REFUSE DISPOSAL AND POWER PRODUCTION

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WITH NINETY-EIGHT ILLUSTRATIONS

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PREFACE

THE production of power from refuse is essentially a modern development, most of the Destructors combined with Electricity and Sewage Works having been erected within the past three years. In the main, this is my explanation for undertaking the preparation of this work, which has involved a considerable amount of labour. Having been responsible for a work [1] on "Refuse disposal," published rather less than three years since, I feel that an explanation is due to the reader.

It has been my endeavour to place sanitation in the forefront as the primary object of the Destructor, and although the power derived is such a valuable asset, yet we must recognize the Destructor as a sanitary necessity, whether the power can be fully utilized or not.

There can be no doubt that the disposal of refuse by the agency of fire has become increasingly interesting to both the lay and professional mind by reason of the very satisfactory amount of power now produced therefrom.

This progress will probably not commend itself to the ultra-sanitarian, as being altogether satisfactory, and there are some who deplore the commercial—or power aspect of the question. They would have refuse destroyed everywhere, whether power was available or not.

From a strictly sanitary point of view, their contention is correct, but seeing that the most perfect cremation is quite con-

[1] *The Economic Disposal of Towns' Refuse.* Published by P. S. King & Son. Westminster, S.W.

sistent with the production of a considerable amount of power, it would be sheer folly to disregard a valuable asset.

It is common in these days to find the commercial aspect too prominent; with the desire for sanitary improvement there is an overbearing anxiety on the part of the layman to know whether such improvements will pay—or commercially speaking—show a profit.

If the councillor is assured that the only benefit accruing will be a lower death rate, his sanitary zeal sometimes does not last long. If a sweeping sanitary reform is calculated to add a few pence to the rates, the erstwhile rabid sanitarian decides that the Council rate must be kept down, even if the death rate has to go up.

It is indeed regrettable to think that this attitude may be largely attributed to the striking success achieved in some towns where Destructors have been employed in connexion with Sewage or Electricity Works; in the case of the former often saving the entire coal bill, and in the latter case materially reducing the same.

The layman too often fails to appreciate the difference between two towns, being possessed of the notion that what has been done in the case of (A) is equally possible in the case of (B); if it is not, then he at once exerts his influence against the introduction of a Destructor.

It will be very evident that this is very mischievous, inasmuch as the Destructor does not appeal to a man of this type as a Destructor—a sanitary *sine qua non*, but as a profitable undertaking commercially speaking, and so we find that in some towns where it is not possible to combine a Destructor with an Electricity Works, Sewage Works, or Water Works, the introduction of the Destructor is resisted, or at any rate, left severely alone, until it cannot be neglected any longer.

Notwithstanding the splendid progress already made in this country, much yet remains to be done. It is, moreover, becoming increasingly evident that every shifty method of getting rid of filth will have to be abandoned, and that destruction by fire will, in course of time, become universal.

PREFACE

Within these pages I have endeavoured to record what progress has been made the world over. At the same time special attention has been devoted to the modern developments in power production and utilization.

The usefulness of a work of this kind is much enhanced by the inclusion of data, tests, and actual working results. For much information of this kind readily furnished, I tender my hearty thanks to many municipal engineers both at home and abroad.

Every care has been taken to include authentic or official figures only, but in the compilation of so many figures, it is possible that mistakes have crept in. Should any such inaccurate figures be detected, I should be pleased to have the same brought under my notice for future correction.

In endeavouring to treat the subject comprehensively it has been necessary to discuss several matters which are highly controversial; in so doing, it has been my aim to discuss principles rather than makes, and to avoid invidious comparison.

It is hoped at this time, when the question of final and sanitary refuse disposal and power production is engaging the attention of so many authorities at home and abroad, that this work will be found of service.

W. FRANCIS GOODRICH.

"GLENLEA,"
WATFORD.

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Chapter I

INTRODUCTORY

REFUSE Destructors may be divided into three distinct classes. (1) The original type of low temperature and slow combustion cells, with which little if any use was made of the escaping gases for power production. (2) Destructors provided with artificial draught and therefore more efficient *as Destructors* by reason of the higher temperature obtained, and greater destroying capacity, but which only provide power for works purposes or clinker utilization, and (3) Destructors of modern types providing the *maximum* amount of power available from the refuse—

(A) For the generation of Electricity, either for Lighting or Traction purposes, or both.

(B) For Pumping Sewage.

(C) For Pumping Town's Water.

(D) For Gas Works or other Municipal purposes, for which power is required.

Destructors which may be placed in this class differ essentially from those previously mentioned inasmuch as the available power represents an actual economic gain, as any alternative source of power supply would involve a definite expenditure ; and as will be seen in many instances a coal bill has either been entirely saved or materially reduced. It will thus be clear that such Destructors should be considered as being in a class distinct altogether from others.

Under each town each installation will be briefly dealt with. Destructors under classes Nos. 1 and 2 can scarcely be treated with as Power Destructors, seeing that in almost every case the limitations are such that only a portion of the available power is utilized.

Again that portion which is so utilized is only turned to such account owing to the provision of the Destructor, that is, the power would not be required unless the Destructor had been installed.

At the same time although such utilization of power does not effect any actual saving in the shape of a coal bill, yet it is eminently useful, because when a plant for the complete utilization of clinker is installed the power which would otherwise go to waste, by operating clinker screening and crushing plant, mortar mills and clinker brickmaking plant enables the clinker products to be sold at reasonable prices, yielding a useful return to be set against capital and standing charges.

In this way, as will be observed in the case of Bolton, a material reduction may be effected in the actual cost of destruction. It will thus be seen that under given favourable circumstances the destructor which cannot be placed under the category of Power Destructors is yet often of remarkable economic value to a community.

It would be unjust to makers of Destructors who have erected many such plants, and misleading to the reader, were this not made perfectly clear. Under favourable circumstances it is possible for such Destructors to be operated without any loss—that is, the sale of clinker and clinker products alone may suffice to meet all capital and standing charges.

Much has already been accomplished in the way of clinker utilization, but a great deal yet remains to be done, and where circumstances warrant we shall undoubtedly see remarkable developments in the utilization of clinker. What is being done in the various installations will be found recorded, and, in addition, a special chapter has been included in which some of the most recent and interesting developments are dealt with and illustrated. At this stage therefore further reference to the matter would be superfluous.

With the early type of Destructor of the low temperature, slow combustion type, boilers were but rarely installed and no attempt whatever was made to develop power. The low temperature gases were useless for steam raising purposes, very frequently not being sufficiently high in temperature to avoid nuisance.

The residuum or clinker was soft and objectionable, having no commercial value, it being impossible to produce a good serviceable vitreous clinker unless a high temperature be reached and maintained in the cell.

As the late Mr. Alfred Fryer stated in a lecture at the Sanitary Institute in 1887, the public prejudice against the adoption of Destructors has been so strong that it was a marvel that the earliest destructors were ever erected.

Even in these days very serious and determined opposition is met with at times, in spite of the fact that the modern Destructor, carefully designed and properly operated, is absolutely free from nuisance.

With the early Destructors there was doubtless just cause for complaint: the design was weak, and an even reasonably high temperature was never reached. That noxious fumes did escape from the chimney is quite certain, and there is every reason to suppose that at times quantities of very offensive dust also were discharged.

The first serious attempt to prevent the escape of noxious fumes from the chimney was the fume cremator patented by Mr. Charles Jones, M.I.C.E., of Ealing, in 1885 (Patent No. 8,690). The cremator may be briefly described as a secondary fire or fires arranged in the main flue in such a position that the whole volume of low temperature gases after leaving the cells must pass over the active cremator fire of coke or other fuel, and under the concave side of a firebrick arch placed over the fire.

That the Jones' Cremator was useful is a matter of history, the escaping gases were to a large extent deodorized, but the cost of this secondary fire was in many cases found to be quite prohibitive, materially adding to the cost of destruction.

Mr. Jones' timely invention helped, however, to silence opposition, to quote the inventor's own statement: "You must speak well of the bridge which carries safely over." The cremator certainly had the effect of bridging over the period between low temperature and high temperature working.

It will be evident that a secondary fire or cremator beyond the cell could not possibly have any effect upon the actual operation within the cell; in this respect, perhaps, the weakness of the cremator was most manifest. Although the cost of destruction was higher, the residuum or clinker was still soft and worthless, and therefore so far the improved Destructor was a greater expense to the community than in its original state, the refuse being burned at a greater cost but still producing little or nothing of value as an asset.

Although there were some few installations with which multitubular boilers had been included at this time, the power produced owing to the low temperature system of working was but negligible. In one instance a drastic departure was made by setting a boiler immediately over a cell, the base of the boiler being practically in the fire; while this arrangement improved matters from the power producing standpoint, it was doomed to failure because the primary purpose of the Destructor was effectually thwarted.

The gases as distilled from the refuse came into immediate contact with the large cooling surface of the boiler, and anything like a reasonable temperature in the cell was thus rendered impossible; in short, efficient cremation was quite out of the question, and so the first attempt to produce a considerable quantity of steam had the effect of demonstrating in the most emphatic manner that complete combustion must be first secured, and that the primary function of the Destructor must always be to destroy, power production being a secondary consideration.

No real progress was made until it was clearly recognized that the old system of low temperature working was wrong, and that it must be superseded by artificial draught. With the introduction of forced combustion and high temperature working, complaints concerning nuisance ceased. The cremator having fulfilled its purpose was but rarely heard of and was no longer adopted.

Forced draught was clearly shown to be the real remedy, and a vital necessity for securing a sufficiently high combustion temperature to avoid nuisance. Instead of the slow low temperature distillation of the gases, or cooking of the material, the fires were now vigorous and the temperature high; the clinker previously soft, offensive and worthless, was now vitreous and serviceable, and not only was nuisance prevented, but the destroying capacity of a plant of given size was doubled, a large and constant volume of hot gases passing through the boiler to the chimney.

It soon became evident that a considerable volume of heat was being wasted, and an effort was made to provide and use steam other than that required for the forced draught; at first this departure was confined to the operation of mortar mills, screens, hoists, provender machinery, and for similarly modest purposes.

As the Destructor maker has been often charged with exaggeration it may be as well to observe at this point that directly the high temperature Destructor was producing a modest amount of steam, enthusiasts began to predict a remarkable future for the Destructor; these enthusiasts were not Destructor makers nor had they any interest in any particular type of Destructor.

The harm done by enthusiastic professional men at this time has had its effect ever since. Results in power production were prophesied which have not yet been attained, and which never will be attained. This is a candid admission, but no apology is needed. The modern Destructor has an excellent record, but it has its limits, and had this been recognized at its advent, much misunderstanding might have been avoided, and as the result greater progress might have been recorded.

Although it must be frankly admitted that there is a very wide difference between the operation and steam requirements of a mortar mill and a high speed engine for electric light or traction purposes, yet it must likewise be admitted that there is a great difference between the Destructor which was first found useful for the former purpose and its modern prototype as combined with the generating station. This the author endeavoured to make clear in a paper read before the Institution of Electrical Engineers[1] (Manchester Section) in November, 1902, from which

[1] See Proceedings (Manchester Section) Institution of Electrical

I cannot do better than quote in order to make the difference quite clear.

When we have reached such a satisfactory position that it is possible to obtain from a boiler fired with Refuse Destructor gases an evaporative efficiency equal to that obtained from a similar boiler direct fired with the best coal, then it may be fairly submitted that the Destructor is a valuable adjunct.

It may be said that such a statement involves the doubt as to whether or not power production has become the primary function of the Destructor. If any reader is possessed of such a doubt he may at once be assured that in the best modern practice, the

Engineers, 1902. *Electricity from Refuse—the Case for the Modern Destructor.* By W. Francis Goodrich.

" I venture to say that the best of modern destructors have only been designed by a process of improvement. Of course there are members of your profession who still assert most positively that the available power is really only suitable for operating mortar mills and similarly modest machinery, which require but little steam, and at any reasonable or may be unreasonable pressure.

" If we are to take such statements as these seriously, then we must perforce believe that we have made no progress during the past fifteen years, because the destructor of fifteen years ago was quite equal to supplying steam for the work in question.

" Can it be seriously urged then that the destructor of to-day is but on a par with its earlier prototype ? Is it a fact that while every other branch of engineering has a record of remarkable progress, this particular branch has stood still ? It is not necessary for me to supply the answer ; those of you who have seen the earlier type of destructor know that immense strides have been made.

" Why was the old lowt emperature type of destructor of little use for power production, and why was it the cause of endless annoyance and litigation ? Broadly speaking, for one and the same reason—worked at a low rate of combustion limited by natural draught, low temperature gases only came into contact with the boiler ; fifteen years since it is safe to say that the temperature of the gases entering the boiler never exceeded 800° Fahr., frequently falling as low as 600° Fahr. Now, in our best modern practice, gases enter the boiler at a temperature of 2,000° Fahr., or even higher, and in a well managed plant the minimum temperature can be kept at 1,600° Fahr.

" In the face of this, is it not reasonable to expect very different results in the way of power production ? and is it not, to say the least of it, a short-sighted policy to still tie the destructor to the despised mortar mill ? "

highest attainable temperature is reached *in the cell*; this being done, the very conditions which are of the highest importance for perfect cremation, are at once such conditions as must exist in order to obtain the very best results in power production.

If you would ask—is the combustion perfect? it may be submitted that the attention paid to combustion in the case of the best modern Destructors is such as cannot be found with the majority of steam power plants where coal is used.

The figures of analysis of the gases of combustion at several Destructor Works will be found tabulated herein and they are worthy of careful perusal and of critical comparison with the analysis of gases taken from the coal fired boilers, working under ideal conditions.

Such comparison will but clearly show that the combustion process in the case of the first-class modern destructor is very much more efficient than with the average coal fired boilers, and the modern Destructor chimney may be readily singled out in manufacturing towns as being the most free from offence, and often the only clear chimney in the town.

If a well designed modern high temperature Destructor is operated with reasonable care the chimney will always bear the closest scrutiny; and generally speaking at the present time, Destructor chimneys all over the country are absolutely void of offence. It is true that occasional complaints are still made concerning one or two low temperature destructor chimneys, but such exceptions only prove the general rule, and when these old installations are "converted" to high temperature working, complaints will cease entirely.

Although very considerable alterations have been made in the design of destructor cells, and although such alterations and improvements have all in the main contributed to the greatly increased efficiency, yet by far the most important innovation was the introduction of forced draught and high temperature working. Had every other improvement, with the exception of forced draught been added to the original "Fryer" cell, it is safe to say that but very little real progress would have been made.

One has only to look at the matter from such a standpoint to fully realize what a drastic and far reaching improvement was effected by the addition of forced draught. Without it destructors would have become increasingly unpopular, and by this time they would be classed among the failures of the past. Sanitation, in so far as the final disposal of refuse is concerned, would have received a rude check.

Strictly speaking many of the modern improvements have only become practicable because of the adoption of forced draught and high temperature working. Prior to the introduction of forced draught, no real advance had been made, and all the many later improvements owe their inception either directly or indirectly to this first drastic improvement, the effects of which have been so far reaching, and of such a character as could scarcely have been anticipated.

In spite of the remarkable improvement due so largely to the use of artificial draught, a few strenuous advocates of the old system still remain. It is manifestly useless to attempt to convert such. If what has been accomplished all over the country during the past fifteen years does not carry conviction, then it is too much to hope that any treatise on the subject can be of avail.

If the fact that no Destructor has been erected for many years past unless equipped with forced draught is not all sufficient evidence as to the value of the improvement, then but little more need be said. When actual demonstration has failed to carry conviction, argument is not likely to be effective.

It is safe to say that the Local Government would decline to pass any scheme for a Destructor unless artificial draught is provided, and herein lies the primary safeguard for the ratepayer, who may rest assured that every scheme submitted to the Local Government Board is carefully looked into in detail.

To the late Mr. Alfred Fryer belongs the credit of first satisfactorily tackling the problem of final and sanitary disposal. It is true that during the twenty-seven years which have passed since Mr. Fryer erected his first Destructor great progress has been made by reason of improvements in design and construction, yet the fact remains that Mr. Fryer solved a great difficulty, and one which has been much aggravated by the rapid growth of our cities and towns within recent years.

The first two Destructor cells erected by the late Mr. Alfred Fryer at the Water Street depôt of Manchester Corporation, in the year 1876, and shown in Fig. 1, are still in daily use. Within the past two years Meldrum's Forced Draught and grates have been applied to these two cells and also to ten other similar cells, greatly increasing the temperature, and also the destroying capacity of the cells.

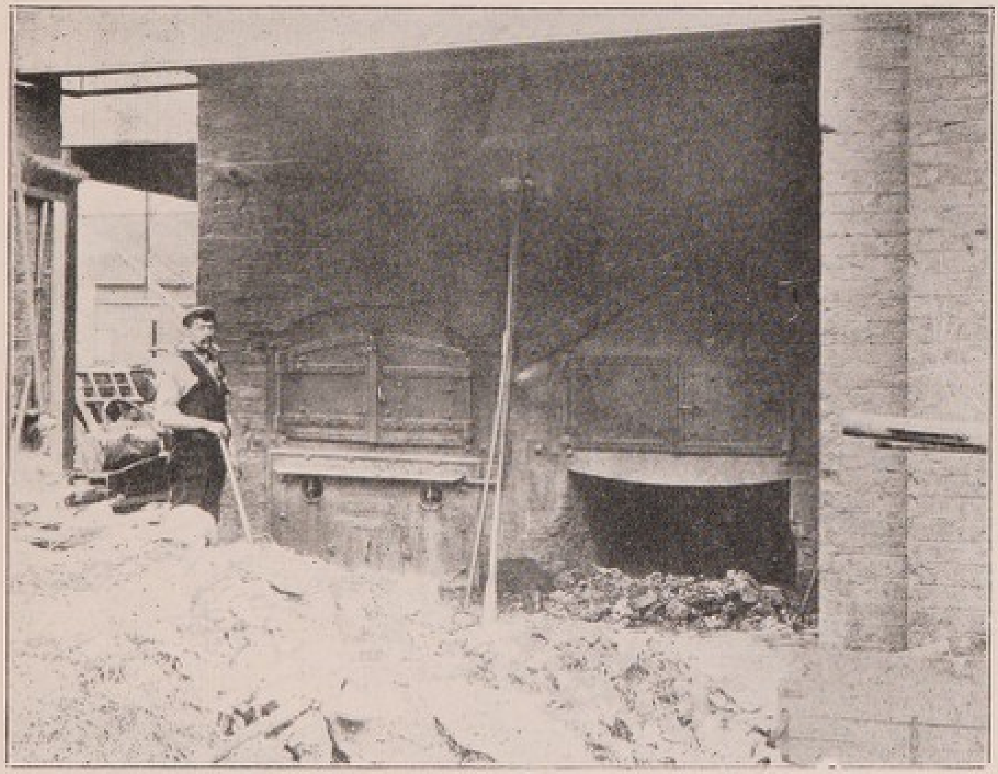


Fig. 1. The First Two Destructor Cells Erected at Water Street Depôt, Manchester, in 1876.

It is a striking tribute to the genius of the late Mr. Fryer that the essence of his original patent still forms the basis of nearly all the top fed Destructors offering. Mr. Fryer stated his principle as follows : "Charging or supplying the refuse to the cells at the back and drawing out the clinker—the residuum—at the front.'

There have been many alterations and improvements in detail so far as the internal design is concerned, but the main principle as laid down by Mr. Fryer is still largely in evidence.

Although experience has shown many weak points in design and construction, the sanitarian will always honour the name of Fryer. While the first destructor was not entirely satisfactory and would fall far short of modern requirements, its advent marked a new era in sanitation, and our present satisfactory position has only been reached by a process of evolution, which process was only rendered possible because of Mr. Fryer's earlier efforts.

In Mr. Fryer's time the destructor had but few advocates, and critics innumerable. The grateful thanks of every sanitarian are due to Mr. Fryer, who had to contend with such determined opposition as would have daunted many men.

Again, Mr. Fryer was offering a destructor far from perfect and nothing more. He could not offer a good vitreous clinker even as an asset against the cost of operation. He could not offer to provide power for electrical purposes, sewage pumping, or water pumping, in fact no return whatever could be offered, and yet in spite of all, destruction by fire was firmly established in this country and is now recognized as the only satisfactory method of final and sanitary disposal.

There are those who are ever ready to criticize, and notwithstanding past experience, the destruction of refuse is looked upon by not a few as a very simple matter calling for no special engineering skill or experience. We need not labour this point, it will suffice to say that the problems involved in combustion have been tackled in such a manner in this country as is without parallel elsewhere either in Europe or America, and our British practice in combustion even with any class of fuel is considerably in advance of what is being done anywhere outside of these islands.

It is generally recognized by those competent to judge in America that our present satisfactory position has only been attained by scientific application, and many American engineers have not been slow to fittingly recognize our premier position, at the same time deploring the apathy shown by their own countrymen, and the lack of attention given to those cardinal principles which govern efficient combustion.

In order to show clearly how our British practice in refuse disposal compares with American practice, I cannot do better than quote from the contributions of some American experts to a discussion[1] on "The Sanitary Disposal of Municipal Refuse" at meetings of the American Society of Civil Engineers, held on December 17, 1902, and January 7, 1903.

Mr. Rudolph Hering, a recognized authority on the subject, said :—

In Europe the Municipalities, under the guidance of experienced engineer officers, generally undertake the cremation by their own long trained employés, while here with us the health boards or council committees select not only the design, but indicate the method of operation, appoint unexperienced employés, or enter into a contract for immediate profit rather than for permanent efficiency.

The difficulties underlying the problem of city refuse disposal, which is almost wholly one of engineering, have been solved satisfactorily where competent engineers have been employed for the purpose. It is hardly to be expected that without professional skill and training desirable results can be reached in this any more than in any other branch of engineering.

Mr. H. de B. Parsons, another expert, said :—

The failure in American cities has been largely due to faulty design of the furnaces and lack of high temperature (a most essential feature).

Colonel W. F. Morse, the distinguished sanitarian, said :—

The comparison between English and American efficient disposal is distinctly against us. . . .

The work has been begun at the wrong end ; a sufficient amount of engineering skill was never applied to it. Municipal Committees have gone about the country and have been persuaded by ambitious furnace builders to instal plants. These plants have been simply experimental —built for a profit. They were not durable, and required extensive repairs. In many cases they were not sanitary ; they emitted odours ; they were not in all respects adapted to the work required of them, and they were expensive to operate. . . .

If progress is to be made, it must be made either by inventing a new furnace, or by adopting other furnaces which have been proved successful elsewhere.

Mr. Geo. A. Soper remarked as follows :—

At the present moment the City (New York) is deplorably dirty.

[1] See *Proceedings, American Society of Civil Engineers.* January, 1903. Vol. xxix. No. 1.

Business men and property owners are complaining that their refuse is not removed. . . .

The street cleaning department is struggling under the disadvantages of an incomplete and outgrown equipment. It may seem like strong language, but it is not beyond the facts to say that the system of cleaning the streets of the Metropolis if followed by a private Corporation would lead to bankruptcy.

This latter quotation has only been included to show that even in the collection and removal of refuse, as in its disposal, much yet remains to be done. The authorities quoted are all recognized as experts in New York; the reader must be impressed by the singular unanimity of opinion, and the admitted unsatisfactory conditions obtaining.

The whole position may be summed up by saying that current American practice is but on a level with our practice of fifteen years since, and that our gradual but definite progress towards sanitary efficiency, and power production has been without any material effect in America.

Certain it is that our position can only be approached by progress on the same lines as have been dictated by actual experience here, and such results as we now obtain can only be reached by practical and scientific application. Until this is clearly recognized no real progress will be made. This opinion is expressed not in any boastful spirit, but merely as the result of clearly appreciating the fact that the paramount difficulties presented in American practice are in the main practically the same as have been met with and sucessfully overcome in this country.

Even as the design and construction of the destructor must always be recognized as the work of the experienced engineer, so should the choice of the type of the destructor most suitable for the requirements of a particular town be more largely left to the engineer or professional adviser. It is a common practice for a deputation of town councillors to visit various towns and inspect different types of Destructors in operation. While the worthy councillor leaves his business without a murmur, and gladly gives his time and services, he is not an engineer, he has no knowledge of the subject. His experience is such that it is manifestly impossible for him to critically compare different systems with any degree of fairness.

A few minutes in a Destructor house with an anxiety to keep as far away from the dust as possible, does not assist the councillor in coming to a fair conclusion, nor under such conditions is it possible for the layman to acquire any really useful information. Owing to the variety of destructors now offering, and their difference in design, working conditions, and results obtained in power production, a hurried visit, a few questions, and a superficial examination are of little service.

To make critical comparison demands engineering knowledge and an acquaintance with Destructors generally. Without such knowledge it is impossible to detect the weak points during an inspection. The average town councillor is not technical, and yet he is constantly called upon to exercise a choice which demands technical knowledge. If it were not for the controlling guidance of the permanent official—the municipal engineer—the ratepayer's money would often be very badly invested.

Chapter II

REFUSE TIPPING ON LAND

EARLY in 1902, the Bury St. Edmunds Corporation made application to the Local Government Board for sanction to borrow the sum of £300 for the purchase of a Refuse Tip.

In due course, Major C. E. Norton, R.E., one of the Inspectors under the Local Government Board, conducted an inquiry into the subject of the application, and during the course of the inquiry he asked "*why the Corporation did not provide a Refuse Destructor?*"

After due consideration, the Local Government Board declined to sanction the loan application. The Corporation, not anticipating a refusal, had concluded the purchase of the land, which amount has consequently to be provided out of the revenue.

Although I cannot cite a similar case to this in any part of the country, it must be conceded that a very ominous precedent has been established, and we may confidently anticipate that the attitude of the Local Government Board towards the tipping of refuse will be less favourable in the future.

The case of Bury St. Edmunds furnishes a remarkable object lesson for hundreds of Municipal authorities in this country, who still accumulate filth. At the same time the sanitarian must be encouraged by the ominous decision of the Local Government Board, accompanied as it was by the recommendation that a Destructor be provided.

Mr. G. A. D. Mackay, the well-known and able Cleaning Superintendent to Edinburgh Corporation, in his Presidential address, delivered at the Edinburgh Congress of the Association of Cleansing Superintendents of Great Britain, in July, 1902, spoke as follows—

> Tipping in places of low depth, *and when isolated from dwelling houses and sources of water supply*, is not, *when carefully directed*, an insanitary method of refuse disposal. *When, however, the depth is considerable, the benefit of aeration is absent, and no depositing* should take place, *unless the organic portion of the refuse is first removed by a process of incineration.*

Mr. Mackay is a distinguished sanitarian, and we may accept his advice as sound; but the more closely we examine his statements, the more firmly must we be convinced that he fails to present any logical argument in favour of tipping.

Fig. 2. Refuse Tip at Sudbury, Suffolk.

Refuse Tips are too often *near* to dwelling houses, and being frequently provided by the scavenging contractor, they are not carefully directed. Again, the depth is often very considerable; in the case of the huge tip illustrated in Fig. 2, the maximum depth is nearly 60 ft.

Mr. Mackay expresses his opinion that the depth of deposit must not be considerable. We know that in the case of hundreds of tips the depth is very considerable; in fact, the favourite site for a tip is an old gravel pit, clay pit, or some hollow which has been excavated.

When sites of this character cannot be obtained, the refuse rises from the level ground skywards, as is seen in Fig. 3, and so the tendency is all toward getting considerable depth, excepting, of course, when refuse is spread over land for manurial purposes.

FIG 3. 20,000 TONS OF REFUSE AT WATFORD.

Concerning the use of refuse for manurial purposes, it may be said that the farmer has had quite sufficient of the modern refuse ; all over the country there is a growing disinclination to use refuse on the land, largely because of its changed composition. The alarming percentage of tins and bottles in average refuse has caused the farmer to seek his manure elsewhere. This cannot but be very satisfactory to the sanitarian, and it further serves to emphasize the fact that the Destructor is the only solution.

There is another aspect of the refuse tipping question, which must not be lost sight of—the cartage cost. Where tipping is as well directed as a filthy process can be, the tip is well outside of the town. Many instances might be cited where refuse tips are situated from two to three miles out of the town. Not only does this inflict a heavy cartage cost on the ratepayer as compared with cartage cost to a reasonably central destructor site, but the countryside is marred. Many a lovely landscape is blighted by an unsightly, evil-smelling, dangerous heap of decomposing filth.

Let us recognize clearly that not only does this shortsighted policy of accumulating filth entail the maximum cost of cartage to a community, but insult is added to injury by vitiating the atmosphere of the countryside by these vile deposits.

On the whole, very little indeed can be fairly urged in favour of tipping. If Mr. Mackay's remarks are carefully perused, it will be seen that tipping can only be recommended under certain specific and ideal conditions such as do not obtain in or near the average town.

But why in the name of common sense should the hoarding up of filth be reduced to a fine art? Why devote study to a system which generally speaking stands condemned from Dan to Beersheba, a system which can never be final, and which was recognized as an impossible one even before the Christian era?

Medical Officers of Health have long been aware that apart altogether from the disease-spreading properties of the pestilential odours arising from refuse deposits, there is much to be feared from the enormous numbers of flies.

Every refuse tip has its plague of flies, breeding and feasting in the filth, and they multiply at an alarming rate. Wherever organic refuse, excreta, or carcases, either large or small, is deposited, there flies may be found.

That flies do not confine their operations to the refuse, is shown by the serious epidemic at Fratton only a year since. At the coroner's inquest on one child out of three in one family who had succumbed from an attack of virulent diarrhœa, the Medical Officer of Health and other expert witnesses emphatically asserted that the cause of the epidemic was the presence of insanitary refuse heaps in the locality, from which the infection was carried to the house by flies, which were in such numbers as to constitute a veritable plague.

In his evidence, the Medical Officer said that on several occasions, he had recommended the Corporation to provide a Destructor, but the suggestion had not been sympathetically received because of the expense. The jury found that the cause of death was "*entero-colitis*," brought about by the contamination of food by bacteria, brought by flies from the refuse heaps.

Here is a clear case of one community seriously suffering from the filthy deposits of another larger community—the important town of Portsmouth. The Medical Officer of Health, Dr. Mearns Fraser, has repeatedly urged upon the Corporation the necessity for providing a Destructor. Portsmouth with its two hundred tons of refuse daily is still without a Destructor, but the Fratton epidemic had the effect of rousing the Corporation, and it will not be long now before a Destructor is erected.

Not only does organic refuse attract, and aid the rapid multiplication of dipterous insects, but every large refuse tip has its colony of rats, in some instances running into thousands; houses in the vicinity are infested with the rodents, and neighbouring crops are in some instances ruined by their depredations.

In the town of Watford, owing to the presence of a large refuse tip in close proximity to the Workhouse and Infirmary, it has been found necessary in hot weather to provide "mosquito nets" to protect some of the infirmary inmates from the numbers of flies entering the open windows, and recently in the casual wards able bodied men have declined to work by day, because the incoming rats have prevented their sleeping at night.

It is indeed incongruous to find a large town provided with electric light and electric traction, but without any sanitary means of refuse disposal, for instance even at Portsmouth, where Dr. Mearns Fraser tells us the Destructor question was not a popular one, because of the expense; within the past few years about £250,000 has been spent on electric traction.

In Dublin, where a similarly enormous sum has been expended on Lighting and Traction, the refuse disposal question is also generally unpopular because of the financial aspect. In both cases, less than one-tenth of the sum found for electrical purposes would have sufficed to provide modern Destructors of sufficient capacity for many years to come.

Many other similar cases might be cited; such cases abound, serving to show that there is a strange reluctance upon the part

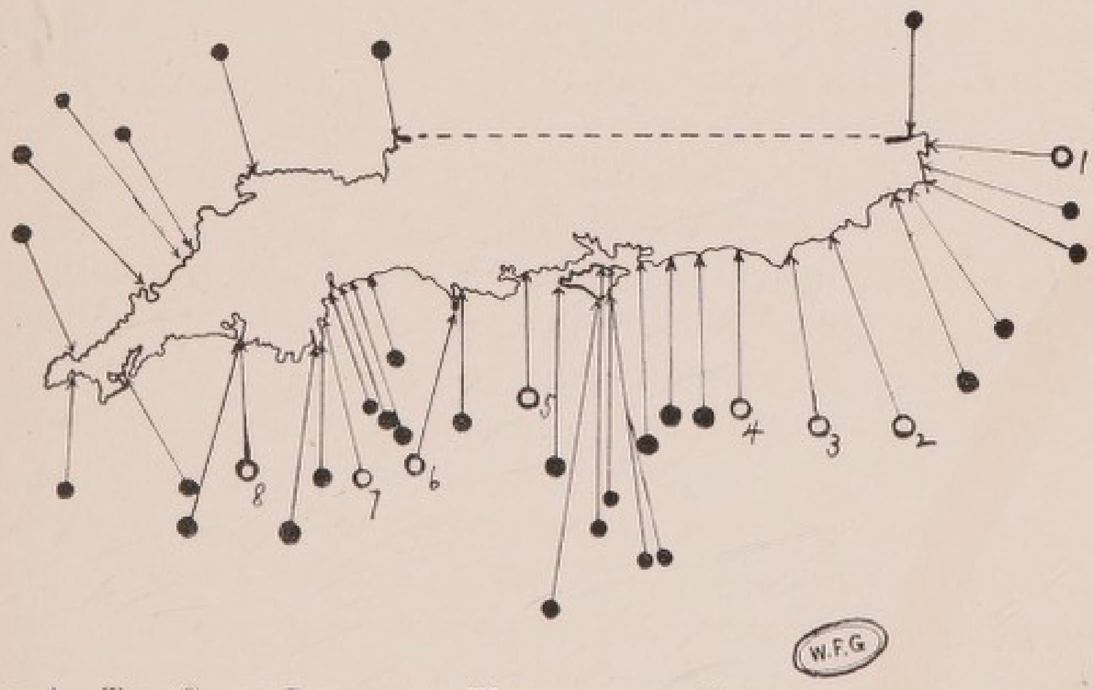


Fig. 4. The Coast Line from Weston-super-Mare on the West to Margate on the East.
○ Seaside Resorts having Destructors.
● Seaside Resorts without Destructors.

of many important authorities to face a sanitary problem, although their first charge is undoubtedly the preservation of the health of the community.

