admitted that the first report of the Commission was by no means an alarmist report. The following quotation from the conclusions of the commission was very different from the report made after the experience of an exceptionally hot summer and low rainfall:—"That it does not appear that hitherto the sewage discharge has had any seriously prejudicial effect on the general healthiness of the neighbouring districts. But that there is evidence of certain evil effects of a minor kind on the health of persons employed on the

river; and that there may reasonably be anxiety on the subject for the future." The witnesses for the Metropolitan Board said that nothing was wanted under the existing circumstances, and they were right on matters of fact. Because a few exceptionally dry summers had for a limited time caused the river to be a nuisance, Dr. Tidy took alarm, and would plunge the ratepayers into an expenditure of millions of money, in a vain and useless attempt to turn the river-water at Barking and Crossness into the condition of drinking-water. Dr. Tidy's second point was his refusal to discuss the quantity of suspended matter in the London sewage. In this he was wise. His statement that the Author had left out the storm-water was incorrect. If he meant that the storm-water discharged from the storm-overflows was not included, he was correct, as Mr. Dibdin's object was to ascertain the quantity in the sewage which arrived at the outfalls under all circumstances, which was generally considered to be what was meant by the suspended matter in London sewage. The storm-overflows might be looked upon for all ordinary purposes as things which would have their way independent of the outfalls, and could not be included in any question of the amount of sludge likely to be derived from the sewage treated at the outfalls, which was the quantity to be considered in connection with the subject of the Paper. Dr. Tidy's sixth point had, so far as it affected Dr. Dupré, been answered by that gentleman. The ninth point was a misrepresentation on the part of Dr. Tidy. The moment he applied to a responsible officer of the Metropolitan Board of Works, he obtained what he wanted, and unlimited permission to have as many samples of sewage as he pleased. Now to deal with Dr. Tidy's serious attempts at criticism. His third point was as to the quantity of lime intended to be put into the sewage by the Metropolitan Board. He ridiculed it, but he did not deny the fact that the matters in suspension were precipitated. Now in Dr. Tidy's evidence given before the Royal Commission, in answer to question 18,529, p. 81, Vol. II. of Minutes of Evidence, he said: "Now the first question is, what is the cause of the nuisance? The nuisance complained of arises in my opinion from the solids in suspension being discharged into the river. I am convinced that if this solid suspended matter was removed the nuisance would be materially diminished, if not entirely prevented. These solid matters amount on an average to 25 grains of dry solid matter per gallon; or, taking the quantity of sewage at 120,000,000 gallons daily, to 200 tons of solids without moisture." Dr. Tidy had recently stated the same thing in stronger terms at the Society

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Mr. Dibdin. of Arts.[1] Therefore, however he might try to hark back, he was bound to admit that in removing the suspended matters the Board would be doing all that was necessary. The particulars of the method were unimportant. Dr. Tidy and others gave evidence before the Commission upon various systems of chemical treatment, and upon those data the Commission estimated that a certain quantity of sludge would be obtained. Now, what were the facts? By treatment of the sewage by only 3·7 grains of lime and 1·0 grain of sulphate of iron the Board obtained, after allowing for the reduced quantity of chemicals added, just the amount of sludge estimated by that Commission. Therefore, having removed what should, in the opinion of the Commission, be removed, as much and no more could be left behind than the Commission contemplated would be left after treatment of the sewage by the best known process. That simple fact could not be explained away. The following statement showed the estimate of the Royal Commission as against the actual results obtained from the treatment of nearly 500,000,000 gallons of sewage at Crossness by means of 3·7 grains of lime and 1·0 grain of protosulphate of iron :—

	Royal Commission Estimates.	Metropolitan Board's actual results.
	Per day of 150,000,000 Gallons	Per day of 150,000,000 Gallons.
Wet sludge as precipitated	Tons. 4,500	Tons. 4,620
Reduced to second settlement in special tanks .	Not contemplated by Royal Commission.	2,745
Pressed Cake	900	803

The value of Dr. Tidy's criticism was also shown by his statements, repeatedly made, that an effluent could be obtained by chemical means equal in purity to the river-water into which it was to be turned. The experience of the whole country was against that mischievous statement. Dr. Tidy had tried it at place after place, and had never accomplished it. Therefore, on the ground taken by him Mr. Dibdin had a right to argue that Dr. Tidy's future statements on the sewage question were vitiated beyond recall. Dr. Tidy's fourth point was on the change in condition of the iron from a ferric to a ferrous state. Was it not

[1] Journal of the Society of Arts, vol. xxxv. p. 78.

