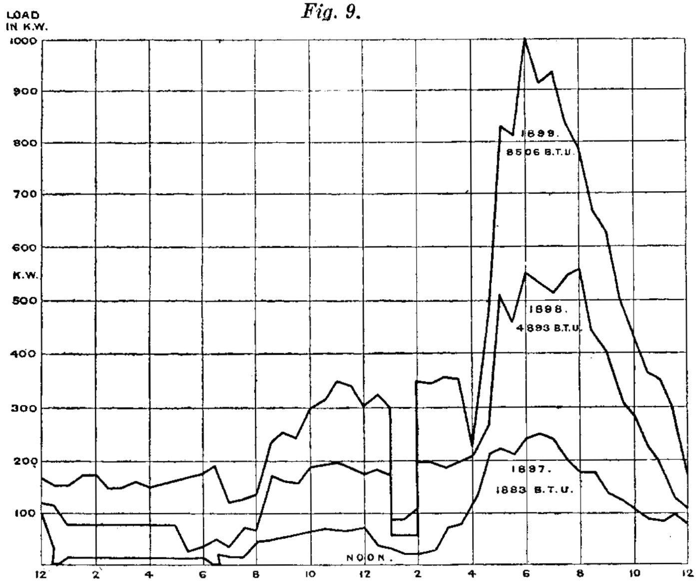
Discussion.

Sir Douglas Fox. Sir DOUGLAS FOX, President, said the members would wish to accord their thanks for the very important and interesting Paper to which they had listened. The subject was one which especially appealed to those who lived in great cities and still more to those who lived in their vicinity. In the neighbourhood in which he lived, a constant struggle was going on between those who wished to enjoy what was, perhaps rather facetiously, called the country, and the authorities who were constantly covering the fields with the material of which the Author had spoken that evening. It was really a serious matter, both for the Metropolis, and also for the great provincial cities. It was well known that the first attempts to introduce the system of Destructors were not by any means successful; in fact, the evils they produced were almost worse than those they were endeavouring to cure. But the Author had referred to a most successful effort in the direction of abating the nuisance, and there had been others of a similar kind, and he thought it might be hoped before long that what had been a serious evil would become a source of considerable profit.

The Author. The AUTHOR exhibited a diagram, *Fig. 9*, which he had recently prepared, to show the progress of the supply during the 3 years the works had been in existence. It would be seen that the light load increased very regularly, in accordance with the street lighting, but at 8 o'clock in the morning it began to rise with the use of the electric motors in the works, and gradually increased until 1 o'clock every day, when there was an abrupt drop of some 200 kilowatts. Again at 2 o'clock, there was a rapid rise, but the switchboard-attendants were now so used to it that there was no difficulty in dealing with the matter. At 4 o'clock a number of factories stopped for ½ hour for tea, and the curve also then showed a drop. At 8 o'clock there was another abrupt drop and also at 9 o'clock. The load went off very suddenly, but there was no difficulty in dealing with that sudden switching off of so many motors. Most of the motors were used for wood-working machinery, and it was found that, instead of keeping the motors full of work, the men, as soon as it was 8 o'clock or time for leaving work, stopped feeding the wood into the machine, and it automatically as it were switched itself off. The motors were all running light, and so the real switching off only affected light motors, and the diagram showed the abrupt drop thus caused. He had laid on the table several articles which had passed through the fires. They were very interesting as showing the temperatures that obtained in the refuse-furnaces. He exhibited specimens showing a lock partly fused, a cast-steel chisel partially melted, the remains of bottles, showing that the glass was close on the fusing point, a revolver, a sword, scissors, and many other articles which had passed through the furnace. Some of the articles obtained were most interesting, and, strangely enough, quite a number of old locks came in with the refuse. He also The Author.

Fig. 9.



exhibited samples of flue dust taken over 3 years, which showed a very uniform quality. It was sold for a nominal sum to form a base for disinfecting powder. He had not samples of the old tins, but he understood they were used for making paint. The small portions of broken clinker slabs he exhibited to show the section of the fracture, and to show how well the slabs could be made when the clinker was ground fine and pressed into blocks. Some of them had been used in Shoreditch for some time, and were answering very well as paving-stones. With reference to the feed-storage vessel, it only represented the amount of weight found in the vessel at the end of the 7 months' run. There was

The Author. undoubtedly a great deal of lime thrown down at the end of the run, but owing to the blowing-down operations which took place two or three times a week, a great deal of the deposit was blown down the pipes, and there was no way of taking account of it. The weight, 2,000 odd lbs., stated in the Paper was only what was found in the vessel in the form of soft scale after the 7 months' run. The cost of destroying refuse per ton given in the Paper also included the handling during the first year of 480 tons of coal, and in the year ending March, 1899, 1,340 tons of coal. Besides dealing with the refuse, the furnace dealt with that amount of coal fuel, and there was no means of dividing the wages. The cost of destroying the refuse ought to have some credit for that. With further reference to the clinker paving-slabs, he mentioned that the samples which were exhibited in the Institution lobby, which were brought from Shoreditch, were not made there, although it was a Shoreditch clinker. The Hornsey District Council were good enough to allow the Shoreditch Vestry the use of their machinery for making the slabs, and Mr. Lovegrove, the Council's engineer, had very kindly supervised it, and he was very much indebted to him for that. In addition to that, Mr. Lovegrove had sent some interesting specimens, showing what really could be done with the ground clinker when mixed with Portland cement and subjected to hydraulic pressure of something like $1\frac{1}{4}$ ton on the square inch. The figures in connection with the evaporative tests, which he had given, 0·99 lb. of water per lb. refuse burned, were, of course, the average, but on occasions there had been noticed a maximum evaporation of 1·3 lb.

Mr. Blair. Mr. W. N. Blair stated what had been experienced at St. Pancras with a combination of a refuse-destructor and an electricity station. It was by no means as successful as Shoreditch, but that was scarcely to be expected. The St. Pancras people had been the first to adopt the combination, and the lines upon which they worked had not secured the result that had been hoped, the principal shortcoming being in regard to the very variable pressure of steam. He did not think it was more variable than he had noticed in the diagram shown by the Author of the results at Shoreditch, and it certainly was a matter of surprise that, where there were steam-pressures varying between 90 lbs. and 170 lbs., the Author was able to say that it had very little ill effect on the production of current. He should certainly have thought that a variation in the boiler-pressure of 100 per cent. would have produced a marked variation in the voltage through the variation of the speed of the machines. The manner in which

Mr. Blair.

Shoreditch benefited so distinctly was in the relative position of the furnaces and the boilers. There was no doubt that if the boilers were removed 20, 30, or more feet, from the furnaces, there was a very marked loss in the evaporative power of the gases. The installation at St. Pancras took roughly the form of the letter T. On each side of the stem of the T there were six furnaces, and against the crosshead of the T there were also six. They began by putting one small multitubular boiler at the end of a row of six, with the gases passing through the tubes and round the shell. All the steam the boiler would produce was raised, and it was allowed to blow off at 80 lbs. per square inch. It was found that much more steam could be produced, and on the floor above a multi-tubular water-tube boiler was added, which was utilized to its full capacity; but in both cases the boiler was placed at the end of a row of six furnaces, and there was no question that the same temperature was not obtained in the boiler-tubes that could be obtained by putting the boilers immediately adjoining the furnaces. As there was still a large amount of waste heat, two boilers had recently been added, though they had been placed at the ends of a row of furnaces, and two boilers were used solely by the electricity station. The other two boilers were very largely used for the works in the destructor station, such as the supply to the engines which drove the fans, the mortar-mills, a stone-breaker, and other plant. The two last-placed boilers were supplying steam now to the electricity station. But from information received the other day, he knew that they were only available for the lighter day load; and that when the heavy load came on about 4 o'clock, the steam from those boilers was shut off, the gases were diverted another way to the shaft, and the electricity department depended entirely upon its own Lancashire boilers. With regard to the fan pressure, it was stated in the Paper that each fan was designed to give 8,000 cubic feet of air per minute. It was not stated what they actually did give. Anybody who tested the two conditions would find a very marked difference between what a fan was designed to give and what it actually gave. Again there was a great discrepancy between the air-pressure at the delivery of the fans, namely, 3 inches of water, and that in the ash-pits, which was only about 1 inch. Such a marked difference in a comparatively short distance must be accounted for, he thought, by friction, possibly by reduced passages; but in his judgment there ought not to be such a great reduction in the pressure at the delivery from the pressure in the ash-pits. He thought those who had seen some of the most

