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

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

furnaces showed 5 lbs. of this light refuse—weighing 6 lbs. per cubic foot—to be equivalent to 1 lb. of coal in useful heat effect. The following data was derived from a year's running of a factory which performed double crushing and had "triple effect" evaporation. The fuel available was 3·75 tons of megass per hour, consisting of 2·03 tons of fibre and 1·72 ton of water. This was burnt in five furnaces, illustrated in *Figs. 1* and *3* of the Paper referred to. This allowed per minute to each furnace 4·24 cubic feet of megass, weighing 6·6 lbs. per cubic foot, but in actual work with megass from good canes sufficient steam was maintained with a consumption of only 3 cubic feet. Each furnace had a grate area of 20 square feet, and each gave heat to a multitubular boiler containing 1,300 square feet of heating surface. The chimney draught was 40 feet per minute, and the temperature, as shown by a Bailey pyrometer, 500° F., and the furnace temperature, melting copper and partially melting cast iron, say 2,000° F. The steam obtained from these five boilers and furnaces concentrated and purified 9·45 tons of juice into $1\frac{1}{4}$ ton of pure yellow sugar per hour. The work actually performed per hour by the steam obtained from these boilers at 75 lbs. pressure per square inch was as follows. The juice was extracted from the canes with a pressure of 250 tons on each of the ton rolls, and the 8·20 tons of water in the juice were evaporated. The remaining 1·25 ton of sugar was cured, and the molasses converted into rum and second sugar. To do this the 3·75 tons of megass aforementioned, without the assistance of any other fuel, supplied all the heat and power to work engines and evaporators, equivalent to a total of 463 indicated engine-power calculated at actual speeds and cut-offs. In addition there were the various evaporators worked by exhaust steam, together with the addition of about 100 HP. high-pressure steam. These data showed what was actually done in everyday practice with light fuel burnt in suitable centrifugal combustion chamber furnaces, of which that illustrated in the Paper referred to was a type. The Author's experience at Shoreditch as to the amount of fine dust accumulating on the boiler tubes was in accord with the practice obtaining in the refuse-driven factories previously referred to, and from the experience there gained there was no question that where the water was good the ordinary cylindrical multitubular boiler most efficiently met all the requirements of cleaning, also giving a storage or reservoir of power. For instance, every tube of a multitubular boiler could be brushed or scraped to any extent, and this without hauling fire or materially interfering with the Mr. Abell.

Mr. Abell. steam-supply of the battery. They also gave at a lower cost than any other type of boiler the most efficient kind of heating surface for the large volume but low temperature gases with which all refuse boilers were supplied.

Mr. Ackermann. Mr. A. S. E. Ackermann thought the following additional particulars as to the thermal storage would be of interest:—the thickness of the metal shell and the nature and thickness of the lagging material; the loss of heat per square foot of external surface per degree F., difference of temperature between the water in the vessel and the air surrounding it; the mean temperature of the water in the vessel, and its variation from point to point. In trials of a warming apparatus at a hospital in Great Ormond Street, he had found the loss by radiation particularly large, even where the pipes were well lagged. It did not appear clear whether, in calculating the 2*s.* 4·39*d.* and the 2*s.* 6·9*d.*, p. 194, the sale of current had been allowed for; and whether, on the whole installation, and allowing for interest and redemption, there was a profit or loss.

