Mr. DEACON explained that the suction Waste-water Meter consisted of a truncated hollow cone, the small end of which was on the upper side, with a disc exactly fitting the upper side, capable of moving in it parallel to the axis of the cone. When the disc stood at the top of the cone no water could pass, unless in extremely small quantities; but the moment the body of water above the disc began to move, or pressure was applied, it pressed upon the surface of the disc, and in so doing raised a weight of a constant amount through the space corresponding to the distance down which it passed, until it reached a point at which the annular area for the passage of water between the truncated cone and the disc was sufficiently great for the pressure, due to the body of water on the upper surface of the disc, to balance the weight. Accordingly, to every particular velocity of water the disc found a particular position in relation to the zero line, which stood at the top on a revolving drum carrying a diagram with quantities in gallons per hour marked upon it. The drum revolved once in twenty-four hours. The whole of the diagrams (Plate 5) started from a quantity of about 4,500 gallons an hour. At ten minutes past four in the afternoon the water was suddenly turned off by closing the valve, and a pencil dropped as suddenly to zero. Until a quarter past five in the morning the drum travelled along so that the zero line covered the pencil at each hour. At a quarter past five in the morning it as suddenly rose, and, in the first instance, to above the limits of the diagram, because in filling the mains and cisterns which had been emptied during the night a very large quantity of water was required. After the average for a week had been obtained in the intermittent supply, the constant supply was put on in each case.

Mr. BERREY said he was sure the Author would take any remarks he made in a friendly spirit, although he differed from him in general upon the principle as to the Waste-water Meter being the sole cause of the prevention or discovery of waste. The main object of the Paper appeared to be to under-estimate the value of house-to-house inspection; but, in Manchester, this had been invaluable, and the consumption of water had been reduced for domestic purposes from about 35 gallons per head per day to 14 gallons. That reduction was due to the internal inspection, and to the introduction of proper regulations with regard to the fittings. The Waste-water Meter might be a very valuable instrument as an auxiliary for the prevention of waste, and every one must hail with satisfaction anything that would tend in that direction, particularly as the watersheds of the country were

becoming so valuable, and the population was increasing so rapidly. He thought there were several serious objections to the mode in which the Author proposed to deal with the waste externally. Placing the stopcocks on the outside of the houses, and so near the surface, in the first place, rendered them liable to be frozen, and, in the next place, the public authorities would be responsible in a great measure for their being closed in case of accident, and serious claims for damages might arise. He thought rather too much importance had been attached to the discovery of waste by the noise of the water, because the passage of water through a pipe in the night was, in a great number of instances, particularly in warehouse districts, constantly taking place. Numbers of warehouses and manufactories could not possibly obtain all the water they required in the course of the ordinary daily use, but during the night they had large reservoirs which were filled up through the service pipe, and this, as a matter of course, would make a noise. He could not agree in the recommendation to abandon the internal inspection; for without that inspection the constant waste, caused by defective fittings, or wearing out of fittings, could not be ascertained. To afford permanent protection to any corporation or waterworks company visits to the premises must be made. The Author had taken a very sanguine view of the matter. It appeared that, for the population of six hundred and thirty-four thousand persons in Liverpool, the cost of fixing the meters was estimated at about £39 7*s.* per thousand persons, which would give £25,000 for Liverpool alone, and that would be a serious item in the expenditure of waterworks. The test of listening to the noise was of a very uncertain character. A man who was wasting water, or taking water improperly, would allow it to run until such times as he knew that the night inspector would be coming. Then he would shut the stopcock, and, consequently, no means would be left to discover the mode in which he was dealing with the water. He thought that scarcely sufficient experience had been acquired to justify definite conclusions as to the use of the apparatus. The supply of water in a large town like Liverpool, where the consumption had been excessive, demanded the serious attention of those who had the direction of it; but as the means resorted to in Manchester had been so successful it would be scarcely fair to abandon the course adopted there; and he differed entirely with regard to the abandonment of internal inspection of the fittings. At Norwich, where the consumption had been about 40 gallons per head per day, and where, by the introduction of systematic arrangements, and of internal inspection, it was reduced to under

14 gallons per head per day, there was no Waste-water Meter, and the result was far superior to that obtained by this instrument. He was convinced, from a long experience in the management of the largest waterworks in the country, that no permanent prevention of waste could be insured without periodical visits being made to the interior of the premises supplied.

Mr. JAMES LEMON said the Waste-water Meter was in his opinion one of the most perfect instruments of the kind. The results arrived at confirmed that opinion. He could not admit the advantages of daily inspection. In Southampton, where there was a constant supply of water, the daily inspection was a mere farce, so far as the prevention of waste was concerned. When the inspectors were going their rounds the persons who had their taps open, seeing the inspectors coming, turned them off. The waste chiefly took place during the night. In Southampton a reservoir had been connected with the high-level district. No water ran into the reservoir, except that which came from the waterworks; and being on the high level, there was a very little leakage into the sewers. The quantity of water used between the hours of twelve at night and five in the morning was very great; while it was certain that persons did not want a large quantity during those hours, especially as there were no warehouses in the town that required to store water. It therefore followed that, if the constant system was to be adopted—and he trusted the day was not far distant when it would be, in every town in the kingdom—the question of waste must be fairly considered. In his judgment, the only way by which waste could be checked was by night inspection. It was well known that by a double system of mains —or what were called riders—the water supply could be shut off during the night; but that might lead to considerable inconvenience. In Southampton the consumption had been about 33 gallons per head per day on the constant service, including trade purposes. At one time it had been thought advisable to shut off the water during the night; but the idea was abandoned; and since then various means had been adopted to reduce the consumption, though up to the present time no success had been attained approaching that in Liverpool. The Author's method showed not only the amount of waste, but also the time at which the waste took place—and that was a very important matter. Sanitarians who objected to the water-closet system alleged, as one of their objections, that the waste pipe from cisterns was connected with the drain, so that the gases often found their way into the cisterns. Under the constant system that would not occur, but the water

would be supplied in all its freshness and purity directly from the main, and there need be no connection with the cistern except to supply the closet.

Mr. BATEMAN, Vice-President, was happy to find a growing conviction in the country at large that a constant supply was not inconsistent with economy in the distribution of water. The apparatus, the peculiarities of which had been so clearly explained, could not be too highly valued by those who were endeavouring to substitute the constant system for the intermittent system, and to show that in the use of the former no greater quantity of water was necessary than in the latter. He had been instrumental in supplying many towns with water, but with the exception of two or three for the last thirty years they had all adopted the constant system; and in the north of England no other system had been introduced except in very few instances. In 1850 water was brought to Manchester from Longdendale by the Corporation, in place of the previous supply by the Manchester and Salford Waterworks Company, which had been intermittent and insufficient. It was felt that the inconvenience of turning the water on upon the constant system, with the old fittings and pipes, would be so great that the change could not at once take place; so the fittings were all carefully altered, until a time arrived when it was supposed that everything that could be done for the purpose of preventing the waste had been accomplished. The district in which the change had taken place was then supplied on the constant system, and similar steps were taken with regard to other districts, so that in a period of four years the whole of the city was under constant supply. He had been told by the Chairman of the Water Committee in Liverpool, that the serious attention of the authorities was first turned to the question of the introduction of the constant system in Liverpool by a Paper, which he had read to the Social Science Association in January 1867, in which he gave various instances of the economy of the constant, as against the intermittent system, with a view of showing how a constant supply could be given in London with no greater consumption of water than upon the intermittent system. If both distributors and consumers honestly and legitimately did their duty, he believed that a constant supply would be found more economical than the intermittent supply, while the advantages to the consumers were so great as scarcely to admit of comparison. All kinds of objections had been made in London to the introduction of the constant supply. It had been said that it would ruin the water companies, because the people would use such an

immense quantity that it would be impossible to meet their demands. He did not believe it; but very great care must be exercised, and some time must elapse before the constant supply could be introduced into London. More than that, the authorities who had the distribution of the water must be armed with very stringent powers, in order to see that there were no means by which waste might take place. In the Paper which he had read before the Social Science Association, he had given several instances of the manner in which the consumption had been reduced by the substitution of good fittings in place of old and imperfect ones, and by proper house-to-house inspection. One of those cases was that of Cambridge, where, in the first half-year of 1865, when no preventive measures had been adopted, the consumption was 31·2 gallons per head per day; and the domestic consumption, after deducting the trade supply, was 23·1 gallons. A house-to-house inspection was then carried out; bad cocks were replaced by those of the best construction, and the fittings were also improved; so that the result was that in 1866 the general consumption was reduced to 19·56 gallons, and the domestic consumption to 11·1 gallons. In the case of Newcastle, the consumption was so great that the resources of the company were almost exhausted; but the measures adopted to prevent waste reduced it from 55 gallons to 34 gallons per head per day in one district; in another from 60 gallons to 39 gallons; in another from 61 gallons to 25 gallons, and in another from 62 gallons to 26 gallons. Various other experiments were then made, with the following results:—In one block, taking the number of inhabitants at nine hundred and thirty, the meters before the improvements registered, from December 20th to March 22nd, 1866, 32·4 gallons per head per day; and after the improvements, from April 12th to June 26th, 16·6 gallons; while in one district, consisting entirely of tenemented property, where the consumption had been 31 gallons, it was reduced to 12 gallons. He did not wish in any way to depreciate the great value of the invention described in the Paper, but he simply regarded it as a detector and a valuable adjunct to the other means which might be taken for the purpose of preventing waste. He agreed in thinking that it was possible that the Author might have attributed to the Waste-water Meter greater credit than was its due. The Paper showed that, before the meter was introduced, every possible precaution had been taken to detect leaks in the pipes in the streets, and to remedy defects; but the whole of the improvement was put down to the Waste-water Meter. The bulk of that reduction was, he thought, due to the improved taps and the better supervision. In Glasgow,