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an established fact that in the presence of organic matter ferric oxide was reduced to the ferrous, or protoxide, as Dr. Tidy preferred to call it? This was the admitted cause of the presence of sulphide of iron in mud. Dr. Tidy said he had tried it; but he did not deny it. As to the value of iron in preference to alumina, Dr. Tidy informed the Royal Commission that he obtained "as good an effect by about 6 grains of copperas as . . . . from about 10 grains of sulphate of alumina." But he objected to it because it would turn black. The very action of which he asked for proof! His fifth point was thoroughly absurd. The iron was put in with the lime, and did its work in company with that lime, and was precipitated with the sludge, and no iron was left in the effluent. If an excess of iron were put in he would be correct, but Mr. Dibdin did not propose to put in an excess, and therefore he was incorrect in thinking that the permanganate to be added to the effluent would be interfered with in any way. His seventh point was an attempt to throw discredit upon the Table, Appendix I. Why did he not continue his argument, and carry on the comparison with the lime and alumina? The same argument applied, and with greater force. Take column 16, where 5 grains of lime and 5 grains of sulphate of alumina removed 18 per cent. In column 2, it was shown that 5 grains of lime alone removed 15 per cent. Therefore the alum, his pet precipitant, removed only 3 per cent., or 0·6 per cent. per grain of alum as against 2 per cent. by the iron. Further examination of the Table in the same way would bring out this fact more and more. His eighth point, the cost of lime, was one which Mr. Dibdin would leave him to fight with the lime burners. Whatever might be the actual cost by the time it was landed, stored, slaked, and put into the sewage, mattered not for his present purpose. A unit was taken for comparison, and it served that purpose. His tenth point was the comparison of the effluent from Crossness with a sample of sewage taken from the Fleet Sewer. Mr. Dibdin could well imagine Dr. Tidy's indignation, if such a preposterous thing had been brought up in evidence against himself. He thought he was aware that sewage varied day by day, and hour by hour. With regard to his eleventh point, in which he misrepresented the Author pointing out the mistake made by many (to no little extent on Dr. Tidy's representation), that an effluent was pure because it was clear, bitter experience had brought this error home to so many that he would leave Dr. Tidy's misreading of his statement as not worthy of further notice. The inference from Dr. Tidy's last and twelfth point was, that the Metropolitan Board of Works, in not calling him in for advice, was

Mr. Dibdin. doomed to failure. On this point, the action of the Board had nothing to do with the Paper, and required no further remark than that which he had made elsewhere, "We believe we are on the right track, and are doing what is right in the interests of sanitation and the ratepayers." Mr. Maudslay had remarked that "if those who had the power would only try it for London, they would probably obtain the same beneficial result as had been obtained at Southampton." If he had carefully examined the Table, Appendix I, he would have seen that experiments had been made with both alumina and charcoal, with no better results than were obtained by means of lime and iron. It had been stated that alumina and charcoal were the two principal ingredients of porous carbon, so that it would seem that no better results were to be expected from the use of this material than from the other two substances, viz., lime and iron. Mr. Strachan's remarks did not however bear out Mr. Maudslay's ideas. Mr. C. Jones said that sludge consisted almost entirely of carbonaceous material. The analysis of the Crossness sludge given in Appendix III showed that it only contained some 16 per cent. of organic matter. He heard for the first time of Mr. Jones's invitation to Ealing. The facts of the case were simple. If the cost of pressing was prohibitory, as it appeared to be in the Metropolis, what was the use of considering the question of burning it? Mr. Jones did not contend that he could burn the unpressed sludge, but only the pressed. Therefore, if it were decided to carry the sludge to sea, what good would be done by considering a point which could only be arrived at by first doing something which was not intended to be done? The cost of pressing the sludge of the metropolitan sewage was far greater than in many other cases, in consequence of the additional quantity of lime required to be added to it, namely, from 2 to 4 per cent., or from £20,000 to £40,000 per annum; a sum which would in itself go a long way in paying for the transit of the unpressed sludge to sea. No one doubted that small quantities of cake could be burnt without nuisance. It was a question of advisability, and not so much of practicability. By burning, the whole of the value of the sludge, whatever it might be, was absolutely lost; but when it was taken out to sea, it served to manure our fish-fields instead of our corn-fields. This point had been dealt with by Sir J. B. Lawes, and was confirmed by the researches of Dr. Sorby on the support of aquatic life by sewage matters. It was interesting to hear the opinion of Mr. C. Jones that sludge was a thing to be got rid of at the least expense, as it confirmed the opinion given in his Paper. Mr. Mansergh,