The conditions are precisely the same in a very large number of our boasted health resorts, both on the sea-board and inland; while in many cases every modern improvement is adopted to enhance the natural attractions, the sanitary aspect does not receive attention, and so it is that many of our so-called health resorts are insanitary in the extreme, and from a sanitary point of view will not bear comparison with some manufacturing towns.

At the present time, 100 well known and popular health resorts in this country are without means of final and sanitary disposal of their refuse; it may be assumed that in most cases the filth is accumulated in heaps such as are here illustrated. Only a very few authorities send the refuse out to sea, and when this is done a considerable quantity is usually allowed to accumulate either at a depôt or in a barge until a cargo is ready.

The time is coming when these unsatisfactory methods will have to cease; a health resort will yet be judged by its sanitary condition, and only in so far as it conforms to a modern standard will it rank as a health resort. A pure water supply, an efficient system of sewage treatment and disposal, and final and sanitary disposal of all civic waste by the agency of fire will yet be demanded as the essentials of a health resort.

Out of a total number of 124 well known seaside and health resorts in England and Wales, twenty-four only have adopted Refuse Destructors. A glance at Fig. 4, showing the coast line from Weston-super-Mare on the west, to Margate on the east, will show the slow progress in sanitation in well known seaside resorts. Between these two points, eight seaside towns only have adopted Destructors, and in the case of one town at least the Destructor is altogether inadequate in destroying capacity and of old design.

Fig. 5 is reproduced from a photograph taken by the author. It shows a large refuse tip estimated to contain 5,000 tons, and situated between Newport and Cowes, in the Isle of Wight, within a few yards of the main road which was frequently used by our late Queen when driving in the neighbourhood of Osborne House.

Some large pigs will be observed in the foreground, while yet others are reposing in the filth, whereon apparently the pigs had been placed for feeding purposes. Is it possible for the average man, even if devoid of sanitary knowledge, to look upon such a scene as this with satisfaction? Can such a practice be defended under any circumstances? One intimate with methods of Refuse Disposal might perhaps expect to find such an example as this in some districts, but hardly in the Isle of Wight—the Garden of England—and within three miles of a Royal residence ?

It may be as well to remark here that Refuse Tips are common in the Isle of Wight, and many a lovely spot is marred by a heap of decomposing filth. Not one of the popular seaside resorts on

FIG 5. PIGS FEEDING ON REFUSE AT NEWPORT, ISLE OF WIGHT.

the Island is provided with a Refuse Destructor, and so far as the writer is aware, no refuse is sent out to sea.

Some of the technical sanitary journals, notably the *Public Health Engineer*, have again and again called attention, in leaders and leaderettes, to the glaring indifference shown in the case of many seaside and health resorts, to the final and sanitary disposal of refuse. Publicity of this kind has had the effect in some cases of inducing the authorities to face the question, but the figures here quoted indicate only too plainly that much yet remains to be done.

At a meeting of the Worthing Town Council, early in March, 1903, Councillor Aston, Chairman of the Sanitary Committee spoke as follows :—

> The committee had arrived at the unanimous decision that it was their duty to erect a Destructor. They spent a lot of time and money in beautifying their town and providing attractions for visitors, *but the sanitary condition of the town was of even higher importance.*

The above recommendation should not be passed over lightly, for in it we have a most hopeful sign of the times. It is in effect a frank admission that the sanitary condition of a health resort is of greater importance than the provision of attractions.

While this is only too obvious, it is not often admitted ; as a rule money is spent freely in every direction in order to bring a health resort up to date, with the exception of its sanitation, which too often is crude and unsatisfactory in the extreme.

That same enlightened policy and keen appreciation of the essentials of a health resort which we see shown in the case of Worthing might with advantage be emulated at some ninety-nine other health resorts in this country ; as such is not the case, however, we can only be led to the conclusion that sanitation is not yet considered of vital importance.

The disease-spreading properties of organic refuse are too serious to be passed over lightly, and when refuse is accumulated in close proximity to houses the consequences may be very disastrous. Organic matter dug up after having been buried for many years has been found to be in an active state of putrefaction.[1] It would seem that in many cases enormous heaps of refuse are allowed to accumulate in the hope that in some mysterious manner purification would take place automatically.

Needless to add, purification does not take place under average conditions, and it is impossible to defend such a system ; it is

[1] See *The Economic Disposal of Towns' Refuse.* W. F. Goodrich.

filthy and unsatisfactory in the extreme. The advocates of the refuse tip are well aware that it is a menace to the public health, but they fondly imagine that their every action will be finally judged from an economic standpoint.

After twenty-seven years of disposal by fire, and with such a large number of successful Destructor installations, there is no reasonable excuse for the continued accumulation of organic waste. In a recently issued small volume,[1] Dr. G. Vivian Poore clearly points out that organic refuse is the most deadly enemy of the soldier, and it may be as truthfully said that accumulated organic refuse is a danger to a civil community.

Refuse tips have been sarcastically termed "Monuments of Municipal Wisdom" and when photographing the immense heap illustrated in Fig. 3, and said to contain 20,000 tons of the filth of Watford, it occurred to the writer that a huge notice board bearing the inscription: "Video meliora proboque, deteriora sequor,"[2] would be a peculiarly fitting addition, not only to this filthy heap, but to many hundreds of similar composition, large and small, all over this country.

Such an inscription would suffice to explain, why the filth had been so deposited and allowed to accumulate.

The Local Government Board, much maligned as it is, has done not a little in the encouragement of real sanitary progress. The reports of the Medical Officers to the Local Government Board concerning the sanitary condition of various towns furnish most instructive reading.

An outbreak of zymotic or preventible disease is generally quickly followed by searching investigation, and every weak spot in sanitary administration is not only laid bare and criticized, but a remedy is suggested. In perusing these reports the writer has been much impressed by the singular unanimity of opinion expressed by these qualified medical men as to the Disposal of Refuse. They do not recommend tipping on land or at sea, whether the town be large or small, the district urban or rural; a Destructor is recommended as a sanitary necessity.

[1] *Colonial and Camp Sanitation.* By Dr. G. Vivian Poore.

[2] I see and approve of the better, but follow the worse.

It should be remembered that the medical man advises as a sanitarian, and not as a utilitarian; his standpoint is public health, the power aspect of the question does not appeal to him, and it is manifestly absurd to attach the commercial stigma to his opinion. The average citizen has but a faint conception of what he owes to the Medical Officer of Health, and it is indeed curious that one whose labour is of such vital importance should so often be marked as unpopular.

Even in America, where a greater variety of methods of disposal have been tried than in this country, it is becoming increasingly evident that in spite of all that has been attempted, and even done, disposal by fire is now recognized as the only real solution. Whenever the subject is discussed, the weakness and inefficiency of every system of disposal with the exception of cremation is freely admitted, and not infrequently condemned. In the proceedings of The American Public Health Association for 1902 will be found a contribution by Dr. Heber Jones, M.D., President of the Board of Health of the City of Memphis, Tenn. The following extract from this contribution will serve to indicate the general trend of opinion among Medical Officers of Health in the United States :—

> Unquestionably, gentlemen, and I do not care what the size of the city is, whether it be New York with its four millions, or Memphis with a little over one hundred thousand, the proper plan for garbage disposal is to destroy it by fire, and not to try to utilize it for feeding swine, hauling it out and burying it, or making any attempt at reduction. There is plenty of food in the country to feed swine. We do not want to pollute the atmosphere of the suburban portion of our city with the stench which emanates from hog-pens and from the stuff which is hauled there, a good part of which the hogs themselves will not eat. . . . Such, in my opinion, is a menace to the public health of any neighbourhood, and is not only unsatisfactory, but disgusting.[1]

It is refreshing to find the President of the Board of Health for the city of Memphis, Tenn., thus not only advocating disposal by fire, but also scathingly denouncing the feeding of swine with

[1] Dr. Heber Jones, M.D., before The American Public Health Association, in Conference at New Orleans, December, 1902.

garbage, a system of disposal which has been tolerated to some extent in the United States.

As recently as two years since, a " Municipal Hoggery " was established in Worcester, Mass., the overseers of the poor collecting the garbage and feeding swine with the same at the City farm, an average of 1,800 swine being maintained by the garbage collected.

The cost of garbage collection for the year 1900 was $17,000, and the receipts from the sale of pork $11,300, leaving a deficit of $5,700. Evidently the citizens and authorities are satisfied with the cheap method of disposal. Maybe they congratulate themselves upon their success in this Municipal Trading effort. There is certainly no sign that the sanitary aspect receives the slightest consideration, or that it is deemed of any importance.

In the face of such evidence, as is adduced in Fig. 5, we cannot boast; but it may be truly said that in this country wherever garbage is used for feeding swine, it is done secretly by a scavenging contractor. While we have plenty of citizens and some few authorities with very hazy notions concerning sanitary science, yet in this country it is safe to say that a " Municipal Hoggery " is quite impossible.

The advocates of tipping refuse on to the land have again and again referred to its economic advantages. In fact so much has been said concerning economy that one is almost persuaded that sanitary progress can only be permitted in so far as it is economical.

The old analogy of " the cart before the horse " is peculiarly fitting to such teaching as this. Every level-headed citizen, however, must know that the highest sanitation represents the highest economy, and that economy without efficiency is generally speaking to be avoided.

Mr. W. J. Steele, A.M.I.C.E., the Deputy City Engineer of Bristol, recently presented some very interesting figures in a paper entitled " Some Methods of Utilizing Town Refuse." Referring to the City of Bristol, he said :—

During the year ending March 25, 1903, 85,911 tons of refuse were collected, or one ton for every four persons. Of this quantity 33, 149 tons were treated at the Destructor, the remainder being tipped. Had the whole of the refuse been treated at the Destructor, the total difference in cost over the cost of tipping would have been £3,500—equivalent to a halfpenny rate.[1]

A simple calculation will show that to destroy 52,762 tons of refuse which is now deposited on tips, would add *one halfpenny to the rate.* To thus change over from the present filthy and insanitary system of disposal, at the expense of one additional halfpenny to the rate must appeal to the thoughtful citizen as economical. It is a sweeping reform at a very low cost, and such a case as this is typical of many, while in not a few cases it would be cheaper to destroy refuse than to tip the same, even if no power were provided.

[1] Paper read before The Association of Cleansing Superintendents of Great Britain. Bristol Conference, June, 1903.

Chapter III

REFUSE TIPPING AT SEA

IF we examine into the methods of disposal in vogue at towns directly on the sea-board or in such positions as would permit of the refuse being taken to sea, it is both interesting and ominous to find that this method of riddance is not extensively employed.

Although it is often cheaper to thus get rid of refuse, than to destroy it, there are many reasons, which, individually and collectively, tend to pronounce the "drowning" of refuse as unsatisfactory in the extreme. We will briefly review a few of these reasons.

If we take the typical case of a town such as Dover, we find a barge of considerable capacity moored conveniently in the harbour, so that carts may tip their contents direct into the barge, until sufficient refuse has been delivered to constitute a reasonable cargo. Until then the barge remains in the harbour; it is in fact a system of storage so far.

Now it may be fairly submitted that storage of this kind is not satisfactory, nor would it be tolerated in connection with a Destructor, although in the latter case the material would be under cover, while in the barge it is exposed.

Again, barges cannot proceed to sea in unfavourable weather, and so the storage may be protracted. It has in some cases been found impossible even when a barge is fully loaded to allow the same to proceed to sea for several days, when the weather has been unpropitious,

The alternative to storage in a barge is to provide a depôt as shown in Fig. 6, but it will at once be apparent that this method is unsatisfactory. The refuse is tipped in the open, until sufficient has been accumulated to fill the barge, it has then all to be shovelled into the tipping trucks, which are then run out on to the wharf and tipped into the barge or hopper.

With the intermediate handling of the material, this system must be more expensive than tipping direct from the cart into the barge. Again we have that open air storage, which is most pernicious.

Fig 6. Refuse Depôt at Benwell-on-Tyne.

The system illustrated in Fig. 6 is in use at Benwell, near Newcastle-on-Tyne, and as will be observed, the depôt is in very close proximity to houses. As is invariably the case, the Medical Officer of Health condemns the method as insanitary, and local medical men unitedly assert that "it is a menace and danger to the health of the district." It will thus be evident that even the preliminaries attendant upon dumping refuse at sea are most undesirable. Storage either in the barge or at a depôt is inseparable from the system because, as a general rule, some few days' collection of refuse is necessary to make up a cargo for a barge or hopper.

Early in the present year at Benwell, owing to stress of weather, the refuse accumulated at the depôt to the extent of 700 tons. Had this been an orthodox refuse tip, the material would have remained undisturbed, but being destined for dumping at sea, this unsavoury accumulation had to be broken up and handled.

Wherever refuse is thus stored at a depôt for removal by vessel, regularity of removal cannot possibly be ensured; the system may work very well for three weeks or even three months if weather permits, but apart altogether from other considerations, can any system of disposal be deemed satisfactory which is only workable in favourable weather?

If the refuse is tipped direct into a barge or hopper, the same question arises; the vessel with its objectionable cargo can only leave its berth for the dumping area if the weather permits. Briefly, therefore, we may describe tipping at sea as a "fair weather system" as compared with the Refuse Destructor which is usually in operation for six days per week, be the weather fair or foul.

In the case of a town where from 20 to 40 tons of refuse is collected daily, to send a barge out to sea every day, or even alternate days, would be prohibitive because of the cost. With large towns it is open to question, whether it would pay to send the whole of the refuse to sea, because the collection area being wide it must necessarily be costly to bring the whole of the refuse to one point, which is usually not central. But apart from the preliminary collection and storage, is it a final and sanitary system to send refuse out to sea?

Ten years ago Mr. John A. Brodie, A.M.I.C.E., the eminent City Engineer of Liverpool expressed his opinion as follows:—

On a careful consideration of the subject it will be apparent that there are many matters contained in the material known as house refuse, which should not on any account be permitted to be sent to sea, such as vegetable débris, straw mattresses, bagging, matting, baskets, tins, and many other things of a like character, which may be returned to the shores of watering places, or may cause trouble to the fishermen. These materials, however, should be removed and dealt with by the Destructor, and if this was done there cannot be the slightest doubt that disposal at sea is at once the cheapest, quickest, and best system for the greater portion of the refuse *from those parts of Liverpool which lie within a moderate cartage distance from the docks.*

Some years ago Mr. Brodie brought that same intelligent application and inventive genius of his to bear upon the dumping of refuse at sea that he since devoted to the Refuse Destructor, and it may be safely said that the sea dumping at Liverpool was conducted in a far more satisfactory and economical manner than has been the case in any other part of this country either before or since.

In spite of this, however, Refuse Disposal in Liverpool has not developed along these lines; on the other hand, Liverpool has a number of excellent Destructors, producing a very considerable amount of power for electrical purposes, as may be seen by referring elsewhere in these pages.

Mr. Brodie's statement puts the case very concisely. A sorting process is an essential part of sea dumping; sorting is a degrading and filthy process and involves expense. Further, having removed such portions as should not go to sea, what is to be done with that portion which is too objectionable to commit to the ocean? We are told that this portion should be burned in a Destructor. Precisely—but if it is wise to destroy the objectionable percentage, why "drown" that which is not harmful or likely to be productive of nuisance? why not burn the whole? Again, it must not be forgotten that the portion which is not included in the category of objectionable matter is such as would be of great assistance in the cremation of the remainder.

Around our sea-board, it has been conclusively proved that quantites of refuse dumped at sea are returned on the beaches of adjacent seaside resorts. Within the past two years, there has been a serious outcry on the north-east coast, where the beaches of seaside resorts have been defiled with the filth of large towns.

Those who consider that refuse should be returned to the land for manurial purposes should derive some satisfaction from this, for they have as their allies natural forces, and even after the expense of thus sending refuse to sea it returns " back to the land."

It is well known that chemical change in organic matter is a very slow process in the presence of water, and decaying vegetable and animal substances deposited by the tide may be productive of very serious harm. While this filthy system continues, small seaside resorts, although themselves provided with Destructors, will have to suffer from the deposits of larger towns, in some instances a considerable distance away.

Thus to some extent does the dumping of refuse at sea involve the infliction of the filth of one community upon another, even as this is the case with thousands of tons of the filth of London sent into the country and there tipped.

Dr. J. B. Cosby, the Chief Health Commissioner for the City of New York, told the author that it had been found by actual experiment that New York refuse must be taken 60 miles out to sea, to ensure its non-return on the incoming tide. At distances inside 60 miles, constant offence was given, by the deposit of all kinds of filth on the beaches of seaside resorts on the New Jersey coast, also at Coney Island and Far Rockaway.

To take refuse such a distance must obviously be expensive, but the necessity for such transit was clearly shown in the case of New York by actual experience. When Mr. G. F. Deacon, M.I.C.E., initiated this method of disposal in Liverpool in 1879, the refuse was actually carried out to a point 24 miles from the landing stage.

Perhaps the weakness of this system of disposal is most conclusively shown by the fact that many towns having facilities for thus disposing of their refuse have after a trial adopted Destructors.

Again at the present time less than twenty per cent. of the towns on or near the sea-board send their refuse to sea, preferring rather to raise monuments on the land, until such a time as they may decide upon the only method of final and sanitary disposal.

Chapter IV

SYSTEMS OF CHARGING REFUSE INTO CELLS

Direct Charging Systems

WITHIN the past four years, two systems of feeding refuse direct from the cart into the cell without intermediate handling have been devised. Both systems are essentially different in detail, although possessing some advantages and disadvantages in common. It is proposed to consider the direct charging systems in question as distinct from systems of mechanical charging, which will be dealt with later.

It may be well to observe at the outset that there are objections inseparable from the principle of direct charging, either by mechanical means or otherwise; these are put clearly before the reader in the description of each apparatus. It is for the purchaser to decide whether the sanitary advantages which accrue are such as will compensate for the manifest disadvantages.

Stress is laid upon the sanitary advantages of such systems, and as the Destructor is primarily a sanitary adjunct, this aspect must be more or less prominent. It would be idle to deny that a system which provides for the feeding of refuse into cells without serious intermediate handling is worthy of careful consideration.

Direct charging would undoubtedly be very much more popular than is the case, if when once the material was placed in the cell no further attention was necessary, but this is not so; on the other hand, the saving of labour in actual charging into the cell has the effect of rendering the work of those beneath very much more arduous than is the case under ordinary conditions.

It is mainly for this reason that the material reduction in labour cost which was anticipated, has not been realized, and there is now a tendency on the part of the more advanced advocates of direct charging to magnify the sanitary advantages, which are more or less obvious, while the real economic advantages have yet to be demonstrated.

It is scarcely necessary to insist that any system of direct charging should be as free as possible from mechanical contrivances, and in any case the arrangements should be such that in the event of a breakdown an easy alternative system of charging may be at once resorted to, as a stoppage without efficient means of storage might have unpleasant results.

Horsfall's Direct Charging System

As originally designed, a large pit was arranged, in the top of a battery of cells placed back to back, the top of the pit or hopper being level with the top of the cells, its base being formed by an extended table above the drying hearth.

It was anticipated that the bulk of refuse in the large hopper would effectually seal the opening, and with this in view a light sheet iron building was erected over the hopper, the large folding doors opening outwards to enable the cart to back against the tipping beam, and thus discharge its contents direct into the cell.

The main trouble experienced was that the stored refuse not only failed to seal the opening, but instead readily ignited, expelling noxious gases.

It was thus obvious that a means must be found of effectually covering the large opening into the cells in such a manner as would absolutely prevent the escape of gases. After trying various methods for keeping this door or lid tight, the Horsfall Company tried a water seal system which has proved to be quite satisfactory.

Troughs are laid horizontally around the feed opening, being connected with a feed tank which has a ball-cock arranged to maintain the water at a constant level. The lids covering the openings into the cells, each weighing about one and a half tons, are suspended from winches, mounted on trucks which run on rails. The winches are so arranged that by a few turns of the handle the covering lids can be raised about four inches, this takes them clear of the trough and water seal, and by means of the trucks they are then carried clear of the opening.

The departure was a bold one, and of such a character as necessitated actual experiment under ordinary working conditions, in order to arrive at the best methods of avoiding a serious escape of noxious gases.

Having made clear that this system of direct charging is now quite satisfactory so far as the feeding in of the refuse is concerned, let us examine more closely into the handling of the refuse below on the clinkering floor.

A large quantity of refuse having been charged into the cell, the bottom of the mass rests on the table, from which point it has to be dragged forward on to the grate proper, as often as a fresh charge is required for destruction.

As with other systems of direct charging, so with the one we are now considering; the fact of the refuse being in the cell only tends to make more laborious the work of those who toil beneath on the clinkering floor. Let me clearly explain why the work is more laborious—than for instance in the case of the ordinary top fed cell.

In the latter case the refuse is nearer to the operator and it is more readily handled, being detached; and but a comparatively small quantity. Whereas in the case of the direct charged cell the stoker has to manipulate a very long and heavy drag rake, and his difficulties are materially increased because of the greater distance, the radiated heat, and the fact that by the impact of its own weight above and the effect of heat below, the mass of refuse is very solid and swollen.

This difficulty may perhaps not appear at all serious to the lay observer, but it is nevertheless a difficulty, and, moreover, a very serious one.

Mr. J. W. Bradley, M.I.C.E., the City Engineer of Westminster, in a report to the chairman and members of the Works, Sewers and Highways Committee, dated December 30, 1902, remarks as follows concerning a test of Horsfall's Direct Charged Destructor at Shot Tower Wharf—

> With two exceptions the firemen worked well, but there is a tendency to avoid the use of the long pulling down rake, and also to keep the fires too thin in front, which causes the fires in the front to burn in holes, through which large volumes of cold air pass into the cell, tending to reduce the temperature, and as air under pressure naturally seeks the easiest outlet, this air does not pass through the refuse on the other portions of the grate.

Mr. Bradley expresses himself very clearly and concisely, and on the whole his opinion serves to emphasize what has already been said concerning the long rake and the very arduous labour involved in properly using the same.

It should be borne in mind that to drag the material away from a compact mass and spread it evenly over a large grate area is very heavy work, and as this operation must necessarily take place with an open door, the stoker is exposed to intense heat; it is therefore not surprising to find that there is a tendency on the part of the man to shirk this work, as Mr. Bradley points out. If the dragging and spreading operation is not thoroughly carried out, generally efficiency is impossible.

In endeavouring to make this aspect quite clear, there is no intention to unfairly criticize the particular system of charging which we are now considering, but rather a desire to place clearly before the student of the subject and the sanitarian, the incontrovertible fact that however expeditiously refuse may be put out of sight by direct charging into the cells, very arduous labour is in store for those below.

The superficial observer is apt to content himself with watching the charging process only *from above*, and, as compared with other systems which he has seen, he is at once favourably impressed with direct charging; as seen from *above* it is not only sanitary and expeditious, but it also appears to be economical.

The late Mr. John McTaggart, of Bradford, whose name will always be remembered in connection with many useful innovations in Destructor practice, was of opinion that this system of direct charging would be the means of reducing the labour cost to $5\frac{1}{2}d.$

per ton of refuse destroyed. Unfortunately, Mr. McTaggart did not live long enough to realize the difficulties which were presented, and which to a large extent have now been successfully overcome; it is also open to serious doubt whether Mr. McTaggart foresaw what labour would be involved below in the use of the long drag rake.

At the present time, one is obliged to judge the system in question from the performance of one working example only, that at Shot Tower Wharf, now under the control of the City of Westminster; and adverting again to Mr. J. W. Bradley's report, the cost of labour per ton of refuse destroyed is given as 11·5*d.*, exclusive of engineman and fireman (16·5*d.*).

As the complete figures of the test referred to will be found on another page, it is unnecessary to further deal with the same here. It will suffice to say that the labour cost is high, and this must to a large extent be accounted for by the work below, as the rate of combustion was not abnormal, being only 27·2 pounds per square foot of grate surface per hour.

It is, however, but fair to state that a quantity of market refuse has to be dealt with, and a proportion of this material would doubtless be of a bulky nature, as compared with average ashpit refuse.

With this system of direct charging, although refuse is actually stored in the cell, the storage capacity is strictly limited. It may be assumed that further storage capacity in the cell is not practicable; to provide the same would involve greater width between the clinkering floors of the cells, and consequently the dragging forward and levelling of the refuse would become increasingly difficult, as this would necessitate the use of a still longer drag-rake.

Owing to the irregular delivery of the refuse and to ensure actual charging from cart to cell, the only solution is found in the provision of a number of extra carts in which the refuse is stored until required.

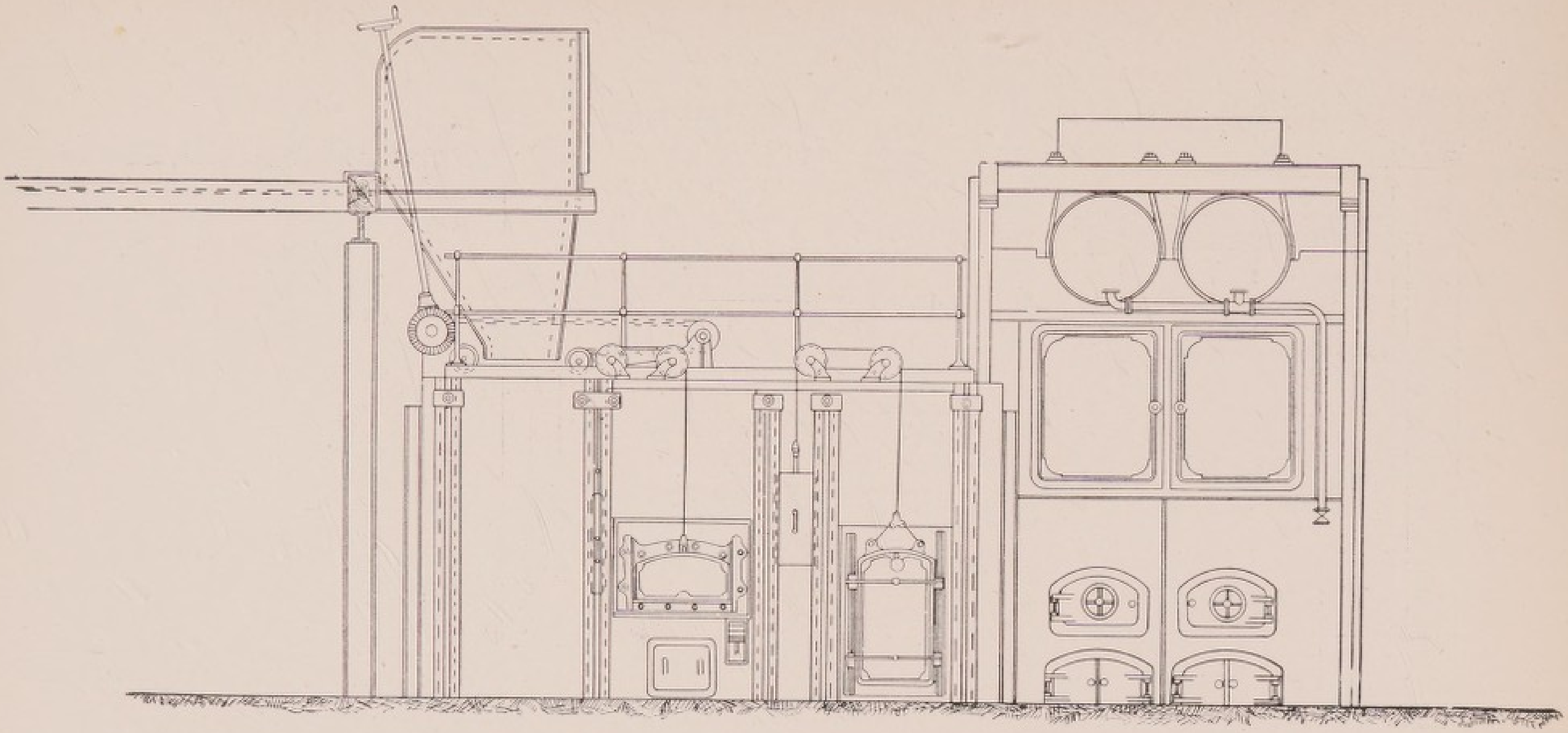
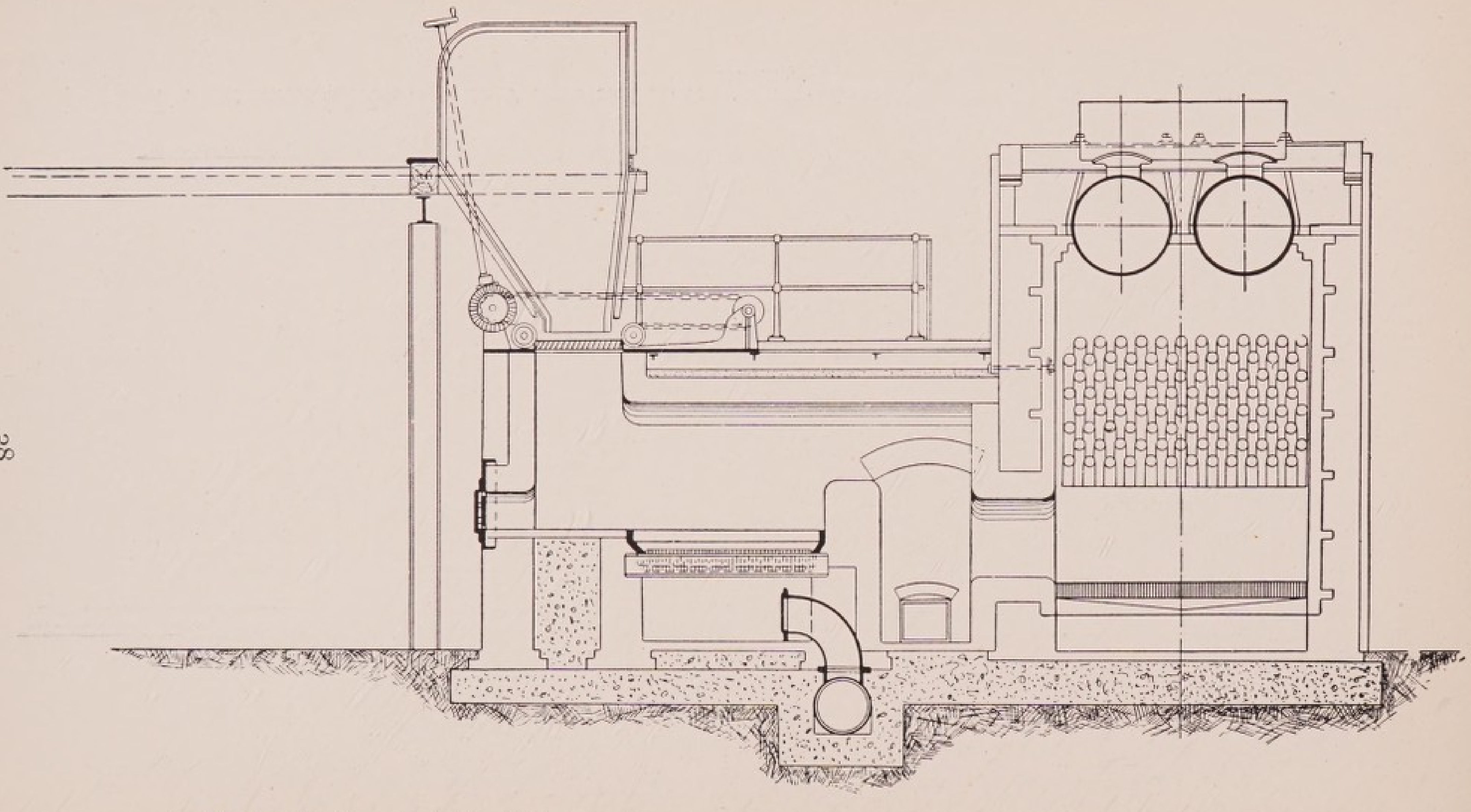


Fig. 7. Meldrum's, Beaman & Deas' Type of Destructor with Marten's Patent Direct Charging Apparatus.
Elevation.



8. Meldrum's, Beaman & Deas' Type of Destructor with Marten's Patent Direct Charging Apparatus.
Section through Cell and Boiler.

Marten's Patent Charging Apparatus

The first charging apparatus devised is shown in Figs. 7 and 8. It is known as Marten's Patent, and is exclusively used in connection with Meldrum's Simplex, and Beaman & Deas' type of Destructor.

Briefly described, the apparatus consists of a wrought iron hopper, placed on the top of the cell, and immediately over the drying hearth. On the right hand side of each hopper, a hand-wheel and lever is placed which operates simple toothed wheel gearing beneath.

It should be pointed out, that the tipping platform must be practically the same height above the clinkering floor level as with the Horsfall Direct Charged Destructor, and Boulnois & Brodie's Mechanical Charging system, viz.—about 18 feet.

A cart arriving upon the tipping platform is backed against the tipping beam. The wheels travelling in guide lines, ensure each cart tipping its contents clean through the hopper. Immediately upon the signal being given from below that the cell is ready for a charge, the man on the tipping floor turns the hand-wheel previously referred to, and the hopper base 5 ft. long by 2 ft. wide, slides clear of the opening. The load of refuse is then at once tipped direct through the hopper into the cell beneath.

The cell is so arranged that the mass can be readily manipulated and levelled, it being possible both to get behind and at the side of the cell. Behind, where the bulk of the work is done, the stokers are within 3 ft. of the refuse and *push* it forward, this work being done under cool conditions, whereas with other systems of back and direct charging, all manipulation is done at the opposite side of the cell, the stoker having to drag from a distance while exposed to the glare and heat radiating from the cell. The rapidity of charging is very remarkable, and no doubt to some extent the very expeditious tipping van employed contributes to this.

At the Tooting Destructor, under the Metropolitan Borough of Wandsworth, where this system of direct charging is in use, not only is the charging got through very smartly, but the labour cost is phenomenally low, being 7½*d.* only per ton of refuse destroyed. The figures of a continuous test of 120 hours, duration with this plant will be found on another page, and are worth careful perusal.

With regard to the question of storage, the system demands probably twice as many collection carts as under ordinary conditions, the refuse being stored in the carts. While this is a very satisfactory method of storage, it involves an extra capital expenditure in vehicles which many authorities will not entertain. Cart storage is, however, not entirely confined to this system of charging, being also the method employed with Horsfall's System of Direct Charging as already pointed out.

In the event of any accident to a hopper, which, however, is very unlikely, owing to the extreme simplicity of construction, it is possible to at once resort to ordinary top feeding, the carts discharging over the tipping beam on either side of the hopper for the time being.