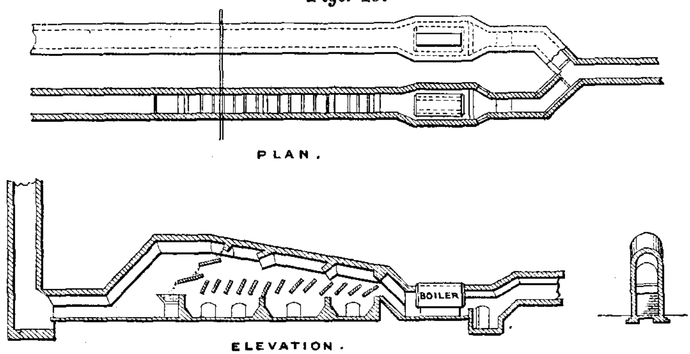
Mr. Blair. recently constructed furnaces, would recognise at once that the capacity of a furnace to destroy refuse in tons per cell per day depended almost entirely upon the air-pressure. If there was a light air-pressure, or if reliance was placed on the natural draught of the chimney, it might be found, by looking at returns that were frequently published, that the consumption might be 5 tons or 6 tons per cell per day, or something like that. With regard to high air-pressures, a case he was fairly well acquainted with was at Leyton, where there was, he thought, something like a normal 3 inches water-gauge. He had seen the water-gauge show 5 inches pressure. There refuse could be consumed up to 20 tons per cell per day, the normal being 16 tons. It was a very important element, in designing a destructor station, especially in the neighbourhood of London where land was so valuable, to get a furnace with a high destroying capacity, in order that the number of furnaces, and consequently the area of land required for them, might be kept as low as possible. A short time ago there was published, in one of the technical newspapers, a list of destructor installations in different places, and in some cases there were returns giving as high a destruction of refuse as 23 tons per cell per day. There the Melville forced draught was adopted. No mention was made of the pressure of the forced air, but he knew as a matter of fact that it was very high. The installation he was referring to was at Rochdale. Another instance was 19 tons, and another, Leyton, was quoted in the list as 16·2 tons per cell per day. But at Leyton the boilers were removed a considerable distance from the furnaces, and while the evaporation was no doubt good, and the general arrangement of the station very simple, seeing that all the furnaces were kept together and the boilers were separate from them, there was really no complication in the work, and there was an evaporation of 0·42 lb. of water per lb. of fuel. But no doubt far more steam was raised than could possibly be used. He thought some of the members would not agree with the Author when he said that destructors tended to emit from the chimney-shaft particles of fine dust. He did not think that ought to be the case, or that it was at all a necessary result, and it might be prevented by dust-catchers. One way was to adopt a dust-catcher of the cellular pattern, by which the dust entering at one point had to pass certain baffle-walls, and went over and under the cross-walls in order to catch the deposit of dust. Another way, and he thought one quite as simple, was to have a large flue before the chimney-shaft was reached. Where the ordinary flue might be 6 feet by 4 feet, by tripling the area of the flue the velocity of the gases was reduced to one-third, and thereby deposition of the dust was secured. The latter form had been adopted in the St. Pancras installation, and although there had been on occasions one or two complaints of dust from the shaft, he did not think that had been proved. The St. Pancras people had never admitted that dust was deposited. That, of course, was natural, but really he could say, without any attempt to fence the question, that no dust had been brought forward from anywhere, from adjoining roofs or buildings, to show that the dust could have been reasonably supposed to come from their chimney-shaft. In connection with the utilization of residuals, the Author had not mentioned at what cost per square yard the slab was produced. If he would be good enough to do that, it would enable the members to compare that slab with other artificial slabs in the market which could undoubtedly be obtained at a very low price. There were some slabs manufactured from crushed granite, which one would naturally say must wear better than crushed clinker, however good the clinker might be. He agreed that clinker was useful in many directions; ground in a mill, either with lime or Portland cement added afterwards, it produced an excellent mortar. Many miles of footways had been paved with that mortar in St. Pancras, and it was almost impossible to lift the flags. He had used the crude clinker as it came from the furnace, largely for concrete, and he had had tests made of 12-inch cubes, some made of crushed clinker, others made of ordinary clinker, and others made of Thames ballast, and the ordinary clinker gave the best results. At the same time, a concrete made of clinker was not impervious in the least degree. While it was very strong to resist pressure it was quite porous, and that was proved by a little experiment he had made. He was trying to split a piece off the blocks, using a heavy hammer and an ordinary mason's chisel, and he found it was quite possible to split a piece off a block made of Thames ballast, but when he tried to do the same with a block of clinker he found he could drive the chisel in without splitting the block, showing it was by no means a dense block. He also suggested that the Author should give an analysed cost of the whole establishment. If he could give the cost of the establishment, separating the electric lifts and all the Boulnois and Brodie tipping-gear from the actual structure of the cells, and those items separate from the buildings, it would be useful to compare with other works. He should like to have said something about the cost of burning the refuse. He could not help regarding the costs as high in Shoreditch, but what Mr. Blair.

Mr. Blair. the Author had said about including the cost of handling coal almost rendered the figures useless for comparison with figures ascertained elsewhere. If it was taken that the cost of destroying in London was 2*s.* 5*d.* per ton—and he thought a good many installations could show it at less than that—there must be added to that the cost of the cartage of the residuals not utilized or sold, and he thought probably Shoreditch would not be able to utilize anything like the whole of what was produced. In St. Pancras it was not even possible to give it all away. Many hundred tons were given away every month, but the cartage of what could not be given away had naturally to be paid for, which cost sometimes as much as 1*s.* 6*d.* per ton. Therefore, on to the cost of burning should be added the average cost of the removal of the residuals, and against that the alternative cost was simply how could the refuse be removed otherwise? The whole of the stuff collected in St. Pancras was not destroyed, and what was not burned was put on three railways for 2*s.* 6*d.* per ton. He thought that would tend to show that if 2*s.* 5*d.* was taken as the cost of burning, plus something for the cost of disposal of the residuals, it was rather unfavourable to comparison with the cost of simple removal by rail.

Mr. Terry. Mr. STEPHEN H. TERRY had for many years taken a very great interest in destructors. He remembered in 1888, when he was an engineer inspector of the Local Government Board, holding an inquiry in connection with the sanction of a loan for a destructor for Blackpool, and at that period he foresaw the advantage of aiding the natural draught by forced draught in some form or other. He on that occasion suggested that where the refuse was very wet it would largely aid the burning of it, and would greatly assist the chimney draught at times when the barometer was low and the air-temperature was high. Since then those ideas had been amply borne out, and he might truly say that all modern destructors were now fitted with some form of forced draught. But in connection with that question there was one point which should not be overlooked, namely, that if the temperature of combustion was increased, and a larger volume of air passed through the chimney, there might be—it was not necessarily so, if the passages were made large in proportion—a much larger velocity of air on its way to the chimney in the horizontal shafts; and if the dust produced by forced draught was of a finer nature than under somewhat slower combustion, provision would have to be made for those particles being deposited between the furnaces and the chimney, so that the neighbourhood of the destructor might not be in any way annoyed by the dust. Mr. Terry. Of course, as Mr. Blair had said, there was no doubt that very little dust escaped from the chimney under proper conditions, but those conditions were not certain to be always fulfilled because the human element was sometimes a little unreliable. Consequently he thought some means of allowing the dust to subside before it reached the base of the chimney must be found. That might be done by expanding the flue, and he thought that the suggestion of Mr. Blair of increasing the sectional area of the flue some three times, and accordingly reducing the velocity, was a good one. There was always a risk of the air making a direct cut through the middle of the flue, with increased velocity there unless care was used, and of having considerably less near the edges; in the middle a velocity being attained whereby the dust would be still carried forward. He thought the true way of getting over the difficulty was by making an expanding chamber, somewhat conical in shape, so as to allow the air to come more and more to rest as it approached the entrances to the chimney; and if the lower part of that chamber was made with bins with feather edges, the bottoms of which bins were considerably below the level of the main stream, he thought all the dust would fall into these bins and would be removed from time to time. That was undoubtedly a very important point, and if destructors were to become general or universal, as he believed they would in due course, that point must not be lost sight of, as the dust from destructor chimneys was undoubtedly a grievance to house property in the neighbourhood if these points were neglected. It had fallen to his lot, a year and a half ago, to investigate an alleged complaint about the Brighton destructor. Certain points had been attended to since; but no doubt at that time, when he investigated the complaints, the cause of the difficulty had already to some extent been removed by the special care which had been and was still being taken, in working that destructor. Mr. Terry had made certain suggestions which he thought were worth considering, one being an expanding air-chamber for getting rid of the dust, and another in respect of dealing with the clinker, which, when brought out of the ordinary destructor cells in a hot state, if allowed to cool in an open yard or under cover, did, during the time of cooling, under some conditions undoubtedly give off a certain amount of gas which was not altogether free from smell. But if what were now known as clinker boxes were provided resembling the hole in an old-fashioned brick-baker's oven, in front of the furnace doors at a lower level with a recess into

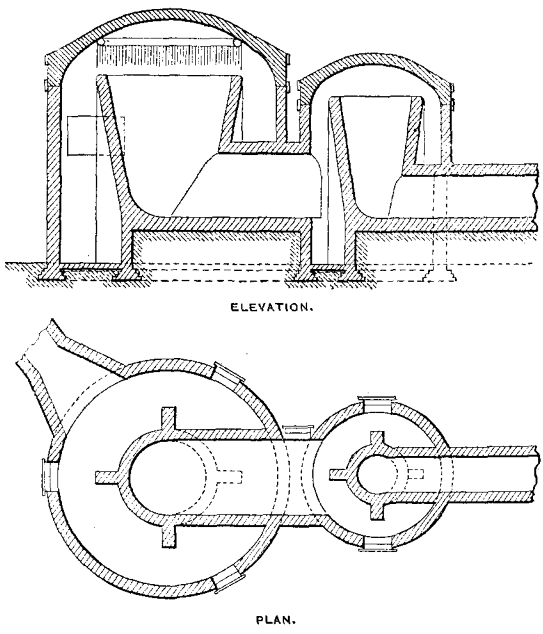
Mr. Terry. which the clinkers could be scraped, and through which the air had to go on its way into the furnace, either by forced draught or suction of the chimney, the clinker would complete its burning and also be cooled by the incoming air after all the carbonaceous matter in it was burnt out, and by the time it was raked out it would not be hot enough to cause any annoyance. That was a very important point when destructors were fixed near a town. There was another point with regard to obtaining heat for raising steam. He quite agreed with Mr. Blair in the importance of having the boilers as near as possible to the furnaces. There was no doubt that was of the very greatest importance. Every locomotive engineer, and everybody who had had to do with boiler design, would know the effects of lambent flame on the firebox plates as a means of steam production, or the mere passage of hot gases through tubes or flues, and would appreciate the relative values of the two. Therefore to get the full effect an endeavour should be made to get boilers as near as possible to the furnaces. There must also be proper provision for having a sufficient number of boilers, so that one might be laid off for cleaning. It was very important to keep the surface clean, because a very small amount of scales or semi-metallic dust (dust which contained silica and iron), if deposited on a metal surface, could, by obstructing the passage of heat to water on to the other side, very seriously impair the heating efficiency of the plates, and therefore provision had to be made for keeping the boilers and tubes clean, which could only be done by having a sufficient number of boilers to admit not merely of removing the scale left by hard water on the inside, but the dust and scale on the outside. It was stated in the Paper that shavings, straw, and so forth, were practically of no value as heating material. That he thought would be the case if that material was put in in such a way that it was liable to catch alight before it was put into the furnace. If the air was allowed to rush in in such volumes that the material actually caught alight before it was put in, there would probably be very little heat value in it, because far too large a quantity of air would be admitted. When he was employed at Messrs. Clayton and Shuttleworth's works in Vienna, he remembered an arrangement which was brought out of a straw-burning apparatus which was fitted to many portable engines, and was used in Hungary. The essential parts were a trough and an upper and lower fuel-roller between which the straw and shavings passed into the fire-box in a continuous stream. He thought something like that might be used in districts where there was a large amount of straw, shavings and such refuse. In that way feeding could be carried on with uniformity, and the upper roller could Mr. Terry.

Figs. 10.



Scale, 1 inch = 48 feet.

Figs. 11.