the water was first introduced from Loch Katrine, in the spring of 1860. In three months the quantity consumed increased 3,000,000 gallons a day. In November it had been 13,000,000 gallons; in March, 15,000,000; in June it sprang up to 18,000,000 gallons. The greatest consumption was between twelve and one o'clock in the day, when the total was at the rate of 22,000,000 gallons; the least consumption being at two o'clock in the morning, when it amounted to about 14,000,000 gallons. The bulk of that 14,000,000 gallons must undoubtedly have been waste. The subject was brought before the notice of the Corporation, and he said that Loch Katrine itself would soon be exhausted if they did not adopt some means to reduce the consumption. Mr. Gale, the Corporation Engineer, had been, upon that, instructed to make a house-to-house visitation, and he found that the waste from badly-constructed and leaky taps alone was as much as 7,200,000 gallons per day, or 20 gallons per head, the value of which if sold for trade purposes would have been about £50,000 per annum. A very rigid house-to-house inspection was then adopted, and the consumption was brought down to about 13,000,000 gallons per day. That figure was maintained for some months; but the people of Glasgow did not like the restrictions imposed upon them, and the town council did not like to be bothered by their complaints, and very shortly the same extravagant quantity of water had been used, namely, 50 gallons per head per day. The consequence would be, that in six or seven years from the present time Glasgow would have to incur an expense of about £2,000,000 in bringing fresh water from the lakes. He believed the population supplied with water in Glasgow was about the same as that supplied in Liverpool and Manchester. In the latter city only 18,000,000 gallons a day had been used on the average, varying according to the season. At present it was 23 or 24 gallons per head per day, one-third of which was taken for trade purposes, leaving about 16 or 17 gallons per head per day as the consumption for domestic purposes and general sanitary purposes. That was lower than the consumption in Liverpool, in spite of the Waste-water Meter. He understood that a very large proportion of the inhabitants of Liverpool had water-closets, whereas Manchester could not be considered a water-closet town. As a rule, the lower orders had no water-closets, though the scavenging of the privies was remarkably well managed by the corporation. The results attained in Manchester, Norwich, Cambridge, and in Newcastle, all depended upon good management, independently of waste-water meters, which, in those cases, could have added but little to the

saving which was effected. The Author estimated that he had saved, on the average, about 7 gallons per head per day by the constant system, as compared with the intermittent system, in the parts of Liverpool where the meter had been introduced; and he calculated that upon the whole population of 632,000, he would be able to save about 4 gallons per head per day, exclusive of trade consumption. The table accompanying the Paper seemed to bear out these figures; but the trade consumption had doubled itself in the last ten years. He wished to ask if the experiments had been tried upon those portions of the town in which the greatest waste probably existed. If that was really the case, the future saving might be expected to be somewhat less than had already been attained. It was stated that the waste from the better class of property had been as great as in the small class; and the Author believed the result he had obtained fairly represented the saving which might be effected in the whole town.

Mr. DEACON said he did not admit that any of the districts had been completed.

Mr. BATEMAN said the Paper appeared to him to prove that it was possible to introduce the constant supply with proper care and protection, at the same time that due economy was practised in the use of the water. It was very important that the fact should be impressed upon the people of London—that, with proper economy and management, a constant supply might be afforded, entailing no greater consumption than under the intermittent system. The quantity of water honestly and legitimately used was constantly upon the increase. In Manchester the increase was, as nearly as possible, 1 per cent. per annum. In 1866 the consumption was about 21 gallons per head per day on the average of the year; now it was about 23 or 24 gallons. This increase was caused by the greater personal cleanliness of the people, and by the introduction of water-closets, garden-watering, &c. One other point to which he wished to direct attention was that in Manchester, under the direction of Mr. Berrey, a system of testing and stamping had been established, by which water fittings were, in a certain sense, guaranteed. That method had been so successful that manufacturers of the fittings now sent their goods to Manchester to be tested and, if approved, stamped; and with the stamp upon them they sold at higher prices than they otherwise would. He was glad that system had been introduced into Liverpool, for he believed it to be the most perfect yet carried out for the purpose of securing good fittings, which he considered to be essential in order to distribute water economically.

Mr. E. CHADWICK, C.B., said it was important to remember the distinction between private distributors and public distributors. When he remonstrated with water companies about the great waste, their reply had generally been, "It is all very well to talk of our reducing the supply, but we cannot govern the public. If any of our inspectors go into their houses, the answer they receive is generally to this tenor: 'We pay your rates, and we will not admit you into our premises, for you have nothing to do with the quantity we consume.'" All the instances of the reduction of waste with the constant supply which had been referred to, with one exception, that of Norwich, were cases in which the supply had been in public hands, and where the person going in to inspect the premises had been a public officer. That made a great difference. The inspector went in uniform, and was received in a different manner from what he would be if he were merely an officer of a trading company. The interests of trading companies had been considered antagonistic, and the public never would cordially work with them as they would with a public authority. He could corroborate the statement that in many places where care had been employed, a great reduction in the consumption had been effected. He had been lately in Berlin, and the manager of the works informed him that while he had more manufacturers and more large consumers there than in any other capital, he had by meterage reduced the consumption to about 17½ gallons per head of the population. Such a reduction could not, however, be accomplished here unless the supply was in the hands of public authorities. Meters could not be forced into the half-million of houses of the metropolis by private companies. The quantity of water now pumped into London was 108,000,000 gallons per day; 56,000,000 gallons from the Thames and 52,000,000 from other sources. He believed that by the introduction of the constant supply, and proper attention to prevent waste, the consumption might be reduced to full half that quantity, thus diminishing the drain upon the Thames, which was so detrimental to the navigation, and at the same time lessening the quantities required from new and improved sources.

Mr. LEMON asked what was the proportion of dry-closets to water-closets in Manchester.

Mr. BERREY said the proportion was 100,000 against 10,000.

Mr. HOMERSHAM said there could be no doubt that the legitimate consumption of water was on the increase, and he believed the increase for domestic purposes would still go on. A fixed bath held from 55 to 60 gallons, and if only two baths full were used in a

household, 110 gallons per day would be required for that purpose only. When baths were more commonly used a great increase in the quantity consumed for domestic purposes must be looked for. Constant supply prevailed in Glasgow, and if the waste from leaks, bad pipes, &c., were remedied, there could be no doubt the amount now supplied would be reduced at least one-half. In Liverpool, notwithstanding the fact that the supply, as at Glasgow, was in the hands of the Corporation, an immense waste had been and was still going on; these two instances were quite sufficient to show, that putting the water supply under public authority was not a certain mode of getting an economical and proper distribution. He could mention fifty or even a hundred towns supplied by private companies, where the use of water on the constant system did not amount to more than 14, 15, or 16 gallons per head per day; he, therefore, did not consider that prevention of waste depended upon the supply being in the hands of the public authorities. The meter invented by the Author was likely to be very useful, for the purpose of ascertaining large varying quantities of water passing in a given time through certain lines of pipe. He did not consider that the meter had been aptly named. It was called "the Waste-water Meter," but he would rather speak of it as a self-registering meter. He had been for many years in the habit of testing the quantity of water passing through mains or into consumers' dwellings or given districts in a town in the following manner. He placed two small hydrants, one before and one behind a stopcock, to which standpipes could be attached in the ordinary way so as to allow a piston meter to be fixed between the hydrants. The connection to the inlet of the meter was fixed to the side the water was flowing from and the outlet connection on the other side. Nothing was then required but to shut the stopcock, and the water which otherwise would pass through that stopcock into the district commanded by the stopcock was registered by the meter, when it was easy to read on the dial of the meter the quantity that passed through in a given time. One of the small meters which he used weighed about $\frac{3}{4}$ cwt., and would give passage to about 700 gallons per hour: similar instruments, however, had been used of various sizes. The Author said that there were three hundred stopcocks in the borough of Liverpool alone opened and shut every day on the intermittent service, which would give two hundred and sixty-six houses, or about sixteen hundred people in each district commanded by a stopcock. The town had been thus already divided into three hundred districts; and all that was required to ascertain the quantity of water passed

into each of the districts was to attach two hydrants, varying in size according to the extent of the districts, one before and one behind the stopcocks, and to fix a meter between them, and in the course of ten minutes or a quarter of an hour the precise quantity of water passing into each district would be ascertained. Over and over again, with a meter of the size he had referred to, he had had the leakage from 30 to 40 miles of main tested in the course of three or four weeks, with one meter only. Some of the advantages of this system over the Author's Waste-water Meter were that the leakage of very small quantities could thus be ascertained, and one meter could be used for a large number of districts: according to the diagram, a portion of the Waste-water Meter was fixed only 1 foot below the ground. In any work under his charge he should be very sorry to have a meter charged with water so near the surface, because the water in it would be liable to get frozen. His opinion was, that it would be found requisite to have another stop-valve, and a by-pass also with a stop-valve in it, to each Waste-water Meter, so that the two stop-valves, one before and one behind, might be shut when the meter required to be taken out and repaired and the by-pass opened. He considered it to be a very serious objection to the meter that it should be so near the surface. The system of putting in hydrants, one just before and one just after each stopcock, which he had adopted many years since, was not very expensive, and, at any time, there was no difficulty in ascertaining the quantity of water passing the stopcocks; this would be especially easy in Liverpool, which had been already divided into so many districts. The Author had said, that before he commenced to carry out his system he took up the pipes in the streets and put in new ones. Of course, under such circumstances, he started with having the pipes tight, but the Author ought certainly to have mentioned what was the relative amount of waste saved by repairing fittings inside the houses, and by remedying bad joints and defects in the pipes in the streets. He, himself, would rather have a couple of hydrants, one before and one behind each stopcock, to admit a meter to be fixed when necessary. With a town thus divided into districts, each containing say two hundred houses, he could ascertain in which district the greatest waste took place, and afterwards by house-to-house inspection would be able to get the necessary repairs executed. If a stopcock on a service pipe at the time the test, by the Author's system, took place showed no waste, it did not follow that the ball-cock in the cistern or a stool-valve used for a closet might not be down at some other time, and a large waste

be thus caused. It was well known to waterworks' managers, that the greatest source of waste in internal fittings had been from allowing stool-valves to closets and the overflow of cisterns to run into soil-pipes and drains. What was wanted was the abolition of stool-valves and a tell-tale pipe to cisterns to discharge waste water outside the house where it could be seen, so that if there was any overflow from the cistern the inspector might at once discover it. With regard to the consumption of water for domestic purposes, he would give one instance of a waterworks, not far from London, which he had constructed in a chalk district, that had been in use fourteen years on the constant system. The service reservoir was 700 feet above the sea, and the district varied from 650 to about 250 feet above the same datum; the maximum consumption in the district, where every drop of water used was supplied by the water company, being 16 gallons per head per day, the minimum being $9\frac{1}{2}$ gallons per head per day, while the mean had been $12\frac{1}{2}$ gallons per head per day. This quantity included the supply for all purposes, the supply to two railway stations, and many wholesale consumers, such as breweries, &c. In that district a leaky pipe could not be discovered by the water appearing on the surface, and the inspectors were obliged to test for all leakage by meter. As much as 100 gallons per minute had issued at a given point, from a faulty pipe below ground, and not a drop had reached the surface, the whole being at once absorbed so porous was the ground in which the pipes were laid.