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appeared to think that household deodorization was not practicable. This was one of the matters on which the public required educating. Many people habitually spent large sums in disinfecting materials. If they could only be brought to use a portion of their efforts in deodorizing the sewage of their own establishments effectually by an oxidizing agent, the problem would be solved. The work done by the Metropolitan Board last summer in deodorizing the sewage as it flowed through the main sewers was productive of great benefit. After passing a deodorizing station the sewage was free from nuisance, in many cases for over 2 miles, when the constant addition of foul sewage from the local sewers again rendered it offensive. The results of the experiments made by Mr. Mansergh and Dr. Ashby at Grantham justified his endorsement of Dr. Dupré's forecast. Mr. Mansergh's theory of the cause of the river-water becoming bad in the last year or two was quite in accordance with his latest observations, the nuisance during the past three summers undoubtedly being due to the suspended and not to the dissolved matters freshly discharged. This was a most important question, and one which should be remembered in the event of the river not being all that was desirable during the first summer after the opening of the precipitation works. He did not anticipate the evil being present to such an extent, but it was a contingent one to be borne in mind. He considered that the remarks of Mr. Birch showed very strikingly the uselessness of excessive quantities of chemicals. In reply to this gentleman's question as to the strength of the sewage, he had been careful to treat the sewage at the outfalls in order that it might be perfectly fresh. In order that this might be done, one of Mr. Dibdin's assistants, Mr. G. Thudichum, had when necessary worked all night, and was entitled to no little credit for the completeness of the Table, Appendix I, as the samples represented hourly samples during twenty-four hours, and might be taken as fairly representing the day's flow. They were not all taken on one day, but over a period of some weeks. A great deal more work should be done in this direction; and he hoped that some new light would be thrown upon the matter by further results. The Author would be happy to give Mr. Birch any information in his power. Mr. Baldwin Latham objected to his statements as to the suspended matter in London sewage. Dr. Tidy formerly held the same view as Mr. Latham, but he had now abandoned that position, as shown by his evidence before the second inquiry of the Royal Commission. The results of the

Mr. Dibdin. treatment of the sewage during only ten hours of the day, which was the time during which the Native Guano Company worked, could not be admitted as indicating the average character of the sewage during twenty-four hours. The estimate of 27 grains per gallon was not founded on the southern sewage only, but on that of both sides of the river. He was not responsible for the results of sewage experiments made by other people at other places, and therefore did not wish to dispute the statements of Mr. Latham; but he should like to ask if he used lime in solution? If not, the results were a foregone conclusion. Mr. Latham considered that 10 tons of manganate would be useless for the deodorization of the effluent produced by the means which Mr. Dibdin suggested, and calculated that the quantity of oxygen coming over Teddington weir was some 15 tons per day during the summer of 1884. He thought that if 15 tons of aerial oxygen were insufficient to keep the river in good condition during that season, 10 tons of manganate would be useless. Now what were the true conditions of this problem, which it was evident that even yet Mr. Baldwin Latham had not grasped? In 1884, the river had to deal, besides pollution from other sources, with the whole of the sludge as well as the dissolved matters. When the Metropolitan Board's works were in operation, the worst part of the sewage—the sludge—would be taken out absolutely. Therefore, all the oxygen of the river would be available for the dissolved matters, which would be equivalent to multiplying the available oxygen of the river-water several fold. Moreover, the admitted cause of the nuisance in the river during the summer months, viz., the accumulation of suspended matters, would be done away with. The mere removal of the sludge would doubtless effect such an enormous improvement, that there seemed little likelihood of any danger in future of the river indicating in any way the presence of sewage matters. As a further precaution, however, it was proposed to add a small quantity of chemically active oxygen to the effluent, and so do away with the possible chance of nuisance, by effecting the oxidation of the small quantity of actually putrescent matters left after precipitation. The quantity so proposed to be added was in the form of manganate of soda, of which from $\frac{1}{2}$ to $1\frac{1}{2}$ grain to each gallon would be used. Those quantities were by no means absolute, but approximate; and during a very dry and hot season probably 2 or 3 grains might be added. If the quantity were thus increased to 2 grains per gallon, the total amount of chemically active oxygen which would be thus introduced would be 1 ton per day.