The sliding hopper base covering the charging hole is perfectly gas tight, and there is no escape of gases even while the base is removed during the charging operation.

The low labour cost with this system is largely due to the fact that the men below work at the cool end of the cell, *pushing* the material at close quarters, instead of dragging it from a considerable distance.

The actual labour involved below, although performed under cool conditions, is nevertheless arduous. That the system is economical in labour cost is clearly shown by the very low cost per ton of refuse destroyed, viz., 7½*d.*, and this in spite of the fact that in ordinary working the average rate of combustion exceeds 60 lbs. per square foot of grate surface per hour, or over 16 tons per cell per 24 hours.

Back, Hand, or Shovel Fed Cells

Perhaps the best known example of the back shovel fed type of Destructor cell is the Horsfall, and it is both interesting and instructive to compare actual working results obtained with this system and those obtained with cells of the top fed type.

It is conceded by the makers that with the back fed type the fires are under more direct control, and it may be assumed that this is quite correct. Further, the system of back shovel feeding has undoubtedly found considerable favour, and largely because it approaches a rational system of firing. By this of course hand-firing is meant.

The very satisfactory results obtained with back feeding, clearly demonstrate the advantages over top feeding. Again the makers invariably recommend the back fed type in cases where it is proposed to fully utilize the power for steam raising purposes.

With this type the refuse is shot on to the charging platform, or feeding bin, the level of which is usually arranged about eighteen inches below the sill of the feeding doors. As compared with the top fed type it will thus be seen that the refuse is stored in a comparatively cool place—a distinct advantage.

All the material is fed into the back feeding doors, and deposited direct on to the drying hearth by shovel; the actual labour involved in shovelling is not serious, the lift being but eighteen inches, as already pointed out.

From the drying hearth the refuse is dragged forward on to the grate proper, the dragging, spreading, and levelling operations taking place from the clinkering floor level beneath and immediately opposite.

The manipulation of the material must be comparatively easy, and far less laborious than is the case with the direct charged cell, because the stoker is now dealing with a comparatively small quantity of refuse, detached, and within easier reach. It will be evident that there are advantages in connection with this system of feeding, as compared with top feeding, which cannot fail to impress the close observer, and it may be safely said that this system of feeding will become increasingly popular.

Although the makers of the Horsfall back fed type of cell do not claim that any economy in labour is possible with this system as compared with their top fed type, yet a perusal of the latest available figures will serve to show that with the back fed type some very low labour costs are recorded. The general arrangement is shown in Fig. 9.

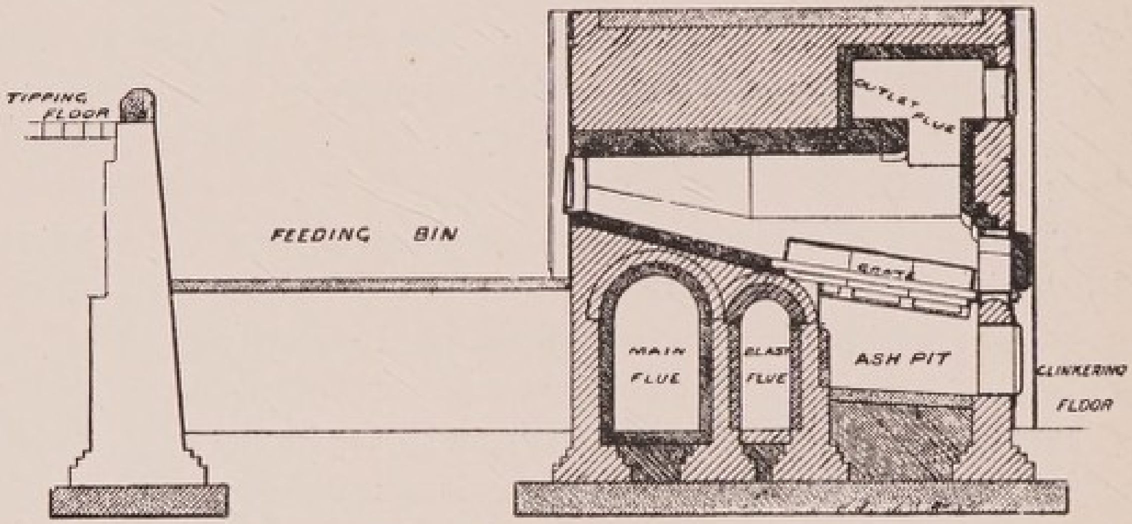


FIG. 9. HORSFALL'S DESTRUCTOR, BACK, SHOVEL, OR HAND FED TYPE.

MELDRUM'S BACK SHOVEL FED TYPE

This type does not call for any lengthy description, being practically the same as the Horsfall type, the gases, however, instead of leaving the top of the cell at the front, have a sideway motion over the continuous grate into the combustion chamber. Figs. 10 and 11 illustrate the general arrangement.

The *Heenan* back fed type of Destructor differs essentially from that designed by Messrs. Horsfall and Meldrum; instead of feeding the refuse direct on to the drying hearth by shovel a hopper is provided at the back of the cell into which the refuse is tipped direct from the cart.

It would be idle to closely compare the two systems, because of the material difference in design and method of charging. With the Horsfall and Meldrum back fed cell, the charging of the material is readily managed, as has been described, the man responsible for charging having direct and convenient access to the drying hearth and cell.

With the Heenan type, however, the main work of charging must necessarily take place from the clinkering floor, the refuse

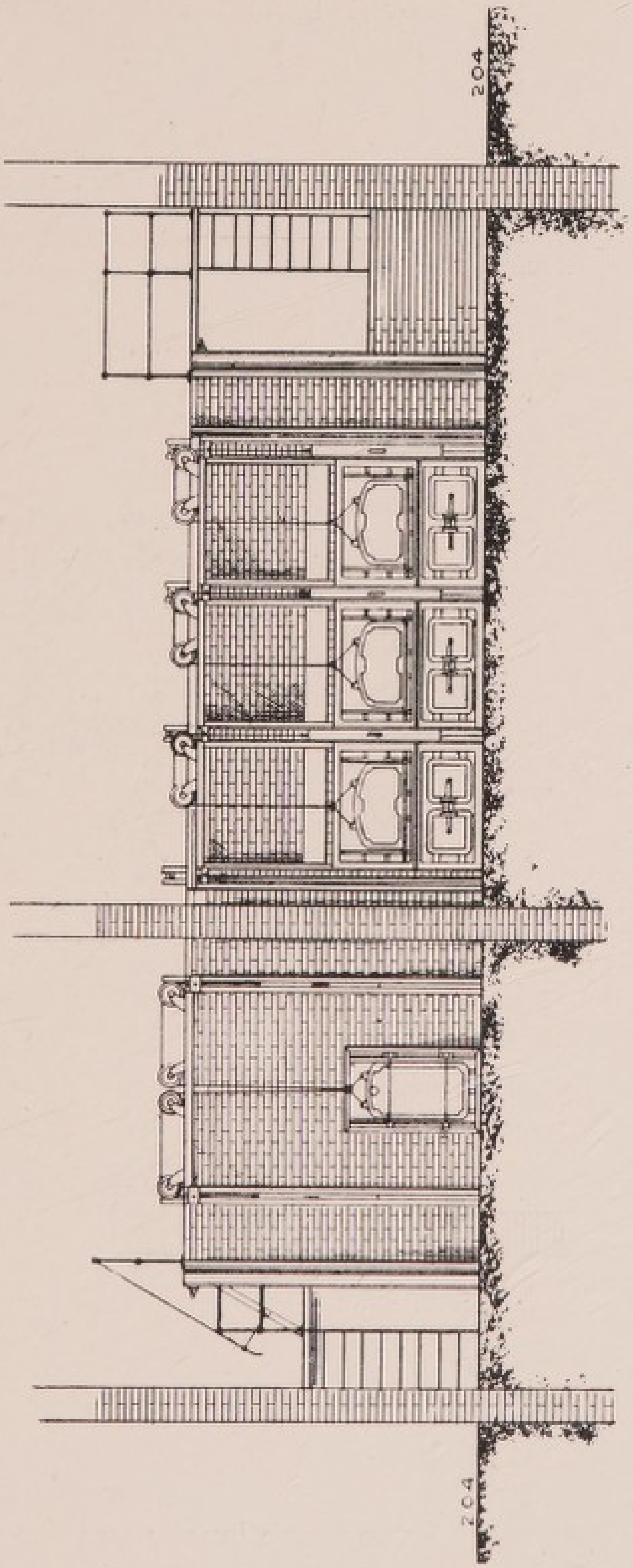


FIG. 10. MELDRUM'S PATENT SIMPLEX REGENERATIVE REFUSE DESTRUCTOR FURNACE, BACK FEED TYPE.
Front Elevation.

being dragged from the hopper base by means of a long drag or rake. If the hopper provided has any appreciable storage

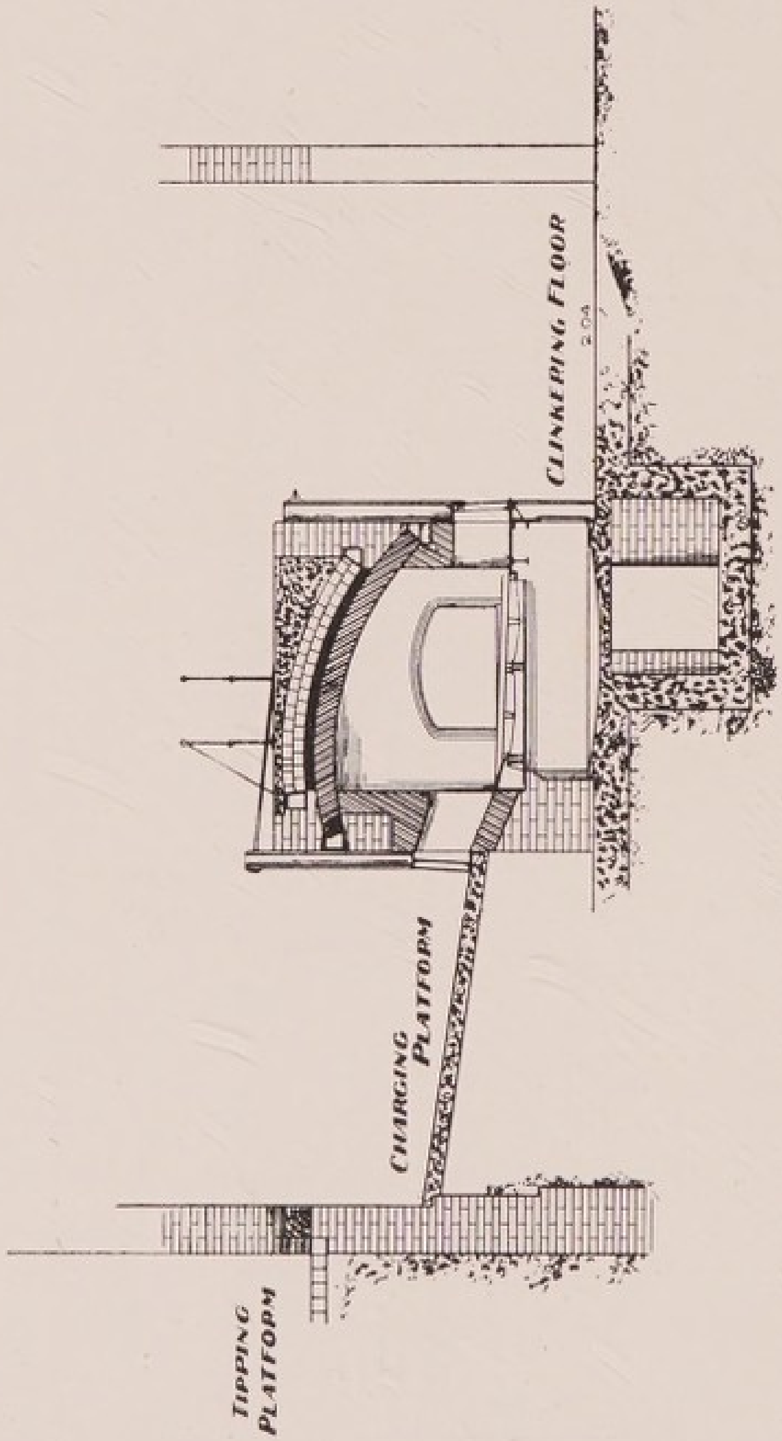


Fig. 11. Meldrum's Patent Simplex Regenerative Refuse Destructor Furnace, Back Feed Type.
Section through Cell.

capacity, the drag must be so much longer and the work involved so much the more exhausting. The back charging hopper is shown in Fig. 12.

Appreciating the difficulties and labour thus involved in charging, the makers of the Heenan Destructor have introduced a ram which is placed outside of the hopper to push the refuse

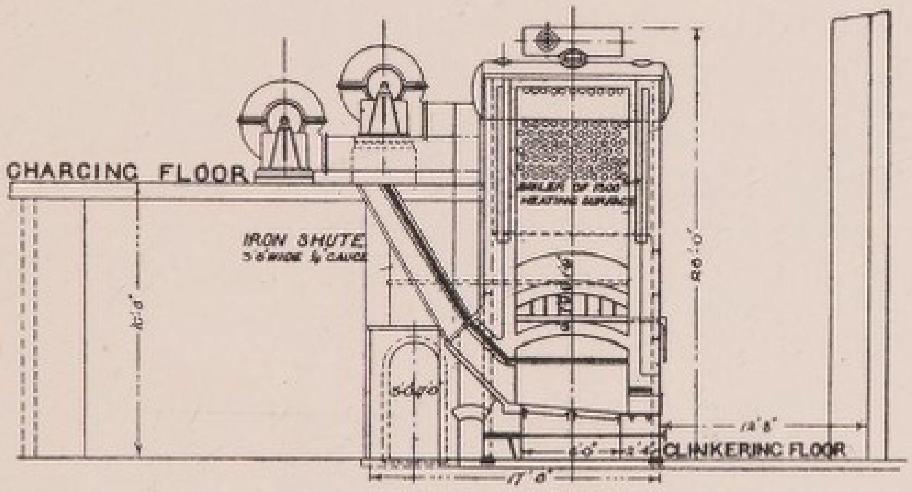


Fig. 12. Heenan's Destructor, Back Hopper Fed Type.
Section.

forward, but as this is a system of mechanical charging, it will be found described among the other mechanical charging apparatus.

Top Feeding

In the top fed type of cell we have practically, in so far as the feeding is concerned, the essence of the original "Fryer" patent.

Briefly, Mr. Fryer's original patent may be described as "charging" or supplying the refuse to the cells at the *back*, and drawing out the clinker or residuum at the front.

It will be observed that the word back is used, but a glance at Figs. 9 and 14 will serve to make clear that while top and back feeding are both alike correct, the former word more correctly expresses *now* where the material was actually introduced.

In Mr. Fryer's time, there was no back fed Destructor as we understand the term now, and it is perhaps necessary to emphasize that the original Fryer Destructor was fed on *top*, as there is a distinct and very material difference between the two systems of feeding.

Mr. George Watson thus clearly defines top feeding—

With top feeding the refuse is merely pushed blindly in.[1]

In a very few words, the operation of top feeding is thus tersely described, and in most systems refuse thus pushed into a charging hole can only be manipulated from one point, i.e., the clinkering floor. Where the cells are arranged back to back this is the case, and as it does not admit of any modification, a serious disadvantage thus exists, for which, owing to the method of construction there is no possible remedy.

This trouble is also met with in older installations of single

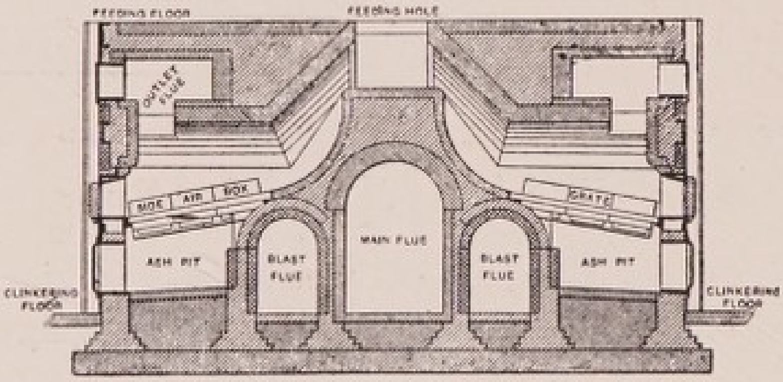


FIG. 13. HORSFALL'S DESTRUCTOR, TOP FED TYPE.
Section through Cells.

row cells, fed at the top, Access is not provided to the back of the cell, excepting of course through the charging hole, and but little can be done in the way of useful manipulation from that point for obvious reasons.

In order to clearly understand this, it is necessary to compare Figs. 13 and 15. How the difficulty has been got over with Meldrum's Improved Top Fed type of Destructor, as arranged in single row, may be seen by referring to Fig. 15. If, however, this particular type of Destructor was arranged back to back the same difficulty must necessarily exist.

Probably the most valuable modification of the top fed type

[1] *Watson on Refuse Furnaces. Proceedings of The Institute of Civil Engineers*, vol. cxxxv. Session 1898–99, Part 1.

of cell was the front exhaust introduced by Messrs. Horsfall to ensure that the volume of green gases, as distilled from the material on the drying hearth can only leave the furnace by passing over the grate proper, and commingling with the hot gases passing therefrom in the same direction. Fig. 13 illustrates the Horsfall Top Fed Type of Destructor as arranged back to back.

The arrangement of the original Fryer cell was such that the entire volume of gases left the cell at the back, passing over a

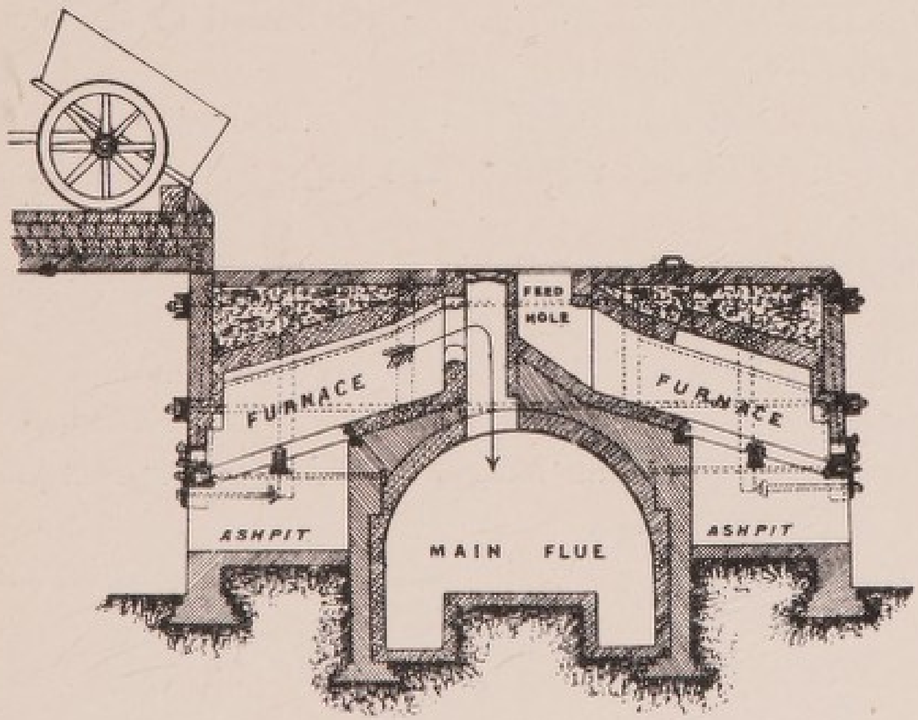


FIG. 14. FRYER'S ORIGINAL TOP FED DESTRUCTOR.

bridge, and thence downwards direct into the main flue. See Fig. 14.

This method of exhaust was unquestionably weak, the noxious gases and dust having direct and immediate access to the main flue, and the fact that the early installations were of the low temperature slow combustion type, added materially to the possibility of nuisance.

One of the great objections to the top fed type of cell, both in its original and modern form, is the presence of large quantities of refuse on the more or less heated top of the cells. Not only is it highly objectionable to thus warm refuse exposed to the atmosphere, but the effect of the constant contact with heated surfaces is to reduce some of the naturally dry material to fine dust. When the mass is disturbed at the time of charging, this offensive dust, which may be of a dangerous character, is liberated.

Even if every door and window in the building is closed, with a fœtid dust-charged atmosphere the conditions under which the men have to work are very offensive. It so happens, however, that in the average Destructor building, some doors or outlets are constantly open, and not a few of the complaints concerning annoyance from Destructors may be attributed to the escape of dust and fumes from the building.

It is safe to say that the top fed type of Destructor is the most grievous offender in this respect, and largely because the refuse is not kept cool.

There is undoubtedly a strongly growing feeling on the part of Municipal Engineers in favour of cool storage. If proof of this be needed, then it may be found in the fact that the majority of Destructors erected during the past few years have been of the hand or front feed and back shovel types, an outstanding feature of both being cool storage.

It is scarcely necessary perhaps to point out that an inclined roadway is a general necessity for the top fed type of Destructor, unless a naturally favourable site be available, abnormal excavation be decided upon, or elevators be provided. The inclined roadway is costly to construct, occupies considerable space, and under the most favourable circumstances cannot be made to look very picturesque. Naturally favourable sites are the exception. Abnormal excavation is costly and often prohibitive, even if not impossible, while elevators, whether operated by hydraulic power, steam or electricity, must be duplicated in view of the always possible breakdown and consequent stoppage. Again, elevators or hoists have to work under naturally unfavourable conditions, and as a general rule they are roughly handled.

Figs. 15 and 16 represent Meldrum's Improved Top Feed Destructor as arranged in single row. The two outstanding features of this make, as compared with other top fed cells in single row, may be briefly summarized as follows :—Instead of dumping the refuse on top of the cell in contact with a hot surface, it is tipped on an inclined steel storage hopper, being dragged forward and fed

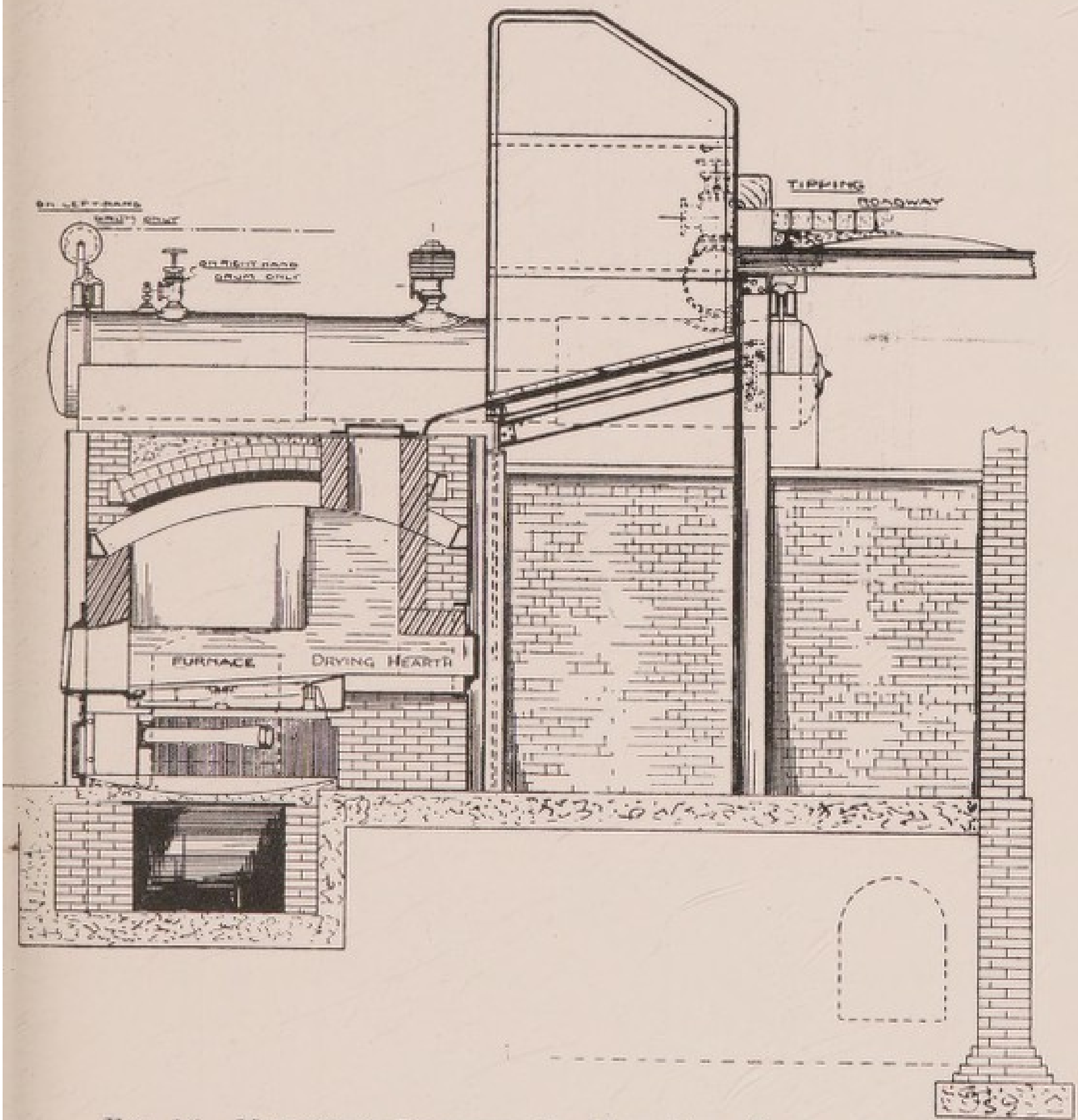


FIG. 15. MELDRUM'S IMPROVED TOP FED TYPE DESTRUCTOR.
Section through Cells.

into the charging holes as required. The advantage of this will be at once apparent; cool storage accommodation is secured, yet within easy access of the charging or feeding holes.

Further, as doors are provided, both at the front and at the back of the cell—under the storage shoot, the clinkering process

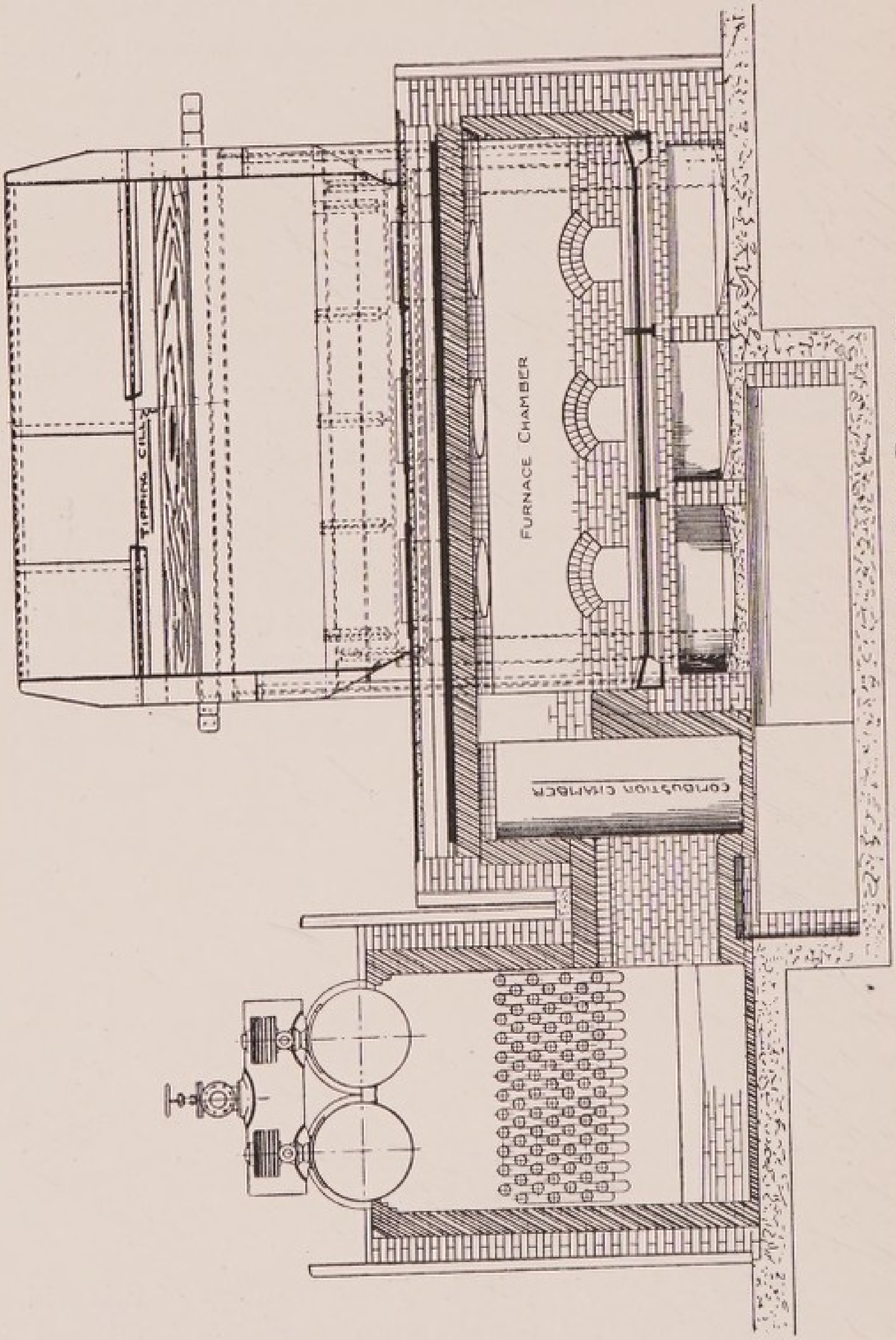


FIG. 16. MELDRUM'S IMPROVED TOP-FED TYPE DESTRUCTOR.
Front Elevation.

is much facilitated. Again, when a fresh charge of refuse is required on the grate proper, the material can be manipulated from the two opposite points. It is thus possible to charge, spread and level a fire very quickly, and with comparative ease, because the usual pulling or dragging operations are supplemented by pushing from the opposite side of the cell.

It must not be forgotten that with the top fed cell objectionable refuse can be charged more readily than is the case, for instance, with shovel feed at the front or the back. Where a proportion of excretal matter has to be destroyed, it would be manifestly objectionable to handle this by means of a shovel. By feeding such material in at the top of the cell, external handling is to a large extent avoided, as it admittedly should be, but with the average ashpit refuse there is no reason, sentimental or otherwise, why the shovel feed should not be employed.

We now come to the economic aspect of top feeding. It is, however, unnecessary to make close comparison here, because this may be readily done by referring to the tabular statements included. It may be said that on the whole top feeding has no economic advantages over front or back shovel feed. The average labour cost per ton of refuse destroyed is certainly not less, and in quite a number of instances it will be seen that shovel feed is rather cheaper.

Front, Hand or Shovel Feeding

The feeding of refuse direct from the storage hopper into the cell by shovel may be said to represent charging in its simplest and most direct form. It is necessary at the outset to clearly differentiate between front and back feeding by shovel, although manual labour and the same tool is employed with both systems, yet there is a very material difference.

With back shovel fed cells, the refuse is stored loose on a charging platform, placed parallel with the cells, the sills of the back charging doors being about eighteen inches above the platform level. In the case of front feeding the refuse is contained in an enclosed storage hopper, placed parallel with the cells, the base of the hopper being eighteen inches above the floor level, and two feet beneath the furnace or cell doors.

It will thus be seen that in both cases the actual labour involved in shovelling is about equal; but whereas in the former case the refuse is fed on to a drying hearth, from which point it has to be dragged, spread and levelled later, this work being done from the clinkering floor level opposite, with front feeding by shovel, the *one operation* suffices to place the refuse where it is wanted immediately. In short, the feeding operation is such that a level fire is obtained forthwith, and dragging, spreading and levelling as an additional and later operation is entirely avoided.

Labour is thus concentrated at the *front* of the cell, there being no additional work involved at any other point. It is necessary that this should be borne carefully in mind, as it goes a long way towards explaining why the labour cost per ton of refuse destroyed is low, notwithstanding the fact that every pound of refuse is handled by shovel.

The fact that the whole of the work of feeding consists of *one operation* only, is the explanation, and it will be clear that apart from the obvious economic aspect, extreme simplicity is a prominent feature.

To the lay observer, shovel firing does undoubtedly appear to be costly, but the close student of the subject is well aware that front and back shovel fed systems can successfully compete with any other system yet devised for low labour cost.

Perhaps front shovel feeding has had its most strenuous advocate in this country in the person of Mr. F. W. Brookman, the Cleansing Superintendent of Rochdale. For nine years past Mr. Brookman has destroyed the refuse of Rochdale at a labour cost of $7\frac{1}{2}d.$ per ton only, a figure difficult to improve upon under any conditions.

It is now clearly recognized by those competent to judge that the system we are considering is economic in labour cost. Three years since Mr. Brierley Denham Healey, in a paper read at the Royal United Service Institution, expressed his opinion as follows—

It is a proceeding which is not more laborious than top feeding, if proper arrangements are made for storing the refuse as regards suitability of level, and distance from the firing doors.[1]

Front feeding by shovel is always associated with the name of Meldrum, these makers introducing the system, and it is still their speciality. It is unnecessary here to describe the type of cell which is used for this system, and which largely contributes to the success of the same, as this is dealt with fully in another chapter.

Some opponents of front shovel feeding have stated that one serious objection to the system is the fact that the clinker is withdrawn from the same door as the refuse is fed in. Those who seriously put this forward as an objection must not forget that this is done with every steam boiler, hand fired with coal, but a fireman worthy of the name would not clinker a fire five minutes after introducing a charge of coal, on the other hand, he would burn his fire down. So with the Destructor in question, the fire is so burned down previous to the clinkering process that vitreous clinker alone remains. If any doubt still exists, the reader may be satisfied by carefully looking into the analyses of clinker in various towns; these are but typical of others, and a guarantee as to complete freedom from organic matter and combustible may be readily obtained.

The feeding of refuse by shovel and in small quantities into a hot and active cell means rapid distillation, and also rapid ignition; the gases being naturally small in volume, the temperature as a whole does not materially suffer.

The fact that with this system the cell is *always active* should be carefully borne in mind—refuse is being fed into a cell which is in work. Now with every other system of feeding, the cell is idle from the time clinkering commences until the fresh charge is ready for treatment. That the cell which is ever active has advantages over all others cannot be disputed.