Sir JOHN COODE desired to correct a misapprehension, on the part of Mr. Chadwick, viz., that there was a difference in the position of a municipal or local authority having charge of waterworks and that of a private company. An Act had been in force for twenty-eight years, by which the surveyor, or any other person in the employ of a waterworks' authority, had permission to enter the premises of any customer supplied by that authority, whether municipal or otherwise, and even in the case of a private individual. Mr. Chadwick was manifestly wrong in his endeavour to institute a comparison between the two cases. Sir J. Coode was Chairman of a waterworks company in a provincial town (not a large one), and it had fallen to his lot to sanction, and, in some cases, to direct the officer of the company to make an inspection of particular houses, where there had been reason to suspect an undue waste of water. No doubt Parliament had given power to waterworks' authorities in the public interest to prevent undue waste. A few years ago, the company to which he had referred belonged to a family represented by two individuals; and he knew

of a still stronger case, within 30 miles of London, where the waterworks belonged to a single individual. Under the 57th section of the Waterworks Clauses Act of 1847, the surveyor, or any other person acting under the authority of that gentleman, had full powers to enter a house in that district between nine in the morning and four in the afternoon, and exercise all the powers and functions that an officer of a municipal authority could do. He would not enter into the vexed question, whether it was more desirable, in the public interest, that waterworks in towns should belong to the local authority or to a company; there was a great deal to be said on both sides of the question; but he wished to correct the misapprehension of Mr. Chadwick, especially as he had endeavoured to build an argument upon it. With regard to the consumption of water, cases had been quoted in which it amounted to upwards of 60 gallons per head per day. There must be something wrong where the consumption was anything like that amount. In the instance to which he had adverted, the pressure over at least four-fifths of the town was due to a head of rather more than 200 feet. In that town the consumption ten years ago had been 15 gallons per head per day, which had gradually increased to 22½ gallons, or 50 per cent., in the ten years. The difference had not been due to waste, but, in a great measure, if not entirely, to increased trade consumption. It showed that, with proper arrangements, well-laid pipes, good fittings, and a constant service, the legitimate consumption, after allowing a margin for waste, need not be much more than 20 gallons per head per day. In London the consumption amounted to 30 or 33 gallons; but he was certain that, with good fittings, under a constant service, it need not amount to more than 20 gallons. If a constant service were introduced, above all things screw-down taps would be a most essential element in the prevention of waste, reducing, as they did, that shock to the pipes from the sudden turning off of the water which had been so injurious to pipes and fittings. Reference had been made to the quantity of water pumped from the Thames and consumed in London. An average of 56,000,000 gallons was pumped daily from the Thames by the five London companies—the Chelsea, the Middlesex, the Lambeth, the Southwark and Vauxhall, and the Grand Junction. They were authorised to take 100,000,000 gallons, but they took a quantity only varying from 53,000,000 in January to 61,000,000 in July or August. Sometimes, when it had been very hot in September, the largest quantity would be taken in that month, notwithstanding the emptiness of London at that season. Recently the East London Company had been empowered

to abstract 10,000,000 gallons a day, but he believed they were not taking quite so much as that. A great deal had been said as to the extent to which the Thames was lowered and prejudiced by the withdrawal of water. The quantity abstracted in 1871-2 would reduce the depth at Richmond about $2\frac{1}{8}$ inches at the time of low water; if the total quantity of 110,000,000 gallons were taken it would reduce the depth 4 inches in the immediate neighbourhood of Richmond. In all cases where the consumption per head per day was referred to, the maximum and minimum pressure in the town ought to be stated; because, manifestly, with a given amount of leakage, it would vary with the head of water. Proper comparisons could not be instituted unless the head to which the town was subject was known. He was not aware whether the consumption in Liverpool varied to the same extent as in London according to the season of the year; probably the Author of the Paper would be able to give some information on this point.

Mr. BRAMWELL asked to be allowed to introduce the observations he had to make upon the Paper by a few words upon the general question of a constant supply of water, especially as applied to London. Those observations would show the value of Mr. Deacon's invention in a case like that of London, or any other analogous cases, if such there were. London was disgraced (he could use no other term) by the fact of its suffering, if not entirely, at all events for the greater part, under an intermittent supply. As far back as 1847 the General Act made it obligatory upon new companies in other towns to give a constant supply. In 1852 an Act was passed, by section 15 of which, after five years, all the metropolitan companies were to give a constant supply; but that Act had been so carelessly drawn as to contain provisions that were absolutely unintelligible, and it therefore became nugatory. In 1871 another Act was passed, and by the provisions of that Act, within six months, the water companies were to issue regulations for the fittings of houses, which regulations were to be complied with before the companies could be called upon to give a constant supply; and, failing the preparation by the companies of the regulations, they were to be made by the Metropolitan Board of Works, and, he believed, concurrently by the Corporation. The regulations were made by the eight metropolitan companies; and, with trifling exceptions, they were identical. He believed that seven were absolutely identical, and that one of them varied a little in the thickness of the pipes in consequence of that company giving water at a less height above the pavement than the other companies were bound to do. Those regulations were submitted to the Metropolitan

Board of Works, who, by the Act, had an appeal to the Board of Trade if they thought the regulations oppressive. The Metropolitan Board of Works consulted him, in company with Mr. Barlow, Dr. Pole, and Mr. Easton, with reference to the regulations. These appeared to be unnecessarily oppressive, and in order to bring the matter to a practical test, they advised that a totally disinterested and eminent surveyor should be employed, and that, with those regulations only in his hands, he should go to houses of various classes, from the highest to the lowest, and ascertain what would be the cost of complying with the regulations before the water supply could be given. Accordingly the surveyor visited houses varying in rental from £11 to £350 a year, and the result had been that the average cost per house throughout the metropolis was estimated at £20. The total number of houses was four hundred and fifty thousand; so that the cost would amount to £9,000,000. At that time the capital of the water companies was £8,000,000; and thus the money to be spent upon the fittings would be £1,000,000 in excess of the then capital of the companies supplying the metropolis. The Metropolitan Board of Works thought themselves bound to resist such regulations. The Board of Trade delegated their powers to a Commission, consisting of the Duke of Richmond, Captain Tyler, and Mr. Rawlinson, who were to hear the water companies, the Metropolitan Board, and the Corporation. When the Commission met, the counsel who appeared said to them, "We are very sorry, but, so far as we know the law, you are an absolutely incompetent tribunal; you are not the Board of Trade." The Commission adjourned for a week, and at the end of that time resolved that they had no powers at all. Thereupon the defect in the Act had been cured by another Act, which was much worse than the evil it had been intended to cure. The Act (which passed through both Houses very rapidly) was briefly this (he was not quoting the actual words but simply stating the sense—or want of sense—of the Act): "When in any Act of Parliament that has been passed or that shall hereafter be passed, any matter is directed to be determined by the Board of Trade, that direction shall be deemed to be complied with if any person or persons nominated by the President of the Board of Trade, or any of the Secretaries thereof, undertake the investigation and determine upon it." With the amended tribunal, they went to work; and the regulations were carefully considered and fought out. The Metropolitan Board of Works had put forward counter-regulations, and the cost of making the fittings according to those counter-regulations would have been only about one-sixth of the

cost under the regulations of the companies. The regulations of the Metropolitan Board had been thought by himself and his friends quite sufficient; the water companies did not think so; and the Commission came to a determination, he believed, more favourable to the views of the advisers of the Board of Works than to those of the engineers of the companies; nevertheless a heavy burden had been laid on the householders of London. Upon the question of the cost of fittings, he had read and heard a great deal of such evidence as this. Mr. A. would say before a Parliamentary Committee, that a $\frac{5}{8}$-inch cock was required, and that the price of it, including everything, was 6*s.* 9*d.*; then that a double-compartment cistern would be required, and the cost of that would be £1 2*s.* 6*d.*; and so he would go on with the list of requirements, costing altogether about £4 for a house of £300 a year rental. But Mr. A. forgot to say that the prices were the values of the things in the ironmonger's shop, perhaps including the fixings; but they were no measure of the damage done to the house itself. It was impossible to lay pipes through a house from the back to the front without cutting through the plaster, and destroying the paper, and the like; and a man would not live in a house seamed with disfigurements of that sort. When, therefore, Mr. Stephenson went, with the regulations in his hand, to the houses, he did as any architect or surveyor ought to do—took into account the total cost of restoring the house to a seemly, habitable, and proper condition; and it was upon that principle that he arrived at the total cost of £9,000,000. Every possible obstruction had been put in the way of carrying out a constant service by the gentlemen who represented the metropolitan waterworks companies. He would give them the credit of supposing that they were doing their duty towards the shareholders; but he was sorry they did think so, because it was contrary to the experience of other towns, and because it caused London to continue to suffer under intermittent supply. It had been shown that, by proper supervision, the constant service, so far from being a source of loss, was a source of profit, and involved less consumption of water. But one London company said, "We have been giving a constant service for years in a large number of our districts." The Commission investigated the matter, and ascertained that in the main pipe there was a diaphragm which the company's engineer called a pea-ferrule. This was a well-known term, and was a proper term when, as the name implied, the hole would pass through it a pea of ordinary size. No doubt such a ferrule in many cases—as in Sheffield, for instance, where in some zones there was a pressure of 300 feet of water—was very desirable, as without