Scale, 1 inch = 24 feet.

be fitted with springs, so that should other materials—bits of wood or iron—get in, there would be no risk of breaking the

Mr. Terry. rollers, and a very small furnace opening could be employed, just wide enough to let the band of moving fuel come in without letting in an undue amount of air. If some of those points were carefully attended to it would be found that that sort of refuse would give very useful heat. He and his friend Mr. R. E. Middleton had devised, some five years ago, arrangements for dealing with the dust of destructors, which he believed would thoroughly intercept all dust; they had allowed the patent to lapse, and his motive in mentioning it was to present the ideas involved to the Institution; the sketches on p. 211, *Figs. 10* and *11*, explained themselves. The principles of the two apparatus were very similar, increased area, reduced air-velocity, deflecting planes and bins in the one case, and centrifugal action in the other; by the adoption of either of these arrangements, or a combination of them, he believed that the whole of the dust could be arrested instead of passing up the chimney.

Mr. Laws. Mr. W. G. LAWS said his experience had been in connection with the old-fashioned destructor without forced draught, where an ordinary chimney was used. Taking the results extending over 10 years' working, he found the cost of burning the refuse had been greatly reduced. Including all the cost excepting collection of the refuse, it had been reduced to $8\frac{1}{2}d.$ per ton, which he thought was a good deal in favour of the old-fashioned ordinary destructor. No attempt had been made in any way to utilize the heat, but an attempt had been made as far as possible to keep down the capital cost and expenses, so as to get rid of the refuse as rapidly as possible, and that object had been successfully accomplished at the price he had mentioned.

Mr. Webb. Mr. F. W. WEBB said the arrangements described appeared to be very well worked out. He was at the present time, for the London and North Western Railway, putting some of the thermal storage reservoirs into the Broad Street electrical and hydraulic installation, where there was very irregular working, and at Crewe he was putting down destructors, after trying some experimental ones, for the purpose of drying bricks. Between 4,000,000 and 5,000,000 bricks were made every year by the London and North Western Railway Company with the refuse clay taken out of the works, and so far with great success; but he could not help thinking that, with the destructor now being put down, one by-product, which at the present moment was almost universally thrown away, would be able to be utilized with advantage—he was alluding to the fine coke ashes that collected in the smoke-boxes of locomotives. At the present moment he had to deal with something like 1,400 bushels of that material per day, and he found that steam could be raised with that and the other refuse. In connection with the large alterations which were going on at Crewe, he might mention that he was putting down some boilers of a description similar to the one shown in the diagram, and he hoped to be able to raise a good deal of steam for electric power and light by utilizing the waste stuff that came from the locomotives. One of the speakers, alluding to some works with which he was connected, had stated that with the destructor he was not able to raise all the steam required during the busiest time; the hot gases from the destructor were sent right up the chimney, and a separate boiler was used for the work, and that with live coal. It appeared to him that, with the apparatus which the Author had so lucidly described, the heat from the refuse could be utilized, and could be supplemented by coal used for the same boiler. He should like the speaker to whom he had referred to say whether he was correct in thus understanding the statement made. Mr. Webb.

Mr. H. R. J. Burstall thought it would be of great interest if the Author would add to the Table a column giving the amount of the steam generated which was used for the steam-jets or producing the draught. In the Oldham destructor the quantity of steam used in the steam-jets amounted to a considerable portion of the total steam generated. If the 0·9 lb. given on p. 199, column 10, was reduced for the amount of steam used in the jets, it came to 0·6. He had the figures that day from Mr. Newington, of Oldham. It was very important, of course, because what it was desired to know, if the steam was to be used for other purposes, was not the steam evaporated, but the steam available. Of course, correction could be made where the steam was used for driving engines for producing the draught through fans, and if the Author could add that, it would be of great interest. The Shoreditch Station, with a load curve such as was shown in *Figs. 6* and *7*, was a specially good instance of a station where destructors could be used. The trouble with a destructor plant in conjunction with an electric-lighting plant was that the material was delivered practically steadily all day from 10 to 5, whereas in the ordinary electric-lighting station the peak came on at the beginning of the dusk and went off very quickly after 6 or 7 o'clock, depending, of course, on the district being served. The only destructor of which he had experience was that at Oldham, where the destructor had been most useful, but no pretence had there been made to place the two plants under one department. Mr. Burstall.

[Mr. Burstall. The destructor belonged to the sanitary committee and was worked by them, and for certain considerations they gave the electric lighting committee as much steam as they could take. The effect was that there had been a considerable saving in wages, and the machines could run practically the whole of the day light load, and also the night light load, off the destructor. The effect had been that, as the station had grown, the battery had been done away with, as it was found it was actually cheaper to run with the steam supplied practically gratis than off the battery. Some little trouble was experienced, however, owing to the varying steam-pressure from the destructor boilers. He was not at all sure whether for ordinary stations that was not the best way of arranging a destructor plant. The Author had mentioned the fact that at Shoreditch, where the destructors had to be supplemented with coal, he did not get the best value out of the coal. He considered the better way would be to have two separate plants, running as much of the load as possible with the destructor plant, and when it was necessary to supplement it by adding the steam plant and work both of them at their best efficiency.

Mr. Jones. Mr. C. JONES considered Mr. Burstall's remarks most pertinent to the question. Those who knew Mr. Jones's views on the matter would remember that he expressed the opinion some years ago, that each portion of the work must rest upon its own merits, and the one installation must be entirely distinct from the other. He represented what might be called the low temperature line, and low temperature had been at work at Ealing ever since the year 1883, so that he had had practical experience of it for a good many years. As far as flue dust was concerned, he did not know what it was. Whether that had to do with the Fume Cremator which made the destructor possible, it was not for him to say, but at any rate, so far, it had been a success. He had had something to say in days gone by about Shoreditch, but he was bound to bear testimony to the splendid way in which the design had been worked out. Whatever faults arose in the beginning, the evidence of the Paper went to prove they had been gradually overcome, as they should be in every work of that sort. The installation there was a new thing, and although at Ealing steam had been raised since the year 1883, still it was not in any way connected with an installation of electric lighting. It answered its purpose well, and, as some of the members were probably aware, at Ealing sewage sludge was being destroyed as well as house refuse. Consequently the question of steam could not arise to any large extent.

One point had occurred to him in connection with the works at Shoreditch, and that was the large amount of residuum, very nearly 30 per cent., and there was also the fact that the residuum was of a soft character. Only a small quantity of refuse (about 5 tons per cell) was burnt at Ealing, but the clinker was a first-rate one. For 16 years or 17 years he did not think a load had ever been given away. It was useful for road-making, for mortar, for the walls surrounding the works and for the construction of the electric station. Sir Frederick Bramwell might remember that he used a good deal of it in the foundations there and in various ways. It had never been a drawback, but formed an admirable asset when dealing with the question of the cost of destruction. He had been staggered at the cost set forth in the Paper, nearly 3*s.* 6*d.* a ton. The expense should always include the capital charge, and those who had to deal with public accounts and had to arrange the estimates every half-year knew what that meant; everything must be included, and therefore the charge of 11½*d.* formed part and parcel of the work done in connection with the destructor, and should be taken into account, so that the charge made was something like 3*s.* 6*d.* a ton. The heaviest charge, if he remembered right, in the schedule of charges in his book on "Refuse Destructors," in 1894, was 1*s.* 7*d.* In his own case the reduction in the value of the total cost arising from the steam used together with the various items that went to form the assets reduced the charge to about 4½*d.* Mr. W. G. Laws had estimated the cost of destruction at 7½*d.*: [Mr. W. G. Laws: No, 8½*d.*]—at 8½*d.*, so that the charge of 3*s.* 6*d.* did seem very heavy, and he could not understand why it should be, except that the installation itself was very expensive. That, in a district like Whitechapel, where land was so costly and wages so heavy, might perhaps to some extent explain the item. One point had occurred to him in connection with a matter which he felt he must speak upon, and that was the great principle of the destructor as a sanitary agent. The President had referred to living in the vicinity of towns. The Paper dealt with large towns, towns with hundreds of thousands of inhabitants. But England did not consist of towns of that class. He thought it would be found that there were a thousand towns in England where the two-celled destructor would be all that would be required. The Author's Paper did not deal with that question. It was, however, a matter of great moment to be able to deal with the bulk of the towns of England, rather than with the larger towns such as Liverpool and Manchester. Such towns did not mind spending many thousands, but with smaller towns, with a

Mr. Jones.

Mr. Jones. rateable value of £50,000 or £60,000, it was a very different thing. Therefore he hoped, in connection with this subject, it would not go out to the world that it was absolutely necessary to incur immense expense in order to provide that which was looked upon as one of the most useful sanitary contrivances of the present day. He did not for one moment say that a high temperature was not a good thing; it was, and he had it now at Ealing. The last model he had put up was on a high temperature scale. It had not yet been made public, but no doubt some of the members would see it by-and-by when it was completed. He had no doubt that a temperature would be obtained of 1,800° or 2,000°, which at once did away with the question of fine dust and fuel, and minimised the importance of his own cremator. That he was not at all sorry for, because it was an improvement he had looked forward to, and he had been surprised that so many years had passed without engineers inventing some scheme, beyond that simple contrivance of his, to get rid of dust in such places.