It has been often said that the secret of burning coal properly

[1] *The Economical Disposal of Town Refuse.* By Brierley Denham Healey. See *Proceedings of The Society of Engineers*, 1900

is "to fire a little at a time and often." Where this advice is carefully acted upon, the smoke trouble is unknown and a remarkable fuel efficiency is obtained.

No one would be so foolish as to dump one ton of coal into a furnace—the result would be disastrous even if the coal was comparatively free from moisture; on the other hand, it is well known that in the destructive distillation of coal it is best from every point of view to introduce the fuel regularly and in small quantities. The best practice in hand and machine firing clearly shows this.

In spite of this there are those who would introduce large quantities of refuse heavily charged with moisture into cells which are in a comparatively cool condition. As a system which is diametrically opposed to the best practice in the combustion of coal, and that system of feeding refuse which we are now considering, it must be judged by critical comparison of the results obtained.

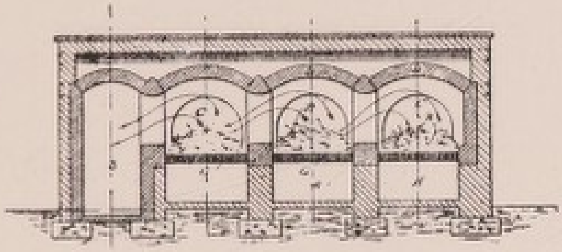
Lastly, it is claimed for back shovel feeding, and rightly too, that the man has direct control over the fire, but it must be conceded that this is also the case to a greater extent with front shovel feeding, because the draught and thickness of the fire are under the immediate control of the man who is feeding the cell. If, for instance, a hole or thinly covered place is detected on the grate, a shovelful of refuse can be immediately supplied.

On the whole, shovel or hand feeding has many conspicuous advantages; that it is becoming increasingly popular is only what might be reasonably expected. The remarkable strides made during the past few years, however, must have surprised even the most ardent advocates of the shovel.

Mechanical Charging (*Heenan's System*)

The Heenan back fed type of Destructor, originally charged in the same manner as Horsfall's Direct Charged Cell has been recently modified with a view to materially reducing the labour involved in dragging the material from the hopper base, and spreading the same over the grate.

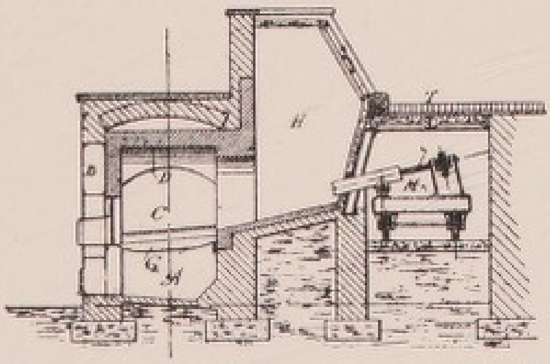
As will be seen by referring to Figs. 17 and 18, a ram is placed external to the hopper base, pushing the refuse forward on to the



Reference: *A*, Ashpit; *C*, Cell; *D*, Deflecting Arch; *G*, Grate; *R*, Refuse. Arrows indicate direction of gases.

FIG. 17. HEENAN'S RAM FED DESTRUCTOR.
Elevation.

grate. The working parts of the ram are exterior to the hopper, the weight and guiding of the ram being taken on rollers. The ram is driven by a worm wheel and screw, and is put into operation by setting a friction clutch in gear. The stroke of the ram is, however, necessarily limited, and refuse is such an unknown



Reference: *A*, Ashpit; *B*, Hot air duct; *C*, Cell; *D*, Deflecting Arch; *G*, Grate; *H*, Hopper; *T*, Tipping platform; *M*, Mechanical loader.

FIG. 18. HEENAN'S RAM FED DESTRUCTOR.
Section.

and extraordinary quantity that it is too much to hope that the drag or rake can be entirely dispensed with.

Again, the grate must be fairly evenly covered, and this must demand attention at the front with firing tools, so that on the whole the sweeping reduction in labour cost anticipated can hardly be realized.

The ram system of charging does not appear to be novel; a patent No. 2,052, of January 26, 1898, was granted to Mr. T. W. Baker, but apparently it has not been put into actual use before.

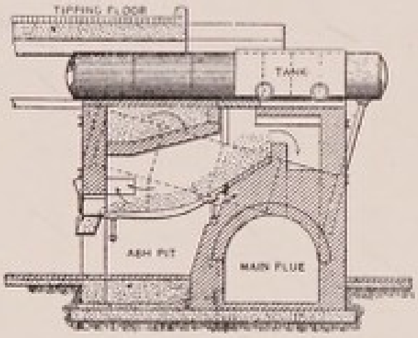


FIG. 19. FRYER'S IMPROVED TOP FED DESTRUCTOR, EMBODYING BOULNOIS, WOOD & BRODIE'S PATENTS.

(Section through Cell.

BOULNOIS AND BRODIE'S PATENT CHARGING TRUCKS

The first system of mechanical charging introduced, and perhaps the best known, is Boulnois and Brodie's Patent, the sole licensees being Messrs. Manlove, Alliott & Co.

The general arrangement will be clearly followed by referring to Figs. 19 and 20, and may be briefly described as follows:—

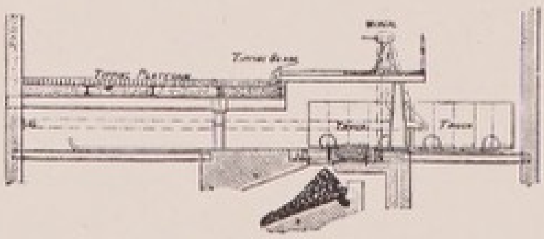


FIG. 20. BOULNOIS & BRODIE'S PATENT CHARGING TRUCK.

Wrought iron trucks are provided, usually 5 feet wide and 3 feet deep, the length being determined by the amount of storage required. Each truck is divided into several compartments, each of which will contain sufficient refuse for one charge. The movement of the truck on rails over the cell is controlled by a winch and endless chain; when it is necessary to charge a cell one of the compartments of the truck is drawn immediately over the cell, and in such a position that the swing door forming the base of the truck will fall away when the sliding door over the opening into the furnace is removed.

The refuse in the compartment of the truck over the opening, being released, falls on to the inclined drying hearth, and the act of replacing the sliding door over the charging hole also closes the swing door under the truck.

With this system an additional platform is necessary, this being about 18 feet above the clinkering floor level; from this point to the top of the cells is usually about 11 ft. 6 in., the additional height being necessary to allow free movement of the trucks under the tipping platform, upon which the carts come in, tipping the refuse direct into the trucks beneath.

It will be readily seen that one advantage of the system is the portable and cool storage; a further advantage is that the cells are certainly more efficient in destroying capacity, being charged regularly and with a fairly definite quantity. It is true that the refuse has to be dragged from the drying hearth in the usual manner and spread over the grate. While the system is undoubtedly cleanly and sanitary, it adds materially to the capital expenditure, and so far as one is able to judge from the data available, the labour cost per ton of refuse destroyed is not materially reduced.

It must not be forgotten that in the Destructor house the conditions are unfavourable to mechanism of any kind; this applies not only to the particular charging apparatus we are now considering, but likewise to ram feeding. If mechanical means of charging be employed, the simpler the system the better, and all working parts should be carefully protected from dust.

Chapter V

BRITISH DESTRUCTORS DESCRIBED AND ILLUSTRATED

"Fryer's Improved" Destructor, embodying Messrs. Boulnois, Wood & Brodie's Patents

THE modern "Fryer" Destructor, as made by the makers of the original "Fryer" Destructor, possesses several novel features in design and construction, and materially differs from other modern Destructors with the single exception of the "Warner" Destructor.

The leading features of the Destructor which we are now considering may be summarized as follows :—

(*a*) The setting of a Babcock and Wilcox boiler between two cells, this arrangement being known as Wood and Brodie's patent system of boiler setting.

(*b*) The charging of the refuse into the top of the cell without intermediate handling, by means of charging trucks which travel on rails on the top of the cell. These charging trucks are divided up into compartments, each of which contains sufficient refuse for one charge. Each compartment is provided with a hinged base, which is automatically opened when the truck is brought into the required position, over the charging inlet on top of the cell. The charging apparatus employed is that known as Messrs. Boulnois and Brodie's patent. The grate area of each cell is 25 square feet, and at the back of the grate a drying hearth is arranged having an area of about 20 square feet.

After clinkering, the refuse contained on the drying hearth is pulled forward on to the grate proper, it is then spread and levelled over the grate. The gases leave the cell at the side through an opening in the side wall of the cell next to the boiler, and at once impinge upon the boiler tubes, the side wall of the cell forming the boiler setting.

The boiler receiving the gases on both sides from the Destructor is accessible in front for coal firing in the usual manner if necessary, or a coke fire may be provided at this point as a cremator if so desired.

The advantages claimed for the method of boiler setting employed are briefly as follows :—

(1) The gases are raised to a high temperature in the firebrick cell, and are passed directly into contact with the heating surface of the boiler, thus saving loss of heat and wear of flues.

(2) The gases after passing through the boiler are much reduced in temperature and therefore in volume and velocity, and more readily deposit the fine dust in the large main flue, from which it is easily removed.

(3) The fire grate of the boiler can be used as a cremator during the drying of the green cells, and afterwards as an auxiliary steam raiser if at any time required.

(4) The boiler can be used as a steam generator, entirely separate from the Destructor gases in the event of any insufficiency of refuse, or if the cells are idle for repairs.

(5) The Destructor cells have an alternative connection direct to the flues, and therefore can be used as ordinary "Fryer" cells in the event of the boiler being idle for cleaning and repairs.

(6) The additional space required for the boiler is reduced to a minimum, and is equivalent to the net length and width of the boilers only.

(7) The side walls of the cells are utilized as the boiler setting, the arrangement accordingly being economical.

Having briefly stated the advantages claimed for the design, we will now consider the practical working of the same :—

Although one pair of cells with a boiler set between constitute "one unit," each cell must be regarded as isolated, inasmuch as it cannot assist the other cell on the opposite side of the boiler. It therefore follows that the actual supply of hot gases to the boiler cannot be constant in volume, and a considerable variation must inevitably result in the working conditions periodically.

For instance, when both cells are in full work, the boiler will receive the maximum benefit, but when either of the two cells is being clinkered and newly charged, the conditions at once materially change. Instead of a hot volume of gases impinging upon the boiler tubes from both cells, the hot volume comes from the active cell only, and a cooler volume from the idle cell, while the latter must of necessity reduce the efficiency of the former.

It will be clear that, during the period of clinkering and charging, there must be one active cell and one idle cell alternately, and it follows that the period of highest efficiency is reached when both cells are in full work. This period of high efficiency cannot be constant, because of the enforced inactivity of the cells in turn for clinkering and charging.

That the arrangement of cells and boiler is compact will not be disputed, as also the claim that the minimum of radiating surface is exposed. It is also so far advantageous to have the boiler so set that it may be fired with coal, either in conjunction with the Destructor gases, or when the Destructor is idle.

The practice of coal firing a boiler, which is also being fired with Destructor gases, has, however, been very severely criticized, it being contended that the fuel efficiency of both the refuse and the coal is reduced materially owing to the inrush of cold air, both through the open furnace doors when cleaning out or feeding fuel, and also through the cell doors during clinkering and charging.

The design, however, is sure to be favoured in the case of some combined electricity and Destructor works, because it tends to reduce the capital cost. As the Destructor boilers can be used for coal firing as desired, it is often suggested that to begin with no extra boilers for separate firing shall be provided.

The system for charging the refuse into the cells as already noted is unique and peculiar to this particular Destructor As the system is fully described in another chapter among other systems of charging, it will accordingly suffice if the advantages which are claimed for the same are just briefly enumerated. They are as follows :—

(1) The carters get rid of their loads more quickly, through having a clear fall from the cart to the refuse.

(2) So long as storage space remains, it can quickly be brought under the tail-board of the cart.

(3) The material is received from the cart and delivered direct to the cell, without the intervention of hand labour.

(4) None of the refuse as stored comes into contact with the heated surface of the cell.

(5) The whole of the arrangements are operated from the upper winch platform, and the men need not go down among the material.

(6) The quantity of material destroyed per day is greater than under the old system.

(7) A reduction in the number of men employed, as compared with the old system of ordinary top charging.

(8) The whole arrangement can be kept in a clean state, and free from objection on sanitary grounds.

The system of storage is undoubtedly cool and cleanly, but, as will be observed, the storage capacity is limited, and if refuse is delivered irregularly and carts arrive at such times as the charging trucks are full, storage in the carts is necessary to avoid extra handling of the material.

In stating this, cart storage is not deprecated; it is a cool and sanitary system, the only objection being the necessity for providing extra carts, which, as pointed out in another chapter, is a special feature of Horsfall's and Meldrum's systems of direct charging.

Records of actual work being done in many towns will be found tabulated herein, and these are worthy of careful perusal. In the case of quite a number of installations where the power is being fully utilized for electric lighting, electric traction and sewage pumping, it will be observed that very satisfactory results are being obtained.

The general design of the "Improved" Fryer type of cell, embodying Messrs. Boulnois, Wood and Brodie's patents, is illustrated in Figs. 19 and 20.

Warner's "Perfectus" Destructor

This Destructor possesses some few points in common with the "Fryer" type. The cells are, however, larger, and a boiler of the multitubular type is almost invariably used instead of a water-tube boiler.

The cells are usually arranged back to back, excepting in the case of very small installations, and top charging is an essential feature, small charging hoppers being provided immediately over the drying hearth, the hopper base being just above the reverberatory arch over the hearth. The hopper base plates

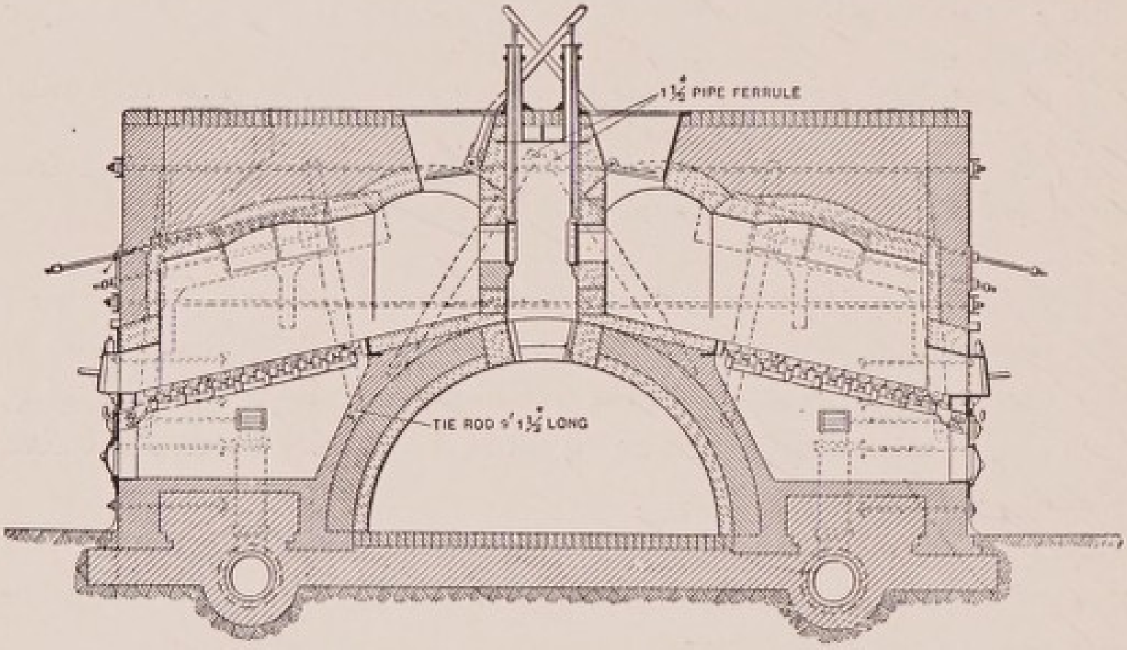


FIG. 21. WARNER'S TOP-FED DESTRUCTOR.
Section through Pair of Cells.

are hinged, and the opening and closing of the base plate as required is controlled by an arrangement of simple hand levers on top of the cells.

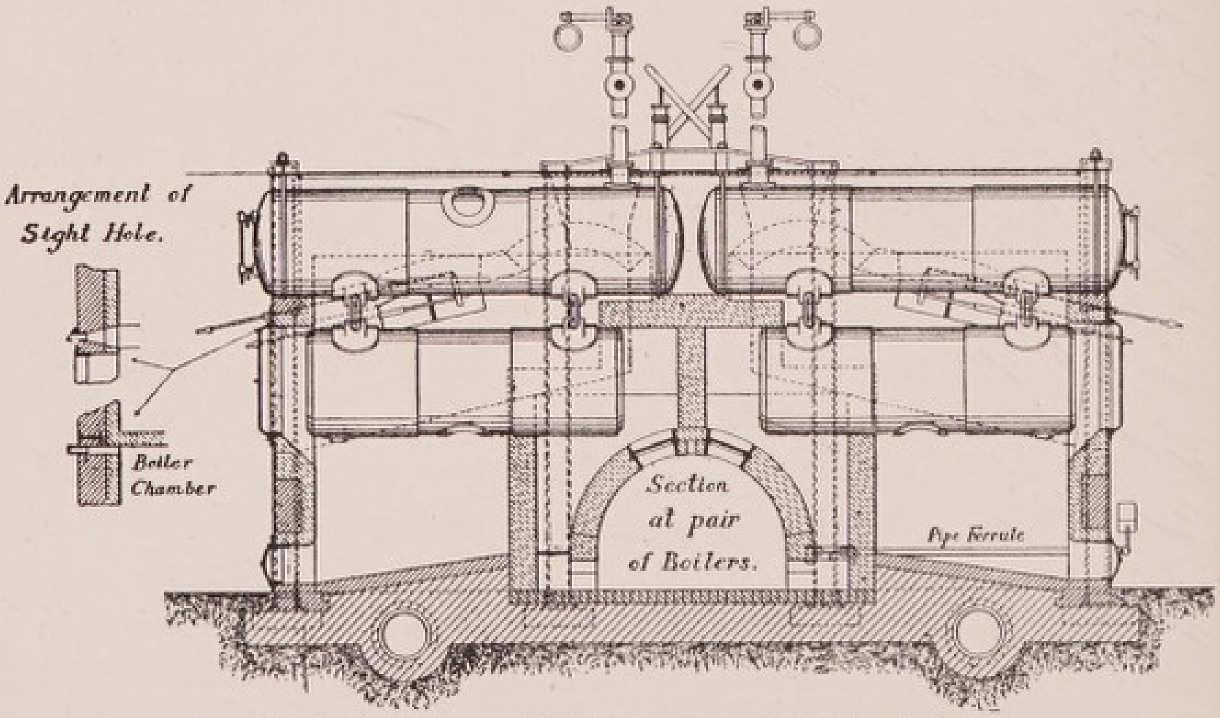


FIG. 22. WARNER'S DESTRUCTOR, TOP FED TYPE.

The gases leave the cells at the side, through an exhaust opening, coming into immediate contact with the boiler. In all modern installations forced draught is provided, Sturtevant Fans, driven by high speed vertical engines, being usually employed.

Figs. 21 and 22 clearly indicate the general arrangement of two cells arranged back to back, these being of the ordinary top fed type, while Fig. 23 illustrates a later arrangement, which provides for direct charging from cart to cell, with storage in the cell.

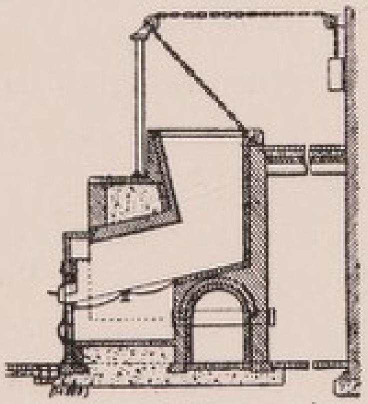


Fig. 23. Warner's Destructor, Direct Charged Type.

It will be observed that this design is similar to Horsfall's system of direct charging, the refuse having to be manipulated from the front (i.e., the clinkering floor), and the same difficulties which were met with in Horsfall's original design are likely to be presented again with this system. As the difficulties inseparable from systems of cell storage are fully dealt with in another chapter, it is unnecessary to further discuss the same here.

The Warner Destructor, as originally designed, was somewhat similar to the early Fryer Destructor, the cells being erected either in single row or back to back, the boiler being placed between the cells, and the chimney in the main flue. The later arrangement of setting a boiler between every two cells dates from 1892, about which time also forced draught was first introduced in connection with this particular make.

Although a considerable number of Warner Destructors have been erected, many are of the early type. Compared with some of the more recently introduced Destructors, no great headway has been made in the production of power.

Horsfall's Destructors

The Horsfall Destructor will always be remembered as the first high temperature Destructor, and its advent marked a new era in the disposal of refuse by fire. Although the name of

Horsfall is always associated with the first high temperature Destructor, yet the temperature obtained many years ago, although high by comparison with the earlier low temperature natural draught Destructors, was not so high as that now reached with the best of modern Destructors.

That the advent of the high temperature Destructors gave an immense impetus to final and sanitary refuse disposal is beyond all question, and it may be safely said that had we not yet adopted high temperature working in this country, our own position to-day in so far as sanitary Refuse Disposal is concerned, would be no more satisfactory than is the case in America.

As the pioneers of the high temperature system the Destructors made by the Horsfall Company are of peculiar interest. At the present time no less than three distinct types of Destructors are associated with the name of Horsfall (1) Back, shovel or hand fed type, (2) The top fed type, and (3) A system of direct charging from cart to cell, this being a modification of the top fed type. All three systems are fully described in the chapter dealing with the various systems of charging in use.

It is not surprising that the first high temperature system should be popular, and great credit is due to the makers, not only for this valuable and far-reaching innovation, but also for improvements in design which have contributed not a little to the present satisfactory position of this country, in so far as final and sanitary Refuse Disposal is concerned.

To briefly refer to one feature in design, which was generally admitted to be a great improvement—the front exhaust. One has only to compare Figs. 13 and 14 to at once appreciate the value of this improvement. Instead of the gases as distilled from material on the drying hearth being permitted to at once pass out of the cell into the main flue, the direction of exit was reversed, the green gases being caused to travel over the active grate before leaving the cell, and only passing from the cell into the exhaust flue intermingled with hot gases, excepting, of course, at such times as the cell may be idle.

Even those who doubt the utility of the drying hearth at all, will admit that, having a drying hearth, the front exhaust is a necessity. Ten years ago, when critical comparison was frequently made between the earlier systems and this new departure, those who had occasion to study the matter even superficially were speedily convinced as to its superiority. Other features peculiar to the Horsfall Destructor, such as the side air boxes, are dealt with in another chapter; that these are useful for preventing the adhesion of clinker to the side walls of the cell has been amply demonstrated.

Within the past two years, coincidently with the developments made in the production and utilisation of power from refuse, the back shovel or hand fed type of cell would appear to have been more popular on the whole than the top fed type. It may, therefore, be of interest to quote Mr. George Watson's conclusions concerning the relative advantages of the two systems :—

> There is practically no difference between the two systems in regard to economy of labour. . . . The work at the front is similar for both types of furnace, and consists in pulling the refuse forward and spreading it over the fire with a long handled iron rake.[1]

It being admitted that back hand feeding possesses no economic advantages over top feeding, its popularity must perforce be attributed to other considerations. In the chapter discussing various systems of charging refuse into cells, the author has endeavoured to show what the real advantages are.

That the very best results recorded with the Horsfall Destructor are being obtained with installations of the back hand fed type is very evident. By best results is meant efficiency in power generation, and also the production of a good hard clinker.

In order to clearly appreciate the difference in the design and arrangement of the top and back fed types it is necessary to compare Figs. 9 and 13. Many installations of both the top and back fed types are herein described, details of several evaporative tests are also included. The reader will find much of interest therein, and not only in connection with installations where the power is fully utilised.

[1] *Watson on Refuse Furnaces.* See *Proceedings of The Institution of Civil Engineers*, vol. cxxxv., 1898–99, Part 1.

Meldrum's "Simplex" Regenerative Destructor

The first Destructor of this type was erected about nine years ago at Rochdale, since which time various minor improvements have been adopted. The main features, however, such as front feeding by shovel, the continuous grate, and the regenerative system of air heating have all been retained and perfected.

With the system of continuous grate and divided ashpits, the principle of "mutual assistance" is embodied in its entirety. As will be seen by referring to Fig. 24, instead of small ordinary cells divided one from the other, one large furnace chamber is provided, but below the grate divided ashpits are

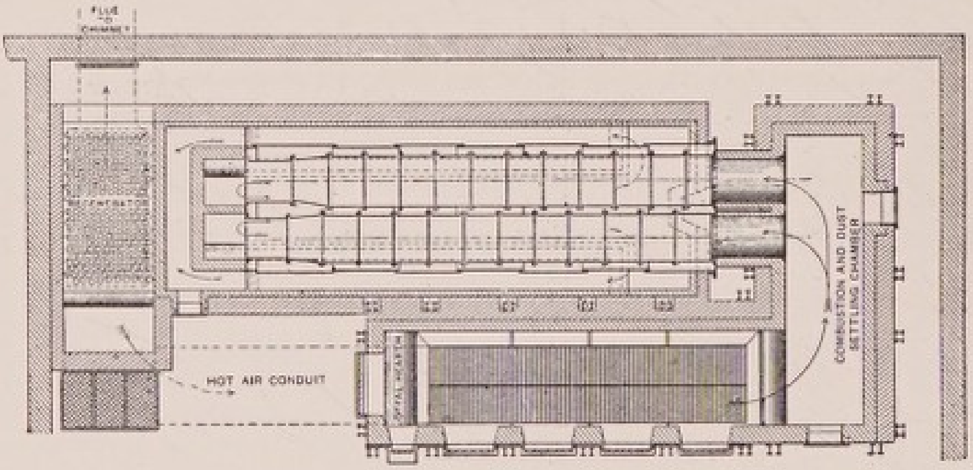


Fig. 24. Meldrum's Simplex Regenerative Destructor, Front Hand or Shovel Fed Type.
Plan showing Passage of Gases, and Air for Combustion.

arranged, each ashpit being provided with two steam jet blowers fitted into a downtake box communicating with the air conduit, which is common to the series of ashpits.

This arrangement of blowers ensures silent working of the forced draught, and as the blowers in each ashpit have a separate steam connection, the fires on each section of the continuous grate area are under separate control.

As usually arranged, the whole volume of gases have a sideway motion; thus the volume of gases passing from that section of the grate on the extreme left must pass over and intermingle with the hot gases proceeding from the other sections of the grate, the whole volume of gases moving in the same direction towards the combustion chamber.

When a fresh charge of refuse is introduced on to either of the two middle sections of the grate, with active sections on the right and left, the newly charged refuse quickly ignites in the zone of active fire. Charging the section on the extreme right in its turn, the hot volume proceeding from the active three-fourths of the grate must pass over and intermingle with the comparatively small volume of cool gases distilling from the newly charged section.

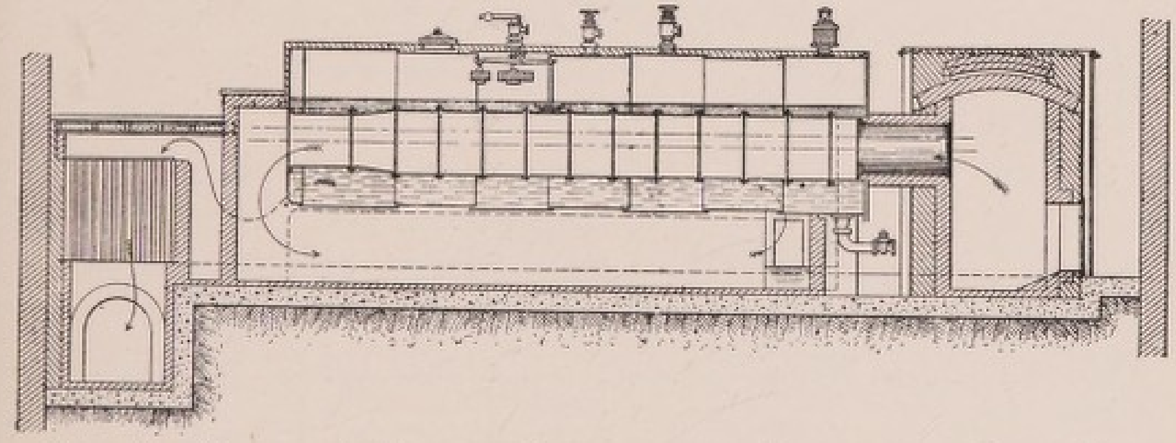


FIG. 25. MELDRUM'S SIMPLEX REGENERATIVE DESTRUCTOR, FRONT HAND OR SHOVEL FED TYPE.
Elevation of Boiler and Regenerator.

It will thus be seen that the cell is ever active; the example here illustrated is known as a four grate unit, three-fourths of the cell always being in full work. With a three grate unit, two-thirds of the cell are always active, and with a two grate unit, one-half of the cell is always in full work.

It is thus that a high temperature is maintained in the cell, the maintenance of high temperature being automatically secured. To a great extent the use of hot air for combustion is also beneficial, quickly absorbing moisture and promoting rapid ignition. Experiments with very wet refuse have shown that with cold air supplied to the blowers the fire would die out, while with air heated up to 300° Fahr., rapid combustion could be maintained.

As will be observed by referring to Fig. 25, after the volume of hot gases leave the boiler they immediately pass through the regenerator or continuous air heater. The regenerator consists of a battery of staggered cast iron pipes. The hot gases pass vertically downwards through the pipes into the main flue, thence direct to the chimney unless an economizer be also provided.

Cold air is admitted to, and circulates around the outside of the regenerator pipes, being drawn therefrom through an air conduit by the steam jet blowers, which then force the volume through the fires. The temperature of the gases after leaving the regenerator is sufficiently high to permit of an economizer being installed for heating the boiler feed water.

It will thus be seen that having secured and maintained a high temperature in the cell, it is not only possible to generate steam in the boiler, but also to heat both air and water. With such an arrangement some 1,600° Fahr. will be absorbed between the combustion chamber and the chimney, the gases being reduced in temperature from about 2,000° Fahr. to 400° Fahr.

Although front hand or shovel feeding is usually associated with the particular Destructor we are now discussing, it will be seen by referring to Figs. 15 and 16 that a system of top feeding can be used while still embodying the leading features of the continuous grate, combustion chamber and regenerator. Similarly also a system of back shovel or hand feeding may be adapted, see Figs. 10 and 11, likewise Marten's direct charging system as illustrated in Figs. 7 and 8. It is unnecessary to here discuss the advantages of the various systems of charging, these being fully dealt with in a separate chapter.

The details of a number of evaporative tests made with Destructors of this type in various parts of the country, together with illustrations of steam pressure charts and temperature recorders, serve to clearly show that excellent results are being obtained, which are in no small measure due to the facilities provided for securing and maintaining a high temperature in the cell.

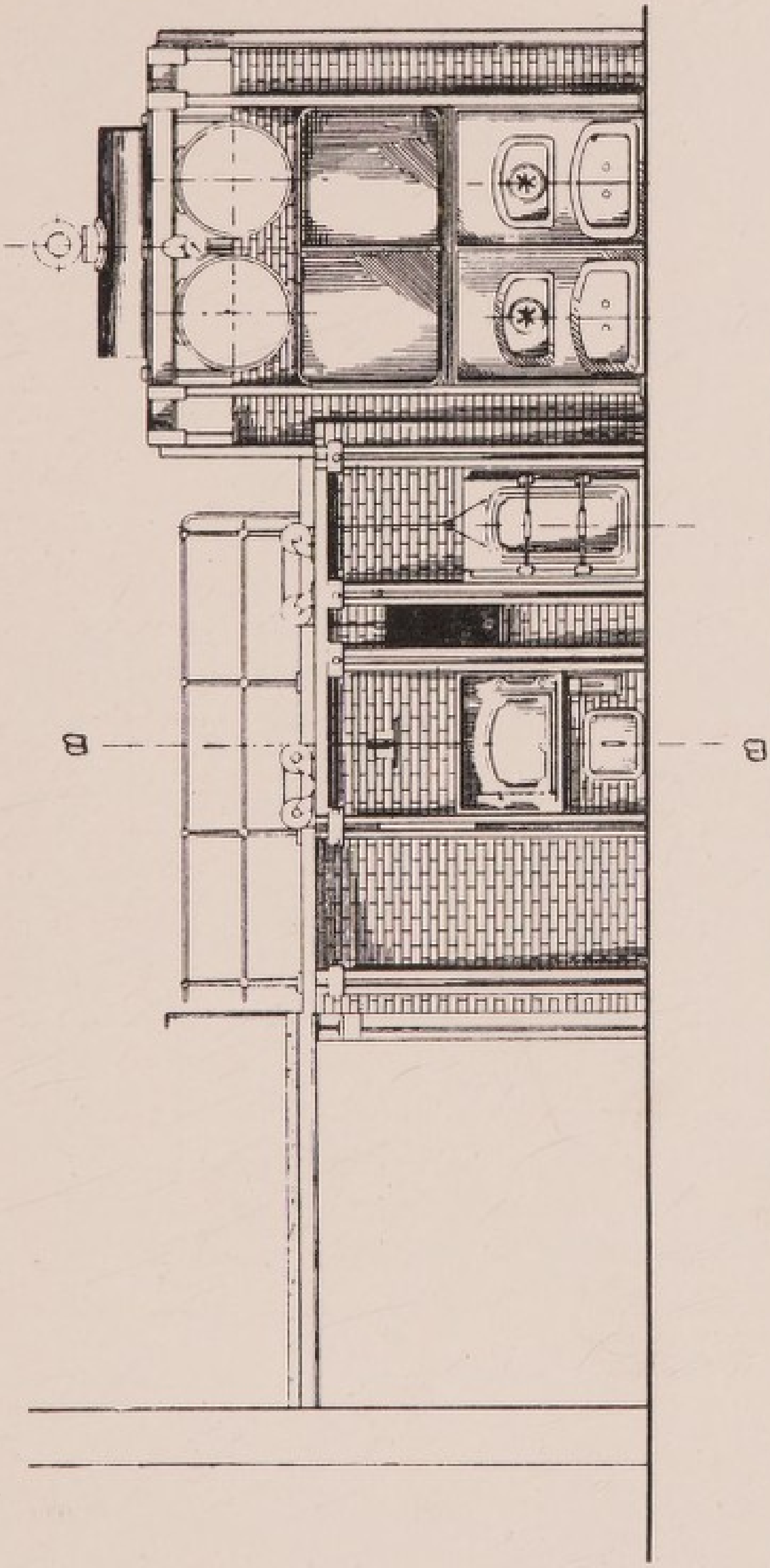


Fig. 26. Meldrum's "Beaman & Deas" Type Destructor.
Elevation.