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With regard to the question of fish, he had kept living fish for many weeks in water containing one-fifth of its volume of effluent obtained in the manner proposed by him for the treatment of London sewage. Mr. Latham's experience, at Northampton and at other places, confirmed his conclusion that under most circumstances mere chemical precipitation was by itself insufficient. The case of the Metropolis was, however, so different from other places that no comparison could be drawn. With regard to the pressing, he had some experience of centrifugal drying-machines for sludge, but could not join Mr. Latham in his sanguine anticipations. Mr. Melliss agreed that perfect purification could not be attained by chemical means; but he probably failed with the lime and iron experiments for the same reason that Mr. Latham had done, but of neither of these experiments did he know anything. Both of these gentlemen seemed to be of opinion that Mr. Dibdin was wedded in some way to exactly 3·7 grains of lime and 1 grain of protosulphate of iron. These figures had so come out from the calculated quantities used, and had been retained for convenience as indicating the system, but meant nothing more. It would have been better perhaps to have put the word "about" before them. The point was to use sufficient chemicals to do the work, whatever it might be, and no more. Sir Robert Rawlinson had fully confirmed all that he said upon the uselessness of trying to purify sewage completely by chemical treatment. Mr. Dibdin would assure Sir Robert Rawlinson that his estimated expenditure, viz., £2,000 for each million gallons per day, or for the 160,000,000 gallons of London sewage £320,000,000 per annum, was not contemplated; and, as had been shown by his Tables, and the published reports of the Metropolitan Board of Works, was unnecessary, the estimated cost, inclusive of all charges for the treatment of the sewage at the outfalls, being £118,000 per annum. If eventually the remaining portion of the Royal Commission's recommendation, as to carrying the effluent to Hole Haven, or filtering it through land, had to be resorted to, then an additional burden would have to be thrown on the ratepayers; but while there was a reasonable hope that all that was necessary could be accomplished for the comparatively moderate sum stated, he contended that such process ought to be tried before resorting to further enormous expenditure; especially so, when the works involved were only those contemplated by the Commission, and this view the Metropolitan Board of Works had adopted. In so doing the Board was by no means bound to remain satisfied should further measures ultimately appear advisable. He would again

Mr. Dibdin. repeat what he had so often said, namely, that if the water at Barking and Crossness were to be used for drinking purposes, he would be the last to advocate the admission of any effluent into it, unless that effluent had been first put on suitable land. But the circumstances were so different, and the volume of river-water so large compared with the sewage, that there could be no doubt but that as the river had been able to deal with the whole of the sewage, including the suspended matter, up to within the last few years, so it would be able to deal, with the dissolved matters only, for many years to come. If the proposed system was not entirely satisfactory, no difficulty beyond time and expense would be experienced in carrying out the further recommendations of the Royal Commission; thus, while the Board was proceeding in the right direction, it was at once on the side of economy and efficiency. Mr. Jerram's remarks were of the highest importance, and, he thought, formed one of the most valuable contributions to the discussion. He quite agreed with him in his explanation of the cause of nuisance in many cases. In the use of iron the great point to be attended to was the precipitation of the whole of it. If some portion were allowed to enter a small stream, unpleasant effects would be sure to follow. Mr. Jerram fairly answered Colonel Jones as to the difficulty of regulating the chemicals to the flow of sewage. Dr. Edmunds repeated the idea of Dr. Tidy, as to the action of the iron salt on the permanganate. But let it be supposed that the whole of the 1 grain of protosulphate of iron would be left in the effluent. The quantity of oxygen required to convert the iron from the ferrous to the ferric oxide would be about one-half of that supplied by 1 grain of manganate of soda. Therefore, the undetectable quantity of iron salt, if any, left in the effluent would be without the slightest practical effect on the manganate subsequently added to the clarified liquid. Unfortunately these two doctors differed as to the reoxidation of the iron oxide by the oxygen dissolved in the sewage. Dr. Tidy disagreed, but Dr. Edmunds agreed with him. Dr. Edmunds' advocacy of the A B C system and the claims of the Native Guano Company was a mere repetition of what he recently said before the Society of Arts,[1] and was no new contribution to the question. Mr. Shelford agreed with him as to the advisability of using as small a quantity of chemicals as possible, but objected to the statement that the average London sewage contained only 27 grains of suspended matter. This point had already been answered in reply to Mr.