some such reducer of velocity, when a child went to draw water in a jug, the jug must be knocked out of its hand by the water dashing against the bottom; but the contrivance used by the company in question was not a pea-ferrule, it was a pin-ferrule, with a hole $\frac{1}{24}$ inch in diameter; the object being to give 1 pint of water a minute, or from 180 to 200 gallons in twenty-four hours. He could quite understand the engineer of a water company, if he cared nothing about the consumers, and thought only of the share-holders' pipes, considering such a ferrule a capital invention, since it would give a uniform draught upon the mains during the twenty-four hours, and would thus enable them to be adequate for the growth of the consumption and thus to remain serviceable for years longer than they otherwise would. The water company brought forward as a witness a doctor, who said he had drawn a jug of water which came out with a gush, and that he wanted nothing better. He was asked how long the pipe was, but he did not know. It turned out to be about 40 feet long, and that he had drawn a pipeful. He was then asked if he had tried to draw a second jug; but he had not. The Commission paid a visit to some of the taps in Whitechapel fed by this so-called constant service. As soon as the tap was opened, the water rushed out to the extent of about $1\frac{1}{4}$ pint; and after that it dribbled at the rate of about 1 pint in a minute, greatly to the edification of the gentlemen appointed by the Board of Trade, who came to the conclusion that an orifice $\frac{1}{24}$ inch for the supply of a dwelling-house was not a compliance with the demand put forward by the companies' constant supply. Amongst the regulations, for a time, had been one declaring that no bath should have an overflow, because, they said, "Your servant may leave the water running to waste." "But," they were asked, "suppose she leave it running when there is no overflow?" "Then it will come down and spoil your ceilings, and you won't do it again." That was thought to be rather hard, and the Commissioners would not hear of it. Then there was a regulation that no cistern should have an overflow except in the nature of a warning pipe, and that warning pipe was to come out where it could be seen by the company's officers as they passed. That might be all very well in detached villas, with several sides visible; but in the case of rows of London houses, where the cisterns were at the back, what was to be done? "Why," they said, "it must be brought through the house to the front." In such a case, suppose the ball-tap to be accidentally stuck fast in the open position, what would happen when the cistern became full? The water would rush out of the

warning pipe without warning. If a lady was passing underneath with a new bonnet, down would come the water from the warning pipe, and what possible excuse could be given by the householder for spoiling her bonnet? He would certainly have to pay for it, and would not be allowed to plead the waterworks regulations. The companies then said that was not what they intended; but that what they proposed had been to bring the pipe to the front of the house and out at the level of the street. He had done this at his own house, and had spent £25 in complying with the amended regulations, but he had not got a constant supply. By the time the pipe was brought from the cistern at the back, through the house to the level of the pavement in front, the cost would, of necessity, be considerable. Again, on the question of cisterns, the Metropolitan Board urged that the essence of a constant supply was that no cisterns would be required. "But you cannot connect the service without a cistern," was the reply. The companies were then asked, "Did you ever hear of the 'Upward' drill?" "No, what is that?" It was a machine, they were told, by which a pipe might be tapped into a steam boiler, with steam of 100 lbs. pressure to the square inch in it, without any coming out. But they could not believe in the efficacy of the 'Upward' drill, and, to convince them, it had to be put to work, subjected to 350-feet head of water, under the guidance of Mr. Easton at the South Essex Works. "Well," said they, "perhaps that might do, but who ever heard of an 'Upward' drill?" That difficulty being overcome, the companies said, "It is all very fine; you may do what you like; seven out of the eight companies have by their Acts the power to compel you to provide cisterns, and constant supply or non-constant supply, you shall have them." That was the way in which the matter was left. They said, however, "We will concede this: you may have close inside the door a stopcock with two branches; and from that stopcock you may lay on two pipes, one to go to the cistern, and the other to supply water for drinking and culinary purposes." It was urged that two pipes from one stopcock would be rather expensive: why not take the water out of one pipe on its way to the cistern? "But," said they, "we have ordered two pipes." "Why so?" they were asked; and no answer had been given to that question. The Commissioners said that they really could not be serious in the proposal; and when they cross-examined them upon it they were not serious; it was too great a joke. They were asked whether, if a servant went to the wrong pipe and drew some of the potable water and used it for scrubbing a floor, would

they send her to the treadmill? Another regulation was that, although cisterns were to be maintained, and thus the pipes under the houses were subjected to no more pressure than before, nevertheless every pipe and every tap must be altered to a given standard, because they were under high pressure. The reply was, "If we are compelled to keep the cisterns: we are not under high pressure; constant supply means high pressure, and it is not constant unless you get rid of the cisterns." "Then," said they, "you shall not get rid of cisterns." It was in compliance with such vexatious demands as these that the bulk of the £9,000,000 of money was to be spent before London was blessed with a constant supply. These recollections of the inquiry before the Board of Trade Commission, in respect of a constant supply for London, led him naturally to the subject of the Paper, for he thought that if they could have gone before the Commission and said, "There is a method by which you may safely put on a constant supply without making a sweeping change in the fittings of all the houses, a method by which you may know when and where the change is required," the Commission would probably have said, "Adopt this plan: go to work with the constant supply, and make the alterations where they are needed." He thought Mr. Berrey, Mr. Bateman, and Mr. Homersham did not quite do the Author justice. Mr. Berrey, the officer of the Corporation of Manchester, said, "Nothing will suffice but house-to-house internal inspection." No doubt he had done a great work in Manchester, and every one who knew him would give him the highest praise as a zealous and intelligent officer, one who had sufficient discretion not to make himself and the regulations offensive, and yet to do the work well. But such officers could not always be obtained, and even if they were obtained people objected to a power of entry into their premises being given to any inspector, whether he were the servant of a corporation, or of a company, or of a single individual. People objected to the intrusion of men from the waterworks because they had bought 10 gallons of water. It was felt to be an annoyance, and there was every reason why inspection should be resorted to only where it was really necessary. It had been said that the Author had taken too much credit to himself, because, before he put the Waste-water Meter to work in a district, he first of all ascertained whether the pipes and mains and fittings were in good order, and if not, he repaired them to the best of his ability; but, except with the four experimental districts, this had not been so, and Mr. Deacon had taken credit for saving under this head. Moreover, an indiscriminate house-to-house inspection, as advocated by Mr. Berrey,

would not show what was the matter with pipes under the street. However a house-to-house inspection might be made, it involved the preliminary examination of pipes under the street and the putting them right, or the waste from them would go on. House inspection had nothing to do with that question; it clearly could only be of use in detecting the adequacy or inadequacy of the house fittings; and with respect to how the invention had acted, the diagrams exhibited by him (Plate 5) showed the consumption when certain districts were supplied with an intermittent service, and again when those districts were put upon the constant service; and it was seen that the amount of water supplied to those districts upon a ten and a half hours' service with thirteen and a half hours' intermission was more than the water supplied by the constant service. Therefore the Author might at all events take credit for doing that which alone in the outset he had attempted to do. His problem was, without increasing the present consumption, to restore to Liverpool, by degrees, the benefits of a constant service: and having done that, afterwards, by further improvement, to reduce the consumption as far as was consistent with the just wants of the inhabitants. That was what had to be done, and what he was inclined to think the diagrams proved had been done. About a year ago the Water Committee of the Corporation of Liverpool consulted him about the Waste-water Meter. He went to Liverpool, prowled about the streets at night in the most disreputable neighbourhoods, and saw the operation of the meters, trying them also for accuracy against standard tanks. He had two points to ascertain: one, whether the meters did or did not detect waste; the other, whether they were in themselves fairly accurate; and he was glad to say the results on both heads were highly satisfactory. He examined the operation of the meters about eleven o'clock at night. At one place they found 3,000 gallons of water an hour passing through. Going down one of the streets of the district, containing eighty or a hundred houses, they went to the stopcocks, and stethoscoped each house. He did not pretend to be able to hear a waste equal to a mere dripping making its way through a stopcock, but he could hear a few gallons an hour going through. The different stopcocks were tried, and where a sound was heard they were stopped. Then when they came back to the meter, they found, instead of 3,000 gallons, 300 gallons an hour were passing through. The fair inference was that the houses where the stopcocks were shut off caused 2,700 gallons an hour consumption or waste, and that the other houses had been practically causing no waste. That being so, there was good ground, on the following day,

for sending inspectors, not to the one hundred houses, but, say, to the ten houses where the waste had taken place. In almost every instance the inspectors had been able to trace the cause, and the people could not complain of an inspection which had been proved necessary by the result. It was said that the people would know when the inspection was going to take place, and would stop the waste; but if that were true with regard to a night inspection, it would be much more so with reference to an inspection in the day-time; for a child might be sent to put the ball-tap right, and stop the waste at once. Mr. Homersham, although he had spoken adversely to the meters, really bore the strongest testimony to their necessity. He said he had been in the habit of going to a part of the town where there was a stopcock, and, having shut it, he connected a hydrant on one side to a hydrant on the other by a pipe going through an ordinary meter which he carried in a wheelbarrow, and then by looking at the meter he ascertained the consumption. Thus he admitted it was necessary to use a meter to find out the consumption; but in a town like Liverpool, whatever might be the case in a small place like Caterham, it would be a very clumsy expedient to carry about a meter in a wheelbarrow, in the way proposed—a meter, moreover, which preserved no record of what took place. He thought it was far better to have an automatic record such as that afforded by the Waste-water Meter, which showed the consumption from minute to minute, and preserved the record. It had been said that the cost of the meters with the stopcock was £39 7*s.* per thousand persons in Liverpool, making a total of £35,000. Taking the population of London at seven times that of Liverpool, the amount would be £245,000 to be expended before constant service could be given to all London, as against £9,000,000, the cost of complying with the regulations proposed by the waterworks companies' regulations, which they insisted upon before the supply was made constant.