Meldrum's "Beaman & Deas" Type of Destructor

This was one of the first high temperature Destructors, being introduced at a time when but little progress had been made in the adoption of high temperature cells. About nine years ago, when the first installation was made, many municipal engineers

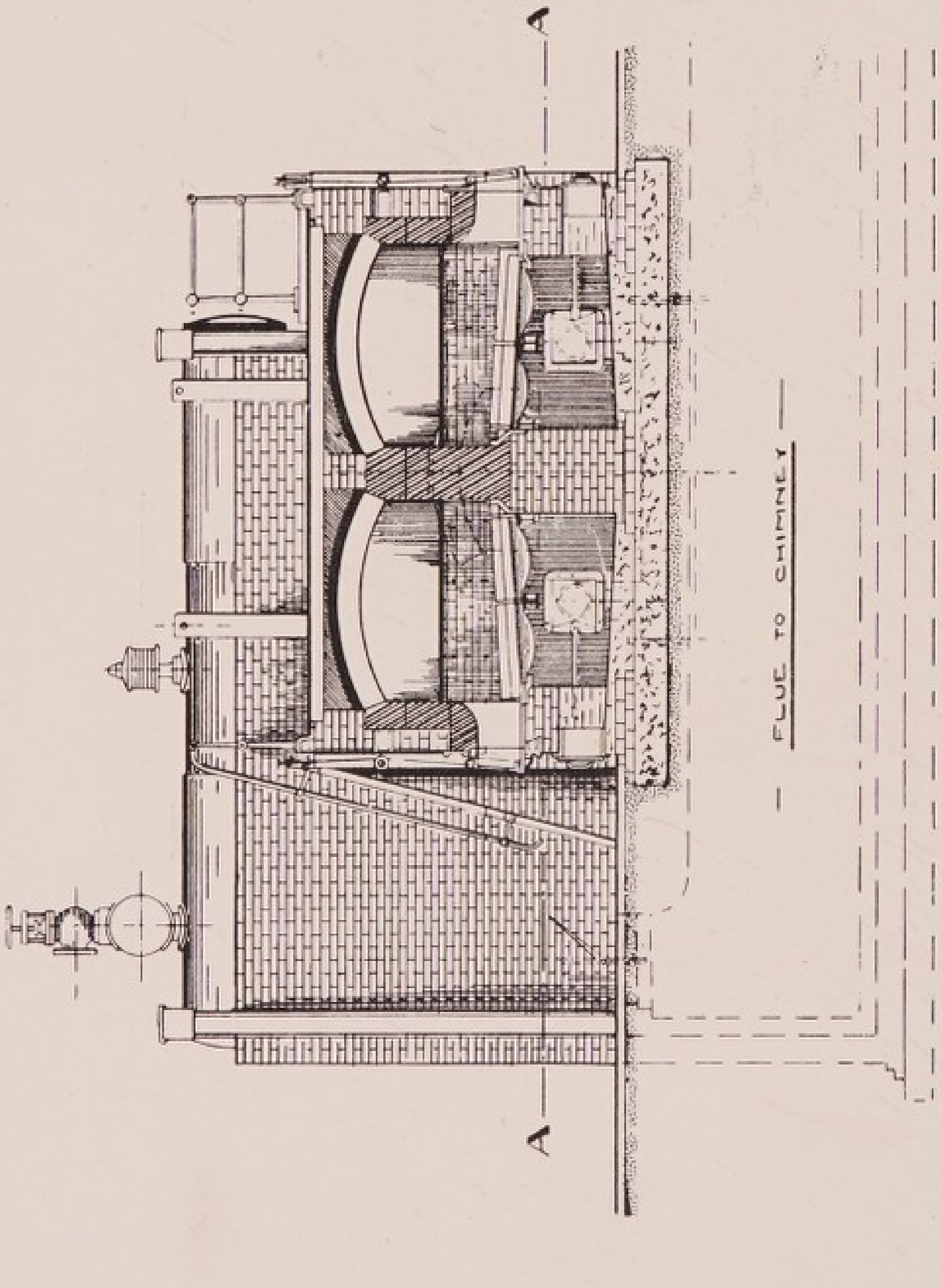


FIG. 27. MELDRUM'S "BEAMAN & DEAS'" TYPE DESTRUCTOR.
Part Elevation, part Section.

gravely doubted whether it was possible to secure the results then claimed.

Time, however, has but served to show that a temperature of 2,000° Fahr., which was then disputed, can be very easily obtained, and likewise a combustion of 15 tons of refuse per cell per 24 hours can be readily exceeded.

In essential principles the Beaman & Deas type of Destructor is the same now as it was in the beginining; a few minor improvements have been introduced, all of which tend to facilitate the

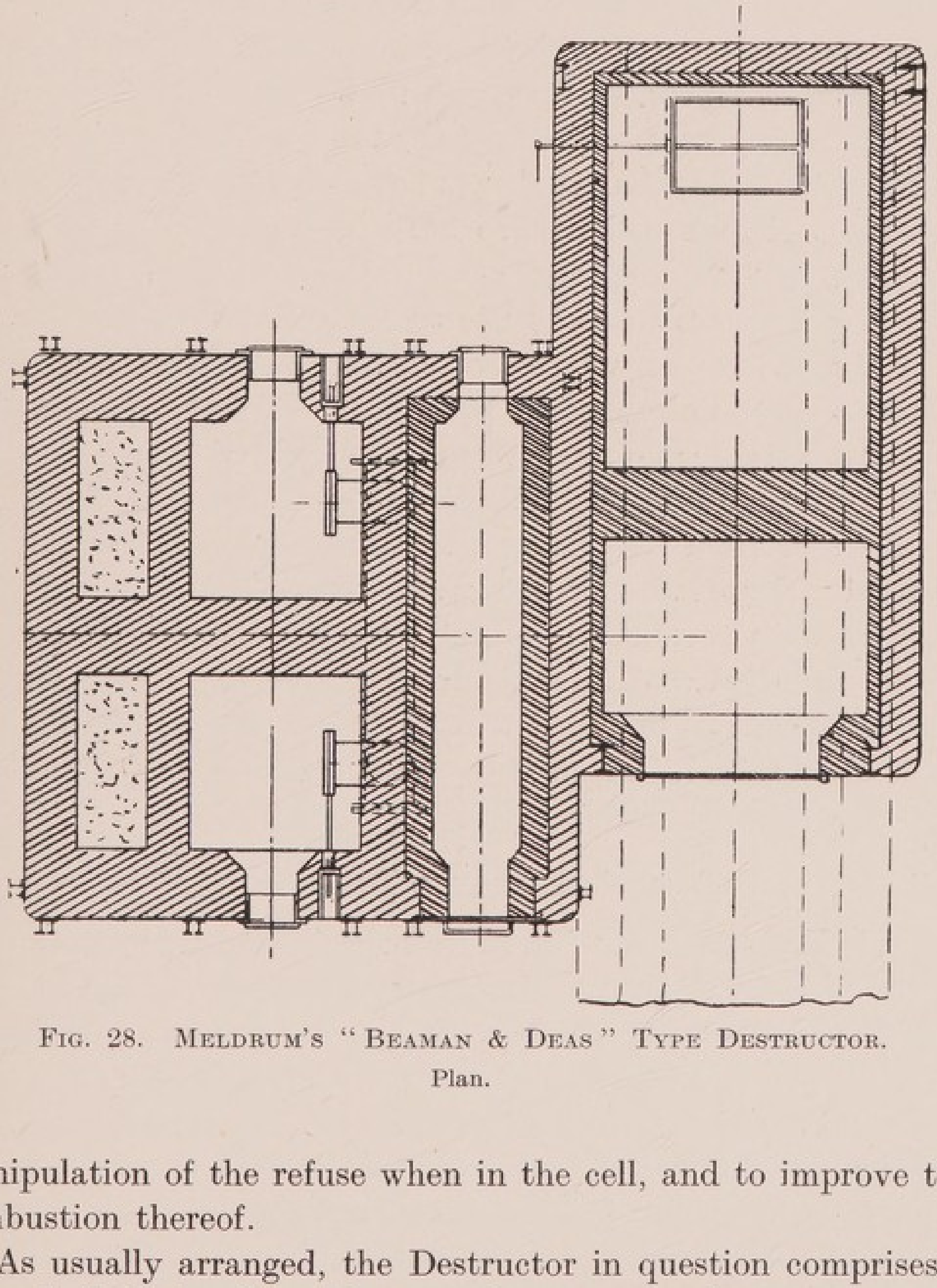


Fig. 28. Meldrum's "Beaman & Deas" Type Destructor. Plan.

manipulation of the refuse when in the cell, and to improve the combustion thereof.

As usually arranged, the Destructor in question comprises a pair of divided cells, with a combustion chamber, common to both cells, and a Babcock and Wilcox boiler, set behind the combustion chamber. The ordinary arrangement of the cells is shown in Figs. 26, 27 and 28. If desired, the refuse may be contained upon a storage shoot, or in a storage bin clear of the cells, being dragged forward and charged in as required. A further modification is the inclusion of Marten's system of direct charging, which arrangement may be seen in Figs. 7 and 8.

The grate area of each cell is 25 square feet, and a spacious drying hearth is provided at the end of the cell furthest from the combustion chamber, so that green gases as distilled must pass over the active grate before entering the combustion chamber.

Fan forced draught has always been employed, and some very high rates of combustion have been reached. In a test at St. Helen's, it will be noted that over 100 pounds of refuse was destroyed per square foot of grate surface per hour.

The provision of a common combustion chamber with the alternate system of charging, ensures the mixing of the gases in the combustion chamber, and each cell in its turn is therefore helpful to its neighbour. Direct access is given to the drying hearth, and from this point the refuse is pushed forward as required and spread over the grate. The cell is clinkered from the side, and a reasonable concentration of labour is thus secured.

As a top fed system, embodying the drying hearth and fan draught, it will be found interesting to compare the results with those obtained with other Destructors of the top fed type.

Baker's Improved Destructor.

This Destructor was introduced about four years ago, and up to the present, so far as this country is concerned, the practical working of the same has to be judged by one example only, a two cell plant, erected at Phoenix Wharf, Lambeth, under the Metropolitan Borough of Finsbury.

Internally this Destructor differs essentially from all other British makes. Two inclined grates are provided, one above the other. The cells being charged at the top, the refuse immediately falls on to the upper grate, which constitutes the drying hearth. At the opposite end of this grate, access doors are provided for the manipulation of the material on the upper hearth or grate, and from this point it is dragged forward over the end of the grate as required and again spread over the secondary inclined grate beneath.

In contra-distinction to all other systems with which drying hearths are used, with this type all fumes from the drying hearth

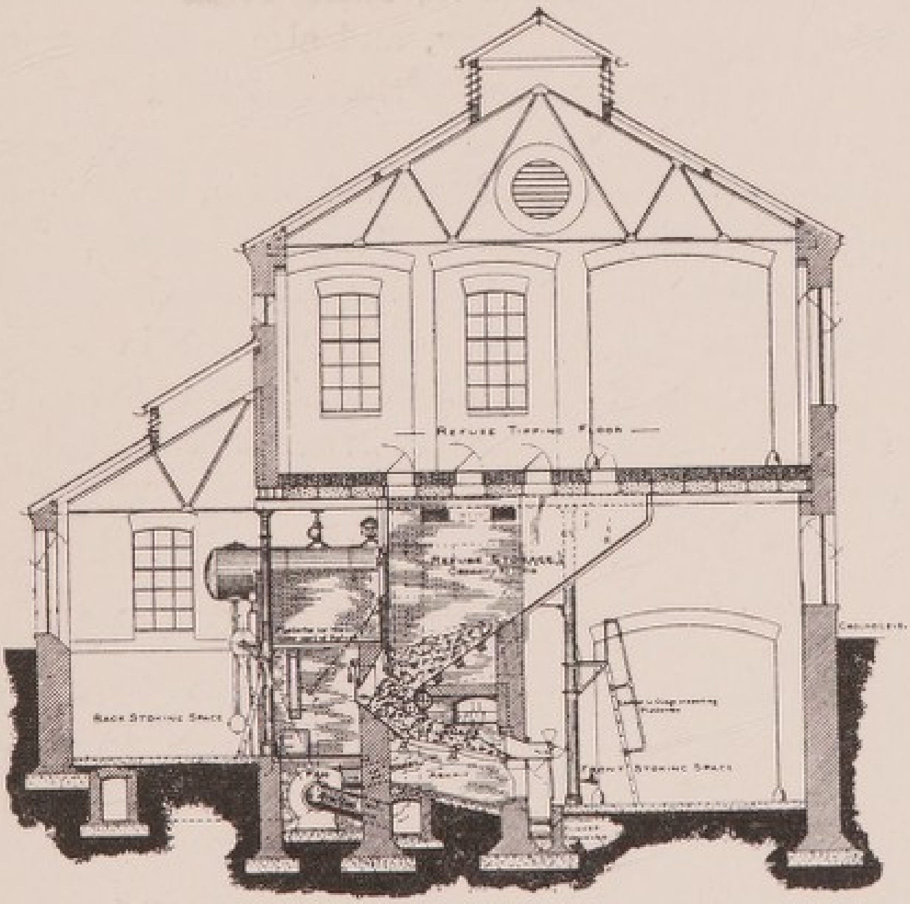


Fig. 29. Baker's Improved Destructor.

are exhausted by the forced draught fan and delivered with the air supply under the secondary grate. This is a good feature, inasmuch as it entirely avoids the neutralizing effect upon the cell temperature which must obtain when low temperature gases are constantly being liberated in a cell where active combustion is also in progress. By this is meant single cell systems with which the drying process is constant in every cell.

Fig. 29 clearly illustrates the general design; it will be observed that considerable depth is demanded, and further that the operation of the cell necessitates labour at three different levels: (*A*) on top of for charging; (*B*) intermediate stoking at the back, and (*C*) levelling and clinkering below at the front. This is not a satisfactory feature, as it prevents that concentration of labour which is always a source of economy.

Whether the very ample cell storage will prove satisfactory yet remains to be seen; past experience would incline one to think that difficulties will be presented, owing to the swelling action of the heat radiated from below, and also because of the great weight of material above a somewhat restricted opening at the hopper base.

There are many novel features embodied in the design, and it will be interesting to clearly follow the results obtained in actual practice. The plant here illustrated differs considerably from the one working example in London, mainly, perhaps, in the provision for storage of refuse in the cell, a departure which has always involved trouble wherever yet tried, in addition to increasing the labour cost.

The "Sterling" Refuse Destructor.

This Destructor, which was introduced about three years ago, is not unlike the Beaman and Deas type in general design, and has given very satisfactory results.

The cells are usually erected in pairs, the combustion chamber being placed between two cells, whereas with the Beaman and Deas type the combustion chamber is arranged at the back of the cells, and between the cells and the boiler.

In the case of larger installations, while the "pair" system is still retained with the cells, the arrangement is such that either 4 or 6 cells discharge their gaseous products into one combustion chamber.

Each cell is provided with a drying hearth, the grate proper having an area of 25 square feet. Fan draught is always employed, and usually Babcock and Wilcox boilers are set in connection with the cells in preference to any other type of boiler.

The storage of refuse in carts is recommended, but as already pointed out in another chapter, this system of storage has commended itself to but few authorities up to the present, owing to the increased capital expenditure involved.

In the case of one or two installations, a system of transporters and storage bins has been provided, notably at Hackney and Aston Manor. Some actual working results obtained with these and other installations are referred to elsewhere, and these are worthy of careful perusal.

Heenan's "Twin Cell" Destructor.

This Destructor was introduced about three years since, being at that time a modification of the "Bennett Phythian"

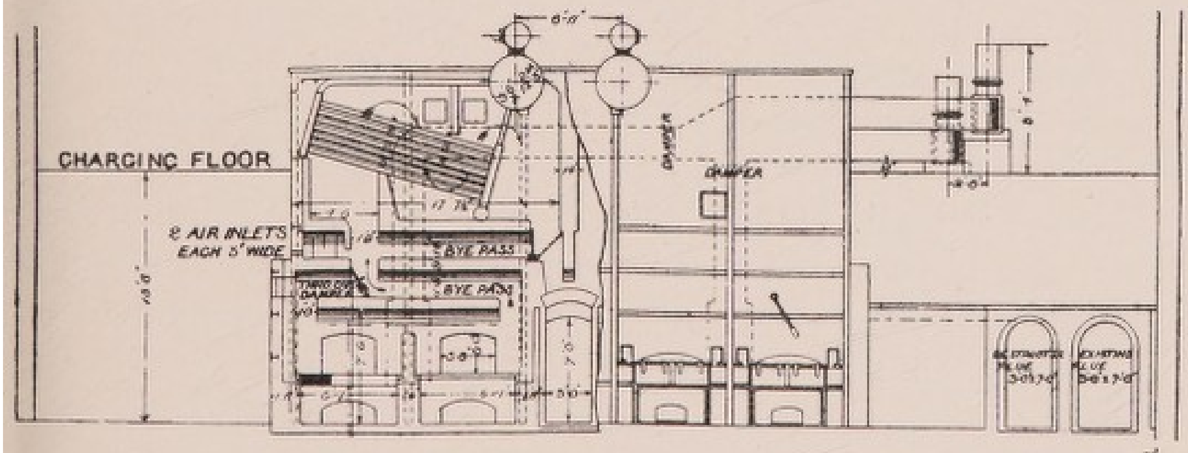


Fig. 30. Heenan's Twin-Cell Destructor.

Destructor. The essential principle of the Destructor is conveyed to the reader in the term "Twin Cell," and the modifications of the original type have all in the main been introduced with a view to securing and maintaining a high temperature in the cell.

To some extent the design has been simplified, and while this has been accomplished, it has not involved any sacrifice in general efficiency. As will be observed by referring to Fig. 30, cells are erected in pairs, and while each cell has its separate ashpit, the two cells form one continuous chamber, divided only above the grate level by a shallow bridge between each grate.

Each cell has a grate area of 30 square feet, and as with Meldrum's system of continuous grate, so with the system we are discussing, a drying hearth is not used. Forced draught is provided by means of centrifugal fans, either electrically or steam driven, and hot air is supplied for combustion, the air being heated in passing through a continuous air heater, known as Howden's system, which method of air heating has been extensively used in connection with forced draught for marine boilers.

In the case of the earlier installations, the refuse was tipped direct from the cart into a back storage hopper, from which the material was dragged over the grate by means of a rake, this operation being performed from the clinkering floor immediately opposite. The Heenan "Twin Cell" Destructor may therefore be termed a back fed Destructor (see Fig. 12).

While the charging of refuse into a closed storage hopper has its advantages, it will be clear to the reader that the hopper feed is always liable to give trouble, for reasons already indicated.

When the material becomes hot, and accordingly swells, it is difficult to move, and when it is only possible to manipulate the mass from one point, and that by dragging from a distance, the disadvantages of hopper charging at once become evident.

Even when refuse is cool, it will constantly "bridge" over in wide hoppers ; it is then dangerous to attempt to dislodge the mass from below even if it is accessible from the underside. To break through the same from above is often found very difficult, and when dislodged the impact of the fall is such as to compress the mass at the hopper base.

It would appear that the makers of the Heenan "Twin Cell" Destructor clearly appreciate the difficulties involved in the hopper feed, as they have recently introduced a charging ram which is arranged to push the refuse forward from the base of the hopper (see Figs. 17 and 18). This method of charging is further discussed in another chapter.

That the Heenan Destructor has been successful, may be mainly attributed to the design and the use of hot air for combustion. The principle of "mutual assistance" has been kept carefully in mind and embodied in the design, with the result that the system has quickly become popular.

Chapter VI

LABOUR COST

THE labour cost in connection with Destructors is a factor of great importance, and demands careful consideration; but it is a great mistake to single this one factor out as the main or only basis for comparison between two or more systems.

Being a standing charge, it calls for serious attention, but it is obviously absurd to lay down the principle that, because with one system it is guaranteed to destroy refuse at 8*d*. per ton as against 10*d*. per ton guaranteed with another system, the former is of necessity the most economical. With the latter plant, twice as much steam may be guaranteed, or the clinker may in the one case be poor, and in the other case vitreous, and commercially speaking very much more valuable.

Again, the question of depreciation is a factor which must be recognized; recent reports serve to clearly show that with some systems the cost of repairs is considerably higher than others. It will thus be evident that a possible economy in bare labour cost for destruction should not be considered apart from various other factors.

The writer has an instance in mind of two recent installations of the high temperature type in a Northern city. Both Destructors are of the top feed type, but the systems are different; the two installations are scarcely two miles apart, and yet in one case the whole of the clinker is disposed of at 2*s*. 6*d*. per ton at the works, while in the other case the clinker is valueless and produces practically nothing.

This case is not an isolated one, nor is it overdrawn. At the present time and for some three years past in connection with a Destructor in one of the Metropolitan Boroughs, the clinker is freely disposed of on the premises at 1*s*. 9*d*. per cubic yard. Five miles away, in another Metropolitan Borough with a different type of Destructor, not only is the clinker too soft to command a market, but at least 2*s*. per ton has to be paid to get rid of it.

Instances such as these only too clearly show that in this respect alone it might be wise to choose one type of Destructor rather than another, even if the guaranteed labour cost was higher.

If for purposes of argument we assume that ·3 of a penny is a fair price to fix as the value of each unit of electricity generated, and that a ton of average refuse is equal to the production of 30 electrical units, such refuse then has a fuel value of 10*d*. per ton. If one maker guarantees this output and a labour cost of 10*d*. per ton, while another maker only guarantees 15 units at a labour cost of 8*d*., it will be easy to determine which will be the best investment for the authority, and accordingly for the ratepayers.

Experience generally shows, also, that where the greatest amount of power is produced, there also is the best clinker produced, so that on the whole a guaranteed low labour cost must be closely investigated, and only considered with a full knowledge of the other important factors involved.

In the case of a sewage works where it is proposed to erect a Destructor, it may be desirable to utilise the clinker for bacteria beds. This being so, the very best clinker is essential, and in every such case, if necessary, it would be policy to pay even some few pence per ton extra for labour cost to ensure the production of suitable clinker.

The broader issues must receive consideration, mere labour cost *alone* is deceptive; it is of the highest importance that the whole of the factors be taken into account. If this be done then that which at first sight appears to be advantageous, may be very seriously discounted even if not entirely obliterated. It is necessary to emphasize the importance of this because so much has been said and written concerning phenomenally low labour cost, that far too much importance may attach to what is only after all *a* factor.

There is ample evidence available to clearly show that even with refuse practically uniform in composition, some Destructors are very much more satisfactory than others in power production, and also in the quality of the residuum. Difference in design will to a large extent account for this: the higher and more equable the temperature, the greater and more satisfactory is the power production and the more virtreous the clinker.

It is quite possible for two modern Destructors of different types in one town to show very different results in steam raising, and also a residuum differing in character and accordingly in value. Although this may be doubted by the layman it is nevertheless a fact, nor is it remarkable when one looks carefully into the matter, critically comparing the difference in design and general arrangement.

Destructor makers are often invited to guarantee the cost of labour when they are not at all familiar with the rate of wages ruling in the town, and as the various systems are so different, not only in the methods of charging, but also in the rate of combustion, or guaranteed capacity per cell, it would seem that a very much fairer form of guarantee would be for each maker to be invited to state how many tons of refuse could be handled by one man in a shift of 8 or 12 hours as the case may be.

To ask for a guaranteed labour cost per ton of refuse destroyed, is often to ask for a guess, or to practically ask for a figure which the Destructor maker may deem a safe one by comparison with what is being done with a similar plant elsewhere. That the wages paid to stokers and chargers do vary considerably in various towns will be clearly seen by referring to the appended table.

Comparative Statement Showing Rate of Wages Paid and Number of Hours Worked Weekly in connection with Refuse Destructors in 28 Boroughs.[1]

Name of Town	Stokers' Wages per Hour	Chargers' Wages per hour	Number of hours worked per week : Stokers	Number of hours worked per week : Chargers
Bradford . .	7*d.*	$6\frac{1}{4}$*d.*	48	48
Birkenhead .	6·5*d.* & 7*d.*	4·52*d.* & 4·91*d.*	48	61
Birmingham .	6·5*d.* & 7*d.*	5·75*d.* & 6*d.*	48	48
Blackburn .	6*d.*	—	54 & 60	—
Bolton . .	5·58*d.*	—	58	—
Bristol . .	7·73*d.* & 8·4*d.*	—	45	—
Burnley . .	6·5*d.*	5·5*d.*	48	48
Bury . .	5·5*d.*	—	60 & 74	—
Colne . .	6*d.*	5·5*d.*	55	56
Darwen . .	6·5*d.*	—	72	—
Derby . .	4·64*d.* & 5·03*d.*	4·64*d.* & 5·03*d.*	62	62
Edinburgh .	7·5*d.*	7*d.*	48	48
Glasgow . .	4·75*d.* & 4·95*d.*	—	58	—
Hyde . .	5·15*d.*	5*d.*	$55\frac{1}{2}$ & $50\frac{1}{2}$	56 & 50
Huddersfield .	5·5*d.*	5·5*d.*	60	60
Leeds . .	7·75*d.*	—	48	—
Liverpool . .	5·45*d.*	4·54*d.*	66	66
Manchester .	5·75*d.*	—	58	—
Nelson . .	6*d.*	5·5*d.*	65	$63\frac{1}{2}$
Newcastle-on-Tyne . .	5·62*d.*	5·62*d.*	56	56
Oldham . .	7·5*d.*	—	48	—
Preston . .	5·58*d.*	4·98*d.*	58	58
Rochdale . .	7·25*d.* & 6·5*d.*	—	44	—
Salford . .	5·35*d.*	4·71*d.*	56	56
Sheffield . .	6·75*d.*	6·25*d.*	48	48
St. Helens .	6*d.*	5·11*d.*	54	54
Warrington .	5·14*d.*	3·8*d.*	63	63
Wigan . .	5·72*d.*	—	$54\frac{1}{2}$	—

It will be observed that the stokers' wages vary from 4·64*d.* per hour at Derby to 7·75*d.* at Leeds, and even as high as 8·4*d.* at Bristol ; it is therefore obvious that if a Destructor of the same

[1] Compiled by the late Mr. John McTaggart of Bradford.

type as that in use in Leeds were installed in Derby the labour cost for destruction would be substantially the same, and it therefore follows that if the Derby Destructor is operated at a much lower labour cost per ton destroyed than is the case at Leeds, then such a difference in favour of the Derby plant is no argument in favour of the particular type of Destructor in use there, but, on the other hand, may be entirely attributed to the cheaper labour available.

It is very necessary that this should be borne in mind because the controlling factor in any one town must inevitably be the rate of wages paid in that town. It will be clearly seen by referring to the tabulated statement that the rate of wages paid per hour in different parts of the country for practically the same class of work varies between fairly wide limits.

Some few years since it was urged that the labour cost for destruction would be very much higher if the power was fully utilized than was the case where the refuse was merely destroyed without any attempt being made to utilize the heat.

As with other more or less plausible theories advanced at the same time, so with this: experience has clearly shown the exact contrary to be the case, and if careful averages be taken it will be seen that even in the *gross* labour cost, the modern Destructor combined with a power plant is no more costly for the labour involved in actual destruction than is the case with the Destructor pure and simple.

Then if the value of the power produced be taken into consideration, the theorist must at once admit that his calculation was very wide of the mark, the *net* labour cost for destruction being so low that even the most rabid partisan must allow that it is wanton waste to discharge high temperature gases into a chimney without any attempt at utilization.

With the great developments in the mechanical handling of material of every kind, there has been a constant demand for some mechanical means of handling refuse. Although great stress is at times laid upon the sanitary advantages accruing from mechanical handling of refuse, the underlying motive has unquestionably been a desire for reducing the labour cost.

Generally speaking, up to the present time mechanical apparatus for handling refuse has but a poor record, not being altogether successful from the sanitary standpoint, and certainly showing no advantage in reduced labour cost.

To briefly deal with the sanitary aspect first, average refuse is of such composition that it is impossible to feed every portion into a cell. Old galvanized baths and pails are frequently met with, also large earthenware utensils and large tins. It is essential that these should be picked out, being not only useless for power production, but tending to choke the fire. Such articles are more easily handled when cold than after being in the cell, therefore a certain amount of handling is necessary.

To this extent mechanical handling is not final and, as is explained in another chapter, expeditious mechanical or direct charging involves greater labour below on the clinkering floor than is the case with ordinary systems of charging.

If the actual charging process represented the *whole* of the work involved, if picking over the material were entirely avoided, if the one operation of charging the *whole* of the refuse in at the top or back of the cell, as the case may be, were practicable and final, then the process would be perfect from a sanitary point of view and undoubtedly very low in labour cost.

However, this is not so, and in addition to the sorting process, the mechanical handling of such material in transporters or conveyors—the tipping from one receptacle to another—means a dust-charged atmosphere, quantities of dust being liberated, and contributing in no small degree to the discomfort of the staff.

Mr. John Brodie, A.M.I.C.E., the eminent City Engineer of Liverpool, in a paper read at the Liverpool Congress of the Sanitary Institute on September 25, 1894, made the following observations concerning the handling of refuse by conveyors, etc.

Experience with this class of material shows that, owing to its varying nature as received from the carts, difficulties arise when attempts are made to deal with it by means of tapered hoppers, and that it is usually quite unsuited for conveyance on mechanically moved bands or conveyors, unless the larger and more stringy materials are first removed.

The extraordinary high labour cost in connection with such systems is an all-sufficient answer to those who insist that labour is reduced. Some of the figures here quoted are alarming and almost incredible, but in every instance they have been taken from official returns and may therefore be accepted as authentic.

It is true that nine years have elapsed since Mr. Brodie clearly expressed the very limited utility of mechanical apparatus for handling refuse, but refuse is quite as extraordinary in composition now as it was then, even if not more so. That curious medley which goes to make up average civic waste defies satisfactory handling by means of any apparatus devised for handling an unvarying material; a roll of linoleum may be followed by some loose straw and some garbage or garden waste by a disused bath or mattress, refuse being anything but homogeneous in character.

The economy in labour which results from the employment of conveying apparatus for homogeneous material is largely due to the automatic character of the installation, and because the minimum of labour and attention is required. With refuse it is impossible to rely upon automatic charging or discharging, and thus to a large extent the utility of the conveyor is not realized.

It is idle to disguise the fact that unless an installation of this kind in connection with a Refuse Destructor fulfils its object, which is primarily an economic one, it is an unwarranted waste of public money. Mechanical handling of refuse will doubtless always appeal to the lay mind, but this will not do; unless the economic desideratum be realized the system cannot be deemed satisfactory.

It has been suggested that the class of labour employed in connection with Destructors is the very lowest—the dregs of the labour market, and further that it is a difficult matter to obtain the necessary men. It would be idle to pretend that every stoker and charger is a man of refinement, but as a class they are respectable and will favourably compare with those engaged in other more pleasant occupations and earning a similar wage. To suggest that the men engaged in disposing of civic waste are the dregs of the labour market is absolutely untrue, and it is a libel on a body of men whose toil is arduous and whose wage is well earned.

Although the work is not of a pleasant character yet there is no scarcity of labour, nor is there any sign that such will be the case. It is true that wages have an upward tendency, but is not this also the case all round ? With an advancing wage a greater quantity of refuse is dealt with per man, and so the labour cost does not increase in the same ratio.

The late Charles Kingsley once said that those who have to do with the disposal of the waste of a community should be the best paid members of the community. While perhaps but few would be inclined to agree with the great poet and novelist, yet it will be generally conceded that such an occupation deserves at least a good living wage.

Generally speaking the working hours are reasonable and a living wage is paid.[1] According to the tabular statement prepared by the late Mr. John McTaggart of Bradford early in 1901, the averages of 27 destructor installations work out as follows—

Number of Hours worked weekly—	
Stokers	56·28 hours.
Chargers	57·00 ,,
Mortar Mill Men	54·34 ,,
Yard Men and Labourers	54·82 ,,
Rate of Wages per hour—	
Stokers	6·12*d.*
Chargers	5·18*d.*
Mortar Mill Men	5·51*d.*
Yard Men and Labourers	5·11*d.*

Eight hour shifts are becoming increasingly popular, and it may be reasonably urged that an eight hour day for the class of work in question is sufficiently long. In a few towns, however, 12 hour shifts are worked. Darwen is a case in point, but here this question was decided by the men themselves, with the result that they earn 39*s.* each for a week of 72 hours—six 12 hour shifts, day and night shifts being taken in alternate weeks.

[1] See *The Surveyor and Municipal and County Engineer*, April 26, 1901.

On the whole it may be said that in spite of the admittedly unpleasant nature of the work and the fact that there are systems in use ranging from simple hand or shovel feeding to an elaborate and complex system of mechanical handling, there is no labour problem to be faced.

Notwithstanding the fact that a wide difference exists between the old type of Destructor, pure and simple, and its modern and perfected prototype combined with an Electricity Station, Sewage Works or Water Works, yet year after year the work proceeds smoothly and labour troubles are practically unknown.

It has been suggested that instead of paying a fixed rate per hour or per shift to stokers, that they be paid so much per ton of refuse passed through the cells. In one or two towns this system has been introduced, and on the whole it appears to work satisfactorily, but as a general rule such systems cannot be recommended.

Unless the supervision is of the very best there is a constant danger of the primary object of the Destructor being thwarted, the men are naturally anxious to earn as much as possible in a shift, and " rushing " the fires may be resorted to, with the result that the clinker is not only too soft for utilization but is also very offensive.

While this system of payment may have the effect of inducing smarter work in charging and clinkering, and so may conduce to steadier steaming, if the primary purpose of the Destructor be not fulfilled it is not worth consideration. The payment of a fixed rate per hour obviously does not call for the maximum of effort, but it does conduce to a regular cycle of operations, which is of the very highest importance.

Needless to add, clockwork regularity is an essential; and should be insisted upon. Adequate control of labour and careful management is of the highest importance. In one town a bonus is given to the men for every ton destroyed in excess of a given quantity, and although in this particular case the result has been entirely satisfactory, yet on the whole it is a system which cannot be recommended for general adoption.