Mr. Boulnois. Mr. H. Percy Boulnois observed, in reference to the Author's remarks as to the failure of the charging trucks at the Shoreditch installation to deal with "straw, paper, or any such light and inflammable material, owing to the tendency for it to catch fire during the operation of charging, and before it can be shut into the furnaces," that it was not his experience after an extensive trial of this method of charging at Liverpool and elsewhere, and that there must be some other cause for this occurrence. With regard to temperature, this was a mere question of forced draught, and, in his opinion, forced air-draught was better than a steam-blast for refuse-destructors. He was further of opinion that a destructor should be so constructed that a break-down or the necessity for any repairs should be as remote as possible, as any stoppage caused a serious dislocation in dealing with the refuse, which must be regularly collected and disposed of from day to day. With regard to the Table, which the Author gave as an appendix of the refuse-destructors in various towns, he desired to point out that, with regard to Liverpool, the Table was somewhat incomplete, as only twenty-four cells were mentioned, whereas there were now four installations, with a total of forty-four cells or furnaces. Also that, with regard to the "fuel used to assist the burning of the refuse," in which Liverpool was stated to use about 20 tons of coke-breeze per week, this breeze was used in a "Jones" cremator placed in the flue of the first destructor erected, but in the more modern installations this cremator was found to be unnecessary. The latest installation at Liverpool consisted of an eight-cell destructor on the Wood-Brodie principle, which destroyed 100 tons of refuse per 24 hours, at a cost for labour only of about $8\frac{1}{4}d.$ per ton, which compared very favourably with the costs given by the Author. The following were a few particulars of this destructor:—The total amount of refuse destroyed per day of 24 hours was 100 tons. There were eight cells, and the residue was composed of about 18 per cent. of clinker and 8 per cent. of ash. No fuel was used other than refuse. The average steam-pressure was 120 lbs. per square inch, forced blast being adopted with an air-pressure at the fan outlet of $2\frac{1}{2}$ inches of water. The steam-power was not utilized at present, but would probably be used for electric-power station, mortar making, etc. A Bumsted-Chandler fan was used, coupled to the direct-acting vertical engine. The boilers were of the Babcock-Wilcox (four) water-tube type, with a heating-surface of 1,098 square feet. There were two shifts, and during the day two feeders at 4*s.* 2*d.*, three stokers at 5s., two clinker-wheelers at 4*s.* 2*d.*, and one foreman at 5*s.* 6*d.* were employed; and at night one feeder at 4*s.* 2*d.*, three stokers at 5*s.*, two clinker-wheelers at 4*s.* 2*d.*, and one foreman at 5*s.* The cost of labour was $8\frac{1}{4}d.$ per ton approximately. The total cost, exclusive of capital cost, averaged 1*s.* 6*d.* per ton approximately, but (varied from 1*s.* 2*d.* to 1*s.* 9*d.*) the total capital cost of the destructor, exclusive of land, was £13,811 5*s.* 10*d.* The height of the chimney was 200 feet from ground-level, and its diameter was 11 feet 6 inches at the base and 9 feet 6 inches at the top. Its cost was (approximately) £2,095. A great deal of misapprehension had existed as to the power-producing value of house-refuse as a fuel, and the Author's Paper was a valuable contribution to the information on this subject, and was derived from practical and not merely theoretical experience. Mr. Boulnois.

Mr. REGINALD BROWN observed that from a sanitary point of view the destruction of refuse by fire was unquestionably the most desirable method of disposal, but in combining a destructor with a power plant it must not be lost sight of, that the first and principal object of destruction was to effectively destroy the deleterious matter in the refuse, and no other consideration should be allowed to interfere with the accomplishment of this. There was no doubt in the mind of any engineer as to the desirability of utilizing the heat from burning refuse for what it was worth, but after all, the principal consideration with local authorities was the question of cost in comparison with existing methods. Mr. Brown.

According to the Author the cost per ton at Shoreditch

Mr. Brown. amounted, in round figures, to:—Actual burning, 1*s.* 6*d.*; supervision, &c., 10½*d.*; total, 2*s.* 4½*d.* per ton, for the year ending the 30th June, 1898; but, owing to the increase in wages, it cost 2*s.* 7*d.* per ton for the year ending the 25th March, 1899. The cost for actual burning was somewhat high, and was, no doubt, partly due to the peculiar character of the Shoreditch Works. Taking the cost at 2*s.* 5*d.* per ton, including burning, supervision, repairs, &c., to this must be added, (1) a charge for electrical energy used by the fans, lighting, &c. (viz., 5 units per ton, at say, 1½*d.* per unit); and (2), repayment of principal and interest of buildings, which was rather high (11½*d.* per ton), which brought the total cost up to 4*s.* per ton; this would be a rather expensive method if the waste heat were not utilized. The cost of dealing with the clinker was purposely left out of consideration, as it was probably balanced by the value received. This also left out the charge per ton for depreciation of the plant. On the other hand, it was necessary to take into consideration the electrical energy generated by the heat. From the Paper this appeared to be on an average 27½ Board of Trade units per ton of refuse burnt, and taking this for power purposes only, viz., 2 pence per unit, would represent 5*s.* 8*d.* per ton. If two-thirds were taken for power at 2 pence, and one-third for lighting at 5 pence, the income would be increased to 6*s.* 10*d.* per ton, which would appear to be very satisfactory indeed, and from the Paper it certainly appeared that the proper thing to do was to combine a destructor with a power plant. One other point which should be emphasized was the large outlay per ton for hoisting the refuse, instead of having an inclined roadway; the latter, no doubt, was best, and preferable where it could be obtained.