Mr. Rawlinson, C.B., said the question of preventing waste of water was one of the most important connected with domestic water supply. It was a question that must receive the intelligent attention of engineers. Water supply upon modern principles was a necessity of civilisation. As town communities were organised, they could not do without it, and that should be the only permissible supply which gave water in abundance, under pressure at every part of the town, to the highest part of every house, and to the abolition of every other form of supply. A supply as given to ancient Rome, to modern continental cities, as to Paris, and to many towns in England at the present moment, which was

only partial and intermittent, which permitted the water cart to go about or the water carrier to intervene, was simply an abortion, a thing that should not be tolerated, and the sooner it could be brought to an end the better. The water that was intermittently distributed, whatever its quality when it was turned into the pipes, would probably, before getting to the lips of the consumer, be contaminated with atmospheric impurities, and so be unfit for drinking. He would not travel over the ground as to the modes of preventing waste. Whether Mr. Deacon's mode were introduced, or house-to-house inspection relied upon, inspection in some form must come, and the less that inspection interfered with privacy the better. With regard to the water supply to London, he necessarily knew something about it, since the water inspectors' reports were passed over to him from month to month. The Government compelled the water companies to employ and pay a water inspector and an auditor (appointed by the Board of Trade). The inspector, Major Bolton, made his reports monthly; and these had been of the greatest possible benefit to London and to the companies themselves. His attention being turned upon the mode of distribution, filtration and the volume supplied, had brought the companies into quickened life; and he was quite sure that those who had interested themselves as to the water supply of London for the last three years must have observed a gradual improvement. Some companies had been making efforts to give a constant supply, notoriously the East London Company; but the Engineer of that company, of whom he desired to speak with the greatest possible respect, had seen fit to introduce that "abomination" which Mr. Bramwell had called the pin-ferrule, which he hoped would be ultimately got rid of. Constant supply meant, at present, a supply to the poorer districts of East London by external standpipes. Unless those external standpipes were of the strongest possible kind, and put in places where they could not be injured, they would be very soon out of order and waste the water. Again, if these standpipes were as perfect as possible, they involved drawing the water externally, taking it into the house, and keeping it, if it was to be used during the night, in some vessel liable to the atmospheric contamination of the room. That, therefore, was not a constant supply in the sense understood by all true sanitarians. The great waste of water in some towns had been deliberately practised as a mode of self-defence, to wash out the soil-pans and to flush the house-drains, where these had been improperly placed, that was, within houses—neither drains nor soil-pipes having

any ventilation other than to the corridor, passage, or room. These mal-arrangements brought discredit on water-closet and house-drain appliances, because they were at all times a nuisance and frequently dangerous; and wasting water by propping closet-valve handles, and leaving taps open, did not remove the danger. A drain should not enter any house, a water-closet should be against an external wall, and a soil-pipe should pass above the roof having the top open. There should, in fact, be no means of admitting sewage gases within the walls of dwelling-houses. At present, many water-closets and sinks were placed upon staircase landings, betwixt bedrooms and within bedrooms, the soil-pipe, the sink-pipe, and the drain forming a direct communication from the sewer to the interior of the house. The danger and mischief in such cases being greater in winter than in summer, as doors and windows were then kept shut, and there was consequently a pull or draught on the sinks and closets, drain-cracks, rat-holes, and ruptured soil-pipes—the drains being flues from the sewers, the soil, and the sink-pipes, continuing to the rooms. It was convenient to have hot and cold water laid on to bedrooms, dressing-rooms, and baths, and to have a water-closet easy of access; but if these conveniences brought sewer-gases into the rooms, the danger to health far exceeded the convenience. Waste of water there would be in houses so defectively arranged, and the water-waste-inspector would be opposed, disliked, and cheated. With regard to the cost of inspection by the apparatus applied by Mr. Deacon, in order to make a fair comparison, it would be necessary to know the cost of the present intermittent supply in London. He could not give any wages account; but he could state the number of men employed. Some years ago Chelsea had twenty foremen and turncocks, East London forty-three, Grand Junction fourteen, Kent one, Lambeth thirty-eight, New River ninety-eight, Southwark and Vauxhall eighteen, West Middlesex twenty-eight, making a total of two hundred and sixty men, whose duty it was to perambulate the streets, and shut off and turn on the water at various times. It might be imagined that the engineers of the companies would instruct these men to give information day-by-day of any visible waste at the street surface. Such instructions might be given for aught he knew; but they certainly were not carried out. He had lived twenty-five years in London, at the West End, and, not once nor twice, but in hundreds of instances, had he seen the hydrants, valves, and (he assumed) the mains, leaking to an extent that would have filled a 1-inch pipe, or even a 2-inch, and in some cases a

3-inch pipe—those leaks going on unchecked and unattended-to for days, weeks, and even months. That certainly showed great negligence. The turncocks necessarily passed those visible leakages as often as he did. If this occurred in the few streets that he traversed, showing this volume of waste at the surface, what must it be in the gravelly subsoil of a great portion of the plateau of London? It had been said that the volume of water (for the most part pumped into the metropolis) varied from 101,000,000 up to 125,000,000 gallons per day, amounting to 32 gallons per head per day, and that probably a moiety of the population did not get 10 gallons per head per day. Surely there should be some change to prevent so excessive a waste. He was not about to advocate Government supervision so as to supersede local administration in regard to water supply. With our free institutions and our habits of free action, municipal bodies had far better be left alone. But water was an exceptional commodity, and might therefore be treated exceptionally. He would not have it sold by trading companies to make a profit, selling the least volume at the greatest price. If he could have his way, he would put the supply of water into the hands of municipal institutions, with a power of appeal by any of the aggrieved ratepayers to a tribunal that should arbitrate between them. He did not advocate this because of any gross mismanagement on the part of companies; but because the supply of water should be upon communistic, and not upon trade principles. In London a man was rated upon his rental, and not upon the volume of water that he used; so that the rich paid for the poor. He was himself rated at £12 or £14 a year for the water he used, and he could safely say that no waste had been permitted in his house since he took possession of it. His poorer neighbours in the East of London had only to pay 10*s.* or 12*s.*, and no doubt many of them used three times the quantity taken by himself. He, however, thought it right and fair that they should have water without having any more to pay; that, however, removed it from a trading speculation. Water could not be dealt with like milk and beer, and therefore the sooner the supply was placed in the hands of municipal institutions, under proper regulations, with power of supervision, the better. He wished briefly to say that there was no mode, neither Mr. Deacon's system nor the Manchester house-to-house inspection, nor any other, that superseded the prime necessity of individual thought, and it would always be upon the judgment, care, and unceasing supervision of the resident engineer that success would depend.

Mr. HANVEY remarked that he wished to give a few details of the efforts made at Dover to prevent the waste of water and secure a constant supply. These had been carried on for fourteen years, and had not yet been successful. The works had been constructed in 1855 and 1856: about five hundred houses were connected, and between the hours of 1 A.M and 2 A.M. (the mains having been charged at twelve o'clock at night so as to fill the cisterns) the consumption had been at the rate of 30 gallons per house per hour. This went on increasing until in 1866 the consumption, in three thousand five hundred houses, had been 76 gallons per house per hour at the same period. The works had been started with the intention of giving a constant supply, and, in order to carry out economy, in first cost, of fittings the miserable expedient of stool valves and stopcocks direct from the main had been adopted. The result might easily be imagined. Two thousand seven hundred closets were supplied in this manner direct from the main. In at least a third of the cases the stool valves and stopcocks were left running while the water was on, and hence the large amount of water going to waste. The water was turned on at night for experimental purposes. At the time when the 76 gallons per house were being used, between 1 A.M. and 2 A.M. the water had been laid on for only nine hours per day, but it was now supplied for eleven hours. The Corporation had been advised by Mr. Hawksley that unless they altered their fittings and substituted a waste preventer all efforts at inspection would be utterly futile. Besides the great waste, there was the sanitary risk involved in a supply direct from the main to the water-closet. One filthy basin might, when the mains were emptied, produce an epidemic. In addition to the inspection, he had been employing a Hood's screw meter, large enough to supply five hundred houses, and by attaching another meter the water could be carried on to a thousand houses. He believed that Mr. Deacon's meter was a most valuable one, especially when coupled with the automatic registering apparatus. He thought, however, that the vertical mode of fixing was rather inconvenient, and that if the spindle were fitted horizontally, its application would be far more simple, getting rid of the objection to which Mr. Homersham had alluded. It had been stated that municipal bodies had powers of entry. That was not so unless they had a special Act. Under the Local Government Act they had no power of entry, and no sufficient power over the character of the fittings. That was a matter for legislation, and the sooner it was obtained the better.

Dr. POLE observed that, as the Author had referred to some reports of his, it would, perhaps, be right to state what they were, bearing as they did on the subject of a constant service in London. He need hardly say that the intermittent mode of supplying water was not a natural mode; that the most natural method was a constant service in pipes, under pressure, as in the case of gas. It would be thought a strange thing for a gas company to say to its consumers, "You must put gasholders in your houses; we shall turn on the gas under pressure during an hour or two in the day; you must collect during that period what you want and burn it from your gasholders." That, however, was what had been done in the case of water. The reason was that, as the supply of towns grew to considerable magnitude, it had been found that, on account of waste from the fittings, the water could not be laid constantly on under pressure, and thus the intermittent system arose.

It had been mentioned by Mr. Bramwell that as early as 1850, the evils incident to the intermittent system had been noticed in the metropolis, and that the Act of 1852 made provision for the introduction of a constant supply. That, however, failed, and there had been an inquiry, called the East London inquiry of 1866, which had for its object the solution of the problem why the provision in the Act had failed. The reasons for that failure had been stated at some length in the report; but about that time a Royal Commission had been appointed, of which the Duke of Richmond was the president, the President of the Institution a member, and Dr. Pole was the secretary. That Commission undertook, among other inquiries, the investigation of the constant-supply question in regard to London, and came to the conclusion that the difficulties were so serious, and that the powers required would be so large, as to form one among many other reasons why the supply of London ought to be transferred from the companies to the municipal authorities.

The Government found that this was far too large a question to enter on at once; but they wished to do something, and they thought that what they could do best was to endeavour to introduce a constant service. They then consulted him, and requested him to inquire into the difficulties in the way of a constant service being introduced into London, and how those difficulties could be best overcome, without the sweeping measure of transferring the companies to municipalities. In accordance with instructions, he went to several towns, and made various reports, to which the Author had alluded. Among other places he went to Norwich, which, under the direction of Mr. Hawksley,

Past-President Inst. C.E., had had the credit of being one of the best examples of the constant-supply system in regard to economy and perfection of detail. Norwich had gone through three phases. There had first been an intermittent supply; then the company had endeavoured to introduce a constant supply, but they found that the waste was so enormous that it was impossible to carry it out. Following Mr. Hawksley's recommendations, the authorities struck at the root of the evil, namely, the bad state of the fittings, and obtained an Act empowering them to alter the fittings in such a way as to prevent waste. After a considerable lapse of time and with a good deal of difficulty, that method was carried out with such success that the consumption—although there was a liberal supply for all purposes required—was now the smallest known, namely, 10 gallons per head per day for domestic purposes, and 4 gallons for trade purposes. He also visited Manchester, where, as already stated by Mr. Bateman, by a great deal of exertion the same thing had been accomplished by attacking the waste at the fittings. He found, also, an interesting state of things in Sheffield, where the inhabitants were going through the process of compulsion in regard to fittings. He likewise visited Liverpool, before Mr. Deacon took charge of the work, and found great waste there. The attempts to check it he thought had not been so energetic as they might have been, and as they certainly were in other towns. The authorities were attempting to use inspection, but they were not applying stringent regulations. It was believed that the inhabitants would not submit to coercion. The Author had explained what had been done since in the way of preventing waste; and the result had been exceedingly creditable to him as the officer who had carried out the intentions of the Corporation. Whether the evil did not lie still deeper than could be ascertained by a mere inspection according to the method pursued he did not know. He was inclined to think that the rules as to fittings were hardly sufficiently stringent. If the waste was to be efficiently checked, the fittings would have to be still further attacked. In Glasgow the entire neglect of the fittings, and the impotence or indifference of the municipality regarding them, had produced a lamentable state of things. Dr. Pole was there very recently, and on going into a water-closet he saw a string deliberately placed for the purpose of enabling any one who went there to tie up the water-closet handle. The result of such a state of things was what might be expected—a consumption of 50 gallons per head per day.