Mr. Preece. Mr. A. H. PREECE had erected at Llandudno a refuse destructor in connection with an electric-light station, on a very small scale, and the arrangement was quite different in every way to that at Shoreditch. The same question had arisen there as in many other places. The refuse had to be destroyed; it could not be carted away, and there were no convenient neighbours who did not mind the refuse being deposited on their fields. The electric-light undertaking was being erected at the same time as the destructor, and it seemed economical, both from the standpoint of capital expenditure and also from the possibility of the annual expenditure, to combine the two. The results of about 9 months' working had not been entirely satisfactory, but they had been sufficient to justify him in carrying out a similar installation in three other cases. The comparatively poor results were due entirely, however, to the quality of the refuse in the summer. The advantage at Llandudno was that one chimney could be used and one staff, and a small amount of additional power could be obtained from the refuse. The actual refuse varied from about 75 tons to 150 tons per week, and being a seaside resort, the maximum came in the summer. Unfortunately there being practically no fires going in the summer the refuse consisted of all kinds of unpleasant materials which could not be burnt; in fact, at times a certain amount of coke had to be used. It was necessary for this destructor to get rid of all diseased animals, old horses, and occasionally a pig came in, while fish offal was very frequent. In an isolated health resort there were no facilities whatever for getting rid of such unpleasant materials, and they had to be burnt; and naturally the results were considerably spoilt from the steam-raising point of view. He estimated that in the whole 12 months of working which would be completed very shortly, a saving in the coal bill would be made of about £50 out of £250, about 20 per cent. The actual costs had been small, probably because at Llandudno there were not so many elaborations as at Shoreditch. It worked out at 1*s.* 9*d.* per ton destroyed for the burning, and about 9*d.* per ton for the interest on the capital expended, making an average of about 2*s.* 6*d.* per ton. There was no cartage of residuals. The neighbourhood being a rising one a good deal of the ash was used for new roads. The old iron was also sold to some works 20 or 30 miles away, where some use was made of it. Further, the results at Llandudno might be accounted for by reason of the small quantity of refuse, the destructors had to be lighted every day and let out again in the evening. They were started about 2 P.M., and worked until the refuse brought in had been consumed. Somewhere about 20 per cent. or 30 per cent. of the refuse was really used in heating up the furnaces to the proper temperature. In the 3 months from June to September, about 7 lbs. of coke was used per unit of electricity produced for public consumption, and this rather large amount was due to the fact that some of the coke was used in the destructors themselves. In the 3 months from September to December, it was reduced to 5 lbs. per unit, simply because the refuse was less in quantity and of improved quality. He was able to compare these results very accurately with a neighbouring station, where coke was also used with similar engines, similar boilers, and a similar staff, and he found that at that station about $6\frac{1}{4}$ lbs. of coke was consumed per unit in the first 3 months, as compared with the 7 lbs. at Llandudno, and in the second 3 months 6 lbs. as against 5 lbs., which showed that at Llandudno in the September to December quarter about 1 lb. of coke per unit was saved through the use of destructors. The fact that the station was on a small scale made this saving not very large on the whole year. The figures given were fairly accurate, and being for a town of about 10,000 inhabitants, rising to 20,000 in the summer, might be taken to be as good as was to be expected from a town of that type. The destructors used were of the Beaman-Deas type, in which a sloping grate and forced draught were used. He did not think there was a very large difference between the various destructors; they all had a very large grate-area and forced draught either from fans or from steam. The

Mr. Preece.

Mr. Preece. feed-water system referred to in the Paper was most interesting, and he should be glad to hear some further facts on that point. At Shoreditch, about 4 units of electricity per ton of refuse appeared to be taken for the fans; that appeared to be rather high. In Llandudno about $2\frac{1}{2}$ units were used. He should like to know also whether, with the feed-water system, dry steam could be ensured. He understood that the steam-pipes were connected with the top of the feed-water heater, and he imagined there was some danger at times of getting wet steam. On the last page of the Paper the Author gave various results of his experience. With regard to the first, he stated that he obtained a result of 0·99 lb. of water evaporated per pound of refuse burnt, the average calorific value in London. That figure did not seem to be quite correct—he thought it was a little too high. He noticed, for example, that on another page the Author assumed that his 1,344 tons of coal had produced 322,561 Board of Trade units. That was very hard on the coal. It meant an average of about $9\frac{1}{4}$ lbs. of coal per unit. Considering the fact that at Shoreditch, as would be seen from the curves, there was a remarkably good load-factor—in fact, the load-factor was about 50 per cent. better than many stations in London—$9\frac{1}{4}$ lbs. of coal per unit was excessive. In a station which he had erected at Hammersmith on an alternating-current system, with a far worse load-factor, a unit was produced from about $7\frac{1}{2}$ lbs. of coal. The Pall Mall and St. James's Company, who had not so good a load-factor, produced their electricity for $5\frac{3}{4}$ lbs., and he believed the Westminster Company were about as good. Therefore he thought that to take 322,000 Board of Trade units as the amount of energy produced by the coal was handicapping the coal and favouring the refuse to an unjust extent. He thought it would be a much fairer assumption to take between 7 lbs. and 8 lbs. of coal, which would mean that 500,000 units were produced from the coal, which left 500,000 units to be produced by the refuse, bringing the average result obtained by the refuse to about 0·75 lb. of water evaporated per pound of refuse. That he thought was a fair average. It was similar to the average of careful tests taken by him at Llandudno. The next point the Author had made was that the cost of destruction of refuse in London was 2*s.* 5*d.* per ton. That figure seemed to be open to correction. He found in the public accounts of the Vestry that £911 was included for carting clinker, and that did not appear to be included in the other amount. That came to about 8*d.* per ton. If the records published the previous week in one of the electrical papers were correct, it seemed that the total cost per ton for destroying the refuse was about 3*s.* 10*d.*, taking the figure given by the Author of 26,000 tons. The total expenditure was £5,025, and that, divided by the total refuse destroyed, gave about 3*s.* 10*d.* To that had to be added the interest repayable on the loan, which came to about 1*s.* 1*d.*, making a total of about 4*s.* 11*d.*, so that he could not follow the Author's figure of 2*s.* 5*d.*, which he thought required further explanation. Taking the Author's figure at 2*s.* 6*d.* for convenience, and assuming that he obtained the evaporation of 1 lb. of water per lb. of refuse; then, as 1 lb. of coal evaporated 10 lbs. of water, it meant that the refuse was equal to coal at 25*s.* per ton. It would be cheaper in London to burn coal at that rate. He advocated the destructors as much as anyone, but there was no question of getting electricity for nothing. It was necessary that the sanitary department should pay for destroying the refuse as they paid at Shoreditch, about 2*s.* or 2*s.* 6*d.* a ton. The refuse could not be taken over and burnt for what it was worth, but the destructor department would have to be paid to burn it to get any assumed value out of it. There was a great deal of refuse in London; the surrounding neighbourhoods were getting selfish, and would not allow the refuse to be deposited in their vicinity, and it was absolutely necessary to destroy it; but when destroying it, it should be clearly understood that the benefit was more to the sanitary department of the Vestry than to the electrical department. In conclusion, he might mention that he was connected with one Vestry in London, that at Hammersmith, where the two plants had not been combined, for the simple reason that the refuse could be barged away at a cost of about 2*s.* a ton, so that it paid that Vestry to get rid of the refuse in that way rather than to burn it as was done at Shoreditch. Mr. Preece.

Mr. E. Manville said that as perhaps it was owing to his advice that the Vestry of Shoreditch proposed to be the first local authority to try to make some use of the waste heat from the burning of refuse, he felt much interested in Mr. Russell's Paper, as to the results that had been achieved commercially from the burning of the refuse. He desired to emphasize once again what he told the Vestry when they were first thinking of making what at that time was a somewhat novel departure. A point which, owing to the large extent to which the Shoreditch example had been followed, had been somewhat lost sight of, was that under no circumstances would it be worth investing capital in order to burn refuse to save the burning of coal, if that were the only consideration. But he thought that the local authorities in the United Mr. Manville.

Mr. Manville. Kingdom took an almost unanimous view as to the necessity of disposing of the refuse in a sanitary manner. It did not matter to them whether they paid 1*s*. per ton for disposing of it by tipping it, or whether it cost them twice or three times that amount to burn it. They felt themselves to be the conservators of the public health, and considered that nothing they did should tend to endanger it, and that even if it cost a great deal more to burn the refuse, it was their duty to do that and to dispose of it in a perfectly sanitary manner, rather than to tip it at a lower cost, to the detriment of the health of the inhabitants in the neighbourhood in which it was tipped. In London the cost of getting rid of refuse was a great deal higher than it was in provincial towns, and therefore it was conceivable that the cremation of the refuse might be effected at a lower price even than the previous insanitary methods of getting rid of it. It was with that sanitary idea in view that most local authorities made up their minds to cremate refuse rather than to tip it, that he suggested that having made up their minds to erect a dust-destructor, it would be better to utilize the gases produced by the combustion of the refuse for the production of power, rather than to allow the hot gases to run to waste. It did not cost more to work a refuse-destructor, in combination with pumping or with an electric-light station, than to work the two separately. Rather it cost less to work the two in combination. The Vestry of Shoreditch, having made up their minds to burn their refuse instead of barging it away, took that view of the case, and the present installation was the result. He did not wish to enlarge upon facts that had already been put forward by the Author, but he thought one fact in connection with the installation should prove a complete answer to the remarks Mr. Preece had just made. Whilst the scavenging committee of the Vestry of Shoreditch effected a saving of 30 per cent. of the cost of barging the refuse away, which reduction had to be paid by the Electric Light Committee, the latter Committee were nevertheless able to supply electricity at the lowest price, without exception, of any local authority or Company in London for private use, and still to have a substantial surplus in each year of their working.

Mr. Watson. Mr. G. Watson remembered that in 1892 Prof. George Forbes had advocated the combination of destructors and electric-light plants—pointing out that refuse had to be burned, and that a certain amount of heat could be derived from it, and he had advocated a combined plant at Paddington. It was not adopted, but since then it was becoming a generally admitted fact that the

Mr. Watson. combination would pay in almost every locality. There was no doubt that Shoreditch was a success from the steam-raising point of view. At Shoreditch it had been found that a pound of steam could be got from every pound of refuse, and that again abundantly confirmed what had already been demonstrated elsewhere. Refuse varied in different localities, but he thought the average amount of steam was 1 lb. for every 1 lb. of refuse. There were one or two points about the design of the Shoreditch plant which he should like to criticise. He thought the designers had laid themselves open to criticism to a certain extent in the fact that the cost of labour in dealing with the refuse at Shoreditch was remarkably high; it seemed to work out at 2*s.* 5*d.* per ton. The Author had stated that the 2*s.* 5*d.* included a certain amount of labour spent in stoking the boilers with coal. He presumed the coal was not required for more than 3 hours per day, and if the coal-burning was credited with the whole of the labour employed on the plant for 3 hours a day, it would still leave 2*s.* 1*d.* per ton for destroying the refuse. It was stated in the Paper that at Oldham the cost was $9\frac{3}{4}d.$ In St. Luke's, a neighbouring parish to Shoreditch, the cost was $8\frac{1}{2}d.$ per ton for labour only. In view of those facts, he thought he might be allowed to make a few remarks on the manner in which the refuse was handled. He was aware there were great difficulties in connection with the site, as it was impossible to secure a proper incline; but he ventured to think the refuse was handled once or twice too often. If the lifts had been so arranged as to tip the refuse on to the deck in the old-fashioned way, the cost of labour would be very much lower, and also the current used in driving the motors, and propelling the tipping-trucks, would have been saved. As a matter of fact, the refuse was first lifted in lifts to the top of the works in the tipping-trucks, into which it was tipped from carts. It was then propelled along the top of the destructor by electrical power, and the tipping-trucks were emptied into a large receiving tank. Below the receiving tank was a charging apparatus, so that altogether the refuse was handled three times, which he ventured to think was twice too often. He did not quite agree with the way in which the boilers and furnaces had been arranged at Shoreditch. The boilers and furnaces alternated. A great many engineers held the view that the nearer the boiler was to the destructor the less heat was lost by radiation, and there was something to be said for that view. On the other hand, the Author's opinion was that the coal burned in the boiler furnaces was somewhat impaired by the amount of cold air coming in from the destructors during