The great danger under such a system is precisely the same as that already indicated when the weight of refuse dealt with forms the basis of remuneration. A given weight of average refuse demands a certain period for proper treatment *within the cell*, and nothing should be allowed to influence "rushing" tactics. Each man should handle a given weight of refuse per shift and no more, and no incentive should be offered to stimulate an energy which may defeat the primary purpose of the Destructor.

Although, as already observed, labour cost is but *one* factor among many, yet it is of interest to review actual costs now obtaining. The various figures here quoted while being of great interest are of necessity somewhat at variance inasmuch as, although in every case they apply to bare labour cost only, yet the conditions obtaining are in some instances antagonistic to low labour cost, while in other cases the conditions are eminently favourable thereto.

The analyses quoted are, however, of general interest, and they will serve to explode some few fallacies. Further, such figures not being those quoted by Destructor makers will have the effect of clearly placing before the student of the subject reliable data.

This statement is not intended to cast any reflection upon the figures quoted by Destructor makers, but it should be borne in mind that such figures as a general rule refer to tests only, and not to extended periods of working under normal conditions.

Generally speaking tests are conducted under more or less artificial conditions, and therefore a labour cost demonstrated during a short test may be very misleading; it is for this reason that in the compilation of the labour costs here quoted test figures, (unless confirmed by actual working experience) have been omitted.

Taking Destructor installations and grouping the same as follows, we get the undermentioned averages—

(*a*) Top Fed Systems. (6 Makes.)

The average of 85 installations gives a labour cost of 13·54 pence per ton.

(*b*) Direct or mechanical charging systems. (4 Makes.)

The average of 9 installations gives a labour cost of 14·83 pence per ton.

(*c*) Shovel or Hand Fed type. (2 Makes.)

The average of 25 installations gives a labour cost of 1*s*. per ton; 17 installations, *Front* Shovel or Hand Fed type, give an average labour cost of 10·88 pence per ton; and 8 installations of the *Back* Shovel or Hand Fed type give an average labour cost of 14⅜ pence per ton.

(*d*) London and District. (6 Makes.)

The average of 12 installations gives a labour cost of 16·01 pence per ton.

(*e*) Installations with which the power is fully utilized.

The average labour cost at 44 such works is 13·07 pence per ton.

(*f*) Installations of old types and others where the power is not fully utilized.

The average labour cost at 68 such works is 13·10 pence per ton.

It is but fair to state that in a few instances the labour cost is abnormal, owing to the quantity of refuse to be destroyed being in excess of the weight which could be dealt with in one shift, but still insufficient to keep the staff fully employed for two shifts.

At Padiham, where the labour cost is given as 2*s*. 10*d*. per ton, this is the case; as also at Aldershot, where the whole of the refuse is destroyed in one and a-half shifts = 18 hours daily, but wages have to be paid for the two shifts (24 hours). The labour cost at Aldershot being 1*s*. 1*d*. per ton, it will be clear that the labour cost is 25 per cent. more than it should be.

To put the case another way, if sufficient refuse were available at Aldershot, 25 per cent. extra weight could be burned for the same wages cost daily, and this would have the effect of reducing the labour cost to 9·75*d*. per ton.

The following table of labour cost has been compiled with every possible care, and may be said to represent present practice—

ENGLAND AND WALES

	s.	*d.*
Accrington	1	5
Aldershot	1	1
Ashton-under-Lyne	0	11·66
Aston Manor	0	11
,, ,, (2 Makes)	0	11
Bangor	1	4
Barry	1	3·50

	s.	d.
Bath	1	3
Batley	1	6
Beckenham	1	9
Birkenhead	0	10·21
,, (2 Makes)	0	10·21
Birmingham	0	9·82
Blackburn	0	10
,, (3 Makes)	0	11
,,	0	10·50
Blackpool	1	6·50
Bolton	0	10
Bournemouth	0	9
Bradford	0	9
Brighton	1	7
Bristol	0	11·50
Burslem	1	5
Burton-on-Trent	1	4
,, ,, (2 Makes)	1	4
Bury	0	10·8
Buxton	0	11
Cambridge	1	3
Canterbury	1	0·986
Cheltenham	0	7·6
Chesterfield	0	7·6
Colne	0	10·50
Darwen	1	0
Dewsbury	1	1·75
Gloucester	0	10
Grays	0	10
Handsworth	0	10·75
Hartlepool	0	11
Hastings	1	6·75
Heckmondwike	1	0
Hereford	0	9
Huddersfield	0	10·50
Hull	1	3
Hunstanton	1	0
Hyde	1	2
Lancaster	1	4
Leeds	0	10·25
,, (2 Makes)	0	10·25
Leicester	0	8·25
Leyton	1	7
Liverpool	0	8·25
Llandudno	1	3·25
Longton	0	11
,, (2 Makes)	0	11

	s.	d.
Loughborough	1	2
Lowestoft	0	11·50
Lytham	0	8
Mexborough	0	11
Morecambe	1	0·12
Moss Side	0	8
Nelson	1	0
Newcastle	0	8·16
,, (2 Makes)	0	8·16
Newmarket	0	11
Oldham	0	9·75
Padiham	2	10
Preston	1	0·12
Radcliffe	0	10
Rochdale	0	7·50
Rhondda	2	7
Rhyl	1	4
Rotherham	1	0·50
Royton	0	9·50
St. Annes	1	4·1
St. Helens	1	2
Salisbury	1	3
Sheerness	1	0
Sheffield	0	11·50
Shipley	0	10·50
Southampton	1	2·50
Southport	1	2
Stafford	1	4
Stockton-on-Tees	0	9
Stretford	1	4
Torquay	0	9·50
Wallasey	0	11
Walker-on-Tyne	0	6·75
Warrington	1	1·75
West Hartlepool	0	10·50
Wimbledon	1	8
Winchester	0	10
,, (2 Makes)	0	10
Withington	0	8

SCOTLAND AND IRELAND

Edinburgh	2	5·50
Gourock	0	10
Govan	1	0
Paisley	0	9·50
Partick	1	7·1

	s.	d.
Belfast	0	9
Dublin	0	9·9
Dublin	0	11·75
Pembroke	0	11·75

METROPOLITAN BOROUGHS (LONDON)

Battersea	2	0
Bermondsey	1	0
Rotherhithe	1	0
Finsbury	0	8·6
Fulham	1	6·88
Hackney	1	7·1
Poplar	1	10·50
St. Pancras	1	1·75
Shoreditch	2	3·3
Stepney	1	4·9
Wandsworth	0	7·50
Westminster	0	11·5

With labour costs varying from 6¾*d.* to 2*s.* 10*d.* per ton, it will be obvious that in order to determine the comparative value of the two systems one must carefully investigate all the circumstances of each case. At the same time it is clear that the difference of 2*s.* 2¼*d.* per ton cannot be wholly accounted for by reason of enforced idleness consequent upon the shortage of refuse.

The averages already quoted will serve to clearly demonstrate that there is a wide difference between the labour cost with various systems, and perhaps nothing is more startling than the high labour cost with systems of top feeding and mechanical charging. Close students of the subject have long been aware that top feeding and mechanical charging are not the most economical systems in vogue. The figures here quoted should convince even the most sceptical.

Chapter VII

CLINKERING

THE clinkering of a furnace, or the removal of the residuum after destroying a charge, is perhaps the most laborious work in connection with the operation of the Refuse Destructor, therefore any practical means of rendering this work less arduous would be welcome, as tending to at once reduce the labour cost and make the work as a whole more pleasant.

So far as the actual removal of the clinker from the cell is concerned, this is essentially work which can only be satisfactorily performed by manual labour. If a charge of refuse is thoroughly burned through and reduced to a satisfactory vitreous clinker, some considerable effort is demanded in order to break up the mass into slabs of such size as may readily be manipulated and drawn through the clinkering doors.

With the best of modern Destructors the clinker is withdrawn in large slabs, either direct into a barrow or into travelling skips or buckets slung from an overhead rail, and in most cases it is then freely slaked with water before being taken to the clinker heap. This is done firstly for the comfort of the men, and secondly to so cool the clinker that flaming may be avoided when the material is tipped on to the heap.

In some few cases shoots and conveyors have been provided for the automatic removal of the clinker, but such an arrangement although very desirable is not practicable. In order to thus remove clinker from a modern high temperature cell, it would be necessary to first break the material up into comparatively small pieces. This would not only materially add to the already arduous labour, but it would have to be done in the cell, occupying some considerable time, retarding the work as a whole, and involving a very serious cooling down of the cell.

The clinkering process in the case of the single or isolated cell system especially demands smartness. It is essential that the clinker should be removed with all possible speed, and although various innovations have been tried, nothing has yet been devised which can compete with a live man. The simple method already described, and which is extensively employed, while being admittedly arduous is best suited to the vital requirements for expeditious and satisfactory working.

Counterbalanced clinkering doors easily lifting upwards vertically are the most satisfactory, and are appreciated by the men, rather than balanced doors swinging outwards. These doors do not fit so tightly as the former, and when raised for access to the fire the radiant heat from the door baffles is a source of great discomfort to the men. Again, the vertically lifting door not only projects its heat on the inner side away from the man, but it is also so arranged that it acts as a shield, and need only be lifted to a sufficient height for easy manipulation of the clinker.

The balanced doors opening outwards at an angle must be practically fully opened to give reasonable access to the cell, and the man is accordingly not only exposed to the heat proceeding from the cell but also to that projected from the inner side of the door.

Reasonable attention to such details as these all tend toward minimizing discomfort, and it will be obvious that not only does the work proceed more expeditiously when the men are thus considered, but it is also more satisfactorily performed under the more comfortable conditions.

While successful mechanical means have been devised for both charging and drawing retorts in gas works, it must not be forgotten that in the drawing of the retorts the material to be removed is practically homogeneous in character, it has not to be broken up from the vitreous mass, as is the case with the Destructor.

While the actual removal of clinker from the building does not offer any considerable scope for labour saving, as already pointed out, the preliminary withdrawal of clinker from the cell as now performed by manual labour is capable of improvement.

Among the various methods which have been tried and abandoned is the tipping grate, which wa sdesigned with a view to tipping the clinker direct into a trolley placed in the ashpit immediately under the grate.

The difficulty which was experienced with this arrangement was entirely owing to the formation of the clinker in a vitreous mass over the whole grate area, and it was accordingly found necessary to break up the mass before it could be tipped into the trolley beneath.

This breaking up of the clinker to such sizes as would readily pass through the available opening involved considerable labour, and it was found as the result of practical experiments that, as less breakage was required to withdraw the clinker from a fixed grate into a barrow, the process was not only more expeditious, but not so laborious.

It is almost safe to say that the present system of withdrawing clinker is not likely to be improved upon; it is an operation which demands careful attention, and such attention as can doubtless be best given by an experienced man.

When the mass of clinker is broken up it should be turned over so that the small loose material on top may be left on the grate to readily ignite the succeeding fresh charge. Further, reasonable care must be exercised in the handling of the clinker tools or the brickwork may suffer damage.

The necessity for breaking up the mass of clinker within the cell presents the real difficulty which operates against the saving of labour. Every scheme devised for minimizing labour cost at the clinkering stage has failed, and largely because of this initial difficulty.

It will thus be clear that apparatus designed for the easy removal of clinker when it is outside of the cell simply means an increase of labour before the material leaves the cell, and thus at once any possible economy is seriously discounted.

Up to the present time there is every indication that the system of removal now in vogue is not likely to be improved upon, although it must be admitted that an improvement would be welcome.

Chapter VIII

THE RESIDUUM AND METHODS OF DISPOSAL

COINCIDENT with the development of the Refuse Destructor, remarkable strides have been made in the utilization of the residuum, familiarly known as clinker.

It has been suggested that the difficulties involved in the disposal of clinker are frequently of such a character as to limit the adoption of Destructors. It may, however, be doubted whether those responsible for such statements are really familiar with the character of good clinker, as also with the variety of purposes for which the same is now used.

Clinker varies very considerably ; the quality of the clinker is governed by several factors, which we will briefly review.

Firstly.—High temperature working is essential ; unless the cell temperature be high and well maintained, it is impossible to produce a good clinker. With the old system of low temperature working a good vitreous clinker was unknown ; generally speaking the clinker was soft, worthless, and even at times objectionable. Residuum of this character has been to no small extent responsible for the slow progress hitherto made in the utilization of clinker.

Secondly.—The material within the cell must be exposed to a high temperature for a sufficient length of time ; this period of time is an important factor. All organic matter should be destroyed, and analysis should show not only a freedom from organic matter, but likewise no combustible. Such clinker should be well fused and vitreous ; its value will not then be disputed.

Thirdly.—The method or system of charging the refuse into the cells and the thickness of the material upon the grates exercises a considerable influence upon the quality of the clinker. Top charging usually means a very much thicker fire than shovel feeding, and in the case of the former, unless the refuse is very carefully levelled and spread over the grate, a thoroughly well burned clinker is not secured.

Generally speaking the very best clinker is obtained from shovel fed Destructors of the front and back fed types, and this may be largely attributed to the very moderate thickness of the fires and the fact that the whole manipulation of the fires is under more direct control. An uneven fire of such thickness as is frequently found with top fed Destructors does not favour the production of the best quality clinker.

With top fed Destructors, especially of the older types, it is common to find refuse on the grates to a thickness of three feet, and very unevenly spread. The stoker cannot possibly look over the top of the mass, and accordingly he is unable to control the condition of the fires, a bare or thinly covered portion of the grate at the back cannot be seen; and, therefore, well covered grates are more the result of accident than judgment.

With fires of such thickness, there is a constant liability of producing inferior clinker. After the clinker is removed, if the mass is broken it will at times be found that although well fused both above and beneath, the inside of the mass is more or less soft and sometimes very offensive.

It should not be forgotten that not only is a poor clinker a source of loss in so far as it it worthless and unsaleable, but it is at the same time very conclusive evidence that the cremation as a process is unsatisfactory, this being due either to the inefficiency of the Destructor, or lack of supervision, or may be a combination of both.

In some few cases, not only are communities saddled with a loss due to the unsaleable condition of the clinker, but in addition to this it is not uncommon to find sums varying from 4*d.* to 2*s.* 6*d.* per ton being paid for removal of the clinker. It has been suggested in some such cases that peculiar local circumstances do not favour the sale of clinker, or that no scope exists for its utilization. As a general rule the real explanation is that the clinker is too soft to be serviceable; it is utterly useless and is recognized as such. Those who would purchase a good vitreous clinker decline even to accept a soft clinker free of charge, and they do wisely.

The writer is acquainted with many such cases, but I am not aware of a single case where any difficulty whatever is experienced in disposing of a good vitreous clinker, and many cases might be cited where a vitreous clinker commands a ready sale at a very remunerative figure, even as high as 2*s*. 6*d*. per ton at the Destructor works.

Generally speaking the clinker disposal difficulty only exists under such circumstances as one might reasonably expect to find productive of such difficulty. It is just as reasonable to expect to find a market for soft clinker as to expect to destroy refuse without the agency of heat.

In issuing specifications for Refuse Destructors within the past two years there has been a tendency to ask contractors to guarantee a fixed percentage of clinker or residue. While it is doubtless desirable that the percentage of clinker to come should be known, it is manifestly quite impossible for any contractor to know exactly what percentage of residuum will be obtained from refuse which may possibly be destroyed a year or even two years after such a guarantee is given.

If the period intervening between the date of the contract and the test was only one week, the situation would still be equally absurd. No two loads of refuse on any one day may be exactly the same in composition, and it should not be forgotten that the percentage of residuum is determined by the composition of the refuse and not by any guarantee. To ask for a guaranteed percentage of clinker is to ask for a guess; neither he who asks for the guarantee, nor he who has to give such a guarantee, can know the composition of the refuse, and without such knowledge a guarantee is but a farce.

It is true that the average throughout the country affords a guide; 30 per cent. is perhaps a fair average, but it is quite possible to get as much as 37 per cent., and this with a clinker free from organic matter and thoroughly fused.

The only reasonable guarantee to ask for is one to the effect that the clinker shall be free from organic matter (which can be proved by analysis), and further that it shall be vitreous. Having secured a guarantee of this character, it is not difficult to find a market for the clinker; its utility is becoming more clearly recognized year by year.

Some analyses of clinker here given are of interest, and are worth comparison.

Nelson Destructor Clinker

Analysis made by Mr. J. Barnes, F.I.C., Borough Analyst of Accrington, December 20, 1900:—

Organic Matter	Nil.
Silica	40·6 per cent.
Lime	11·2 „ „
Alumina	18·5 „ „
Ferric Oxide	22·8 „ „
Magnesia, Manganese and Alkalies	6·9 „ „
	100·00 per cent.

Bradford Destructor Clinker

Analyses of two samples made by Mr. F. W. Richardson, F.I.C., F.C.S., City Analyst of Bradford, March 9, 1900:—

	1. Fine.	2. Medium.
Organic and Volatile Matter	4·12	1·80 per cent.
Siliceous Matter	61·08	67·10 „ „
Iron and Alumina Oxides	21·50	19·30 „ „
Carbonate of Lime	7·80	6·00 „ „
Magnesia	Traces	Traces
Moisture	5·50	5·80 „ „

Torquay Destructor Clinker and Flue Dust

Analyses by Dr. Bernard Dyer, of London, July, 1899 :—

	Ground Clinker.	Flue Dust.	
Moisture, Organic Matter and Water of Combination	1·00	6·52	per cent.
*Phosphoric Acid	1·06	0·96	,, ,,
Lime	10·47	8·40	,, ,,
Oxide of Iron and Alumina	33·54	33·34	,, ,,
Carbonic Acid	4·41	10·38	,, ,,
Siliceous Matter	49·52	40·40	,, ,,
	100·00	100·00	

Nitrogen	Practically None.		
*Equal to Ammonia	—	0·21	per cent.
Equal to Tribasic Phosphate of Lime	2·31	2·09	,, ,,

It is possible that in a few isolated cases, where the circumstances are abnormal, it would not be possible to utilize or sell the clinker, even if it were of the best quality. Under such conditions the clinker might be tipped on to the land or at sea. In either case it would be a harmless proceeding, and very different to tipping refuse. If dumped at sea such material would sink and not come in with the tide and defile beaches, as is so frequently the case with refuse.

If tipped on the land it would occupy considerably less space than its original bulk of refuse ; it would be quite innocuous, inoffensive and harmless, and with all due respect to many worthy councillors it may be observed that they would display greater wisdom if they advocated the filling of disused gravel pits, hollows and excavated land with clinker rather than with refuse.

Bacteria Beds

The utilization of clinker in the formation of bacteria beds for the filtration of sewage offers a scope of the highest utility, and one that is ever increasing. Perhaps nothing is more interesting in modern sanitary science than the utilization of the harmless residuum from one class of civic waste for the purification of the other class of civic waste—the sewage.

With this a high utilitarian standard is reached, and in this connection it is interesting to remember that in many cases where clinker is so utilized, the refuse of which it is the residue has provided power for the operation of the works. The value of clinker for bacteria beds is now generally conceded; a good vitreous clinker crushed and screened to the sizes required for both the coarse and fine beds furnishes at once not only the most satisfactory medium yet discovered, but likewise the most durable medium.

Coke and coke breeze which have been employed in the past have to be purchased; both are costly and at times disintegrate very rapidly. Clinker on the other hand is of such a nature that, while possessing sufficient porosity to allow free passage of the liquid, it yet deteriorates very slowly indeed.

With one or two exceptions, wherever clinker has been used for bacteria beds it has given every satisfaction, the only failures having been where poor clinker was used; the experience, while being an unfortunate one, emphasizes the need for a vitreous clinker.

Enormous quantities of screened crushed clinker and even rough clinker are now taken by contractors, and in many cases very remunerative prices are being obtained. At Tooting Destructor (Metropolitan Borough of Wandsworth) rough clinker straight from the cells is used freely, at 1*s*. 9*d*. per cubic yard, on the works. At Dalmarnock, Glasgow, the whole of the clinker is crushed and screened, being eagerly purchased at the works by contractors at 2*s*. 6*d*. per ton.

These are but two examples; many others might be cited. All the statistics available go to clearly show that enormous quantities of clinker are sold, and apparently the disposal of a really satisfactory clinker presents no difficulty whatever.

Mortar Making

It is not many years ago since the idea of utilizing Destructor clinker for mortar making was ridiculed ; indeed it was regarded as an experiment and nothing more. What do we find now ? Over one hundred mortar mills in operation every day at Destructor works alone. Mortar sells freely and in every case yields a profit ; in fact at many works one is told that they wish it were possible to make twice as much mortar.

As with mortar making, so with other methods of clinker utilization. To look closely into the matter is to be convinced that the utilization of clinker is but yet in its infancy. It is impossible to forecast the future developments in clinker utilization.

Failure has been freely predicted with every new feature of utilization up to the present; as with concrete and mortar, so with paving flags and bricks, but progress is nevertheless recorded, and steadily but surely silences all criticism.

Paving Flags.—It is true that some few municipal engineers are still doubtful as to the value and wearing properties of clinker flags. In a few cases this may be attributed to an unfortunate experience with soft clinker. Those who are familiar with a really good vitreous clinker have no doubt as to its value for the purpose in question.

Others hesitate because clinker flags have not yet been employed under varying conditions for a sufficiently long period to satisfy them as to the wearing properties. But nevertheless remarkable progress is being made and, so far as one is able to judge, this means of utilization is likely to find much favour.

Flag plants are now in use at Liverpool, Bootle, Birmingham, Leicester, Sheffield, Bristol, Bradford, Cheltenham, Blackburn, Withington, Oldham, Ealing, Walthamstow, Woolwich and Fulham.

In Liverpool, even as long since as 1898, paving flags were being made at a cost of 1*s.* 7*d.* per square yard, including all costs and charges, and it is reported that the flags wear exceedingly well, and have an excellent appearance.

Fig. 31 illustrates a three mould hydraulic flag press, made by Messrs. Fielding and Platt, Limited, and embodying several ingenious features, not the least of which is the Patent

Vacuum Lift for transferring the finished flag from the press to the carrying board, avoiding the necessity of handling, and thus leaving the edges of the flag perfectly square.

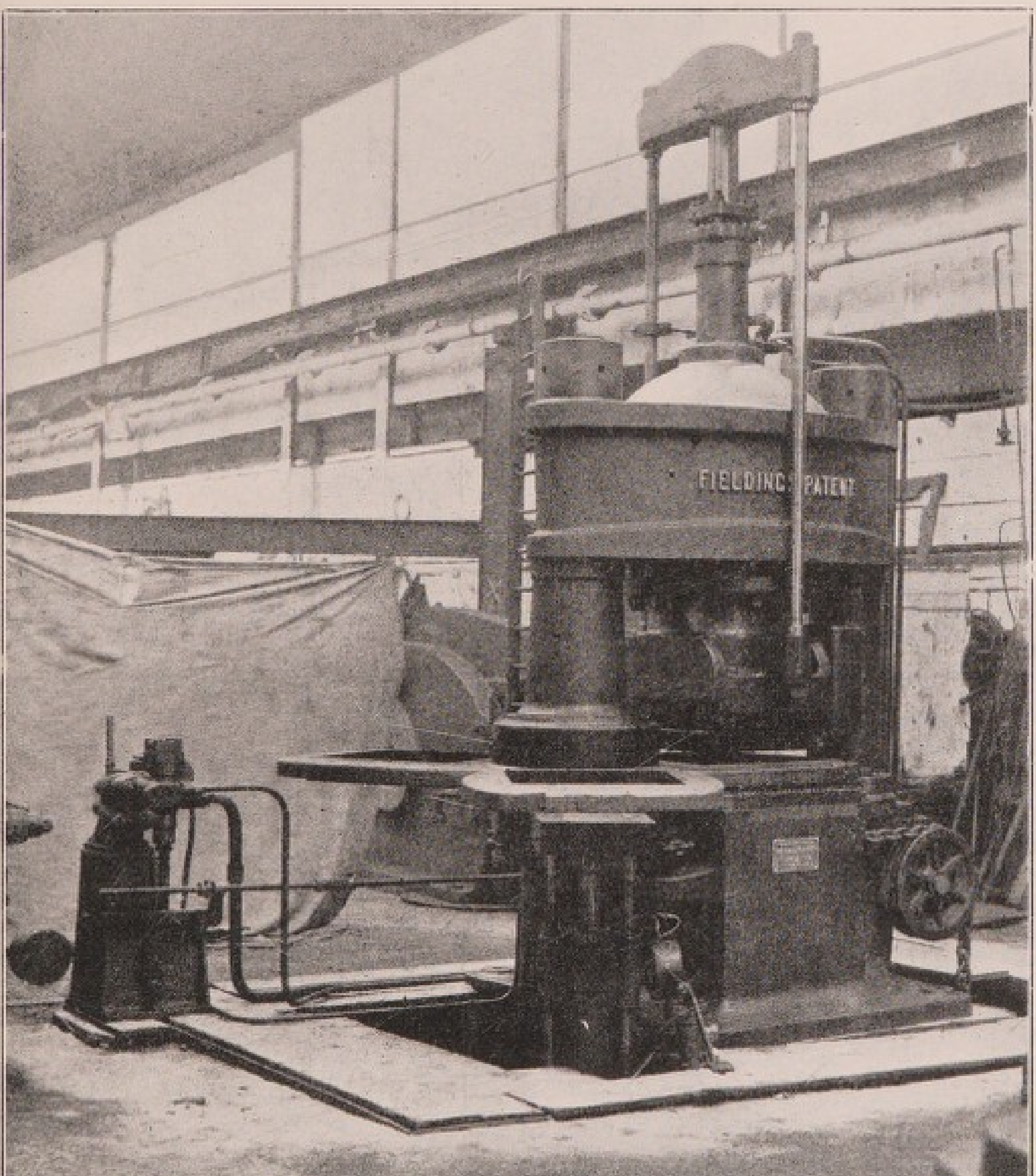


FIG. 31. FIELDING & PLATT'S THREE MOULD HYDRAULIC FLAG PRESS.

In connection with the manufacture of clinker paving flags, the question has frequently arisen as to the period of time which should be allowed for induration, between the time of manufacture and laying of the flags.

The following series of tests were made by Mr. W. G. Kirkaldy, of Messrs. D. Kirkaldy and Son, for Mr. E. J. Lovegrove, engineer and surveyor of the Hornsey Urban District Council, with a view to ascertaining the gradual increase of strength :—

Results of Experiments to Ascertain the Resistance to Bending Stress of Thirty-two Concrete Paving Slabs.

Load Applied across Centre.

Test Number.	Description.	Span.	Dimensions: Breadth, Depth.	Ultimate Stress.		Equivalent upon Slab. B. D. 24·00 × 2·00		Appearance of Fracture.
		in.	inches.	lb.		lb.		
II.	Concrete Paving Slab—All 30 in. × 24 in. × 2¼ in. thick.							
1,743	Marked May 28, 1900. Age when tested—Two weeks.	24·0	24·06 × 2·36	1,505	1,444	1,075	1,032	Sound, uniform.
1,742		24·0	24·06 × 2·39	1,481		1,037		,, ,,
1,740		24·0	24·06 × 2·35	1,400		1,008		,, ,,
1,741		24·0	24·06 × 2·34	1,390		1,008		,, ,,
1,747	Marked, May 21, 1900. Age when tested—Three weeks.	24·0	24·06 × 2·36	1,626	1,551	1,162	1,094	Sound, uniform.
1,745		24·0	24·06 × 2·34	1,509		1,104		,, ,,
1,744		24·0	24·06 × 2·38	1,514		1,066		,, ,,
1,746		24·0	24·06 × 2·44	1,555		1,046		,, ,,
1,750	Age when tested—Four weeks.	24·0	24·08 × 2·40	2,025	1,665	1,402	1,166	Sound, uniform.
1,749		24·0	24·06 × 2·35	1,548		1,114		Slight defects.
1,748		24·0	24·08 × 2·41	1,567		1,075		,, ,,
1,751		24·0	24·05 × 2·38	1,520		1,075		,, ,,
1,752	Age when tested—Two months.	24·0	24·06 × 2·47	2,586	2,264	1,690	1,543	Sound, uniform.
1,754		24·0	24·07 × 2·38	2,305		1,622		,, ,,
1,753		24·0	24·02 × 2·42	2,094		1,430		Slight defects.
1,755		24·0	24·06 × 2·40	2,070		1,430		,, ,,
1,756	Age when tested —Three months.	24·0	24·06 × 2·41	2,223	1,995	1,526	1,367	Sound, uniform.
1,757		24·0	24·06 × 2·40	2,162		1,497		,, ,,
1,758		24·0	24·06 × 2·41	1,795		1,228		Slight defects.
1,759		24·0	24·06 × 2·43	1,801		1,219		,, ,,
1,761	Age when tested—Four months.	24·0	24·06 × 2·45	2,780	2,495	1,843	1,730	Sound, uniform.
1,762		24·0	24·06 × 2·38	2,540		1,786		,, ,,
1,763		24·0	24·06 × 2·37	2,461		1,747		,, ,,
1,760		24·0	24·06 × 2·38	2,200		1,546		Slight defects.
1,764	Age when tested—Five months.	24·0	24·06 × 2·38	3,365	2,849	2,371	1,968	Sound, uniform.
1,765		24·0	24·06 × 2·42	3,153		2,150		,, ,,
1,767		24·0	24·06 × 2·42	3,010		2,054		,, ,,
1,766		24·0	24·06 × 2·40	1,870		1,296		Irregular.
1,769	Age when tested—Six months.	24·0	24·07 × 2·34	2,743	2,339	1,997	1,682	Slight defects.
1,768		24·0	24·07 × 2·38	2,433		1,709		,, ,,
1,770		24·0	24·07 × 2·36	2,126		1,526		,, ,,
1,771		24·0	24·07 × 2·34	2,055		1,498		,, ,,

The slabs which were used for the above series of tests were manufactured with fine ground Destructor clinker, passing through a $\frac{3}{16}$ inch square mesh sieve, and mixed in the proportions of two of ground clinker to one of Portland cement.

The whole of the slabs submitted for testing were made from the same grinding and consignment of cement, the cement being laid out for cooling before use, and passing the standard test of 420 pounds per square inch after immersion in water for seven days.

Excellent results have been obtained in Birmingham, where paving flags have been made since October, 1897. During the year 1899, 8,860 square yards were produced; in 1900, 12,106 square yards, and in 1901, 9,852 square yards. The flags, which are chiefly used for footpaths are 2½ inches thick and faced with granite, the cost of production being 2*s*. 2*d*. per slab, the selling price ranging from 2*s*. 6*d*. to 3*s*. 3*d*.

The following table is of great interest, serving to clearly show the general superiority of clinker as a binding material. The series of tests here tabulated were conducted by Mr. W. Nisbet Blair, M.I.C.E., the Borough Surveyor of St, Pancras.

TESTS OF BRIQUETTES OF CEMENT WITH PIT SAND, RIVER SAND, AND CRUSHED DESTRUCTOR CLINKER

Breaking Strain in Pounds per Square Inch of Section

Proportions.	One month.	Three months.	One month.	Three months.	One month.	Three months.
1 to 1 . .	355	463	335	517	350	560*
1 ,, 2 . .	275	362	230	312	340	500*
1 ,, 3 . .	197	265	250	272	272	230*
1 ,, 4 . .	130	285	145	340	267	443
1 ,, 5 . .	138	257	143	317	165	375

* In cases thus marked the material was in the form of fine ash.

The interesting diagram (Fig. 32,) clearly illustrates the comparative strength of the material employed, and although it is not contended that the tests are absolutely conclusive, it must be allowed that the clinker briquette comes out exceedingly well, and Mr. Blair's experiments only serve to confirm many others made in various parts of the country.

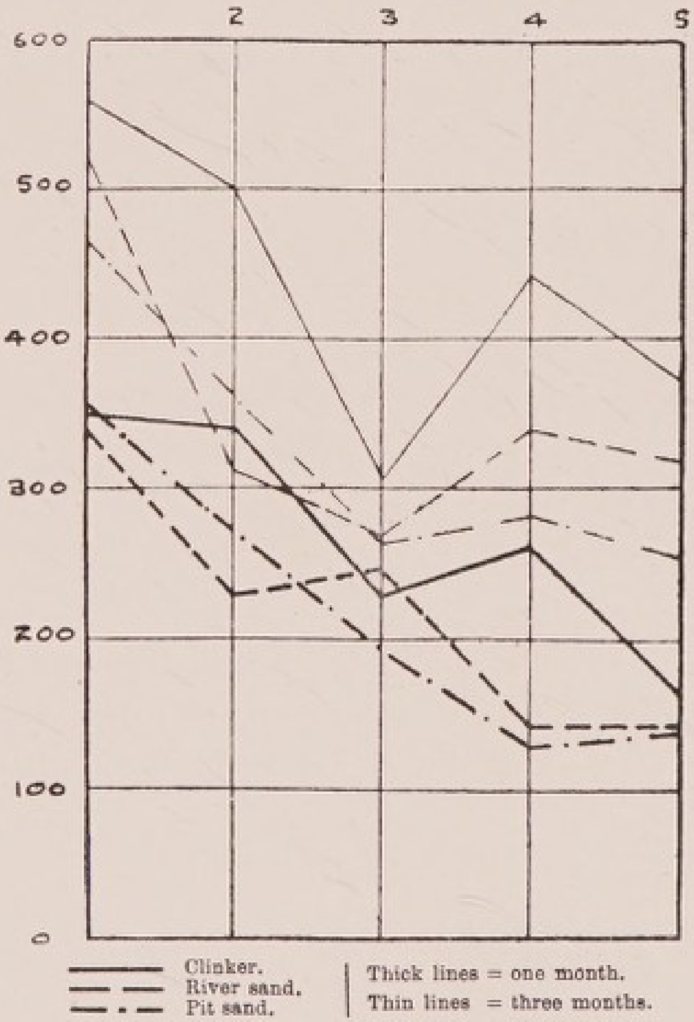


FIG. 32.

BRICK MAKING

Within the past few months two clinker brick making plants have been installed in London, and although up to the present no really valuable data is available owing to the short period which has elapsed since operations were commenced, it is nevertheless certain that this method of clinker utilization has a very remarkable future.

While it is true that very little has yet been done in this country, the clinker brick is not an experiment; for some few years past several brick making plants have been in operation on the Continent, some of which are of British make.