He made his recommendations in the published reports, and he

believed that on those recommendations the Government framed the Act of 1871. He had the honour of being their chief witness before the Parliamentary Committee, and the Act passed, which, in a tangible and practical form, put a constant supply within the reach of the metropolis. At present any service district—any block of buildings attached to one service pipe—might have a constant supply at the instance of the Company, the Metropolitan Board, or the Board of Trade. If either of those bodies made a request to that effect, the regulations which Mr. Bramwell had described, and which he thought were now moderate in their nature, had to be enforced—screw-down taps, valve ball-cocks, pipes of a certain strength, water-closet service apparatus, and the abolition of waste overflows in cisterns. There was one point which Mr. Bramwell, Mr. Barlow, and himself succeeded in obtaining for the inhabitants, namely, that the old fittings, if they were sound and did not waste water, might remain until they did so, and that was still the law.

It had been a matter of some surprise to him that the Act was as yet almost a dead letter. The inhabitants objected to the expense of the alterations, and the Board of Works had not put the Act in force for that reason. He did not think that the expense would be very great. He had had a constant supply laid down in his own house, by the liberal co-operation of the Grand Junction Company, in accordance with the regulations, and it answered exceedingly well.

One of the greatest difficulties in the way was the plumbing. It had been stated before that the plumbing in London, generally speaking, was most disgraceful, and he, from his own experience, fully corroborated it. Before a constant service could be made general in London something would have to be done to remedy that state of things. In the metropolitan regulations the subject had not been introduced, because it was thought that there was no legal power to do so, but the water authorities of Norwich, Manchester, Sheffield, Liverpool, and other places where the waste of water had been successfully checked, had been obliged to coerce the plumbers, and to introduce rules by which they could be brought under compulsion to do their work properly. It would be, no doubt, very difficult to get that done in London in the present state of the trade. In regard to his own house he had at first despaired on this ground, but he had fortunately found an intelligent tradesman who was willing to be guided, and who gave him every assistance in getting the work properly done, so that his house was an excellent example of the constant supply. He could hardly state the exact cost, because

he had done other general alterations, but the part of the work absolutely necessary for the constant supply had been but small. The consumption, although his household were not sparing in the use of water, was exceedingly moderate—not more than 10 or 12 gallons per head per day, and not a single drop of water was wasted from one year's end to another. If every house in London had a similar supply, with a similar consumption, instead of 33 gallons per head per day as at present, it would be a very good thing for all concerned, and he wondered why the companies were not more energetic in introducing the system.

It had been stated that the quantity of water legitimately used was increasing. No doubt that was the case to some extent, but there was a great deal more water used than was necessary. A bath, for example, was a very extravagant thing as ordinarily used. Anybody who would take the trouble of looking into the hydropathic system (which must be admitted to be the most perfect model for the therapeutic use of water) would see that the best possible effects, for enjoyment, for cleanliness, and for health, might be produced if the water were scientifically and judiciously applied, with only a fraction of the volume devoted to a bath of the ordinary domestic kind.

He believed that the Author had done good service by his invention, but he still thought the outside tell-tale would never do away with the necessity of coercing the inhabitants to adopt proper fittings. It might enable the authorities in some cases to ascertain where the fittings were bad, but universal experience had shown that, unless the inhabitants were ruled, in this respect, with a rod of iron, they would never succeed in getting an economical supply.

Mr. DEACON, in replying upon the discussion, remarked that if every speaker did not agree with his views, it was apparent that those who opposed them did not agree with each other. It was scarcely to be expected that a system for which he had claimed such great advantages, and of which time had not enabled trials to be made on a large scale in other towns, should be unanimously accepted by the profession, even though—and this it appeared to him had sometimes been half forgotten—all the statements made respecting it were the results obtained by actual practice, not in a small town or village, but on a scale such as had rarely been presented for the trial of any experiment.

Mr. Berrey, the officer charged with the supervision of the changes in the domestic water fittings of Manchester at the time when constant service was given to that city, naturally advocated

the system which had been adopted there. He had not, however, explained what that method really involved.

In 1847 the Corporation of Manchester obtained an Act of Parliament which incorporated the Waterworks Companies Act of the same year. That Act gave power to enter houses and to exact penalties for waste of water. After seven years' experience it became manifest that those provisions were insufficient to secure the objects intended, and the Corporation desired to increase their powers, particularly as to the quality of the fittings to be used; they therefore, in 1858, went to Parliament and obtained powers to refuse to supply water to any apparatus not so constructed as to prevent waste; but even with that provision they had been unable to reduce the consumption to the required extent, and they applied for and obtained, in 1860, a clause empowering them to prescribe the nature in detail of all new fittings, and to interdict the use of any existing fitting whatever. There were other clauses in the Act with respect to penalties, and with respect to the alteration of fittings, for which they had taken power to charge the owners. But even then they were not satisfied; and they obtained further and more stringent clauses, and ultimately they were enabled to maintain the constant service which had been given on the introduction of their new and abundant gravitation supply. Now it was the powers, or absence of powers, contained in that very Waterworks Clauses Act of 1847, which so utterly failed in the hands of the Manchester people, that the Liverpool Corporation possessed as their sole means of reducing the waste, except in connection with water-closets, which being comparatively uncommon in Manchester did not affect the question; and like the Manchester authorities, the Liverpool Corporation also failed. At this stage began the differences. While the Manchester Corporation were obtaining extended powers enabling them to order the absolute renewal of all water fittings, and were instituting house-to-house inspections of those fittings, the Liverpool authorities had been merely adopting the house-to-house inspections, as the best method they knew for discovering the largest proportion of the actual waste, in order to bring as many defective fittings as practicable within their limited powers. Neither Manchester nor Liverpool possessed any means of discovering hidden waste, except by the occasional want of local pressure or the rising of water to the surface. They were therefore dependent for success almost entirely upon the prevention of superficial waste. The Manchester authorities reduced the waste greatly because they had power to insist upon new fittings being

provided in all cases; those of Liverpool could only retard its increase.

Since 1871, when he first took charge of the Liverpool Waterworks, every effort had been made to reduce the consumption by house-to-house inspection; and so entirely did he at that time participate in this view, that, in 1872, he wrote a report to the Water Committee, the conclusion of which was in substance as follows:—To remedy the excessive waste in Liverpool, as compared with Norwich and Manchester, powers are required to prescribe the specific kind of fittings; to require them to be inspected and stamped before being fixed; to license plumbers, and to order the alteration of all existing fittings that are liable to cause waste. As a consequence of that report, and of previous investigations made by the Committee, a bill was prepared, but, owing to the operation of the Borough Funds Act, it never went to Parliament.

It was now obviously hopeless to depend upon the house-to-house inspections, even with an increased staff, and the necessities of the case turned the Author's thoughts in other directions. He sought for an entirely new method by which a large portion of the waste from fittings could be detected, and by which the waste from pipes and mains could be brought to light.

The system had been fully explained in the Paper, but the tenor of the discussion would lead to the supposition that the advantage of it had not been fully apprehended. It might be explained more concisely as follows:—Under the old system of house-to-house inspection four men could not inspect an average district of three thousand persons or five hundred and fifty houses, and make the returns in less than four days. The same number of men would, under the Liverpool system, examine the same district and make all the returns for two days' wages. They would find all that the house-to-house inspectors found, and they would probably, in addition, detect hidden waste, which would multiply the saving by more than three (see pages 155 and 156). Evidently therefore, the work performed by a single man, under the system described, was more than six times that done by the same man by the ordinary method. This assumed also that the house-to-house inspectors worked conscientiously; but the system of check which the Liverpool arrangement involved, added to the concentration of the men's attention on the most fruitful districts, raised the relative work performed considerably higher than even six to one. It need not, therefore, excite surprise that he should advocate the entire abandonment of ordinary house-to-house inspection. Mr. Berrey's statement, that without house-to-house inspection the

constant waste caused by defective fittings or wearing out of fittings could not be ascertained, was unfortunate, in the face of the fact that the waste had been ascertained in a surer and more economical manner in Liverpool. Possibly some of the speakers might have misunderstood what he meant by the abandonment of ordinary house-to-house inspection. An inspection of every house was still made, but only from the outside, and no house was entered until inspection had disclosed a waste of water.

The next objection had been to stopcocks outside houses, and fear had been expressed that the water in them would freeze, and that serious claims for damages might arise, as the public authorities would be responsible in case of accident. But the first danger did not exist in practice, as the stopcock was out of reach of frost; as to the second, no such claim ever had been, or evidently could properly be made; most waterworks' engineers now placed the stopcock outside, as the position had other obvious advantages. The opinion had been expressed that the Author attached too much importance to the discovery of waste by the noise of water, because the passage of water for useful purposes was continually taking place. This, however, was not the case; an instance of water flowing into a cistern at the time of a night inspection rarely occurred, and had never led to any difficulty; indeed the character of the diagrams of nocturnal consumption on Plate 5 showed that it could not be so. Mr. Berrey's convictions were all based upon his experience of house-to-house inspections with practically unlimited powers to back them up, but if the Manchester Corporation had not possessed those powers it would doubtless be admitted that the method adopted by them was not perfection. Mr. Bateman had been misled by a statement at page 141 which referred only to four small districts, where for experimental purposes the iron mains had been renewed. This work had not been general, and a great saving was being effected in the cost of maintenance of such mains. Nor had the bulk of the reduction been due to the improved taps and better supervision; improved taps had only been fixed where the system in operation had showed them to be necessary; and the internal supervision, except where the system pointed out a leak, had been entirely abandoned. The largest part of the reduction had been due to the repair of hidden defects in pipes below ground, and the rest to repairs of fittings, or to the substitution of the best fittings for defective ones which were incapable of proper repair. Notwithstanding his praise of the Waste-water Meter, Mr. Bateman remarked that in spite of its use in Liverpool the consumption was higher there than in

Manchester, a place which had enjoyed for fifteen years the practically unlimited powers of which he had already spoken. Without any such powers operations had been commenced in Liverpool seventeen months ago, and last month 234,000 persons, to whom the Waste-water Meter system had been applied, but with respect to whom its provisions were still incomplete, were taking on constant service, for domestic, sanitary, shipping, and all trades except certain manufacturers supplied by meter, only 16·47 gallons per head per day. These extraneous supplies probably exceeded 2 gallons, and in Manchester they were measured by meter. The domestic and sanitary supply in that part of Liverpool might therefore be taken at 14·5 gallons. Mr. Bateman stated that Manchester consumed 16 or 17 gallons per head per day for domestic and general sanitary purposes. This was the result of fifteen years of house-to-house inspection in a town where water-closets had been, as compared with Liverpool, very little used and was more than in the Waste-water Meter districts of Liverpool even in their incomplete state.