Mr. Watson. the time that the coal was being burned—that was because the boilers were in too close proximity to the destructors. But he thought there was another reason, viz., that the refuse burned in the furnace was charged and clinkered alternately, the operation being an intermittent one, and at some times the furnaces were much colder than at other times. When the furnaces were cold there was great danger of the gases reaching the boiler-tubes in an unburnt condition. After they had cooled down by the heating surface of the boiler, all chance of destroying them was lost, and they mingled with the other gases in the main flue, which was comparatively cold on account of the amount of heat taken out of the gases by the boilers. Therefore it was very possible that gases might escape from the chimney unburnt in consequence of reaching the boilers too soon. He believed in putting the boilers in a block at the end of the block of furnaces, getting the boilers as near the block of furnaces as possible, but keeping the furnaces close together. The furnaces could then be stayed without the interruption which the boilers caused, and equal evaporation could be obtained from the boilers, as the gases were all mingled, and the temperature maintained at the end of the flue was constant instead of fluctuating. Then again, long steam-pipes were avoided, and most engineers would agree that that was much to be desired. With regard to the blast, the Author had said that, *even* with a blast-pressure of only 1 inch, very high temperatures were obtained. He thought the high temperatures were probably owing to the fact that a blast pressure of only 1 inch was obtained. It had been stated by Mr. Blair that the higher the blast-pressure the higher the temperature; but he rather dissented from that statement, for he thought that the higher the blast-pressure the more labour was required, the less heat obtained, and the more dust was produced. If the blast was increased, the excess of air was increased in the furnaces, unless the rate of combustion was increased in proportion. There was a certain rate of combustion which he regarded as the most economical, about 10 tons in 24 hours, which happened to be exactly the amount burned at Shoreditch. If that amount was much increased the fires had to be disturbed much oftener, and clinkered at more frequent intervals. If 10 tons were burnt every 24 hours, he thought 1 inch of blast-pressure was quite right, and if that was increased an excess of air was caused, and the temperature reduced in the furnaces. The Author had stated that the clinker was somewhat softer than was the case in plant not raising steam for electric-lighting apparatus. He failed to see why the clinker should be any softer in the case of steam-raising plant. All steam-raising plant required high temperatures, and high temperatures always produced the hardest clinker. Mr. Watson.

Mr. H. Boot desired to refer to the results obtained at Shoreditch, Llandudno, and Hereford. The water evaporated per ton of refuse at Llandudno was given at 0·8 lb., at Shoreditch 0·9 lb., at Hereford 1·5 lb. The labour at Llandudno was 1*s.* 4*d.*, at Shoreditch 2*s.* 6*d.*, at Hereford 1*s.* 1*d.* It would be noticed that there was a considerable difference, so much so that it might be of sufficient weight to upset a new scheme. The Author had mentioned that the question of moisture alters the calorific power of the refuse. He might ask if it had ever been suggested to use a revolving grate. It seemed to him that a revolving grate, which would, so to speak, drive the refuse on its way to the hotter part of the furnace, would carry out the Author's apparent aim. He was surprised that the Author found the necessary repairs so very small. His experience had taught him that the necessary repairs of ordinary coal-fired boilers cost considerably more than those mentioned in the Paper. There was only an item of £51 representing the total repairs for the year. Under coal-firing conditions it would be expected that that £51 would be nearly doubled unless the water was exceedingly pure. He would also like to ask the Author whether he found any difficulty with the back pressure on the engines. It would be interesting to know if he found, as he exhausted through a 16-inch pipe for the purpose of heating the cold water in swimming-baths, the amount of back pressure, if he had a gauge on the exhaust, by the engine. Another point was the question of the boiler being fired with coal or refuse. The Author's figures tended to show that in a combined plant it was advisable to have boilers fired by coal separately, working in conjunction with boilers fired with refuse, to obtain the most economical results, and that he believed in many cases was now being done. However, the Author suggested that it was probably due to other reasons, whereas he, Mr. Boot, was disposed to think it was due to the construction, more or less, of the boiler as designed for burning refuse. It would be noticed that the heating surface was much greater, and that the position of the tubes was rather different from the furnace bars. The result of that, of course, would affect the efficiency of the boiler considerably. The Author had mentioned that market refuse was no use from a calorific point of view. He would like the Author to state in his reply what he termed market refuse. He had also heard, from people engaged Mr. Boot.

Mr. Boot. in business in the locality, that considerable trouble was experienced from the dust coming out from the top of the shaft. In going through the accounts of the first and second year, he noticed that labour had increased in the second year from 1*s*. 6*d*. to 1*s*. 10*d*. per ton, and necessary repairs from 0·45*d*. to 1·5*d*. That would be serious if there was any chance of its continuing to increase at the same rate. There was another point with reference to labour, and that was the number of tons of refuse the Author found a stoker was capable of dealing with. He had made experiments with coal-firing, and had found that the maximum amount one stoker could deal with in any shift was, roughly, about $4\frac{1}{4}$ tons of Welsh coal. With reference to the repayment of loans, he understood, from certain remarks made in technical journals, that the loan on the destructor part was granted for 15 years, whereas on the general plant it was granted for a period of 42 years. He now understood that those loans had been consolidated into a period of 30 years, which would, of course, make a great difference in the financial results of the concern. If the financial results could be taken from the technical journals, it would be found that the total amount paid, for interest and sinking fund, only amounted to 0·78 per cent., which, of course, was very small. If the loan was only paid off at that rate, without setting aside a larger amount, the machinery would be worn out before the loan was anything like paid off. Mr. Preece had referred to the question of the coal per unit. If the total number of units generated in Shoreditch were divided by the coal burnt, it would be found that the amount of coal burnt per unit came to as high a figure as 3 lbs. of coal per unit, plus the refuse. He was pleased to hear the observations of both Mr. Preece and Mr. Manville that, before considering the question of refuse destruction, the authority must consider whether it was necessary to destroy the refuse by burning. The sensational accounts of electricity from dust, such as had been seen in the papers, were only calculated to mislead the general public. He should like to ask a question as to the health of the men employed in dealing with the refuse. He noticed there was a storage bin at Shoreditch capable of holding 60 tons, and perhaps the odour given off from that bin was objectionable. If that in any way interfered with the general health of the staff, as was possible, the cost of paying men on sick leave might be considerably heavier than where coal-fired boilers were employed.

Mr. Liversedge. Mr. A. J. LIVERSEDGE observed that the Author had stated that special means had had to be adopted for feeding straw, paper, and other light and bulky material into the furnaces; it was not possible to work the elevators and the trucks with that kind of material. The Author had not, however, described the special means for that purpose. More than one speaker had suggested different methods of dealing with such things, and he had been struck by the unanimity with which the idea of rollers pushing the refuse forward had been received. Such an apparatus was easily used on a material which was of the same character throughout, as straw, or refuse from tan-yards, or spent wood, bark, or chips. It was easy with such material, but he thought an apparatus of that kind suitable for refuse of towns had still to be designed. He knew of more than one case where it would be very gladly adopted. The Author had given the temperature of the flue-gases just before they entered the economizer, but it would have been very interesting if he could have added, especially in view of the importance which was attached to the feed-storage at Shoreditch, the temperature of the gases at the bottom of the chimney or on leaving the economizer. Results had also been given of experiments made with the economizer in use, and the feed-storage tank in use. If results could be given of experiments made, one without the economizer, but with the feed-storage tank, one without the feed-storage tank but with the economizer, and one without either, those results would add immensely to the value and interest of the Paper. The difficulty of storing the heat during the hours of light load was one which would one day be overcome, but it had not yet been satisfactorily solved. With regard to the feed-storage arrangements, the Author had made a test, in the course of which it appeared that a vessel 30 feet long by 8 feet in diameter, at the end of 18 hours was two-thirds full, representing a certain volume and weight of water. That volume and weight of water was apparently raised by steam from the boilers directly injected into it, from 220° F., at which the water was delivered by the economizer, to approximately the temperature corresponding to the pressure of the steam in the boilers, about 358° F. It was known how much heat would be in 1 lb. of the steam so used, and if the result was worked out it came to something like 13,428 lbs. of steam which was used in raising that volume of water from 220° F. to 358° F. The value of the coal burnt at Shoreditch worked out, from the experiments given, at about 8 lbs. of water evaporated per pound of coal. The feed-storage vessel represented about 746 lbs. of steam consumed per hour, and, therefore, at 8 lbs., &c., per day of 12 hours, 8 lbs. of water per pound of coal, say, half a ton of coal, about 10*s*.

Mr. Livesedge.