Excellent bricks have been made on the Continent even with a clinker of a less vitreous nature than good Destructor clinker. In London for some time past, quantities of hand made clinker bricks have been manufactured and used, the results being so satisfactory that one large contractor has recently erected two large clinker brick making plants after contracting with two Metropolitan Boroughs to take several thousands of tons of clinker per annum for a number of years.

To the late Mr. John McTaggart, of Bradford, belongs the credit of first directing attention in this country to the possibilities of the clinker brick. Early in 1899, Mr. McTaggart made a series of experiments, and had he lived, it is likely that we should have seen other developments in clinker utilization.

The following table of results of Crushing Tests of Bricks made with Bradford Destructor Clinker are of interest, as also the figures of tests made with bricks manufactured from Fulham clinker:—

BRADFORD TECHNICAL COLLEGE—ENGINEERING DEPARTMENT TESTING LABORATORY

Results of Crushing Tests of Bricks received from John McTaggart, Assoc.M.Inst.M.E., Destructor Department, Bradford

Date.	Description.	Original Dimensions.				Ultimate Crushing Stress.				Remarks.
						First Crack.		Completely Crushed.		
		Length in inches.	Breadth in inches.	Thickness in inches.	Area in sq. ft.	Total Tons.	Tons per sq. ft.	Total Tons.	Tons per sq. ft.	
1899. Oct. 27	Ordinary Pressed Brick.									
	Sample No. 1	9·0	4·4	3·1	·275	36·31	132	50·76	184·6	Age unknown.
	Sample No. 2	8·9	4·25	3·1	·262	—	—	53·16	202·9	„ „
„	Destructor Clinker, and 10 per cent. Portland Cement.									
	Sample No. 1	9·8	4·7	2·4	·32	19·61	61·3	24·84	77·6	Made 10 weeks.
	Sample No. 2	9·8	4·8	2·4	·33	9·86	30·2	24·49	75·1	
„	Destructor Clinker, and 15 per cent. Portland cement.									
	Sample No. 1	9·3	4·6	3·1	·29	22·91	77·1	28·54	96·0	Made 10 weeks.
	Sample No. 2	9·3	4·6	3·0	·29	11·31	37·7	19·01	63·0	
„	Destructor Clinker, and 15 per cent. slaked hydraulic lime.									
	Sample No. 1	9·9	4·7	2·5	·32	27·70	80·5	38·11	119·0	Made 14 weeks.
	Sample No. 2	9·9	4·6	2·6	·31	—	—	25·58	82·5	
„	Destructor linker, and 15 per cent. unslakedChydraulic lime. . .	9·6	4·8	2·8	·32	32·14	100·4	36·22	113·2	Made 14 weeks.
„	Destructor Clinker, and 10 per cent. slaked hydraulic lime . . .	9·9	4·9	2·9	·34	54·14	129·8	75·48	222·0	Made 18 weeks.

All bricks were faced both sides with plaster of Paris and bedded perfectly true in the machine before applying pressure.

G. F. CHARNOCK, Assoc.M.Inst.C.E.

Results of Tests of Bricks made from Fulham Clinker.

Mark A.—Size, 9 in. by $4\frac{1}{2}$ in. by $2\frac{5}{8}$ in.; weight when dry, 6 lb. $10\frac{1}{4}$ oz.; weight after immersion five days, 7 lb. 5 oz.; increase, $10\frac{3}{4}$ oz.; percentage, 10; composition—hardened clinker, 90 per cent., hydraulic lime, 10 per cent.; character, rough face; similar size stock brick, 5 lb. 5 oz.

Mark B.—Size, $9\frac{7}{8}$ in. by $4\frac{3}{4}$ in. by $2\frac{1}{2}$ in.; weight when dry, 8 lb. $12\frac{1}{2}$ oz.; weight after immersion five days, 9 lb. $4\frac{1}{2}$ oz.; increase, 8 oz.; percentage, 6; composition—clinker, 85 per cent., cement, 15 per cent.; character, smooth face; similar size stock brick, 4 lb. 7 oz.

Mark C.—Size, $9\frac{7}{8}$ in. by $4\frac{3}{4}$ in. by $2\frac{1}{2}$ in.; weight when dry, 8lb. $15\frac{1}{4}$ oz.; weight after immersion five days, 9 lb. $9\frac{1}{2}$ oz.; increase, $10\frac{1}{4}$ oz.; percentage, $7\frac{1}{4}$; composition—not hardened clinker, 90 per cent.; lime, 10 per cent.; character, smooth face; similar size stock brick, 6 lb. 8 oz.

Note.—A fair sample of brick should not absorb $\frac{1}{6}$th of its weight—*i.e.* 16·6 per cent. Crushing strain on clinker concrete bricks, age 10 weeks, equals 113·4 tons per square foot, made at Wandsworth; ditto stock, 84·27 tons per square foot; 10,000 yards of flags will take up about 600 tons clinker; 30,000 bricks, 75 tons clinker; and 600 yards of mortar, 300 tons clinker; total, 975 tons. Equals 30 days' supply.

Although no actual figures are yet available, it is estimated that bricks made with a mixture of 90 per cent. of clinker and 10 per cent. of cement, can be produced at a cost of 15*s.* per thousand. If instead of cement, lime be used, the estimated cost is given as 13*s.* 6*d.* per thousand. Bricks of the former composition would be dried naturally, while in the case of the latter it is preferable to employ the steam drying system, generally known as the Autoclave.

The installations in London are being watched with much interest, and they will afford a most useful object lesson. If the clinker brick can be produced as satisfactorily and cheaply as is predicted, it is quite certain that this means of utilization will be largely adopted, at any rate by the more important municipalities.

Clinker Cottages

While the Liverpool authorities have not been at all troubled in the past with any accumulation of clinker, the latest method of utilization suggested by the City Engineer, Mr. John A. Brodie, M.I.C.E., opens up a new outlet, and the experiment is sure to be watched with great interest.

Mr. Brodie's proposal, which has received the sanction of the

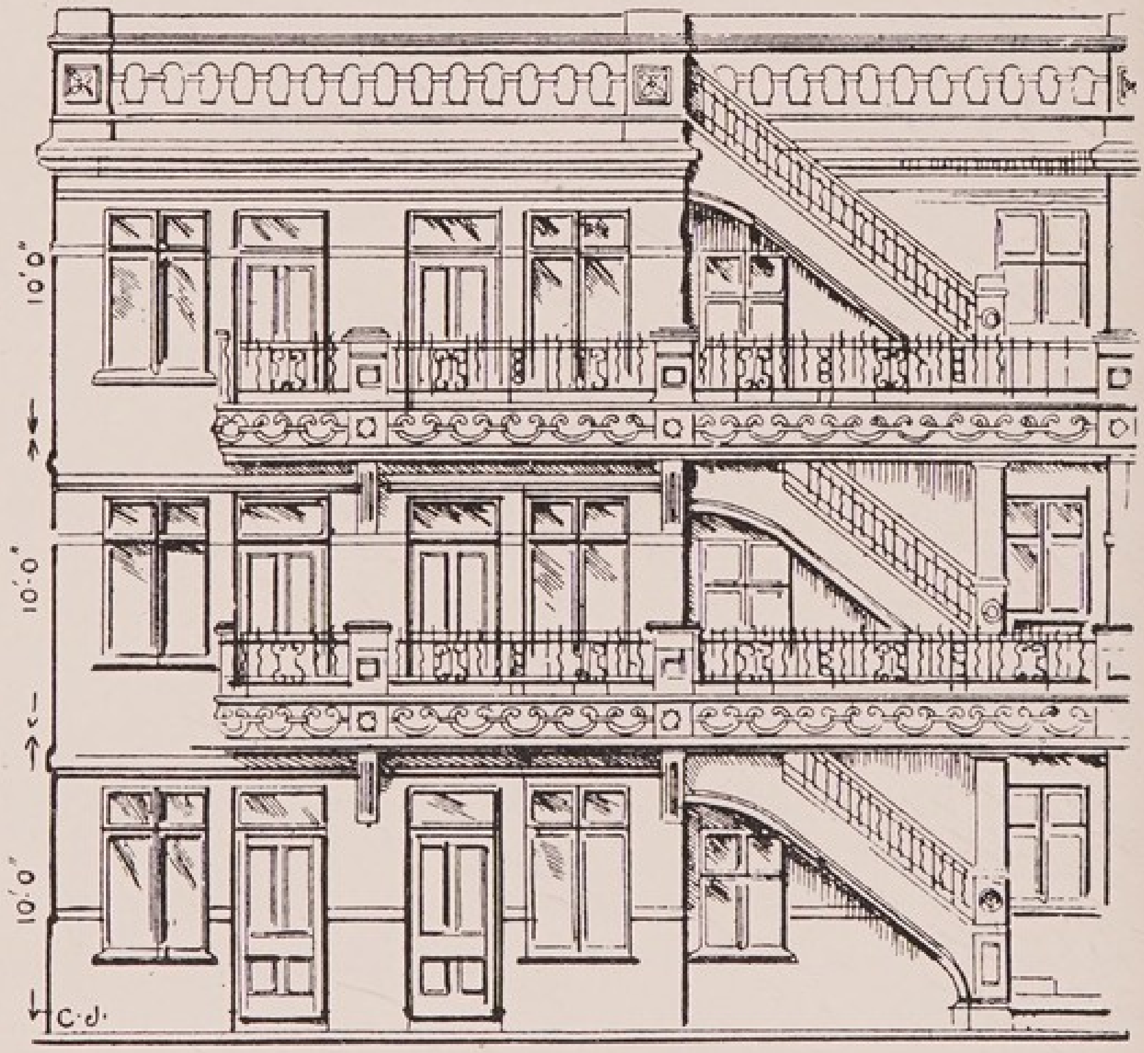


FIG. 33. LIVERPOOL CLINKER COTTAGES.
Elevation.

Housing Committee, is to erect a block of concrete cottages or tenements, the material for construction being crushed clinker from the Destructor and Portland cement, with a small proportion of embedded steel or iron.

The crushed clinker and cement will be mixed in proper proportions at the Destructor works, and filled into moulds to form slabs, each slab representing a complete side, floor or roof of a room.

The openings for doors, windows, fireplaces and flues, will be formed in the slabs, and projections in the nature of dove-tails with their corresponding recesses are provided, so that each of the slabs may be dovetailed to each of the slabs with which it comes into contact when erected, the permanent jointing material being cement mortar.

The balconies, stairs, balustrades, and the chimneys where they rise above the roof, are similarly moulded in blocks. The site of the buildings will be excavated where necessary and the foundations composed of the same materials filled *in situ*, brought up to a level surface at the ground level and allowed to set.

When the various slabs and blocks have matured, they are lifted on to wagons behind a traction engine, and removed to the site of the proposed building. They are then lifted from the wagons by an overhead travelling crane, and deposited in their final position in the building. When the building has been erected, the windows, doors, grates and fittings are set in position and completed as usual.

It is anticipated that the income will be sufficient to pay five per cent. on the capital expenditure ; as many portions of the work are entirely novel, a very reasonable margin has been allowed for contingencies.

The engineer's estimate of the cost of the scheme is as follows :

	£	*s.*	*d.*
Land—			
113 square yards at 12*s.* per square yard . .	247	16	0
Cost of buildings, complete, including drainage and finishing, open spaces, etc . . .	1,230	0	0
	£1,477	16	0
12 tenements (each consisting of three rooms), at 4*s.* per week, making a gross rental per annum of .	124	16	0
Less allowances for outgoings, say 40 per cent. .	49	18	4
	£74	17	8

Fig. 33 is an elevation and Fig. 34 a plan of the clinker cottages at Eldon Street, Liverpool. Mr. Brodie is to be commended for his audacity and foresight in thus being able to provide the

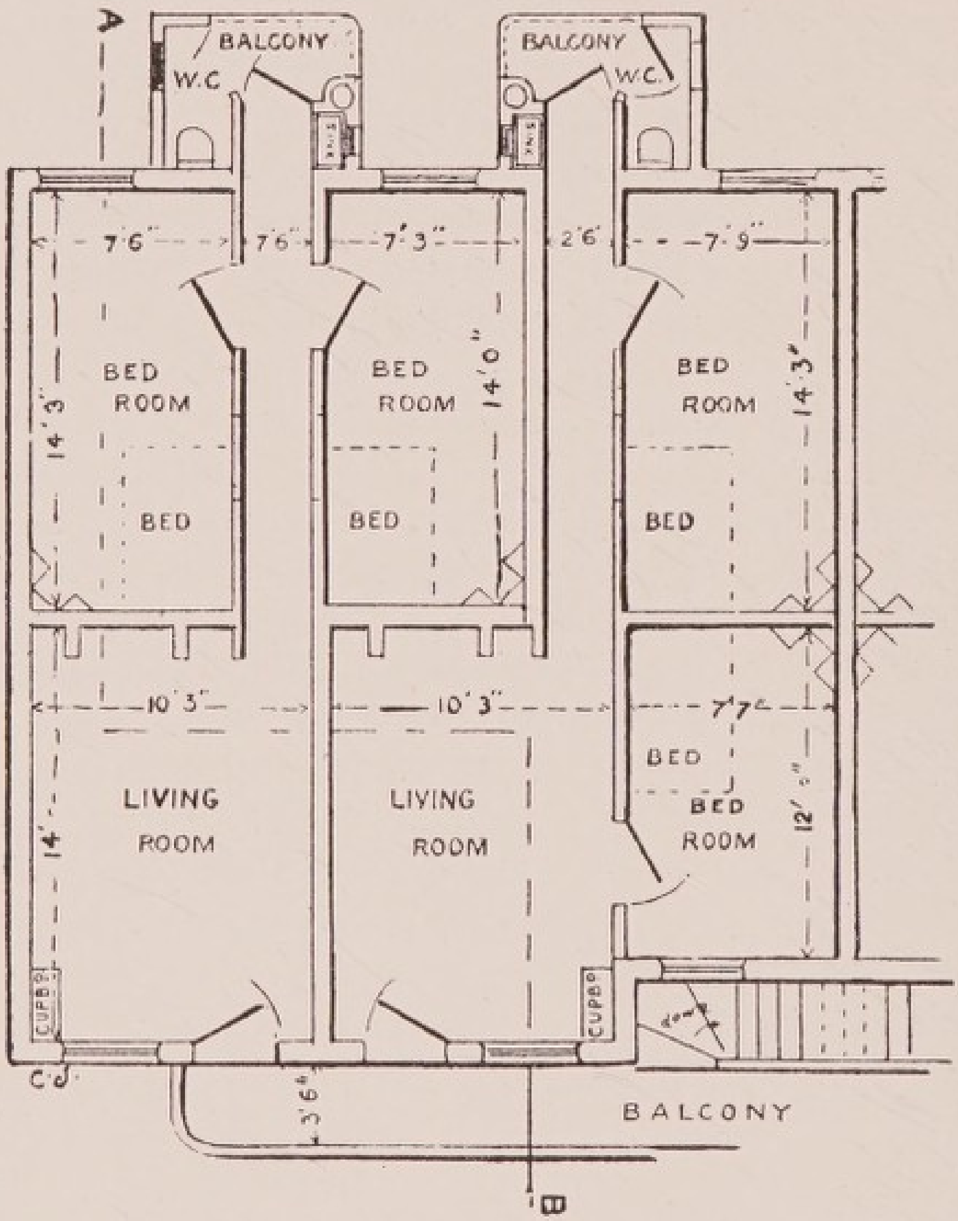


FIG. 34. LIVERPOOL CLINKER COTTAGES.
Plan.

labourer with a really ornate and substantial home at a modest rental.

Chapter IX

REFUSE DESTRUCTORS COMBINED WITH ELECTRICITY WORKS

MUCH has been said, both for and against the combination, and extreme views have been advanced on both sides. Those who have constantly asserted that the combination is worthless, have in the course of time found themselves faced with actual statistics from various towns, clearly proving the combination to be of value, and so the critics have gradually decreased in number, and the situation to-day as compared with that of five years ago has entirely changed.

It is a common delusion that the many extravagant statements which have been made concerning the generation of electricity from refuse have all emanated from the Destructor maker. On the other hand, while some Destructor makers have promised impossible results, it must not be forgotten that the maker of the Destructor is always viewed with more or less suspicion, whereas the statements of a municipal engineer such as "The Golden Dustman" and of a scientist such as Professor Forbes carry greater weight and obtain more credence.

"The Golden Dustman" was a great enthusiast, and an excellent municipal engineer. He had a record of splendid service. It is no exaggeration to say that he made more money out of refuse than has ever been made either by a municipal engineer or a scavenging contractor before or since.

What "The Golden Dustman" said about refuse disposal and power production was believed, so, with the Cantor Lectures of Professor Forbes, great interest was aroused, and both men were taken too seriously. Professor Forbes has been severely criticized, but the substance of his statements was in the main quite correct, so far as power production is concerned.

It may, however, be truly said that the Destructors in use some fourteen years since, when Professor Forbes delivered his Cantor Lectures, were quite unsuitable for producing the power which we were told could be produced, but even as remarkable strides have been made during the past fourteen years in electrical engineering, so have remarkable developments been made in the perfecting of the Refuse Destructor, firstly for its primary object—the destruction of refuse—and secondly as a power producer.

The Destructor of fourteen years since was not capable of performing its primary duty, that of destruction, but in many cases a single multitubular boiler had been included with a battery of cells, and although the refuse was not destroyed, yet the gases passing through the main flue to the chimney were intercepted, and sufficient steam was readily generated to operate a mortar mill or to do other similarly modest work on the Destructor premises.

It may be fairly argued that at this time greater wisdom would have been shown had every effort been directed towards perfecting the Destructor as a destructor, before thinking of even operating the modest mortar mill.

This must be admitted by every sanitarian, while every engineer will recognize the absurdity of passing gases through a boiler when the maximum temperature of such gases rarely exceeded 800° Fahr., while often falling even below 600° Fahr.

To place the modern Destructor on such a level, either as regards its primary duty, or its suitability or value for purposes of power production, is to show either prejudice or ignorance, and a failure to grasp the importance of modern developments.

It is only necessary to observe here that there are but very few points in common between the early and modern Destructors. Instead of imperfect destruction and constant liability to nuisance, we have a perfect immunity from nuisance and absolute cremation. Instead of a temperature of 800° Fahr. as the maximum temperature of the gases entering the boiler, we now have a temperature varying from 1,600° Fahr. to well over 2,000° Fahr.

It is no exaggeration to state that the temperature of the gases at the chimney base with a modern Destructor is frequently but little lower than the main flue temperature with the early Destructors. In the former case the temperature has been reduced to the extent of from 1,200° Fahr. to 900° Fahr. owing to the transmission of heat for useful purposes, whereas in the latter case high temperature at any point was unknown.

Although many station engineers are still antagonistic to the combination there can be no doubt that as time goes on and records of successful work over extended periods are available, opposition will gradually cease. The station engineer is to be commended for being cautious, but much of the opposition still met with is not prompted by caution. In some cases there is a great reluctance on the part of station engineers to admit the value of the Destructor in combination, because they consider that it would be an unpleasant adjunct.

Others, while objecting to take supreme control of a combined works, yet strongly resent divided control, and in one or two cases where divided control has been introduced, friction has been constant.

Professor Kennedy once gave it as his opinion that the man who is held responsible for the utilization of the steam should control its production, and whether the line of argument be appreciated or not it must be allowed that it is reasonable. The position of the station engineer must be unenviable when he is relying upon a supply of steam from another department beyond his control, especially if the necessity of steady pressure is not seriously appreciated at the source of supply.

If the engineer in charge of a combined works be adequately remunerated, his objections to supreme control would not be so frequently heard. The station engineer controls the burning of the coal, nor would it be urged for one moment that this department should be separately controlled, while still holding the engineer responsible for steady running and the minimum fuel cost per unit generated.

If refuse be regarded as a fuel, why then have separate control of its combustion? If the process be considered unpleasant, this may in some instances be attributed to the policy of thrusting a sanitary department upon an electrical engineer, having in mind the saving of a Destructor superintendent's wages by so doing.

One of the arguments advanced against the combination a few years since was that it is impossible to generate steam at a sufficiently high pressure for electrical purposes. It was alleged that a pressure of 60 lb. was the highest boiler pressure possible with refuse. Some nine years since at Rochdale, Mr. F. W. Brookman, the Cleansing Superintendent once and for all disposed of this argument by working two large Lancashire boilers up to a pressure of 120 lbs. This example was soon followed at the Oldham combined works, and in both cases not the slightest trouble was experienced. In September, 1899, at Darwen, a further advance was made, the Lancashire boilers provided with the Destructor for a working pressure of 200 lb. confirming all expectations, and while steam was required at the engines at 160 lb. pressure, no difficulty was experienced in working the boilers up to the full pressure, reducing valves being provided for ensuring a steady delivery of steam to the engines at 160 lb. pressure.

The successful demonstration at Darwen has had far reaching results and high steam pressures from refuse are now so common that the early critics have long since ceased to trouble.

Having disposed of this question, it was next said that anything like steady steaming was absolutely impossible with refuse as fuel, but here again experience has clearly shown the contrary to be the case. It is quite true that some of the steam curves reproduced and illustrated in this volume are not altogether satisfactory, but in studying the same it must be remembered that they are diagrams taken under normal working conditions, and that the type of boiler, and the design of the plant as a whole have a very material effect, not only upon the steam production, but also upon the steady maintenance of the working pressure.

Steady steam pressure is only possible when suitable boilers are installed, and the volume of hot gases supplied to the boiler at a constant high temperature, with but the minimum of fluctuation. Continuity of high temperature is to a very serious extent governed by the design of the Destructor, but as this feature is fully discussed in another chapter it would be superfluous to enlarge upon the same here.

Having a plant designed in the best possible manner for ensuring steady high temperature working, and so steady steaming it is still of vital importance to insist upon methodical working, a regular cycle of operations; this demands careful and intelligent supervision.

That steady steaming is practicable is beyond all question, but wishing to avoid bare assertions, it would perhaps be well to quote the opinions of engineers controlling combined works. Perhaps two such opinions will suffice.

Mr. W. Sillery, M.I.E.E., of Wrexham Combined Works, says—

No difficulty is experienced in keeping steam pressure constant, both for traction and lighting; . . . the steam is easily controlled.

Mr. W. B. Maxwell, Partick Combined Works—

We have no difficulty whatever in maintaining a steady pressure without the use of coal, except on Sundays or holidays, or when there is insufficient refuse to meet the demand for electricity.[1]

In designing a combined plant it is undoubtedly advisable to arrange for a reasonable margin between the boiler pressure and the pressure of steam required at the engines. As already pointed out, at Darwen there is a margin of 40 lb., the boiler pressure being 200 lb. and the engine pressure 160 lb.; this margin is most helpful, allowing as it does for a reasonable fluctuation in the steam pressure at the boiler, which will happen at times, however carefully the work is supervised. Such a margin, while involving no difficulty if first-class reducing valves are used, ensures steady steam pressure at the engines.

Some electrical engineers, while not questioning the value of the Destructor as a power producer, have expressed doubts as to

[1] See *The Electrician*, December 12, 1902.

the thoroughness of the combustion. It has been said—Is the combustion perfect? Are you not sacrificing the primary object of the Destructor in endeavouring to satisfactorily realize the secondary? In reply to such questions it may be fairly said that with the well designed modern Destructor the combustion is far more perfect than is the case with the average steam boiler fired with the best coal.

This question is exhaustively dealt with in another chapter, and it will be clearly seen that the efficiency of the combustion process as shown by analysis reaches a standard which is approached by very few coal fired steam plants in this country. The principles governing perfect combustion have certainly received very much closer attention in connection with the design of the best modern Destructors, than is the case with boiler furnaces, generally speaking.

The high temperature reached, the reasonable margin of fluctuation in temperature, the high percentage of CO_2 in the gases of combustion, all afford conclusive evidence of excellent practice in efficient combustion and those who carefully study this important phase of the subject cannot fail to be impressed with the very satisfactory conditions existing.

Comparative Statement showing the Number of Electrical Units Generated per Ton of Refuse Destroyed at Twenty Combined Electricity and Destructor Works.

Town.	Make of Destructor.	Type of Destructor.	Type of Boiler.	Average Number of Units Generated Per Ton of Refuse Destroyed.	Average Weight of Refuse Destroyed Daily in Tons.
Accrington . . .	Horsfall	Top Fed	Lancashire	25	60
Bangor . . .	Meldrum	,,	Hornsby	20	9
Cleckheaton . . .	,,	Hand ,,	Lancashire	35	12
Colne	,,	Top ,,	Babcock	20	18
*Darwen . . .	,,	Hand ,,	Lancashire	33	35
*Fulham . . .	Horsfall . .	Top ,,	Babcock	26·62	100
Gloucester . . .	Heenan	Back ,,	,,	35	25
Grays	Meldrum	Hand ,,	Lancashire	33	8
Liverpool . . .	Manlove	B. & B.	Babcock	29·5	97
Llandudno . . .	Meldrum	Top Fed	,,	32	15
Nelson . . .	,,	Hand ,,	Lancashire	40	30
†Partick . . .	Manlove	,, ,,	Babcock	27	42
Rhyl	,,	,, ,,	,,	15	16
*St. Helens . . .	Meldrum	,, ,,	,,	37·3	32
‡Shipley . . .	,,	Hand ,,	Lancashire	37·8	25
*Shoreditch . . .	Manlove	B. & B.	Babcock	20	80
Stepney . . .	,,	Top Fed	,,	32	165
Warrington . . .	Meldrum	,, ,,	,,	80	50
§Wimbledon . . .	,,	,, ,,	,,	45	54
Wrexham . . .	,,	Hand ,,	Lancashire	38	35

* Average for 1 year. † Average for 3 months. ‡ Average for 1 month. § Two-thirds refuse, one-third sludge.

In the case of a small town, under the best conditions it is obvious that the maximum benefit in the way of power production is secured from the Destructor in the first few months' working of the station, because, while the demand for current is ever increasing, the quantity of refuse available, while increasing slightly in a growing town, cannot possibly increase in the same ratio as the demand for current.

It should be borne in mind that in the case of combined works using electrically driven fans for providing forced draught, and also electric hoists or elevators, the electrical output per ton of refuse destroyed is *inclusive of* the current actually used in connection with the operation of the Destructor.

To take two examples: At St. Helens for the year 1900–1 the average number of units used on the works per ton of refuse destroyed is given as 7·1. At Shoreditch the average for one year gives nearly 5 units per ton of refuse destroyed as used for works purposes.

It will thus be apparent that in order to arrive at the actual number of useful units available per ton of refuse destroyed it is necessary to deduct such current as is used for works purposes, and this must be done in order to enable fair comparison to be made with the results obtained where the fans are steam driven or steam jet blowers are used.

At a combined works where steam jet blowers or steam driven fans are used, the electrical output per ton of refuse destroyed is a *net* useful quantity, and the proportion of steam used for purposes apart from the actual generation of electricity represents so much *extra* power produced per ton of refuse destroyed.

In a few towns no coal whatever has been used for the first six months' working, in one or two towns refuse has supplied all the steam required for the first year, but in every town sooner or later it becomes necessary to use coal, and while the weight of coal consumed is gradually increasing, the quantity of refuse available practically remains stationary.

Although this is so very obvious that it would seem almost unnecessary to admit it, we constantly hear that the combination is of doubtful value because refuse will not supply the necessary power for all time. It is further said that combined plants are only suitable for small towns. Perhaps the most conclusive reply to such a statement is to cite such a case as Liverpool, where power is being produced for traction purposes every day from some 300 tons of refuse. Other large towns might be mentioned, while still others such as Preston, Burnley, Nottingham and Wolverhampton, all tend to show that there is a considerable difference of opinion.

When large towns such as Wolverhampton, Nottingham, and Preston decide to erect Destructors to deal with such quantities as 80 tons of refuse daily and supply power for electrical purposes, it must be admitted that the "small town" argument falls rather flat, the more so when it is borne in mind that at two out of these three towns Corporation electricity works, equipped with a number of coal fired boilers had been in operation for some years before the installation of the Destructor was decided upon.

Cases such as these tend to considerably strengthen the case for combination, and most conclusively show that as the result of careful investigation it has been considered worth while to produce electricity from refuse.

Although there is a very considerable variation in the electrical output per ton of refuse destroyed at the combined works included in the table of comparative results, it must not be forgotten that different conditions obtain in almost every case. In some instances the load factor is high, in others very low. The Destructors differ in design and method of charging, the boilers differ in type; while some are set as close as possible to the cells, others are a considerable distance from the cells. With some installations hot air is used for combustion and economizers are provided; in other cases neither of these useful accessories are included.

Again in some stations the refuse is all destroyed during that period approximating to the period of lighting or power demand, while in other cases, a proportion of the hot gases go to waste through the bye-pass flue, the Destructor working steadily throughout the whole twenty-four hours.

It is but fair to point out that in such cases it may happen that the refuse burned does not get full credit in the number of units generated per ton of refuse destroyed, because while the steam may only be used for eighteen hours, during the remaining six hours the refuse is being destroyed practically at the same rate, and the total number of units generated during the day is divided by the total number of tons burned.

As already observed, the attitude of the station engineer has changed and by not a few the combination is now regarded with favour.

As I write this chapter I have before me letters from sixteen station engineers, expressing favourable opinions concerning the combination. It is impossible to quote all these opinions; we will. therefore, make a brief selection.

The electrical engineers at the undermentioned towns express themselves as follows—

CLECKHEATON.

So far we have every reason to be satisfied with the results. I consider that our combination is most efficient.

WREXHAM.

The combination in our case is most useful, and no difficulty is experienced in keeping steam constant for both traction and lighting.

ACCRINGTON.

The combination is useful in connection with a small works, which has a day load.

BECKENHAM.

A combined electric light station and Destructor is undoubtedly useful when a day load is obtainable.

ASHTON-UNDER-LYNE.

The Destructor now contributes heat equal to what would be produced by several hundred tons of coal.

LINCOLN.

Mr. Stanley Clegg (late of Darwen).

From my own experience I know that a Destructor and electricity works can work together for their mutual advantage. . . . It would certainly be impossible to raise the steam pressure to normal working pressure after a fall due to cleaning out, as quickly by any other firing process. [1]

[1] See *The Electrician*, p. 608. January 30, 1903.

While some engineers of combined works have no complaint to make concerning the presence of dust in the engine room, there certainly have been instances where trouble has arisen through dust reaching the engine room; but this is no real argument against the combination, it merely indicates what has for a long time been obvious to many, i.e. that great care is demanded in the general planning out of the whole scheme. The arrangement and design of the buildings, calls for special attention. The Destructor boilers while being as close as is practicable to the engine room, must, as part of the Destructor, be isolated from the engine room.

The arrangements for the deposit of clinker should be such that its dust is not blown about. The destructor house should be ventilated, preferably by a well-devised system of downward exhaust, and if this be done, the atmosphere will not only be more congenial for those employed in the Destructor building, but dust will be prevented from escaping therefrom.

Lastly, but not least in this connection, when the refuse is delivered, the carts (which should be covered) should disappear within closed doors. If these matters receive careful attention, when the plant is being designed, there is no excuse for any dust trouble either inside or outside.

Some critics of the combination have put themselves to some considerable trouble in endeavouring to show that refuse has a varying calorific value, and that it is accordingly very unreliable as a fuel.

Little can be gained by producing an array of figures, in order to refute that which is not disputed. It is generally admitted that the calorific value of refuse varies to a considerable extent, but, as the result of considerable experience, the average value is now known, and as a general rule, this average forms the basis of a guarantee for steam raising.

The Surveyor of the Urban District Council of King's Norton, near Birmingham, being anxious to ascertain the calorific value of the refuse, arranged for the sampling of loads as collected on specified dates, the several samples being sent to an analyst, with the remarkable result that the calorific value of the refuse was shown to be about 4,500 B.T.U.

The analysis of one pound of refuse gave the following result—

Carbon	36·8	per cent.
Hydrogen	·29	,, ,,
Nitrogen	·29	,, ,,
Sulphur	·19	,, ,,
Oxygen	7·3	,, ,,
Ash	41·7	,, ,,
Moisture	12·12	,, ,,

It is not contended that the average refuse has a calorific value of 4,500 B.T.U.; this particular sample was obviously a very good one. The average calorific value of refuse as a fuel may be safely put at 3,000 B.T.U. Many actual steam raising results in various parts of the country clearly demonstrate this.

The many tests recorded herein will serve to show that after allowing for all the unavoidable losses, in the cells, combustion chamber, flues and boilers, the calorific value of the refuse must necessarily have been as high as is claimed for the average refuse.

It should not be forgotten by those who suggest that the Destructor can never be a satisfactory power producer because of the varying calorific value of refuse, that coal also varies considerably in calorific value.

The varying calorific value of refuse being fully appreciated, is not the troublesome factor which some would have us believe. The Destructor is not designed simply for dealing with homogeneous material; on the other hand it is capable of dealing with every class of waste. Such is indeed expected, and can be readily dealt with.

On the other hand, when variable coal is delivered to any public works or generating station, unless the steam boilers are equipped for dealing with a variety of fuels, which is not an easy matter, considerable trouble is experienced.

Again and again when action has been taken by local authorities against electricity works or manufacturers for permitting black smoke to escape from their chimneys, the excuse has been that fuel such as usually employed could not be obtained, or that Welsh coal was not procurable, or maybe the coal merchant is blamed for delivering inferior fuel.

It is now almost impossible even in London to purchase fuel on analysis, that is to contract for a supply of expensive fuel of a known calorific value, which value shall be guaranteed. The explanation simply is that even expensive fuels are to some extent unreliable, and the vendor knowing this declines to take the risk.

Is it not unreasonable to expect a standard calorific value from refuse, when such cannot be relied upon from expensive coal ? It is beyond all question that the varying calorific value of refuse never gives anything like the same trouble as that experienced from the occasional delivery of inferior coal.

Other critics of the combination pronounce it useless because the Refuse Destructor falls short of their own standard of general efficiency. It is considered by such critics that, because every ton of refuse the whole year through cannot be relied upon to evaporate the same weight of water, therefore the Destructor is useless.

As my friend Mr. Frank Broadbent, M.I.E.E., recently pointed out in the columns of *The Electrical Review* during a controversy over "The Fuel Value of Refuse," the Refuse Destructor is scathingly condemned by some because it falls short of such a standard as is not even expected from the steam boiler fired with coal, the high class steam engine, or the dynamo.