Over the whole district of 634,000 persons the consumption was probably at present a little higher than in Manchester, but a large portion of the town had not been dealt with, and yet the diagram on Plate 4 showed how greatly the total consumption was reduced in spite of the rapid restoration of constant service. The Waste-water Meter system had been applied to all classes of property, but the out-townships, where he expected the greatest saving, had as yet received but little attention. No attempt had been made to complete the prevention of waste at present, the object being merely to restore constant service as quickly as possible, and thus the first savings had been absorbed in each district. When constant supply had been everywhere given there was every prospect of a further reduction of waste.

He inferred that Mr. Homersham had scarcely apprehended the full purpose to which the Waste-water Meter had been applied when systematically adopted as in Liverpool. The method of testing the quantity of water supplied to a district, by causing it to pass through a small portable meter by inlet and outlet hydrants, placed respectively before and behind a valve on the main, had often been adopted, and had in some instances proved useful, but it could in no case serve as a means of attaining the economy resulting from the more complete system. He had much experience of the advantages capable of being attained by the use of piston meters, for the piston meters had controlled the supply to more than 31,000 persons. It had, however, become

apparent that no satisfactory result could be obtained without leaving a locomotive meter in its place while the leaks were being detected, and while the work was being renewed, and the result of those repairs ascertained; but even if this was done, such a systematic treatment as that now adopted would be impracticable. A knowledge of the quantity of water passing into a main, during an experiment lasting a few minutes, could not be obtained by the method mentioned by Mr. Homersham. A $\frac{3}{4}$-inch piston meter might be carried about, and hydrants might be fixed on each main whereon to attach it temporarily; but the reading taken from such a meter placed on a 3-inch or 6-inch main would be delusive unless the flow of water were small in relation to the size of the main. Even then the water wasted would not be distinguished from the water used; the process would take two or three men at least, and would occupy a considerable time for each main; and an erroneous figure would be obtained for one district in the same time that a single inspector could obtain full information with respect to a number of districts by taking off the complete diagrams, distinguishing water wasted from water used, as shown on Plate 5. The same speaker had fallen into a mistake concerning the number of persons to each meter district, as would become obvious on reference to sections 9 and 12, pages 145 and 160. In former times the authorities of Liverpool had not been idle in these matters. Besides the Author's investigations, the late Mr. Duncan, M. Inst. C.E., had adopted, with great energy and ability, almost all known means; but the meters then available were only piston or turbine meters, which might be called "integrating meters," in contradistinction to "differentiating meters," which recorded the rate of flow for every instant, and therefore the nature of that flow. It was a mistake to suppose that a small discharge could not be ascertained by the Waste-water Meter; for smaller quantities could be read than had ever been found to pass through any service main, the smallest dribble, in fact, from a single tap was registered, while the size of the main alone limited the flow.

Only the dry part of the Waste-water Meter was within 1 foot of the surface. The portion charged with water might be kept at any desired depth, and the fear of frost was shown last winter to be entirely unfounded, for eighty meters had been subjected to one of the most severe frosts which had visited Liverpool for years, without a single case of freezing. The objection by Mr. Homersham that "it would be found requisite to have another stop-valve and a by-pass also with a stop-valve in it, to each Waste-water Meter,

so that the two stop-valves, one before and one behind, might be shut when the meter required to be taken out and repaired," would be true of any other meter, but it could not be true of the Waste-water Meter, for by raising the cover and removing five nuts, the frame, Fig. 11, Plate 6, might be lifted out, and with it every portion of the meter except the outer casing, which was really part of the main. A blank flange being placed upon the opening, the water might be turned on again as if no change had been made. Experience, however, had shown that the only repair required was the renewal of the bush J and wire I: this could be done in ten or fifteen minutes at a cost of 2*s.* 6*d.*, and in such cases even the blank flange was not used.

The supposition that the pipes under the streets of Liverpool had been renewed had been contradicted by Mr. Bramwell. If so great an expenditure had first taken place the Author would not be justified in regarding the work as the most economical of the kind which had yet been accomplished.

The consumption of water in Liverpool was influenced both by the temperature and rainfall. It fell with the temperature down to 32° Fahr. and was diminished by rainfall. Frost, however, always produced an increased expenditure owing to breakages. The highest consumption was usually in July, the lowest in November; the difference being about $2\frac{3}{4}$ gallons per head per day, but this included water for garden and street watering, and for flushing drains.

The account by Mr. Rawlinson of the staff of foremen and turncocks, and of the obvious waste in London giving faint tidings of what was taking place unseen, showed the pressing necessity for systematic arrangement by which such news would at once be conveyed to the authorities. Under the Liverpool system it would be the fault of the heads, and not of the servants of the department, if such cases existed.

Such a system as that adopted in Liverpool was evidently required in Dover. It would be necessary to deal stringently with all cases in which waste had been actually discovered, and to require the best fittings where those causing the waste were incapable of being altered to prevent it. The proprietors of nearly all water-works had sufficient power to enable them to act in cases of actual waste. While speaking highly of the automatic registrations, Mr. Hanvey appeared to think that the Waste-water Meter would be more convenient in a horizontal form. Mr. Deacon had tried several arrangements, and the one now in use alone fulfilled the necessary condition of almost entire absence from friction, as the fine wire

connection between the disc and the registering apparatus was only available in that form, while, as already explained, the supposed objection on account of frost did not exist. If any horizontal arrangement were adopted, its present direct and perfectly simple action must be abandoned.

Referring to Dr. Pole's visit to Liverpool, he thought that, with few exceptions, strenuous efforts to prevent waste had formerly been made; but they had not been successful as in the other towns visited, because the Corporation had no control over those fittings which were not actually wasting water. Hence the necessity as already explained for the present system.

The case of Liverpool had not been quite the same in respect to the plumbing as that of other towns. The authorities had not the advantage of parliamentary power over the plumbers; all they did was to invite them to sign an agreement to work in conformity with the regulations, the inducement offered being the publication of their names on the backs of the waste-water notices. The plumbers had nearly all signed the agreement, and few of them were willing to risk being struck off the list by offending against the regulations. It would be inferred from Dr. Pole's remarks, that the inhabitants of Liverpool were not coerced to adopt proper fittings. This was scarcely the case. Water was not laid on until all new fittings had been examined, tested, and stamped; but all old fittings were deemed proper unless discovered to be actually wasting water. With ordinary house-to-house inspection this would not do, because the fittings might go on wasting much longer without detection than was possible under the existing arrangement.

Some of the speakers could scarcely have apprehended the fact that the Liverpool system had passed beyond the bounds of mere experiment, and had been worked on a scale of great magnitude with a degree of economy nowhere else attained. If he had introduced the subject to the notice of the Institution immediately after the first experiment with ordinary meters on the 31,000 people, there might have been room for discussion as to the application, of that more complete system which the experiment had suggested, to the whole of the Liverpool district or to any other city. But the system had become an established fact. At the beginning of October 1875, the number of persons receiving constant service had risen to 470,000. The number of Waste-water Meters in operation was one hundred and seventy, and the average consumption of the whole 640,000 persons was about 22 gallons per head per day, excepting only the water measured by

meter for manufacturing purposes. He could only invite those engineers who were still in doubt to visit Liverpool and to examine the actual work performed in twenty-four hours. It was a significant fact that persons who had opportunities of seeing the system at work even in its infancy as Mr. Bramwell, expressed no doubt whatever as to its complete success.

Mr. JAMES M. GALE remarked, through the Secretary, that the Author had stated that the saving of water had been effected "without altering a single fitting which had not been found to be actually wasting water." It would have been useful if he had given information as to how far alterations on fittings had actually been made, and what the nature of those alterations had been. In Glasgow, as the result of many years' inspection, he found one tap wasting water for every eight taps examined. For the last two years, by reason of a greater number of inspectors having been engaged, this had been reduced to one in ten. On an average three taps, or apparatus of various kinds, served one family, so that water was wasted in every third house. Now it was important to know how such cases were dealt with in Liverpool; for he was of opinion that, unless these defective and imperfect fittings were removed, no permanent saving of water would be made either under the system which had been so far adopted, or under any other.

Without this, Liverpool would still remain, even after meters had been placed upon the whole city, what it was at present, a town full of fittings of bad design and imperfect workmanship, watertight for a few days only, or weeks, as the case might be, after being repaired; where many of the closets had the water laid on by common taps; and where the bulk of them could be made to run continually if the handle was tied up. These fittings would continue to waste water and to be improperly used, and the necessity for constant inspection would still remain, as no repairs could be considered permanent.

The fixing of district meters, however, would enable the greatest amount of attention to be given to the worst districts, and thus a greater amount of effective work might be done by fewer men; but the cost of this meter system had to be taken into account. In Liverpool the cost for the whole town was expected to reach £36,000, of which £5,000, or £6,000 would be for meters. Including maintenance and repairs of meters, this represented an annual charge of £2,000 or £2,300, but for this sum about thirty additional inspectors could be employed.