[1] Journal of the Society of Arts, vol. xxxv. p. 41.

Baldwin Latham. Mr. Shelford, however, further asked for the data on which the statement was founded. Mr. Dibdin would refer to his evidence before the Royal Commission, when he gave the results of the examination of samples of sewage collected at the outfalls every four hours, day and night, from the 12th of March to the 16th of May 1883 at Barking, and from the 23rd of March to the 19th of May 1883 at Crossness. Mr. Shelford considered "that the satisfactory solution of the sewage question was almost as far off as ever." Mr. Dibdin could not agree with this opinion. Hitherto the great stumbling block in the way of a proper solution of the difficulty was the interested motives and unfounded statements of patentees, many of whom were absolutely unacquainted with the practical difficulties of the question at the time of their so-called "inventions." If his efforts to tear aside the veil from these various mysterious processes were in any way successful, an enormous stride would have been made. Immediately sanitarians recognized the facts that the power of chemistry in this matter was limited, that sewage-sludge had to be got rid of at the cheapest rate, whether profitable or not, and that common sense was the best guide, a new era in the treatment of sewage would have arisen, and rapid progress might be anticipated. Mr. Shelford agreed that the carriage of the sludge to sea was, in the present state of knowledge, the readiest way out of the difficulty of relieving the Metropolis. He acknowledged with pleasure the generous support of Dr. Thudichum. Mr. Eachus agreed with his advocacy of household treatment of excrementitious matter. This was a point which had engaged his most serious attention. In the case of the Metropolis it was a big question, but not more so than many others which had been strongly advocated by influential members of the Institution. Some few years ago there was a strong agitation for an additional water-supply, to be used for dietetic purposes only. It was now generally admitted that the present supply was all that was required in that direction. But if there was no longer a necessity for that purer supply, he thought that there was a very strong necessity for a sanitary water-supply. Let each water-closet be supplied only by a special main, which should be charged with a solution of such disinfectant of an oxidizing nature as might be chosen. The same supply should be laid on to urinals, &c. Waste could be prevented by the use of waste-preventer cisterns, such as were now being compulsorily fixed where the companies were laying on a constant supply. The deodorizing substance employed, whatever it might be, should not act as a