The question of the supply of air by fans or steam-blast was interesting, but the energy absorbed by the electric fans certainly seemed to be excessive, viz., about 14 per cent. of that generated by the refuse. As the Author stated that steam-blast plant was also installed at the Shoreditch Works, it would be interesting to know his experience as to the comparative cost, bearing in mind the number of units generated per ton when steam-blast was used. It was evident that the sandwiching of the boilers in between the cells did not give the full efficiency of the coal when this fuel was used for firing purposes; it showed an excess of air beyond that required for perfect combustion, and probably no system of dampers could be adopted to maintain the exclusion of excessive quantities of air from the boiler during clinkering operations; it might be better to consider the battery of cells as a whole, and to place the boiler as near as possible to them, using a separate boiler when it was found necessary to use coal; the boilers would then be in a better position for convenience in repairing than if placed between the cells. Another objection to placing the boilers in the position adopted at Shoreditch was the rapid accumulation of dust on the boiler tubes, which would not take place if the boiler was fixed away from the cells; and, according to the Appendix, the results obtained in lbs. of water evaporated per lb. of refuse burnt were about the same, whether the boiler was placed away from the cells or "sandwiched" as at Shoreditch. A departure from the usual practice was made at Shoreditch in the use of a thermal storage vessel, from which much was expected, but the arrangement had not been so successful as was anticipated. It was a question whether it would not be better to work the destructor boilers at full pressure all day and store the electricity generated in accumulators. The cost per ton for burning was too high, it being given in the Appendix as 1*s.* 10*d.* against about 10*d.* for cells worked on the Horsfall principle at Oldham; and it was, therefore, doubtful whether one could not go too far in adopting so-called "labour-saving devices." The capital cost per cell, at Shoreditch, amounted to about £1,300, as against £500 per cell at Oldham, and it would be interesting to know where the excessive cost came in. The Author was to be congratulated on showing such favourable results for the works under his control, as the Shoreditch Works clearly proved that London refuse had a considerable calorific value if burnt in a properly designed destructor, with proper provision for the utilization of the heat evolved. **Mr. Brown.**

Mr. R. B. Hodgson observed from the Paper that the Shoreditch plant, when burning refuse, evaporated 0·96 lb. of water, and that when burning coal on the grates, the full efficiency was not obtained with either refuse or coal, therefore the plant was neither capable of dealing with refuse or coal in the best manner. In the case of such combined refuse and coal-firing furnaces, neither the refuse nor coal could possibly give such good results as when burnt on furnaces entirely disconnected. Possibly a large amount of surplus cold air was drawn between the boiler tubes, and through those grates not in use, diminishing the efficiency of the portion of the plant which was working; and there was little doubt that this surplus air had very much to do with the poor result obtained. It would therefore be instructing to know the percentage of CO_2 contained in the products of combustion. Had two distinct sections been erected on the best **Mr. Hodgson.**

Mr. Hodgson. known lines, one section for burning refuse, the other for burning coal, then either section of the plant could have been depended upon to give a much better result than obtained by the Author. Whilst he thoroughly endorsed the Author's opinion that the value of destroying refuse by burning, from a sanitary view, was incalculable, he did not agree that the cost of destroying should not enter into the question, seeing that so much had been spent upon experiments during the past few years. Experience, thus obtained, showed that in considering the question of new destructor works, the following items were of vital importance: (*a*) Capital outlay for destructor plant; (*b*) Cost of working destructor plant; (*c*) Cost of maintenance. And should the scheme be a combined refuse-destructor and power-plant, then:—(*d*) The weight of water that could be evaporated per pound of refuse was an important point that should be well considered. But in any case the cost of working or destroying the refuse should have very close attention, because this item had to be met continually from year to year.