Mr. Liversedge. That seemed to be the value of the feed-storage apparatus as at present arranged, deduced from the figures. He would ask the Author if the whole of the surplus heat of the destructor, during the hours of light load, was utilized in raising the water through that range of temperature. If so, the surplus heat during those light hours seemed to be very small. Perhaps it was a somewhat narrow view to take of that new storage arrangement, because, while the value by itself appeared small, its importance might be very great, owing to the fact that it might be used at a particular time. He presumed that probably its value was much more due to that consideration, than to anything which could be expressed in mere pounds of coal saved per day. A good deal had been said about the evaporation results at Shoreditch and other places. He was responsible for carrying out the design to which Mr. Preece had referred, at Llandudno, and he scarcely thought Mr. Preece had given sufficient weight to the fact that the cells there were very much more powerful than were required for the regular combustion of the refuse available. The quantity was about 50 tons to 150 tons a week. The cells which were erected at Llandudno were capable of burning 60 tons in 24 hours, *i.e.*, more than 1 week's production in 1 day. It would therefore be obvious that they worked under disadvantageous conditions. Mr. Preece had given the results for a certain length of time; tests which had been made for shorter periods gave a much better result. There were some figures in the Paper with regard to evaporation which were very interesting, but it was difficult to understand exactly how they were obtained. Mr. Preece had deduced $9\frac{1}{4}$ lbs. of coal burnt per electrical unit. The evaporation per lb. of coal deduced from the figures was 8 lbs. If therefore those two figures were correct, the Author used something like 72 lbs. of steam per unit. On p. 190 there appeared 0·96 lb. of water evaporated per lb. of refuse, which was a figure expected in an ordinary destructor, but that test was only of 5 hours' duration. Turning to p. 189, the test was for 24 hours, and the evaporation was only $\frac{3}{4}$ lb. per lb. of refuse. During the test given on p. 190 the destructor was evidently forced. As Mr. Watson had stated, the average consumption of refuse seemed to be about 10 tons per cell, but on the latter occasion the consumption was 16 tons per cell. He found no record of the quantity of clinker produced at that test. It would be easy to put a large amount of refuse in the cells and to take out a large amount of clinker, but obviously conclusions under such conditions could not be very satisfactory. Whether any weighing of the clinker was done on that occasion was not stated, and if the Author could add it it would be of great use. With regard to the arrangement of the boilers in relation to the cells, Mr. Watson preferred to put them at the end of a long chamber, but the Author had adopted the plan of putting them close to the cells. Nobody nowadays would think of endeavouring to burn refuse or that kind of fuel directly upon the grates of boilers immediately under the tubes. The results would be unsatisfactory, not only with regard to evaporation, but also with regard to smells. In all probability the wisest course was a mean between Mr. Watson's and Mr. Russell's arrangement. That was the plan he worked upon himself, and it appeared to give very good results. The last tests made at Canterbury on one of his designs, showed an evaporation of over $1\frac{1}{2}$ lb. of water per lb. of refuse, in a trial of nearly 10 hours' duration. Mr. Liversedge.

Mr. Ed. C. De Segundo remarked that he hardly thought that the Author's conclusion "That domestic refuse in London had an average calorific value equal to 0·99 lb. of water per pound of refuse burnt," was applicable to the whole of London. Refuse varied in composition in almost every parish in London; the garbage and refuse obtained from Covent Garden was totally different from that obtained from a residential or manufacturing district. An investigation of what the evaporation of 0·99 lb. of water from 1 lb. of refuse involved, in the way of calorific value of the combustible portion of refuse, yielded results of some interest. Taking the Author's figures, that there was 20 per cent. of moisture in the refuse and 33 per cent. clinker, there remained as combustible 47·2 per cent. in every lb. of refuse. Assuming that the moisture was evaporated at 212° F., about 220 thermal units would be absorbed in getting rid of the moisture per lb. of refuse. If it was assumed that at least 3 lbs. of air passed through the furnace at Shoreditch for every lb. of refuse burnt, and that the temperature of the waste products of combustion escaping up the chimney was, say, 550° F., about $3 \times 0{\cdot}23 \times 550°$, or nearly 380 thermal units would be lost in this direction. At the feed temperature and pressure recorded in the Author's Table in the Appendix, 0·99 lb. of water evaporated would account for a further 1,020 thermal units, or $1{,}020 + 380 + 220 = 1620$ thermal units altogether, without taking into account the heat lost in fuzing the clinker. To that should be added something for loss by radiation, which he thought might be put down at 80 thermal units, bringing it altogether to 1,700 thermal units. That amount of heat had to be supplied by 0·472 lb. of combustible, which corresponded to a calorific value of over 3,600 thermal units Mr. De Segundo.

Mr. De Segundo. per lb. of combustible, or between one-quarter and one-third that of pretty good coal. In the above calculations the amount of air passing through the furnace per lb. of refuse burnt had been arrived at on the basis of the results obtained by Lord Kelvin at a test of the Horsfall destructor at Oldham, but in years gone by, when, according to Colonel Codrington, at least 10 lbs. of air passed through the furnace for 1 lb. of refuse burnt, the calorific value of the combustible portion of the refuse must have been very high in order to evaporate any water at all. The percentage of moisture reported by the Authors as the average value at Shoreditch seemed low. Colonel Codrington, as the result of several tests made at Bradford, Leeds, and Whitechapel, found it varied between 30 per cent. and 93 per cent., and in Bradford the average moisture was 47 per cent. With 47 per cent. of moisture and 33 per cent. of clinker there was only 20 per cent. of combustible, and in that case that 20 per cent. of combustible matter must have a calorific value of 5,085 thermal units per pound in order that the refuse should be able to burn itself, apart from any evaporation at all. If that particular refuse with 47 per cent. of moisture and 32 per cent. of clinker was able to evaporate even $\frac{1}{2}$ lb. of water, it would run the calorific value of the combustible part of the refuse up to about 5,500 thermal units per lb. That was rapidly approaching a high calorific value for what was termed refuse. It would be seen from the figures given above that rather more than 50 per cent. of the heat produced by the combustion of the refuse was lost in evaporating the moisture and in the issuing gases. No doubt, moisture in refuse would always be a source of loss of heat, but the heat going to waste in the products of combustion could be minimized by careful design of the destructor furnace, and it was a very interesting feature in Lord Kelvin's Report on the Oldham destructor that the air consumption, as accurately as could be determined, was only about 20 per cent. in excess of that theoretically required during the trial. In conclusion, Mr. De Segundo regretted that so far no systematic observations of the performance of destructors extending over a lengthy period seem to have been made, because it was only in this way that reliable average results could be obtained. What would be considered a comparatively long engine or boiler test would be a wholly inadequate period over which to test a destructor; in fact, a destructor test might with advantage extend over a year, in order that the performance under the varying conditions of refuse during the winter and summer could be duly noted.

Mr. J. B. ALLIOTT had been associated with destructor furnaces from the time the first was erected in Manchester 22 years or 23 years ago. That first destructor furnace, though not used to raise steam, was used to evaporate and to concentrate, and the second set of destructors which were erected in Leeds, had a multitubular boiler erected in connection with them, which provided steam for driving an engine to work mortar mills to grind up the clinker. In those days the public bodies who purchased destructors had usually little or no use for steam, and consequently the object sought was not to raise steam but simply to destroy and get rid of the refuse in a sanitary way, without nuisance. The first destructors were erected purely for the object of sanitation, but having erected them for that purpose it became a question as to how they could best be utilized. When refuse or anything else was burned some heat resulted, and it was found that, under suitable conditions, a very considerable amount of heat might be generated, and a considerable amount of steam could be raised. In the early days of destructors, the refuse was generally of a lower quality than was usually found at the present time. The Bradford refuse which had been mentioned, consisting of 47 per cent. of water, 33 per cent. clinker, and 20 per cent. of combustible matter, was a sample of very many refuses to be found in other districts. It must be remembered that one could not simply take the thermal units of that 20 per cent. of combustible and consider that it was to be burnt under the most favourable conditions, and that the heat so produced could be used in any desirable manner. If in a fire burning in a grate, consisting of six lumps of coal, one of the lumps of coal was taken and put in the middle of the hearth, and the four others were put at the four corners of the hearth, only one being left in the fireplace, all six would shortly be extinguished. That was not quite the condition of the incombustible refuse, but in the Bradford refuse, each unit of combustible was surrounded by 4 units of incombustible matter, and, consequently, the difficulty of burning it was considerable. The Author had described the first attempt on a large scale to combine the raising of steam by destructors with the production of power. That was the first attempt, and naturally the arrangements were not so perfect as they would be made to-day, because there was experience to go upon, and some improvements had been made in the plant more recently erected. There were difficulties in Shoreditch. First of all, there was a scarcity of room, and that forced the introduction of arrangements which Mr. Alliott.

Mr. Alliott. were not desirable in themselves, but which were necessary to meet the special conditions. In those special arrangements due to scarcity of room would be found the key to a good deal of the cost of working that destructor. The cost of working, as had several times been mentioned, was considerable. It was very considerable compared with the cost of working at Liverpool. But then it also had to be remembered that at Shoreditch the men worked in three shifts, while at Liverpool they worked in two, and the rate paid for labour was also considerably higher at Shoreditch than at Liverpool. He thought it would be found that there was another difference. In the Appendix, which contained a great deal of most interesting information, mention was made of Oldham, and it was stated that the cost of labour there, including supervision, was $9\frac{3}{4}d.$ per ton. In another report, prepared by the borough engineer of Ashton, it was stated that $9\frac{3}{4}d.$ was the cost of stokers' wages at Oldham. The cost at Shoreditch included a good deal of work in the yard. He was quite certain that the stokers' wages would not include the cost of work in the yard, and the cost of work in the yard at Shoreditch was considerable, because of the special conditions making it difficult at present to get rid of the clinker, and on account of the restricted space. Something had been said about the effect of high blast, and Mr. Blair had stated that the only thing to be done in order to get a large consumption and a large amount of work was to give plenty of blast. He agreed with what had been said by Mr. Watson that that was not the only element. In order to burn a very large quantity, it was necessary not only to have a strong blast, but a great deal of labour; and it was very easy to go beyond the economical point and to employ more labour than was represented by the advantage of burning a greater quantity of refuse on a given area of fire-grate.