The placing of meters, however, gave correct and reliable information of what was going on in each district; it might be worth the expense, and although somewhat doubtful, he was making a trial of it in Glasgow. He believed that, apart from the removal of imperfect fittings, which he looked upon as the only possible solution of this difficult question, it would not produce much permanent reduction upon the enormously large consumption of 50 gallons of water per head per day over a population of six hundred and ninety thousand. In Liverpool about 4 gallons per head per day were sold for trade purposes by meter; in Glasgow 7 gallons were sold, leaving 43 gallons per head per day for domestic and trade purposes, not supplied by meter. In Glasgow the water-fittings were very numerous, and as the great bulk of the house property had been put up by speculative builders, they were, as a rule, neither sufficiently strong nor properly finished. He did not anticipate any improvement in this direction until the authorities instituted a system of stamping and testing every fitting before it was allowed to be used, which had been so long successfully carried out in Manchester. Steps were, however, being taken for having the system introduced in Glasgow. At present reliance was placed upon inspection only, but fittings of improper construction had not been removed, the existing rules as to the apparatus allowed to be used not being retrospective.

A difficulty would be found in introducing district meters throughout Glasgow on account of the short lengths into which all the distributing pipes had been divided, especially in the densely-built parts of the city, to give greater supplies in case of fire. A 4-inch pipe was rarely, except in the suburbs, more than 150 yards long, and each pipe of this size supplied from fifty to one hundred and fifty families only. This arrangement would enormously increase the number of meters required, and if it was altered, the benefits arising from its introduction by Mr. Bateman, when the Loch Katrine works were designed, would be lost. The warehouses in Glasgow were increasing greatly in size, and the goods stored in them were increasing in quantity and value. The losses by fire lately had been large, and a considerable length of 4-inch pipe had recently been lifted, and 6-inch, 8-inch, and 9-inch pipes substituted, and more of this was in hand for the same object. A larger hydrant also was being used in connection with these pipes. The question of affording facilities for drawing large volumes of water in cases of fire should not be lost sight of in designing a comprehensive water-supply for a large city, and the placing and maintaining of meters upon those large pipes would be very costly.

One feature of the system introduced by the Author would, he thought, produce good results, either with or without district meters. He alluded to a systematic night inspection. He had done a good deal in that way himself many years ago, and had lately revived the practice with the best results.

The water meter used in Liverpool was the Author's own invention, and naturally he liked it. But the only thing he advanced in its favour was that it acted as a check upon those inspectors who might be dishonest, and inclined to neglect their duty when left to themselves at night. It might do this, although he thought it quite possible a man might be doing his duty without the meter showing any result on the diagram, even for a whole hour; but in his estimation there were fatal objections to its general application. It was inferential above any water meter he had seen. It might record the flow in the pipe during the night, when the quantity passing through was not varying much, with some approach to accuracy; but during the day the diagram produced was so confused and irregular, that no reliable result could be obtained, even after much labour. The clock-work, which drove the recording drum, would deteriorate rapidly underground, and would be seriously injured by accidental flooding. It would have to be wound up and oiled at intervals, and a diagram paper had to be attached when an observation was wanted; and when left alone for a time it preserved no record of the quantity of water passing through. It was also a little more costly than some other good and approved meters of the same size, and occupied rather more space in the ground.

A good Siemens' meter would record the quantity of water passing through for any length of time, to within a small percentage of error, while one hour was sufficient to get from it the flow during the night. Flooding would not injure it, as he had recently observed, and it might be left for several years without requiring any attention for repairs. No computation was required, and any trained inspector could take the indication, and see at once what quantity of water was passing through. He did not think it was necessary to provide against collusion between the meter inspector and the fittings' inspector, provided care was taken in selecting the men, and that they were moderately well paid. In fact, the reading of the meter might be left to the inspectors themselves, with probably a change in the men at intervals. He had mentioned Siemens' meter only, but others, he believed, would answer the purpose as well, and meters of this class had been made to suit any size of pipe. Piston-meters could not be applied for this

purpose, as they were too bulky to be fixed in the roadways. Possibly the Author's meter could be made tolerably successful by having the clockwork constructed so as to be easily attached when an observation was to be made, and kept detached and in a place of safety when not in use.

Mr. J. N. SHOOLBRED observed, through the Secretary, that he was somewhat acquainted with the circumstances of the water-supply in Liverpool; moreover, he had on several occasions had the advantage of personally testing the Waste-water Meter, and of investigating the system in operation. Through the courtesy of Mr. Deacon, he had been permitted to make, for his own satisfaction, a series of tests in the Corporation yard at Liverpool, by causing the water after passing through a waste-water meter, taken from among others about to be fixed, to enter a tank provided with a graduated gauge-tube in which the various quantities could be measured with the greatest nicety. The tests had been made with rates of flow varying regularly from 100 gallons per hour up to 5,000 gallons per hour. The pressure, in most cases, being about 40 lbs. per square inch; but in two instances it was taken as low as about 8 lbs. per square inch, in order to determine whether the pressure of the water apart from its velocity influenced the registration. The results were detailed in the table annexed. Whence it would be seen that the average percentage of error (assuming the tank-measurements to be absolutely correct), as against the Waste-water Meter, was less than 1 per cent. A result which could not fail to be considered as satisfactory, especially when the very different rates of flow were taken into account.

RESULTS of TESTS of a DIFFERENTIATING WASTE-WATER METER, by causing the WATER passing through it to enter a graduated TANK.

Pressure in Main per Square Inch.	Rate of Flow per Hour.		Error in Meter.
	Tank Measurement.	Meter Register.	
lbs.	gallons.	gallons.	per cent.
42	100·44	100	0·44
40	525	520	1·00
40	1,044	1,030	1·34
39	1,509	1,500	0·60
42	2,052	2,040	0·58
42	3,000	2,990	0·20
42	4,110	4,120	0·25
42	5,082	5,100	0·35
8	5,120	5,180	1·17
8	5,190	5,280	1·73

Arithmetric mean of errors in meter . . 0·76 per cent.

In order to acquaint himself with the details of the application of the Waste-water Meter system, he accompanied on one occasion two of the night inspectors on their ordinary round, which on that evening lay in a district containing about two thousand inhabitants, and three hundred and seventy houses of a low class of property. The inspection lasted little over an hour, from 12 to 1 A.M. Yet during that time, by the temporary closing of two dozen taps, where water was evidently passing to waste, a stoppage of waste of no less than 1,500 gallons had been effected; most of which it was hoped permanently to save when the leaks were made good by the day inspectors. Moreover, each one of those leaks had been localised (and two had been detected under the carriage-way), not merely by the inspectors, but also upon the meter-diagram, where there remained marked both the time at which it had been closed, and the amount of waste it had been causing. The diagram also showed the work done by the inspectors: its commencement, its termination, and each operation whether of closing or of opening a stopcock, were all faithfully recorded. With such a tell-tale against them, and further stimulated by the premiums offered by the Corporation of Liverpool on the saving of water effected, the inspectors might be anticipated to do a fair amount of regular work. A result almost hopeless to anticipate without the aid of the Waste-water Meter. He thought it unlikely that regular and systematic inspections each night (the time most suitable for detecting waste) could be carried on without the aid of some complete check on the operations, such as the meter and its diagram afforded; or that the ordinary house-to-house inspection, unaided by the meter, could have examined the supply of three hundred and seventy houses (as in the case above mentioned) during the short space of one hour, and have detected and localised a waste of 1,500 gallons of water. To the meter was due the entire economy of the system, for by its invention were utilised methods of detection which, though previously known, were of but little use, and capable of only very limited application.

Some years ago, when water began to be scarce in Liverpool, it was resolved to further utilise the valleys above, and bordering on the Rivington reservoirs, by converting one of them, the Yarrow Valley, into a reservoir. The operation had been long and costly, about £200,000, it was understood, had been expended. The annual yield of this reservoir was not expected to exceed 360,000,000 gallons; or, according to the details given in the Paper as to the effect and the cost of introducing the meter system, one-third of the amount of water saved by the waste water meter system at about ten times the expense.

Mr. DEACON remarked, through the Secretary, that the greater part of Mr. Gale's objections, having been answered in his reply to the discussion, would probably not have been made had that gentleman been present. He would therefore only refer to the new points which had been raised.

All fittings or pipes found to be wasting water were treated as follows:—If only a new washer, wire, or other simple adjustment were required, the work was done free of charge by the inspectors. If the fitting was capable of repair, a notice was served to repair it to the Engineer's satisfaction; if, on the other hand, renewal was necessary, a notice was served to that effect, in which case the new fitting was required to be tested and stamped.

The cost of applying the system to each thousand people was given at page 159, both for a town with stopcocks and without stopcocks. The interest on the money expended for 630,000 persons, even where the expense had to be incurred of providing outside stopcocks to the houses, would not cover the cost of employing fourteen house-to-house inspectors, and these fourteen inspectors could not have produced satisfactory results; while night inspections, by which alone the hidden waste could be detected, would, if established without the aid of the meter, involve outside stopcocks to all premises, so that the most important part of the expenditure would have been incurred; and the extra cost of supervision, and of the class of men necessary to make the night inspections efficiently, would greatly increase the cost, while all the other advantages would be lost. He was glad the system of testing and stamping fittings was advocated. In Liverpool it had been the principal means of insuring the Corporation against the repetition of those cases of waste which had been detected. The difficulty of applying the Liverpool system to Glasgow, on account of the short lengths into which the distributing pipes were divided in the densely-built portions of that city, would require consideration in detail. The great size and short lengths of these mains had for fire purposes become necessary, no doubt, from the fact that a volume of more than 50 gallons of water per head per day was flowing through them when no fire existed. In many parts of Liverpool the pressure of water had been increased nearly 50 per cent. owing to the reduced velocity due to the decrease of waste. This was an advantage in case of fire, but in some of the services the pressure had become so high, that it was contemplated to apply reducing valves.

He attributed to the Waste-water Meter many advantages besides the check upon the men, which, however, was invaluable. It was

not his experience that a man could be doing his duty for ten minutes without the meter plainly showing it. Mr. Gale's remarks as to the diagrams were answered by an examination of Plate 5. The clockwork was made of unoxidizable metals, and no deterioration took place in practice. In fact, no difficulty had been found with the clocks as now made. The clock chamber was water-tight and nearly air-tight, and to prevent the diagram papers becoming limp when the chamber was opened on a wet day, and the damp air inclosed, a little chloride of calcium was kept in a saucer at the bottom of the box, but for the clock this was unnecessary. On inquiry he thought there must be a mistake as to the relative cost of meters. However, such a comparison was unnecessary, for integrating meters had their proper uses, and differentiating meters had an application of a totally different kind. Such precautions as had been suggested had never been found necessary in practice.