Water-tube boilers were by no means the most suitable type of boilers to use in connection with destructors of refuse. In cases where the space available was limited, then the water-tube boiler was used with advantage, particularly in naval practice; but there were many reasons why they were not the most economical or useful for land practice. Their construction was such that they were not so well protected against corrosion as other types, which rendered it essential that very good water should be used. Moreover, their complicated details of design made it necessary for them to have very skilled and vigilant attention given to them. The Lancashire boiler as a steam-generator stood pre-eminent where space permitted its being introduced. A 30 feet by 8 feet Lancashire boiler contained nearly 20 tons of water, and with such a large capacity sudden fluctuations in demand for steam were scarcely felt owing to its ample reserve, whilst irregular firing was not of so much importance for the same reason. Again, modern boiler construction and methods of manufacture gave a Lancashire boiler of ample strength to stand a pressure of 250 lbs. per square inch, and as regards durability, the Lancashire and Cornish boilers surpassed all other types. In fact, the Lancashire boiler combined the advantages of steam generation and thermal storage in the best possible way, without the great drawbacks as when these items were separate. It was stated that the Author had found the fan system of draught preferable; he had found the opposite result for many reasons, the most important being the enormous cost of engine and fans, and of maintenance of them Mr. Hodgson. as compared with the steam-jet. A large percentage of energy was used to drive the fans according to the Author's statements, whereas a properly constructed steam-jet was not expensive, and would supply the necessary draught with a small amount of steam. The wear and tear was also very small, so that for capital outlay, cost of maintenance, &c., there was no comparison between the two. One of the greatest troubles hitherto experienced with combined plants had been the great variation of steam-pressure. The same trouble had occurred at Shoreditch, *Fig. 6*; the variation during 24 hours was 53 lbs., and in *Fig. 7* the variation was 75 lbs., and in neither case were boilers worked up to full boiler-pressure, and therefore the plant would not be depended upon to steadily supply steam at 200 lbs. Yet it appeared that such a combination as described by the Author might be relied upon to supply steam at 200 lbs. per square inch, which he looked upon as a very bold assumption after he had given such curves. With regard to water-evaporation per pound of refuse, 0·99 lb. was obtained at Shoreditch. This result was less than two-thirds the evaporation of that being obtained at several destructor works, for example, at Hereford. He had seen this plant many times, and there was no difficulty whatever in obtaining $1\frac{1}{2}$ lb. of water evaporated per pound of refuse.

The combined refuse-destructor and power-plant recently erected at Darwen was undoubtedly one of the best plants in the kingdom, and reflected great credit upon the Engineer. The steam generating-plant at Darwen was entirely dependent upon the refuse-destructor for means of providing the necessary heat, and this was done without the use of any other fuel but the refuse. The type of destructor in use here was the first of its kind that had been used, being of a design lately introduced, though the main principles contained in the design were similar to other destructors by the same makers. It was evident that the much-discussed object of effectually destroying refuse without creating a nuisance had at last been effectually and satisfactorily settled at Darwen, and it was also evident that the type of destructor in use there might be depended upon to run an electric plant. The water-evaporation being 1·55 lb. per pound of refuse, and the average steam-pressure during a 48-hours' trial 183 lbs., the regenerator, for supplying heated air to feed the ashpits, was a decided improvement; also the method of regulating the air-supply by means of steam-jets and dampers was particularly worthy of attention, seeing the great difficulty that had been

Mr. Hodgson. experienced at Shoreditch. The success of refuse-burning lay more or less in the fact that a forced-draught avoided the great waste—met with under natural or chimney draught—by enabling the supply of surplus air to be regulated, and the high temperatures that could be obtained in destructor-cells from unscreened refuse was very largely due to a proper control of the air-supply, coupled with a proper management of dampers.