The fuel cost or value of the Board of Trade unit sold at Shoreditch had been the object of remark both in the Paper and in the discussion. From statistics published in *Lightning* it would appear that in the adjoining district on one side, the City of London had spent for fuel $0 \cdot 94d.$ per unit sold, but its output was six times that of Shoreditch; so that it was reasonable to suppose that its cost for fuel would be less owing to more economical working on a larger output. Also it appeared that in the adjoining district on the other side, the Clerkenwell and St. Luke's station had spent for fuel $1 \cdot 42d.$ per unit sold, but the output was not quite half that at Shoreditch, so that the cost might be expected to be greater. Further, it was stated that while Islington and Hampstead were neither very far away, and the output in each case closely approximated to that at Shoreditch, the cost of fuel per unit was 1·23*d.* at Hampstead and 1·21*d.* at Islington. It would appear, then, from comparison with neighbouring districts that 1*d.* per unit sold was taken, if anything, on the low side, and a value of 1·1*d.*, or even 1·2*d.*, might perhaps be justified. The information given in tabular form in the Appendix was of a very interesting character, yet, however much care might be taken in such matters, it was difficult to get reports which could fairly be compared with one another. In reference to Oldham, the first place on the list, he had already pointed out that while 9¾*d.* had been given to the Author as the "actual cost of labour per ton, including supervision," the same figure had been given to the borough surveyor of Ashton, and published in 1896 as the "cost per ton burnt in stokers' wages." If only cost in stokers' wages were reckoned at Shoreditch the labour bill would be halved. In the same report it was stated that six men were employed in working six cells, while the report made to the Author stated that four men worked ten cells. The cost quoted is probably not on all fours with that given for Shoreditch. The refuse destructors at Brussels and Hamburg were not combined with power plants, but the details given were interesting, especially as regards percentage of clinker. The clinker and fine ash at Liverpool were stated to amount only to some 26 per cent. or 27 per cent. of the refuse, while at Brussels they amount to 57 per cent., and at Hamburg to 59·5 per cent. A report by Mr. F. Andreas Meyer, published in 1897, stated that Berlin refuse treated at Hamburg in March, 1896, gave in residuals from 55·1 per cent. up to 74·8 per cent. It was obvious that no furnace in the world was likely to reduce the 59·5 per cent. of clinker at Hamburg, even though this may have been somewhat imperfectly burned down to the 26 per cent. or 27 per cent. reported from Liverpool. It was equally obvious that such refuse as that at Hamburg would not show as high an evaporative efficiency as that, say, at Shoreditch. It might be of interest that the steam-jet blast originally provided at Hamburg had recently been removed and a fan blast had been substituted, thus confirming the judgment of the Author in preferring the fan blast. At p. 445 of vol. cxxii. of the Minutes of Proceedings of the Institution it was stated that Berlin refuse treated in two forms of refuse destructors (one of the forms referred to in the Appendix being one of them) could not be kept burning without the addition of some extraneous fuel. Without such addition it was usually extinguished in four or five hours, even when the furnace had been previously made thoroughly

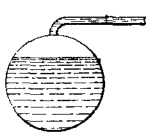
Mr. Alliott.

Mr. Alliott. hot. That did not prove that such refuse could not have been burnt satisfactorily in a furnace properly designed for refuse of a low class, and properly fed: probably it could have been made to burn quite well under such conditions; but it did show that towns' refuse was exceedingly variable, and that the results obtained from it must be expected to vary with its quality. Too many of those who had to do with the erection of refuse destructors were inclined to think, or at least to act as if they thought, that one ton of refuse must be as like to every other ton of refuse as one pea usually was to another out of the same pod. They asked for a guaranteed evaporation per pound of refuse and a guaranteed percentage of clinker, while they were quite unable to tell what the refuse contained, or, at any rate, unwilling to give any guarantees on the subject. It would be well to remember that no guarantees would enable a furnace to produce more heat from a ton of refuse than its combustible contents could generate, mixed as they were with incombustible matter; and, in like manner, no guarantees would insure 26 per cent. only of clinker and ashes where the refuse contains 33 per cent. of incombustible matter. If impossible guarantees were accepted by authorities a manifest injury was done to more prudent or better informed persons, who would only guarantee what was possible; while, when impossible guarantees proved to be impossible of fulfilment, the authority or engineer was put into a position almost as difficult and unpleasant as that of the contractor, and perhaps even more anomalous. With regard to Warrington, the refuse there was of exceptional quality. An evaporation of 1·7 lb. of water per lb. of refuse was obtained there with the original form of the Fryer destructor before it had been modified with a special view to steam-raising, but simply fitted with slightly altered fire-bars and provided with a fan-blast. A recent test at Bradford had shown that 618 lbs. of water were evaporated per cell, and that during the test 852 lbs. of refuse were consumed, equalling 0·72 lb. of water evaporated per lb. of refuse. The blast was there produced by means of steam-jets, and a further test made on the same occasion showed that these jets consumed 389 lbs. of steam per hour for each cell, so that the net steam available for power was greatly reduced. The refuse destructor plant at Charters Street, Liverpool, was specially interesting, because of the twenty-four cells, or furnaces, twelve were fitted with the Boulnois and Brodie charging trucks like those at Shoreditch, and twelve were without them. In all other respects the sets of furnaces were practically the same, and were worked under the same conditions. They burned practically the same quantity of refuse weekly; but the set of furnaces fitted with the special charging trucks was kept supplied with refuse by two men, while four were required to feed the other. The breeze used, as stated in the Appendix, was not burnt in the refuse destructors but in a fume cremator. It was only required because the furnaces were of old design, and were not fitted with modern appliances for producing high temperatures. Such appliances were, however, now in course of construction, and when completed the consumption of breeze would cease. At Hereford only a portion of the refuse was burnt. At Reading, in like manner, a portion of the refuse used to be selected and burnt in an ordinary boiler. Cases such as these did not in an ordinary sense compare with a furnace burning all the refuse that was collected. At Cambridge the refuse destructors were used for producing power for pumping. The engines indicated 140 HP. The supply of refuse not being sufficient, they were sometimes worked by steam produced from coal, the consumption of coal being 2·6 lbs. per I.HP. Under these circumstances it was found that the cost per 24 hours, working with coal costing 15*s.* 4*d.* per ton, was for coal £3 1*s.* 4*d.*, for labour 18*s.*—together £3 19*s.* 4*d.* When working with refuse the cost of labour was £1 2*s.* 0*d.*, so that, taking in one case the items of coal and labour, and in the other case the refuse (delivered free) and labour, there was a saving of £2 17*s.* 4*d.* per 24 hours for fuel and labour when the steam was produced by refuse. Mr. Alliott.

Mr. Druitt Halpin remarked that from the curve given on p. 188, on a 24 hours' load, including light load and heavy load, the quantity of steam used per unit was 49·3 lbs.; and if the results given on the next page were taken in the two other tests, one, the very light load, came to 68·7 lbs., and the heavy load to 50 lbs. But certainly the average of the 24 hours was well under 50 lbs. The Author had referred, in his description, to the amount of deposit found in the thermal storage vessel, and running that out roughly, it was about one-sixth of the total amount precipitated in the vessel, and capable of being deposited from the class of the water which was used. But the Author had mentioned in the discussion that they continually blew off. What was found remaining was only the residue after the 7 months' working, and regularly blowing the tank off accounted for the relatively small quantity of one-sixth. On p. 187 the Author had referred to water-hammer in the feed-pipes. Mr. Halpin had found the same trouble. The means adopted at Shoreditch to obviate it was putting in economizers and a hot feed, which entirely overcame it. He was not at all opposed to economizers. He believed there was Mr. Halpin.

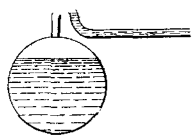
Mr. Halpin. quite a legitimate economy to be gained if gases were leaving at 700° F. or 800° F. and any of the heat could be retained. He would mention a very easy way of getting over water-hammering. As he had originally arranged a vessel, the water entered as in *Fig. 12.* He did not know exactly how it was done in Shoreditch, but possibly it was in the same manner. When the feed-pump was stopped the water flowed or dribbled down, and when the pump was started again the cold water was met by the steam, condensed and produced disastrous effects. The way to cure it was simply to put in an inverted sewer-pipe trap, a simple bend. The water ran up there, and that was the only part where water could come in contact with the steam, *Fig. 13.* It could not possibly do any harm. There was another matter he wished to mention in connection with the storage, because, apart from the fact, referred to by the Author, of the vessel enabling the very heavy load to be got over, which otherwise could not be done, and apart from the fact that it was used in purifying water—and he thought that

Fig. 12.



THERMAL STORAGE TANK.

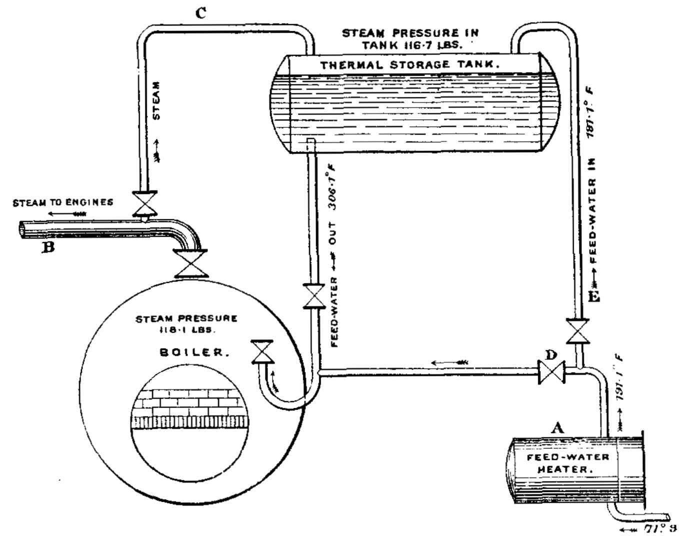
Fig. 13.



THERMAL STORAGE TANK.

experience had shown, if time enough were given, the whole of the sulphates could be precipitated at the temperatures now used—apart from that, when thermal storage was used, there appeared in working the extraordinary paradox, that very much increased results of evaporation were obtained. Professor W. C. Unwin had been kind enough to make a test for him, one day running with thermal storage, and the next day running without it. The boiler was run on both days practically under the same conditions, and the results were broadly as follows. When running without thermal storage, the evaporation was 10·02 lbs. of water evaporated from and at 212° F. per pound of fuel, but by simply changing over the two cocks, and throwing the water into the thermal storage vessel, that 10·02 lbs. was changed into 11·94 lbs., giving an increase of 19·5 per cent. *Fig. 14* showed the arrangement diagrammatically. A was an exhaust steam feed-water heater, into which the water entered at 71·9°, and went out at 191° F., both when feeding direct to the boiler and when feeding through the thermal storage vessel. When the water was put into the boiler at 191·5°, the evaporation was 10·02 lbs. B was a pipe taking steam to the engines, and C was a pipe taking steam to the thermal storage vessel. On the second day the cock D was closed and the water was forced through E into the thermal storage vessel. The temperature and the pressure in the boiler and in the thermal storage vessel were practically the same, and at the expense of steam condensed in the vessel, and supplied by the boiler, the feed-water was raised to 350° F., the temperature of the boiler, and an anomalous increase of evaporative efficiency of over 19 per cent. was brought about. It troubled him for a long time to find any reasonable explanation of the matter. He had at last found one Mr. Halpin.