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Mr. Dibdin. precipitant so as to choke the sewers. The effect would be marvellous. No sewer gases either in house or street, the arrival of the sewage at the point of disposal in a harmless condition, and undoubted benefit to those engaged in or upon the lines of sewers. This idea might at first seem a startling one, but not more so than many others which had taken root and brought forth fruit to the benefit of both the public and those who had taken it up. He firmly believed that some such scheme would be in operation in the not far distant future. Mr. Eachus was under a wrong impression regarding the character of the liquor from the sludge-presses; it was clear and brilliant instead of being black. It was, in fact, a solution of lime strongly charged with dissolved organic matter. He found that it could precipitate a fresh portion of sewage. It would be useless to attempt to re-treat it, as but few matters could be precipitated from it; and those held in solution would have to pass on ultimately with the effluent whether it was attempted to keep them back or not. Mr. Eachus thought that the Metropolitan Board might obtain some 20,000 or 30,000 acres of land at a very low price. Was he not aware that immediately a public body required land it became by some mysterious process "highly elegible building sites," and must be paid for accordingly? Mr. Giles's experience in the Committee Room of the House of Commons, with samples of the effluent proposed to be obtained by Dr. Tidy from the Lower Thames Valley Main Drainage Works, intended to be established at Mortlake, was both amusing and instructive, and a curious commentary on Dr. Tidy's declared intention of producing an effluent as pure as the river-water into which it was to be discharged. Mr. Giles joined with the strongly swelling tide of opinion as to the advisability of taking the sludge to sea. Dr. Stevenson asked for the results of experience on an extensive scale of the process proposed by Mr. Dibdin for the London sewage. The precise plan proposed for the London sewage, which was to be discharged into a large volume of river-water, had answered completely in the case of the River Soar, into which at times only sewage effluent was flowing, after all other plans had failed, including Dr. Tidy's lime, alum, iron, black ash waste, porous carbon, &c. Dr. Stevenson supported his advocacy of dissolved instead of undissolved lime. He had not been able to detect any protosalt of iron in the effluent obtained by the addition of only 1 grain of the sulphate to a sewage charged with 3·7 grains of dissolved lime. Dr. Stevenson joined with him in his statement as to the oxygen-carrying power of iron salts; and

as might have been expected from his position of member of the recent Royal Commission, agreed with the suggestion of taking the sludge to sea. Mr. Lloyd thought that the sludge was practically useless, and showed that calculations of the manurial value of sewage-sludge from its percentage composition, as far as the phosphoric acid and nitrogen were concerned, were useless. In this he agreed with him, and also in the proposition that in view of the expense of getting the stuff to the farm, the sludge, whether pressed, dried, or wet, was not worth the having. Mr. Lloyd, as an agricultural chemist, agreed with his proposal to use as small a quantity of chemicals as possible, as thereby the effluent, where used for irrigation, would be more valuable than if highly charged with large quantities of injurious chemicals. Sir John Coode did not seem to be afraid of Mr. Sillar's term "disgraceful," as he was jealous to claim the credit of the proposal to take the sludge to sea for the Royal Commission. Major Flower saw Canvey Island in the distance, and seemed to think it the only solution as regarded the Lee difficulty. As all the Lee Valley sewage was eventually turned into the Thames near Blackwall, and, no doubt, contributed in no small degree to the condition of the river in that locality during the last three summers, Mr. Dibdin agreed that it would be better to divert the sewage from that stream; but in this proposition he saw no necessity for taking it all the way to Canvey Island. So far as the disposal of the Lee sewage was concerned, there was no reason why, after the construction of the proper sewers, &c., the whole of it should not be treated at Barking, and thus relieve Blackwall and the reaches above from this great nuisance, and the present Metropolitan outfalls from the reproach of being the cause of a nuisance for which there were so many other sources. Major Flower should have carefully studied the Paper instead of looking through it merely to see how far "black ash waste" was referred to. He had no desire to criticise patent schemes. If, however, Major Flower wanted information on that subject he would refer him to Mr. Gordon's experience at Leicester. He also considered that the Metropolitan Board would have exhibited true wisdom in what practically would have amounted to spending some £4,000,000 instead of only £750,000 in working expenses, and in constructing works which would occupy some six or seven years before they could come into operation, instead of eighteen months, as by the system adopted. He was, of course, entitled to his opinion; but Mr. Dibdin could not agree with him. Major Flower next considered at full length the advantages of black ash

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Mr. Dibdin. waste, and stated that the active agent in this substance was the sulphurous acid. To this he could only reply that if he required sulphurous acid he would buy, at one-half the price, a substance which contained only a few per cent. of that material in an available condition. Major Flower also asserted that he had stated that the cost of pressing the sludge was 2*s.* 6*d.* per ton. This was a mistake. On p. 167 he said, "Evidence has been put forward in numerous Papers that the cost of pressing is about 2*s.* 6*d.* per ton." He declined to take the responsibility of that statement, as it was not borne out by his experience; but he was willing to make allowances for exceptional circumstances. He was glad to hear that there were business men ready to relieve the Metropolitan Board of the task of disposing of the sludge by a remunerative method. He promised them all the support in his power.