Mr. Lovegrove. Mr. E. J. LOVEGROVE considered that the results obtained at the Shoreditch Works were due primarily to the calorific value of the refuse and also to the position of the boilers in relation to the furnaces. With regard to the calorific value of house refuse, if residential districts were compared it would be found that the refuse obtained from high-class property was of a much lower value than that obtained from the poorer class districts. This was largely due to the practice which prevails in the larger houses of sifting and re-burning the cinders. Further, the quality of the refuse varied during the year; in the summer season the value was not only very low, but, owing to a certain amount of garden refuse which was inevitably collected, it was at times difficult to keep the furnaces alight, particularly where there was natural draught only. Stress was laid upon this point because it had been stated that the average calorific value of London refuse was equal to 0·99 lb. of water per pound of refuse burnt, and it could hardly be suggested that Shoreditch was an average class London district. In many of the suburbs the refuse would be of an inferior value. Various authorities had, since the erection of the Shoreditch Works, looked upon electric lighting as accessory to a dust-destructor. This, speaking generally, was not justifiable. In many towns the supply and character of the refuse would be found quite inefficient to meet the requirements of the electric lighting installation; in such cases the steam could be more usefully applied for running machinery in municipal workshops, for planing, drilling, sawing, slab-making, &c., and the electric-lighting works might with advantage be kept at a greater distance from the dust and dirt of the destructor and clinker yard. Even at Shoreditch the use of coal was necessary to assist the furnaces, but where this was adopted a prudent course would be to have separate furnaces, and not reduce the value of the coal by burning it in conjunction with the refuse; and, further, it should be noted, in taking the results as a guide, that for the year ending June, 1898, nearly 10 per cent. of the refuse burnt was trade refuse. This would not obtain in an ordinary residential town or suburb. With regard to the construction of the destructor, there were many types of furnaces, but, as the Paper appeared to deal more particularly with the raising of steam for power-plant, it would perhaps be sufficient to refer to the question of the position of the boiler. Too much consideration could not be given to this factor in steam-raising, as, if the boiler was misplaced and at some distance from the furnaces, several hundred degrees of heat might be lost. The cost of disposal per ton was shown at 1*s.* 5·98*d.* and 1*s.* 10·20*d.* for the years 1898 and 1899 respectively; this rate of cost was due undoubtedly to the mechanical lifting and method of feeding, and, compared with the system of an inclined roadway where the refuse could be shot on the top of the furnaces, it was very high. At works under Mr. Lovegrove's control, the cost, after the material had been tipped from the carts on to the feeding platform, including burning, clinkering, and wheeling to the clinker yard, was at the rate of 1*s.* per 25 cwt., or 9·6*d.* per ton, and the men employed earned, by piecework, an average of £2 10*s.* 0*d.* per week. With regard to the nuisance which was said to arise from some destructor chimneys, and in respect to which in at least one case an injunction had been successfully obtained, resulting in the closing of the works, greater trouble was experienced from furnaces with forced draught than with natural draught. A high chimney was a great assistance in preventing trouble in this direction, and it was desirable to work the furnaces as long as practicable with natural draught rather than forced draught; this would also prolong the life of the furnaces and reduce the expenditure for repairs to a minimum. The introduction of destructors had to a great extent solved the difficulty of disposing of a large amount of refuse of an obnoxious character, but, although the bulk was reduced by fire (taking the English results) to between 25 per cent. and 30 per cent. of the original quantity, there was still—particularly in London—some difficulty experienced in disposing of the clinker. This appeared to arise from a misapprehension of the value of the residue. The following were some of the uses to which it might be put:—The rough clinker formed one of the finest classes of hardcore for roads and paths, particularly on a clay soil, where it was superior to ordinary brick rubbish hardcore, as it provided a drainage bed so that the surface of the road was kept drier than was the case with other classes of foundation. As a concrete, mixed in the proportion of one of cement to five of clinker (care being taken to have a sufficient amount of fine ash), it was superior to what was generally considered in London the best class of concrete, viz., that composed of one part of Portland cement to five parts of Mr. Lovegrove.