Fig. 14.



which he would put before the meeting, and which he believed was the solution of the apparent anomaly. Every boiler must be working under one of two conditions, when evaporating water—either feeding the boiler, or not feeding the boiler—was going on. If the boiler were not being fed, evaporation went on at its maximum rate, because the latent heat only was being put into the water. If it were being fed, practically it was universally being fed with water at a lower temperature than the water already in the boiler. The result was that, taking the ordinary case where no feed-water was being introduced and only evaporation was taking place, every particle of water that approached the flue was

Mr. Halpin. impregnated with heat and rushed up as fast as it could to the surface; but directly it was fed, colder water than that already in the boiler was being injected, and all the particles of water that were rising impregnated with heat, instead of rising directly to the surface, were confused and thrown down, and the whole circulation was greatly retarded. In that way he fancied the diathermancy of the plate was very much interfered with, and that to his mind this accounted for the extraordinary rise of nearly 20 per cent. in evaporative efficiency observed when using the thermal storage apparatus.[1]

The Author. The AUTHOR, in reply to the discussion, remarked that a pressure of 3 inches of water was obtained on the discharge side of the fans and 0·9 inch in the ashpits. The difference was accounted for by the enlarged air-ducts as the air approached the furnace, and by leaks in ashpit doors and imperfectly covered furnace-bars, caused either by the refuse not being evenly distributed over the grate, or, as most frequently happened, portions of the refuse burning away more rapidly than other portions, thus leaving a free passage for forced draught. The delivery of the fans stated in the Paper was that guaranteed by the manufacturers. The present cost of removal of clinker was 7½*d.* per ton of refuse burned; and the cost of producing pressed clinker paving-slabs 2½ inches thick was about 1*s.* 6*d.* to 1*s.* 9*d.* per square yard. He thought the proposal to feed straw, paper, etc., into the furnaces by a sort of chaff-cutter feed-motion was a step in the right direction. The only objection to this proposal was that, as the class of refuse in question formed but a small percentage of the whole, and burned as fast as it could be fed, there would not be enough of it, at any rate, at Shoreditch, to keep one furnace going for many hours a day, even supposing it was all delivered in one lot, instead of at intervals. A furnace specially fitted with such apparatus would be necessarily idle for the greater portion of the time. He agreed that spare boilers should be installed in order that proper attention could be given to the removal of dust from the tubes; he considered the question of dust deposit on the surface of the boiler-tubes of the utmost importance, and one which should have most careful consideration in the design of all future plants. It was found at Shoreditch that, starting with a boiler that had been thoroughly overhauled, in even a few hours the

[1] Mr. Halpin showed upon the screen an optical illustration of the phenomena taking place inside a steam boiler, when fed in the ordinary way and when fed by thermal storage.

lowest four rows of tubes became coated with a spongy scale, which caked on the tubes, and after 2 days or 3 days would be found ½ inch thick. It hung in the form of stalactite, and when the furnaces were in full blast the whole of this deposit became incandescent. The deposit could only be removed by mechanical means, and it was not only a source of trouble, but reduced the efficiency of the boiler to a serious extent, and afforded a further reason why the full calorific value of coal was not obtained when burnt under boilers in such conditions. Now that it had been so amply demonstrated that refuse might be relied upon to raise steam, he thought that the use of coal under boilers fired also with refuse should be avoided where possible, and a separate range of coal-fired boilers should be provided to take up the load whenever it approached such a point that the refuse could not cope with it. A separate range of five coal-fired boilers had been erected at Shoreditch, but owing to the maximum load having increased to nearly 1100 kilowatts, it was still found necessary to use coal during the heavy load under the refuse-fired boilers. But this practice would be discontinued as soon as the new generating station in hand was completed. There was no difficulty in working refuse-furnaces, and supplementing them by the use of coal burned on separate grates, as shown in *Fig. 4*, excepting the sacrifice in efficiency of coal as fuel. In cases where it was not desired to have separate coal-fired boilers, the disadvantage must be taken into account at the onset. At Shoreditch all the ashes taken from the ashpits of the coal-fires were burned again by being mixed with the refuse. During the test, the results of which were given in the Paper, the only forced draught used was air-draught, and no steam whatever was employed for forcing the fires. Experiments, however, were carried out with steam-jets some time ago, with the result that the proportion of steam taken by the jets was so excessive that it was discarded for economical reasons. The orifice was annular, having a diameter of 0·138 inch, and two jets were fitted to each furnace, making four per boiler. With the cocks full open, the total area was 0·0572 square inch. No doubt a more improved form of steam-blast would give much different results. Suburban districts, such as Ealing, were in the best position possible for easily disposing of residue, inasmuch as, owing to the great number of new roads being made, and new districts being opened up, a great demand existed. With a destructor, however, situated within about 1 mile of St. Paul's, where there were no new roads to make, and the residue had to be carted several miles, it was apparent how the situation affected

The Author.

The Author. the costs. In considering also the costs of destruction at Shoreditch, it must be remembered that wages were much higher and other charges in proportion. Land, for instance, at Shoreditch cost about 12*s.* per square foot. He desired to warn those interested in the subject of the costs of destroying refuse, that to take for comparison simply the costs per ton was most misleading unless all other conditions of working were duly considered. The Ealing costs were, as it would be expected, much lower than those of Shoreditch; and again, comparing the 8½*d.* per ton given for Newcastle with the 1*s.* 7*d.* at Ealing, the discrepancy at first sight would appear amazing. If, however, the circumstances of each case were carefully considered, it would be found that the conditions of working were different. From a purely commercial point of view the question of the disposal of residue at a profit was of equal importance to that of steam-raising. The smaller provincial towns—and suburbs of large towns—had a much better chance of making a commercial success of a destructor and its products than had very large cities; and it was an open question with the latter whether the destruction of refuse should not be undertaken by central authorities, having several plants—in London about six—situated at a convenient distance from the centre, and to which all refuse could be sent for disposal. There would be many advantages in such a scheme. The arrangement adopted at Llandudno could scarcely be expected to give good results until the fires were kept continually going. With a supply of refuse as stated, and with a furnace of proper dimensions, it should be a matter of no difficulty to keep at least one furnace continually burning, and that would avoid the heat lost in the cooling of the brickwork every day. With the feed-water system in use at Shoreditch, dry steam was easily obtained. The price, 1*d.* per unit sold, for coal, was given as the average of seventeen London electricity-supply stations, and was accordingly considered a fair one, especially considering that the dust on boiler-tubes so reduced the fuel efficiency. This also applied to refuse fuel. The cost of disposing of the clinker worked out at about 7½*d.* or 8*d.* per ton, but this item must not be confused with the cost for labour in destroying the refuse; as in most cases, at other destructors, not situated in the midst of populous districts, the clinker was a source of revenue instead of a loss, as at Shoreditch. The item should, while having due consideration, be kept separate. The amounts of refuse burnt during the years 1898–99 were correct as given in the Paper, as well as the analysis of the costs per ton. Moving grates had not been tried, and trials of such grates made by others appeared to have been unsuccessful. A gauge was fitted on the exhaust, and the amount of back-pressure was not noticeable. Market refuse meant vegetable matter, such as cabbage-leaves. The amount of refuse one stoker was capable of dealing with in a shift of 8 hours was about 6 tons. Very little trouble was occasioned by odour from the storage bin, which was practically cleared out every day. The general health of the staff was not affected. The special means of dealing with refuse such as straw, paper, etc., mentioned by the Author, was not intended to convey the idea that special apparatus had been designed to deal with it; but rather that, instead of going through the usual routine by being shot into the Brodie charging trucks, it was conveyed direct to the horizontal furnace door, *Fig. 4*, and was passed into the furnace by hand. He found no special means of handling were required for the refuse from tan-yards; it was easily dealt with by the ordinary apparatus in use at Shoreditch. The temperature at the base of the chimney, after the gases had left the economizer, was found to be 470° F. The following were briefly the results of experiments upon the economizer and feed-storage vessel:— The Author.

Without Economizer.—The arrangement was impracticable, owing to water-hammer, caused by attempting to force cold water into the feed-storage vessel.

With Economizer, but without the Feed-Storage Vessel.—This was a practical arrangement, but, with the demand for power at Shoreditch, the feed-water had to pass through the 240 tubes of the economizer at such a rate that it entered the boiler much below 212° F., consequently the boilers had more work to do and received more lime-deposit than when the feed-storage vessel was in operation.

Without Economizer or Feed-Storage Vessel.—This implied feeding the boilers with cold water, and the result of such an experiment was obvious. The surplus heat during hours of light load was not only utilized for raising the temperature of the feed-water, but a large quantity of live steam (amount unknown) was utilized in the public baths and washhouses adjoining the destructor works. With reference to the difference in evaporative values obtained, no two tests gave like results, probably owing to the amount of moisture in the refuse and the boiler and economizer tubes being coated with dust, etc. The clinker produced during the tests was carefully isolated and weighed, and the amount was found to be 32 per cent. The idea of some refuse being shown to be equal in value to one-third that of good coal was too good

The Author. to be true; the explanation of the problem would, he thought, be found in the fact that what Mr. Segundo had taken for incombustible matter, namely, clinker, was really not so. Clinker, in connection with refuse-destructors, seemed to have the reputation of being that part of the refuse which it was impossible to burn, but that was not so. The 32 per cent. of clinker, in most cases, if dealt with in proper furnaces, could, he was satisfied, be reduced to 10 per cent., and he understood that this result had easily been obtained in one of the later types of plant. The method mentioned by Mr. Halpin was not adopted at Shoreditch, the hot feed-water being injected into the feed-storage vessel at the top, and allowed to disperse on settling trays.

Correspondence.

Mr. Abell. Mr. W. PRICE ABELL, in constructing furnaces in which all the steam was derived from light pithy fuel, composed of 45 per cent. of woody fibre, 46 per cent. of water, and 9 per cent. of sugar, and a sawdusty, fibry fuel, consisting of 60 per cent. of water, 0·44 per cent. of sugar, and 39·56 per cent. of woody fibre, had also experienced the great losses—often amounting to half the useful heat—resulting from influx of cold and surplus air referred to by the Author. This had to a great extent been overcome by means of a check and spreading arch,[1] which enabled the refuse to be utilized to form its own door or seal, thereby replacing the metal dampers previously used, and the frequent burning out of which rendered them impracticable. These fuel dampers, combined with a suitable system of rocking or progressing firebars, practically overcame the difficulty from cold air. Respecting the Author's experience that shavings and fine wood chips, straw, paper, &c., were of no practical value, the early "diffusion" and "cane refuse" furnaces were supposed to do well if they were able to consume the megass or refuse in a green state, and this without giving any useful heat or doing any useful work. It was now quite a common result for refuse resembling sawdust and shavings, but containing 50 per cent. of water, to produce the whole of the steam for large factories. Repeated experiments with efficient

[1] Described in a Paper on "Megass- and Refuse-Furnaces," Minutes of Proceedings Inst. C.E., vol. cxxiii. p. 369, *Fig. 3.*