Mr. Crimp. Mr. W. Santo Crimp, in reply to the discussion, proposed to confine his remarks solely to the criticisms on the question of sludge disposal. Much dogmatism had been displayed by many speakers, not only with regard to sewage-treatment, but also with respect to the manurial value of sewage and its sludge. On one side there were those who claimed an extreme value for the manurial properties of sludge; on the other side, those who said that it was valueless. Two systems of sludge disposal had been brought prominently forward, namely, those of Southampton and of Ealing. The well-known Birmingham method was also mentioned. With regard to Southampton, it was unfortunate that all the facts were not presented, because, in the absence of full details, erroneous conclusions were likely to be arrived at; in a lesser degree this was also true of Ealing. In a report of recent date, Mr. Bennett stated that the sewage at the platform, or western, outfall, only was treated; the volume was said to be 500,000 gallons per day; the number of persons contributing the sewage was thirteen thousand, whilst the sludge produced amounted to 3 tons per day. That quantity of normal sludge contained 6 cwt. of dry solids; the yield, therefore, was at the rate of 9 grains only per gallon. Of these 9 grains, 4 grains had been added to the sewage as an insoluble precipitant—porous carbon—leaving 5 grains per gallon only as the amount of solid matter precipitated from the sewage. The quantity of sludge, therefore, dealt with was extremely small, and he was not surprised to hear that, even after the ancient method of mixing ashes, street-sweepings, or other absorbent, had been applied, there was no difficulty in disposing of it. Let all the sewage of Southampton be treated, all the solids in suspension precipitated, and then try the method, which was said to be, and

indeed might be, successful, on a small scale, and he ventured to say, that the system would be unworkable. Mr. Bennett's suggestion, as to the application of this system to the disposal of the whole of the refuse of London, was not new; it had been fully discussed by Mr. Booth Scott, M. Inst. C.E., and all the details of the scheme were given in one of the International Health Exhibition Handbooks, that on "Cleansing Streets and Ways in the Metropolis and large Cities" (W. Booth Scott, 1884). With regard to Ealing, he regretted that Mr. Jones had not stated the quantity of sludge actually burnt in the destructors. It should also be clearly understood, that before the sludge was burned it was pumped into large tanks, and there ashes were added and the mixture was exposed until sufficiently solidified to admit of its being dug out and placed in the furnaces. It was, indeed, up to this point, precisely similar to the system which it was found imperative to abandon at Wimbledon, in consequence of the foul smells generated. Another point, which should be mentioned, was that in summer myriads of flies bred in the sludge pits; was it nothing, from a sanitary point of view, that these insects should emerge from this mass of gruesome filth and fly to the nearest house, there to crawl over and into their food? He had seen the ceilings of houses, situated near the Wimbledon Sewage-works, at the time when this system was in operation, literally black with these pests. The formula, "sludge is a thing to be got rid of," had been freely adopted, and to this he would add, it must be got rid of quickly; and whether it was cast into the sea, or converted into an inoffensive material by means of machinery, or dug into the ground as at Birmingham, it might be said to be "got rid off," provided that these operations were quickly and properly conducted. Mr. Baldwin Latham adverted to the expense of pressing, and to the desirability of reducing this expense; too much must not, however, be expected from the suggested substitution of direct-acting pumps for the pneumatic system, because, if the details of the cost of pressing were examined, it would be observed that out of a total cost of 2*s.* 6*d.* per ton, fuel amounted to 3*d.* only, and this was the only item in which a saving could be effected by the adoption of direct-acting pumps. Mr. G. E. Eachus fell into a strange series of errors when, in alluding to the filter-press, he said, "it laboured under the great disadvantage, that it squeezed out a liquid which was a black and foul one, and produced a manure which was of no value;" whilst a little later on he said that, "according to the chemicals used, the sludge must have more or less value for different crops." In the experiments of Dr. Munro and his own, the dried and

Mr. Crimp.