Mr. Lovegrove. Thames ballast; it was tougher and less subject to cleavage. This on soils such as clay, where the ground was subject to expansion and contraction and the buildings to settlement, was a very important factor which should not be overlooked. The same remark applied to the use of the ground clinker as a mortar. The writer had also used the material for plastering and rendering to a somewhat large extent, but, while it made a very hard plaster, there was one defect which showed itself to a greater or less extent, viz., that after the plastering or rendering had been finished for a few months, signs of blowing had occurred, causing small circular flaws about $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in diameter in the face of the plaster; on examining these they appeared to be due to minute particles of iron in the clinker. In cases where this occurred these small places were cut out and made good, and no further trouble was experienced. At the same time, the writer considered it advisable to call attention to this risk, particularly where the rendering was used for water-tight tanks. Up to the present time the use of the flue-dust for disinfecting powder had not been very successful, the great objection being that it attracted moisture in apparently dry stores, where ordinary powder would not be affected, thereby rendering the powder useless for the purpose for which it was required. Very successful tar paving could be made by crushing the clinker and sifting it to the various sizes required for bottom and top dressing, and this could be laid at a cost varying from 1*s.* 6*d.* per square yard to 1*s.* 9*d.* per square yard, according to the distance of cartage from the works. It appeared to equal in durability the ordinary granitic tar paving, but it was not suitable for paths where the foot-traffic was heavy. The use of the clinker for making paving slabs was not new. Many of the earlier hand-made slabs were faced with granite, thus losing one of the great advantages of the clinker slab, viz., the non-slipperiness of its surface. The adoption of the hydraulic press had done away with the necessity for granite facing. These presses had been in use for some time, particularly at Liverpool and Bootle, but at present the only machine of the kind in use in or near London was that belonging to the Hornsey Council. The slab produced was even in texture and non-slippery in wear, the effect of heavy foot-traffic after four to five years being practically imperceptible, so that it compared very favourably with other manufactured paving slabs, and the cost of production was considerably less than one-half the cost of ordinary granitic concrete paving:—The clinker drawn from the refuse furnaces was ground in a mortar mill driven by steam obtained from the destructor boilers, and, after being sifted through a $\frac{1}{4}$-inch square mesh sieve, was mixed with Portland cement in the proportion of two of ground clinker to one of cement. The concrete was then placed in strong iron travelling moulds and run by hydraulic power under the hydraulic press, which exerted a pressure gradually increasing up to $1\frac{3}{4}$ ton per square inch. The slab remained under pressure for about 3 minutes, when it was removed from the mould and placed on a rack to dry under cover for about a week, and was then stacked in the open until required for use, it being found that after 3 months the slab was in good condition for laying. The dimensions of the moulds in use were 3 feet by 2 feet, 2 feet 6 inches by 2 feet, and 2 feet by 2 feet, and the thickness of the paving was $2\frac{1}{2}$ inches. This process could not be looked upon in a large way as a method of disposal, but rather as a useful and economical method of using the waste material. The cost of manufacture was largely affected by carefully planning the works, so that there was sufficient mill-power to keep the presses at work, and the position of the mills being between the furnaces and the machinery room, unnecessary labour in wheeling was thereby avoided. He had carried out various comparative tests for personal information to ascertain the value of clinker-paving and briquettes compared with other materials, the results of which were annexed. With regard to these tests, it was not suggested that the most reliable test for paving could be obtained otherwise than in actual wear, but, as a question of comparison, it had been found, particularly in regard to the attrition test, that the actual wear, whether of macadam for roads or paving for footways, bore a very close relationship to the results obtained by the test. Mr. Lovegrove.

This test was applied by placing samples in a cylindrical testing machine, the cylinders being cast iron and $11\frac{1}{2}$ inches in internal diameter, with three 1-inch by 1-inch angle-bar ribs riveted lengthwise on the inside of each cylinder; each class of material

TENSILE STRESS OF VARIOUS BRIQUETTES.

—	Number of Days in Water.	Average Breaking Stress per Square Inch.
		lbs.
Neat Portland cement	7	473·00
Clinker and Portland cement (2 to 1)	14	176·16
Thames sand and Portland cement (2 to 1)	14	147·00
Standard sand and Portland cement (2 to 1)	14	158·33

Mr. Lovegrove.

CRUSHING STRESS—SAMPLES OF PAVING.

Test-pieces 6 inches square.

	crushed at
1. Natural York paving	63 tons = 3,920 lbs. per square inch.
2. Clinker paving (2 of ground clinker to 1 of Portland cement, hydraulic pressed)	51 „ = 3,173 „ „ „
3. Granitic paving (Portland cement and granite chips)	44 „ = 2,738 „ „ „
4. Artificial York paving (2 of old York ground fine to 1 of Portland cement, hydraulic pressed)	43 „ = 2,675 „ „ „

ATTRITION TEST OF SAMPLES OF PAVING, REFERRED TO IN CRUSHING TEST.

—	Loss per Cent. of Original Weight	
	By Dry Test.	By Wet Test.
1. Natural York	12·06	27·05
2. Clinker paving	15·62	37·99
3. Granitic paving	22·26	47·26
4. Artificial York paving	22·55	45·99

was subjected to 8,000 revolutions at a speed of 20 revolutions per minute. In the wet tests the materials were weighed dry, and about ½ a gallon of water was put in the cylinder, the weight after the test not being taken until the samples were again thoroughly dry.

Mr. Meyer. Mr. F. ANDREAS MEYER remarked that at Hamburg the steam generated was so large in volume that not only was all the light in the station produced and all the machinery, as electric cranes, fans, and clinker-crushing, driven by it, but also the sewage pumping-station for the district, situated below the high level of the River Elbe, was driven by this steam (by means of electric transmission of the power generated).

Mr. Smith-Saville. Mr. R. W. SMITH-SAVILLE had recently completed a combined scheme for refuse-destruction and electric lighting, and after experiments had come to the conclusion that the ordinary refuse of a town had a calorific value sufficient to justify its application to boilers without any means of applying other fuel by means of special grates, which not only caused additional expense in an installation, but also, as the Author appeared to show, by not being able in practice to be perfectly tight, allowed cold air to

Mr. Smith-Saville.

enter and so reduce the temperature. This must have an important effect upon the great variation which he observed in the steam-pressure as shown by *Fig. 7*. This variation must be considerably augmented by the use of water-tube boilers, which, whilst being rapid steam-raisers, were also rapid coolers. This was an important element to be taken into account in dealing with refuse fuel, owing to its great variation in calorific value, naturally causing the heat obtained from its combustion to vary considerably, the variation being further increased when it was remembered that only two refuse fires were provided per boiler, so that the risk of having dull fires to any particular boiler was but spread over two fires, although in a large works, such as the Author described, this contingency was minimized by the number of boilers he was able to have in use at one particular time. He was able to justify these views from the results which his own works had given, as with small works he had been able to maintain constantly a load of 100 kilowatts entirely with refuse[1] and a variation not greater than 30 lbs. of steam-pressure, and in doing this had been able to obtain an average water-evaporation of $1\frac{1}{2}$ lb. per pound of refuse consumed. The steadiness of the steam-pressure was largely due to the fact that Lancashire boilers were in use, and that the heat to these was supplied from four fires in series. By the use of these boilers the maximum water-storage was obtained, and therefore, when once hot, their thermal value was maintained for a longer period, and with using four fires the risk of a unit of furnaces being deadened by bad refuse was considerably reduced. The cost per ton of dealing with the refuse appeared somewhat high, but this was largely a matter of wages; but from the experience he had gained of refuse destructors, both for power and merely for use as destroyers of refuse, he was convinced that, if the full amount of steam-power had to be obtained from the refuse, it would cost more per ton for the labour of firing than if destruction only was desired, because not only was more care required in firing, but a superior and consequently higher waged class of labour was necessary, because of the added complications of boilers, pipes, etc.; but as the Author had wisely pointed out, to be dealt with in a proper hygienic manner the burning of refuse was an absolute necessity in any case, and therefore any benefit derived from this must be a clear gain to the community.

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[1] Except for re-starting the fires after flue cleaning, not an ounce of coal or coke has been used at any time since starting 3 months ago.

The Author. The AUTHOR, in reply to the Correspondence, in particular to Mr. Abell's observations, wished it to be distinctly understood that his remarks as to straw, paper, etc., being of no value for steam-raising purposes, only referred to the inefficient arrangement for dealing with this class of refuse at Shoreditch; if dealt with under better conditions a different result would be obtained. He had been unable to gain the whole of the information asked for by Mr. Ackermann, but he was able to say that the thickness of the shell of the thermal-storage vessel was $\frac{7}{8}$ inch, and there were no stays of any kind. The temperature of the water in the vessel was the same as that of the steam in the boilers. In calculating the cost for the year ending March 1899, sale of current was not allowed for. There was a decided profit on the whole installation, and full particulars of the financial side of the question might be obtained by a perusal of the Shoreditch Municipal Reports and Accounts, 1898–1899.

There had been a misapprehension as regards the cost of hoisting refuse; if the figures in the Paper were referred to it would be seen that the cost of hoisting was really very small. The cost of current for driving the fans was, however, as pointed out in the Paper, a very serious matter. The Author was unable to give comparative costs of steam *versus* air-blasts. He desired to acknowledge specially the valuable and interesting comments of Mr. E. J. Lovegrove, who, however, seemed to be under the impression that coal was mixed with the refuse. This, however, was not the case. As already mentioned in the Paper, no coal or other fuel was mixed with the refuse, which burned freely, and the Author mentioned this matter again here, being desirous that the point should be made quite clear. He was pleased to note from the communication received from Mr. F. Andreas Meyer of Hamburg, that the heat from the destructors was utilized not only for lighting the works, etc., but also for the sewage-pumping station. The observations as to the extra cost of labour, where the full amount of steam-power is to be obtained from the refuse, were in agreement with the experience obtained at the Shoreditch works.

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19 December, 1899.

SIR DOUGLAS FOX, President,
in the Chair.

The discussion on "Combined Refuse-destructors and Power Plants" occupied the evening.