Mr Crimp. powdered sludge gave the best results; whilst the statement, as to the nature of the liquid from the presses, was entirely erroneous, for, so far from being black, it was transparent, and, indeed, exactly resembled in appearance very light-coloured urine. An extraordinary feature of Mr. Eachus's remarks was the statement that, after taking the solids out of the sewage in the tanks, they were afterwards admitted to the distributing pipes, to be carried with the effluent water to different parts of the farm! He had no hesitation in saying that such a system would not be tolerated at Wimbledon for a single day. Mr. E. J. Lloyd endeavoured to prove that, from a chemist's point of view, sewage-sludge ought not to contain any valuable manurial properties, and that other manures were therefore preferable. To this he would reply that Colonel Jones stated "that he had been using air-dried sludge side by side with farmyard manure, on similar land, for fifteen successive years, without, as a rule, being able to detect any great difference in the resulting crops." Dr. Munro had also proved by experiments that the sludge did contain manurial properties to the degree stated by him; and by his own experiments he had proved that, in the case of four crops out of the five experimented upon, the sludge was superior to farmyard manure. At Salisbury, no difficulty was experienced in obtaining 4*s*. per ton for all the pressed cake, the sewage works being situated in an agricultural district. The question was scarcely affected by the statement, that "farmyard manure was made upon the spot"—*i.e.*, where required on the farm; because, in consequence of the universal and ever-increasing use of machinery for performing farming operations, fewer horses were kept by farmers than formerly, and the farmer must therefore buy more manure, and the manure he would buy was that which to him was the cheapest. In the suburbs of large towns, sewage-sludge would naturally have a less market value than elsewhere, because of the glut of stable and other low-grade manures constantly produced in such towns, which must, to a large extent, be disposed of near the place of production. The market gardeners took their produce in wagons to the towns, and brought them back, laden with these manures. For this reason, and also in consequence of the difficulties of pressing London sludge, unless an excessive quantity of lime was used, as mentioned by Mr. Dibdin, he agreed with those who thought that the best mode of disposing of the London sludge was to take it to sea. At Wimbledon, filter-presses were erected, not to manufacture a manure, but to remedy a nuisance; but, admitting the sludge to be a manure, its market value would depend almost entirely on the locality where it was pro-

duced. In conclusion, while he fully agreed that other methods of sludge-disposal were in successful operation, his opinion, as to the suitability of the filter-press for the treatment of sewage-sludge, had been endorsed by several eminent authorities, who joined in the discussion. He did not for one moment recommend its universal adoption; for that system of disposal was the best, which most fully met all the requirements of each particular case. Mr. Crimp.

Correspondence.

Mr. W. ASTROP explained his sludge-drying process at Waltham-stow. Sludge containing 95 per cent. of water was pumped to the machine, and was then run into a tank fitted with a number of revolving fine wire-gauze drums, to which were fixed exhausters, with a fall of about 12 feet to the outlet. This maintained sufficient vacuum to separate about 55 to 60 per cent. of the water from the sewage, which was then in a thick, pasty condition. It was now run over a fine wire gauze, 8 feet wide by 24 feet long, over vacuum boxes, at the rate of about 30 feet per minute; it next passed through a series of squeeze-rolls, which had the effect of reducing it to a thin cake; and from thence to the floor below into a cylindrical revolving wire-cage. This cage was subjected to a current of dry air, at a temperature of about 90°, from a Blackman's air-propeller, at the rate of 26,000 cubic feet per minute, the effect of which was that, as the solid matter dried, it was sifted through the cage, and carried to the lower end by an Archimedean screw, when an elevator placed it in a sack as a fine dry powder. Mr. Astrop.

When the sewage was thus treated, quickly and while fresh, it had considerable market value as a manure. About 100 tons of sludge could be treated in three hours at a cost of about 3*s.* 6*d.* per ton of dry powder; but with a little alteration in the machinery, namely, increasing the supply and dimensions of the gauze-drums, the same result could be produced in one hour at a far less cost.

Mr. F. R. CONDER remarked that it seemed to be assumed that the foul semi-fluid called sludge was a necessary product of the treatment of sewage. Such an assumption was entirely opposed to fact. Sludge was produced by the mixture of lime or clay with sewage. These materials, acting at first as mechanical precipitants, clarified sewage with a rapidity that had led to their Mr. Conder.