The Refuse Destructor is tested over considerably longer periods than the coal fired boiler, the engine or the dynamo, but while a few hours' run is considered quite satisfactory for these, even a test of one month continuously is not considered satisfactory for the Destructor.

Evaporative tests are here recorded covering periods of from a few hours up to one month. Some tests have been carried out in the summer months, others during the winter, and under a great variety of conditions. If these tests are carefully studied it will be observed that even with varying rates of combustion, as in the case of Nelson, the efficiency is well maintained. Further, it may be fairly submitted that if coal were burned under such varying conditions the fuel efficiency would vary to a far greater extent. On the highest rates of combustion the fuel efficiency of coal would be seriously reduced, while with refuse the efficiency is scarcely affected.

Up to the present time combined works are either in operation or have been definitely decided upon in over sixty towns, comprising in the aggregate 370 Destructor cells and 140 high pressure steam boilers, the total destroying capacity being over 3,200 tons of refuse per day.

In the London district alone nearly 800 tons of refuse is being destroyed daily, the resultant power being used for generating electricity; and yet, in spite of such a remarkable record of progress, the utility of the combination is still questioned by not a few engineers.

The above figures will probably be startling even to those in charge of combined works and others intimate with the subject. Such figures cannot be seriously quoted as merely showing a resolve for foolish emulation. It is idle to submit that scheme after scheme has been decided upon without investigation and satisfaction, and furthermore, it should not be forgotten that every scheme has to be approved by the Local Government Board, who not only give close attention to the technical details, but also devote some considerable attention to the economic aspect.

An amusing case came under the writer's notice some few months since in a town near London, where a municipal electricity works had been in operation for about three years with a heavy net deficit each year.

It was decided to erect a Destructor at the adjoining sewage works, utilizing the power from some 30 tons of refuse daily to pump the sewage, and by so doing to save a coal bill of nearly £1,000 per annum. The scheme was no sooner decided upon than the Electricity Committee began to exert themselves with a view to securing the Destructor for combination with the electricity works, but they were too late, and much to their chagrin, they were reminded that the combination which they were at length so anxious to bring about, had been previously considered by them and, wisely or unwisely, abandoned as useless.

When it is borne in mind that nothing short of actual results in power production could popularize what will always be regarded by some as an unsatisfactory combination, it must be admitted that with sixty combined works, either in progress or in course of erection, wonderful strides have been made. It would be idle to suggest that this remarkable progress is but a passing craze, that all these schemes have been initiated blindly, or as the result of what has been termed "that strange fascination for producing light from dust."

On the other hand, it must be admitted that these combined schemes have only been decided upon after searching investigation: indeed it is no exaggeration to say that this combination is perhaps even now more closely investigated than any other contemplated municipal enterprise.

Progress has been made, not because of a mere desire for emulation, but as the result of close scrutiny. It is true that the sanitary aspect is ever a weighty factor, but in itself this presents no conclusive argument for the combination, the determining factor is whether the combination is a desirable one from the point of view of economy.

That the combined electricity and Destructor works has come to stay there can be no doubt, and with the development of electric traction we shall undoubtedly see many more combined works erected in the near future.

The record of combined works up to date is a very satisfactory one, and when it is remembered that as recently as five years since only two such works were in operation, there is every reason to feel satisfied with the progress made.

To those who still doubt the value of the combination, the writer would say—investigate personally, inquire closely into every aspect of the question. If you are a layman you will find such investigation of more than passing interest. If you are an electrical engineer, I still say investigate; even if you have had personal experience of one combined works, and that experience has not been wholly satisfactory, it is still well worth your while to investigate, because there is a vast difference between the efficiency of various Destructors, as you will have observed in the tabulated statement of results.

Chapter X

REFUSE DESTRUCTORS COMBINED WITH SEWAGE WORKS

ALTHOUGH the combination of the Destructor with the Sewage Works is becoming increasingly popular, yet the progress made up to the present has been but slow compared with the other combination already discussed.

In some 38 towns Destructors have been erected in connection with sewage works, the number of cells in the aggregate being 150, while 68 steam boilers have been installed for working pressures varying from 60 to 160 pounds to the square inch. The total weight of refuse destroyed daily, and from which power is being produced for pumping the sewage of 38 towns, is about 1,100 tons.

This combination is the ideal one from the point of view of some few electrical engineers, who do not favour the other combination. But while there is much to be said in favour of the combination, very careful consideration is necessary before deciding to erect a Destructor at a sewage works rather than at an electricity works, because certain conditions frequently obtain which are not met with in the former case.

Firstly.—As a general rule, sewage works are not erected on central sites: a sewage pumping station is usually situated on the outskirts of a town; and unless the town be very compact, it is necessary to take the whole of the refuse to one point, and that on the outskirts. The cartage cost must thus inevitably be very much heavier than is usual when the Destructor is erected on a fairly central site, such a site, for instance, as is usually chosen for an electricity works.

Secondly.—It is likely to become increasingly evident as Destructors continue to be erected at sewage works that in normal cases the refuse of a community is frequently in excess of what is actually required for pumping the sewage produced. This will not be satisfactory to the economist, for various reasons. If the whole of the refuse is carried to a site on one side of the town at a heavy cost, and one-half of the refuse only, is sufficient to save a coal bill of £300 per annum, then the remainder must be simply destroyed, and the heat allowed to run to waste, and this after incurring a heavy cartage cost and also the labour cost for destruction. Briefly, the only asset is such satisfaction as may be derived from the knowledge that the sanitary ideal has been reached.

At Hereford and Aldershot, and also some few other places, it has been clearly shown that all the steam power required at the sewage works can readily be supplied with far less refuse than is available. For six years past at Hereford one-third of the available refuse has supplied the whole of the steam required for pumping over 1¼ million gallons of sewage every day in 10 hours; also for operating sludge presses and lime mixers, and for the lighting of the works. The 10 tons of refuse is collected within an area as close as possible to the sewage works, to keep down the cost of cartage. In the first 5 years the economy effected at Hereford sufficed to pay every charge in connection with the Destructor up to that time, the installation having cost rather less than £1,200.

To provide small Welsh coal previous to the erection of the Destructor involved an expense of £350 per annum, and not one pound of coal or fuel other than refuse has been provided at the sewage works since the Destructor was started. It will thus be readily seen that had the remaining two-thirds of Hereford refuse been taken to the sewage works, the cartage cost would have been a very serious item, the labour cost would have been nearly trebled, and as the power could not be utilized, the loss involved in destroying the two-thirds would all but render a net saving quite impossible.

The reader may say, Why not destroy the balance of two-thirds at the Electricity Works? But surely it would be a very questionable proceeding to erect two distinct Destructors installations in so small a city.

Whenever a Destructor is combined with an electricity works, and more particularly in the case of a small town, it is essential that the whole of the refuse be destroyed there. *Firstly*, because, as a general rule, the whole of the power can be fully utilized; and, *secondly*, because it is open to serious doubt whether it would be worth while to incur the necessary capital cost to deal with only a portion of the total refuse produced, especially when that portion can only supply a comparatively small amount of power, as compared with the total power required.

It would be idle to deny that the sewage works load is eminently suitable; generally speaking, it is a constant load. The pumping may occupy only 10 hours out of the 24, or it may be necessary to pump through the whole period. In either case the work is usually very steady.

Even if the pumps are only in operation for 8 hours daily, no difficulty is experienced in banking the fires with refuse from day to day, and so much heat is conserved in the brickwork, that the working steam pressure may be quickly reached from banked fires.

Although, as already observed, the sewage works load is a fairly constant one, yet it frequently happens at some combined works that an abnormal flow has to be dealt with in time of storm; at such times the work is exceedingly heavy, and although the conditions then obtaining are all against the Destructor, yet again and again it has been demonstrated that with intelligent handling it is quite equal to the abnormal demands.

At Aldershot during last summer, although the normal flow of sewage does not exceed 550,000 gallons daily, yet during the torrential rain storms as much as 2,500,000 gallons had to be pumped, and this with very wet summer refuse, of very low calorific value, and with an abnormal percentage of moisture; but in spite of this, not one pound of fuel other than refuse was used.

When an abnormal flow has to be pumped during the summer months, the Destructor is very severely tested ; almost invariably less refuse is available at this season, and the percentage of moisture is high, owing to the greater proportion of green material in the refuse.

Fires being but little used, the percentage of cinder is very low, and the calorific value of the refuse is very materially reduced, as compared with that produced during the winter months.

Yet in spite of this, not only at Aldershot, but in other towns the refuse alone has constantly sufficed to provide power for pumping a very heavy flow, in some instances five times the normal flow. This but serves to show that the modern Destructor possesses considerable elasticity, and that when intelligently handled, results can be obtained, even under the most adverse circumstances, which might at first sight be considered impossible.

The elasticity of the modern Destructor is a very strong point in its favour for use in combination with an electricity works. This is merely mentioned here in passing, because this useful elasticity is so clearly exemplified in such cases as have been mentioned, where the demand over a given period, although abnormal, is yet satisfactorily met, and without the use of coal.

The record of the Destructor combined with the sewage works is, up to the present time, a highly satisfactory one, and we may confidently expect that the combination will increase in favour.

Curiously, the average councillor has not shown anything like so much enthusiasm over this combination as with that previously discussed, but this may perhaps be attributed to the fact that electricity is always more fascinating than filth to the average individual.

There is but little glamour about filth, either in the form of sewage or refuse ; and although, strictly speaking, perfect sanitary conditions should appeal far more strongly than lighting or traction, yet the fact remains that there is too often a desire to forget the filth, while much time and attention is devoted to the more attractive municipal problems.

A sewage disposal works is not looked upon as a profitable undertaking, commercially speaking. It is recognized as a necessity from a sanitary point of view, and it is clearly understood that in itself it must have a charge on the rates.

In the past there has been a tendency to instal Gas engines at sewage works, more particularly in small towns; but with the many excellent combined sewage and Destructor works now in operation, a gas plant can only be recommended under exceptional circumstances, specially favouring this form of motive power.

It may be assumed that 5 tons of refuse daily will provide sufficient power to pump the sewage of a population of, say, from 5,000 to 7,000; and as the clinker is now recognized as a valuable asset at many sewage works for use on bacteria beds, even in the case of a small town the Destructor offers distinct advantages as compared with the gas engine.

If gas engines be chosen, or if a steam plant be installed with coal as the fuel, the refuse question has still to be faced; and if the bacteriological system of sewage treatment be decided upon, without clinker available, this must be purchased, and often from a considerable distance. It is true that coke, or coke breeze, may be used, but these have to be paid for; ordinary furnace clinker is sometimes available, but neither of these three mediums can be compared with good vitreous clinker; and this is now generally admitted.

The clinker, then, is valuable, and being produced on the spot, is in itself a considerable source of economy. To the thoughtful citizen, it must be interesting to know how one form of civic waste will, in the process of destruction, furnish power for dealing with the liquid waste, and that the innocuous residue from the former offers the best known medium for the purification of the latter.

To the sanitarian this acme of utility must appeal with force. It must be admitted that very satisfactory progress has been made, but which, perhaps, can only be fully appreciated by those who have had opportunities of carefully studying the problems involved.

In a few towns electrically driven pumps have been installed at sewage works, but little headway has been made. This may mainly be attributed to the fact already alluded to, viz. the location of the sewage works. To lay a cable, in some cases over a distance of one mile, means a serious initial expense, after which transmission losses have to be reckoned with.

In one or two cases electric driving has been substituted for steam driving, mainly to provide a day load for the electricity works, but with very unsatisfactory results financially to the sewage works.

A case of this kind recently came under the writer's notice—a town within 100 miles of London, where for many years, with a steam plant, the coal bill had never exceeded £500 per annum. The conversion to electric driving involved a payment of over £1,100 per annum to the electricity department for the supply of current to do practically the same work. Incredible as this may seem, it is absolutely true, and it represents nothing more or less than the deliberate crippling of one department in order to support another which should be self-supporting.

In two towns where both the sewage and electricity works are on the same site, good results are being obtained; but in both cases it is interesting to note that Destructors are also combined.

In the above case it may, perhaps, be fairly argued that the Sanitary Committee should only pay the Electricity Committee the same sum as was previously paid for coal; but, rightly or wrongly, that sum was increased to the amount quoted.

Whatever advantages may accrue from the electrical driving of sewage pumps, the fact remains that it cannot be compared with the combination which we are discussing; just as the gas engine falls short of the ideal, so does electric driving. The Refuse Disposal question remains unanswered.

A Destructor can often be erected at a sewage works with but little expenditure, as compared with an entirely new and complete installation. This, when fully appreciated, must carry great weight.

In many cases Destructor cells might readily be adapted to existing coal-fired boilers; the same chimney would also suffice, thus the capital expenditure may be very materially reduced.

At Hereford, Nuneaton and Aldershot, among other towns, this course has been adopted; and the Destructor adaptation has been highly successful, fulfilling all expectations at the absolute minimum of cost.

Having steam boilers within a building, and a suitable chimney, the Destructor, with a building and accessories only, have to be installed. The structural alterations usually necessary are not serious, and involve but little expense.

The adaptation of Destructors to existing boilers at the sewage works at Hereford, Aldershot and Nuneaton, for example, cost less than £1,200 in each case, the result being the saving of the whole amount previously paid for coal; this being as follows—

Hereford	£350 per annum.
Aldershot	£300 ,, ,,
Nuneaton	£200 ,, ,,

In addition to the above saving, the clinker is fully utilized for the bacteria beds and other purposes, affording an additional source of economy.

In many towns where steam plants are now in use at sewage works, involving a fuel cost of from £500 to £1,000 per annum, Destructors might be adapted and the whole of the present fuel cost saved.

To effect such a saving in every case would involve an expenditure varying from, say, £1,500 to £3,000, according to the weight of refuse to be dealt with. It must be admitted that this presents a very strong argument for the combination, and further, that such combination would be of immense benefit to the long-suffering ratepayers, apart altogether from the realization of the sanitary ideal, which must be ever foremost.

Chapter XI

REFUSE DESTRUCTORS COMBINED WITH WATER WORKS

ALTHOUGH up to the present time little has been done in the combination of Refuse Destructors with Water Works, there is no doubt that during the next few years many such combined installations will be erected.

If the Destructor is carefully designed and contained within suitable buildings, contamination need not be feared, even with open reservoirs in use. In such a case, however, the question of design calls for special attention. The buildings must be so arranged that the Destructor plant is entirely closed in, air being drawn into the building for ventilation, and exhausted by suction for purposes of combustion.

The arrangements for storage of refuse, as may be necessary, should be as perfect as possible. The clinker, instead of being wheeled out into the open, should be stored under cover. The refuse must be delivered at the works in closed or covered vans, and tipped within the building with preferably closed doors.

If no open reservoirs are in use, and the deep well pumps are enclosed within a distinct building, then the combination of the Destructor does not involve so much expense in the arrangement of the buildings, there being practically no risk of contamination if reasonable care be exercised.

Some few months since a section of the Council of a town in the Eastern Counties were anxious to destroy the refuse of the town at the water works, mainly with a view to saving the coal bill. The quantity of refuse available being found inadequate for the purpose, the scheme was abandoned.

Curiously, only a few months before the matter was introduced to the Council, they had unanimously censured their water works manager for keeping a goat and a few chickens in his garden at the works ; contamination of the water was feared, and the live stock had to quit. Such an incident is only mentioned to show how inconsistent some Councils are. If pollution or contamination were possible owing to the presence of a few chickens and a goat, what might be expected from the filth of the town ?

As already observed, in order to meet the special requirements of the case, it may often be found necessary when erecting a Destructor at a water works to spend rather more money on the buildings than is usually the case. It may also happen that the special arrangement of the Destructor will involve a slightly greater expenditure than under normal conditions. Should this be deemed advisable, let it be entered upon cheerfully, having in mind the special circumstances of the case and the absolute necessity for unusual care.

Sentimental objections having been overcome, one of the causes which is likely to operate against the combination of Destructors with water works will be the location of such works.

As with sewage works so with water works. As a general rule, they are not situated in central positions ; in fact, in not a few cases water works are a considerable distance from the town. In such cases the cartage cost must be the determining factor.

A few years ago any suggestion to combine a Refuse Destructor with a water works would have been ridiculed. I may go further and say that the weight of sentimental objection followed by the veto of the Local Government Board would have at once rendered the combination impossible. It may at once be admitted that, even a few years since, the combination was not advisable. The Destructor had not been perfected, and, generally speaking, the design was crude and unfinished. Those details in design and general arrangement which are so essential for this combination had not been considered. Under such circumstances the combination of a Refuse Destructor with a water works would have been productive of trouble, and examples of the kind would have seriously militated against future combination.

Happily, there are no failures to record; this, perhaps the most critical combination of all, was only entered upon at the right time, i.e. when the Destructor was perfected, therefore with a clear record and no unfortunate past, this combination must find favour, and we shall see many combined works in the immediate future.

At Sheerness, where a Destructor is erected in combination with the water works, the results obtained have been exceedingly satisfactory, with the exception of Sundays, when, of course, there is no collection of refuse. No coal whatever is used, the daily collection of refuse providing the whole of the steam required for lifting the town's water supply from the deep wells.

Perhaps no more central site could be found than that at Sheerness, and, fully appreciating the absolute necessity for preventing nuisance of any kind, the building was so arranged that the carts, when bringing the refuse in, disappear within closed doors. The Destructor end of the building is also so screened off that any escape of dust, either when charging or clinkering the cells, is rendered absolutely impossible.

In order to clearly appreciate the position of this Destructor it is necessary to refer to Figs. 81 and 82. Not only is the Destructor within a few yards of the water works, but, within a few feet of the tipping platform, a school is situated; this building will be observed in Fig. 82 on the extreme right.

In front of the Destructor buildings are the Council offices, while the whole site is surrounded by houses. The writer, who advised the Sheerness Urban District Council, was quite convinced that, notwithstanding the abnormal conditions, it would be quite possible to erect a Destructor in this unique position, providing careful attention was given to the details and also to the design of the building.

The general arrangement of the building was discussed with the Council's surveyor, Mr. T. F. Berry, and we were able to design a building which, while being in every way suitable, was at the same time so arranged as to absolutely prevent nuisance of any kind.

Few water works in this country are so centrally situated as in the case of Sheerness, and it is safe to say that there is not another Destructor similarly located. It may, therefore, be of interest to briefly review the reasons which induced the Sheerness authorities to decide upon the site in question.

Faced with a scavenging account of over £26 per week, which amount had to be paid to a contractor for collecting and tipping some 70 tons of refuse weekly; burdened with a coal bill at the water works of £500 per annum, it is not strange that economy was sought. The author, after looking carefully into the case, strongly advised the Council to erect a Destructor at their water works, because this would effect a twofold economy—*Firstly*, the scavenging and collecting cost would be reduced to the minimum; and, *secondly*, the coal bill would be saved.

It was clear that by choosing the site in question an economy of at least £900 per annum could be effected. It now remained to arrange the plant and the buildings to meet the peculiar necessities of the case, as already observed. This was done, and as I write this, the first six months' working, just completed, shows an economy at the rate of nearly £1,000 per annum—equal to a reduction of 3*d*. in the pound on the rate.

The unique interest attaching to such a case as Sheerness is my excuse for dealing with same at such length. The experience gained with such an installation is of the utmost value, even apart altogether from the particular combination in question. A Destructor working under such abnormal conditions is a most useful object lesson, and should do much to popularize the Refuse Destructor and instil confidence.

Chapter XII

DESTRUCTOR SITES

THE real *vexata questio* now, generally speaking, is not whether a Destructor shall be adopted or otherwise, but rather as to where it shall be located.

There is a prevalent and mischievous delusion that, for the most part, Refuse Destructors have been erected at a considerable distance from houses. This is absolutely incorrect. On the other hand, no less than 94 per cent. of the Refuse Destructors working at present in Great Britain are in close proximity to houses.

Naturally the question of site is one of great importance in connection with the Power Destructor. Electricity works are invariably erected on central sites; sewage works and water works are also, as a general rule, situated within reasonable distance of the centre of a town. In a large number of towns it is therefore possible, with a reasonable cartage cost, to destroy the refuse on such a site as offers an outlet for the profitable utilization of the resultant heat for steam generation.

It is very remarkable that those who would have the Destructor erected beyond the limits where the power can be utilized, are the same people who would raise no objection to the filthy accumulation of refuse on a tip in a very much more central position. They aggravate their incongruity by insisting upon a considerably heavier cartage cost for sanitary and final disposal than would satisfy them in connexion with the primitive and filthy method of hoarding filth. It is ignorance of this type which we have to combat; and the task would be very much more difficult than it is, if it were not for the very reasonable attitude of the Local Government Board.

There could, perhaps, be no more striking tribute to the general excellence of the modern Destructor than the fact that the Local Government Board are constantly sanctioning schemes where it is proposed to erect Destructors in very central positions.

It cannot be urged that the Local Government Board have any self-interest ; and it must be conceded that each case is carefully investigated publicly on the spot, and afterwards considered on its merits.

If any sympathy has been shown by the Local Government Board towards schemes providing for the fullest utilization of the power, which course is clearly for the benefit of the ratepayers, such sympathy or interest is always dominated by the main factor, which must always be the suitability of the proposed plant for the specific conditions existing.

Every Destructor scheme does not pass the Local Government Board without modification, and suggestions are frequently made either by the Inspector when examining the site, or at a later date, when the evidence and plans are under consideration at Whitehall.

Local Government Board inquiries concerning Refuse Destructors are by no means devoid of humour. Perhaps I may be permitted to enliven the dull pages of a work of this character with one reminiscence. In a town near London, which shall be nameless, an inquiry was being held, and many witnesses gave evidence against the proposed site, although it was by no means centrally situated. One worthy member of the Urban District Council—who, by the way, had never seen a Destructor—addressed the Inspector for some few minutes with much vehemence, but with little logic. The Inspector, who was visibly wearying, at length asked the witness whether he would be so good, before proceeding further, as to enlighten him (the Inspector) whether he was speaking *for* or *against* the proposed Destructor. Needless to add, the worthy councillor quickly resumed his seat.

The question of a suitable site is such a vexed one to the lay mind that few Local Government Board inquiries concerning Refuse Destructors pass without opposition. Having given evidence at a number of inquiries, the author is in a position to say that the opposition, as a general rule, is of a frivolous and ignorant nature. The proposal to introduce a Destructor is resisted frequently by a number of well-meaning but, nevertheless, ignorant citizens.

The experience gained by the Local Government Board Inspector is such that he is readily enabled to sift evidence, and appraise the same at its real value. If this fact were only recognized by some energetic citizens, who will talk about that which they have never seen and do not understand, the result would be a great saving of time and money.

Among the illustrations here reproduced a few will be found showing Destructors erected in somewhat unique positions. These are, however, but a few out of many such installations. As already observed, the majority of the Destructors in this country are in daily operation in close proximity to houses.

That complaints of any kind are almost unknown should be an all-sufficient answer to those who doubt; and it should be borne in mind that a considerable percentage of the Destructors which have been erected in close proximity to houses were erected many years ago, and, accordingly, are not so well designed or so complete as modern Destructors.

Much has been said about depreciation in the value of property as the possible result of the erection of a Destructor near to houses; but this may at once be dismissed as untrue. Again and again has the author heard this aspect argued at Local Government Board inquiries, on some occasions by eloquent counsel, on other occasions by the trembling property owner; but never yet have I heard any logical evidence whatever in support of such an assertion, nor have I ever heard a single example quoted to show that property does depreciate.

On the other hand, I have heard a mass of evidence to the contrary, and I have heard cases cited where property has increased in value, this, of course, not being due to the erection of the Destructor, but merely owing to local circumstances. Such cases do, however, clearly support the case for the Destructor. Granted that a Destructor can be erected upon a central site, and operated without nuisance, such a site should be chosen, if for no other reason, then for the common good of the ratepayers.

In every town of reasonable size the cost of collection of the refuse is a factor worthy of very careful consideration; and every effort should be made to bring down the cost of collection to the minimum.

The minimum of cartage cost, combined with the fullest possible utilization of the power, offers at once the maximum of advantage to the ratepayer. If he is so ill-advised as to resist this, in the result his own pocket is touched.

Chapter XIII

THE COMPARATIVE ADVANTAGES OF STEAM JET BLOWERS AND FANS

THE comparative advantages of steam jet blowers and fans for use in connection with Destructors presents a highly controversial subject. Much has been written in defence of each; but in spite of this the question is still a vexed one, and there is every indication that it will so remain.

Destructor makers who employ fans lose no opportunity of asserting the superiority of the Fan over the steam jet blowers, while the makers of the latter avow that steam blast possesses distinct advantages over dry air blast.

It must be admitted at the outset that in so far as actual steam consumption is concerned, the fan usually has the advantage, and this is, perhaps, the main advantage claimed for the same by its advocates.

Another advantage which is realized in some combined electricity and Destructor works is that it is possible to operate an electrically driven fan earlier after standing, while steam jet blowers could not be used until a reasonable steam pressure had been reached in the boiler.

It should not be forgotten, however, that in most combined works, although the Destructor may be standing with banked fires for many hours, the steam pressure in the boiler is usually sufficiently high to enable steam jet blowers to be supplied and operated immediately.

As the result of considerable study, the writer has come to the conclusion that the economic advantage already mentioned is, generally speaking, the only real advantage possessed by the fan over the steam jet blower.

Allowing that the fan is more economical in steam consumption, the steam jet blower still has distinct economic advantages over the former. These may be briefly summarized as follows—

(*a*) That the first cost is considerably less.

(*b*) That the cost of upkeep and maintenance is but trifling.

(*c*) That it is exceedingly simple, and self contained, the steam consumption being in direct proportion to the work done.

That the steam jet blower equipment is very much cheaper will not be disputed, as also the fact that the cost of upkeep and maintenance is negligible; whereas it is not only necessary to provide fans in *duplicate*, but the depreciation is serious; attention and lubrication are also essential.

The advantage of the steam jet blower from the point of view of simplicity is so obvious that it may be passed over. Again, if a fan is provided to supply draught to, say, six cells, the fan must still be used, even if only two cells are in use, and the steam consumption is not *pro rata* with the reduced work. Further depreciation must still be allowed for, and the fan demands perhaps as much attention as though working up to the maximum.

On the other hand, with the steam jet blower, if only one cell out of six is in use, the steam consumption is in direct proportion to the work done. With a four grate unit Meldrum Destructor, for instance, if only two grates (only half of the cell) are in use, the blowers under those two sections of the grate only are in use.

It has been recently suggested that with the steam jet blower, moisture may be deposited upon the back end of the boiler and economizer pipes. This suggestion is without any foundation in fact; hundreds of cases might be cited where steam jet blower draught has been in use for over ten years past, and moisture has not been detected upon the end plates of boilers or upon the economizer pipes. On the other hand, wherever this system of forced draught is installed, the efficiency of the economizer is materially increased, resulting, of course, from the higher combustion temperature.[1]

In a paper read in Dublin early in March of the present year, Mr. H. Norman Leask, the writer of the article already mentioned, again referred to the alleged deposit of moisture, and advocated the use of dry hot air as against saturated heated air.[2]

That dry hot air is of immense value for combustion there can be no doubt, but what is meant by saturated heated air is not at all clear, unless a combined system of steam jet and fan is intended, as shown in Fig. 35.

This illustration shows Heenan's Patent, No. 9,065 of 1900, and provides for the employment of a steam jet in connection with a fan, preferably to utilize exhaust steam. It is said that—

> This method of heating the forced draught or air supply utilizes the

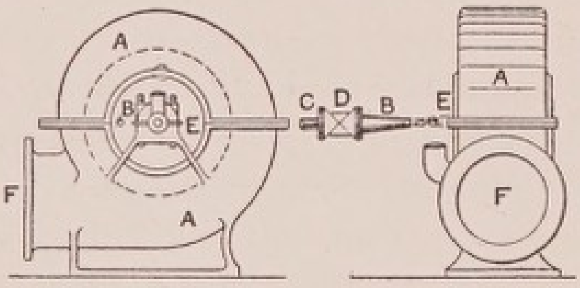


Fig. 35. Heenan's Patent Combined Centrifugal Fan and Exhaust Steam Jet.

> heat of the exhaust steam, which would otherwise be lost, and at the same time effects a considerable advantage in the combustion of the furnace.

Now if, as Mr. Leask submits, a deposit of moisture and ultimate corrosion may result from the use of live steam, often at 150 and even 200 lbs. pressure, with steam jet blowers, then it is but reasonable to suppose that this trouble must be very much more serious if exhaust steam is used.

Again, if exhaust steam will materially add to the temperature of combustion, it must be conceded that high pressure steam

[1] See *Surveyor*. January 30, 1903.

[2] See *Proceedings of The Institution of Civil Engineers of Ireland*, 1903.

should greatly increase the temperature ; and for the saturation of heated air it is quite certain that exhaust steam must be very much more effective than live steam even of low pressure.

It is, perhaps, only natural that the advocates of fan draught are not content with the candid admission that in actual steam consumption they have the advantage, because, as will be seen, there are other vital considerations apart altogether from the actual consumption of steam necessary to move a given volume of air.

With further reference to the question of moisture, it is interesting to note that even in some large modern Destructor installations provided with fan draught,[1] provision is made for turning on a supply of live steam previous to clinkering, thus at once admitting the value of free steam.

Mr. H. Norman Leask, in the paper already referred to, argues that a higher temperature can be obtained with fan draught ; but this is entirely contrary to actual experience.

The highest temperatures and the highest average temperatures on record have all been obtained with steam jet blower draught, together with an altogether remarkably successful record.

This is not a question of one maker against another, but of the comparative merits of two entirely different systems of air supply.

Mr. W. H. Maxwell, Chief Engineer of Partick electricity and Destructor works, where a high class fan draught plant is installed, and also steam jet blowers, expressed his opinion as to the comparative value of the two systems, as follows—[2]

> The relative advantages of fan and steam blast is a point of great importance. I have made no tests, but from actual working we have found that with the latter a steadier steam pressure is maintained, and more steam per ton of refuse is available at the engines.

The Partick installation is a modern one, being opened in March, 1902. Three centrifugal fans are provided, each capable of delivering 10,000 cubic feet of air per minute, each fan being

[1] This is now a common practice with Fan Draught.

[2] *The Electrician*. December 5, 1902.

driven by an independent single cylinder high speed engine. Two fans are capable of supplying all the air required, the third fan standing idle in case of a breakdown.

Mr. Maxwell's opinion obviously cannot be lightly passed over. It is clearly expressed, and substantiates what has been claimed for the steam jet blower.

Nearly three-fourths of the modern high temperature Destructors in this country are provided with steam jet blower forced draught; moreover, in a few instances fans have been removed and replaced by steam jet blowers; and in connection with several Destructors where complete fan plants are installed, steam jet blowers are also fitted.

It may be reasonably asked, why steam jet blowers are installed in addition to a duplicate installation of fans? It may further be observed, why is the former installed under any circumstances if it is so inefficient as we are told?

We may assume that steam jet blowers are included, in addition to fans in duplicate, because, although duplicated, it is still possible for the fans to break down. As to the alleged inefficiency of the former, this must be judged by the reader, who has facts and figures before him directly bearing upon both systems.

The steam jet blower was once defined as "a cast iron pipe, having a steam pipe at the inlet end." The writer fears that this is a definition which might be given by many critics, but the fact remains that such a definition fails entirely to convey an accurate description of a good steam jet blower.

It may be truly said that even as there are fans and *fans*, so are there blowers and *blowers*. That a remarkable difference exists in the efficiency of various fans is well known. Even if not generally known it is none the less true that there is a very wide difference in the efficiency of steam jet blowers.

The problem which the maker of steam jet blower apparatus is confronted with may be briefly stated as "how to move the greatest volume of air with the smallest volume of steam," and correct scientific proportion and design enter largely into the production of the first class steam jet blower. The close student of the subject will be aware that steam jet blowers differ in efficiency to perhaps a greater extent than fans. Blowers are in use in connection with Destructors using from 12 per cent. to 40 per cent. of the total steam produced.

Whilst it is of the highest importance, especially with the modern power Destructor, that the draught should be produced for the lowest possible steam consumption, yet as will be evident there are other considerations of great importance.

Some of these we have already discussed ; there now remains the question of water gas in combustion. Generally speaking our British refuse is sufficiently rich in carbon to produce and maintain a temperature sufficiently high to decompose the steam, the result being the formation of water gas in the cell.

The water gas is formed during the passage of the steam through the bed of incandescent fuel on the grate. The underside of the clinker when removed differs essentially from that removed from a cell worked with fan draught. In the former case the underside of the clinker has a clean and vitreous appearance, leaving the grate surface with comparative ease, the result being that the clinkering process is less arduous, and the fire-bars have a much longer life.

With fan draught, unless supplementary steam is used, the labour involved in clinkering is materially increased, and the fire-bars suffer by the adhesion of the clinker, and so need more requent renewal.

The water gas, far from having a deterrent effect on combustion, as has been alleged, is of very great benefit. More or less plausible theories have been advanced with a view to explaining away the value of water gas, but as against theory there is accumulated evidence of fact. Mr. George Watson has clearly demonstrated its value, and has done not a little to put on record comparative results, which all go to prove that the formation of water gas is of material advantage. It would appear that the effective chemical combination of certain gases is more definitely ensured with vapour present than with dry air.

Some years since, when Lord Kelvin and Professor Barr conducted exhaustive experiments at Oldham Destructor works, they were deeply impressed with the utility of steam jet blower draught, as the following extract from their report will show.

> The steam is condensed by contact with the cold air which it injects, and the water thus produced is re-evaporated in contact with the furnace bars, keeping down their temperature. In this way the life of the furnace bars is greatly prolonged. A more important function is, however, fulfilled by the steam. In coming into contact with incandescent fuel it is decomposed, the hydrogen being freed, while the oxygen combines with the carbon in the fuel to form carbon monoxide.
>
> This decomposition of the water is effected by heat abstracted from the lower part of the fire, where it can be of comparatively small value for the cremation of the distillate.
>
> The " Water Gas " (Hydrogen and Carbon Monoxide) passes upwards to be burned by the excess air which it meets with over the fire, thus serving to increase the temperature which would otherwise exist at the meeting of the products of combustion with the gases distilled from the raw material.

The formation of water gas has always been regarded as one of the advantages of the steam jet blower, and as being peculiar to this type of draught, but a glance at Fig. 35, and a perusal of the extract from the patent specification, will show that the use of an exhaust steam jet with a centrifugal fan must inevitably have the effect of producing water gas. To quote from the specification, we are told that

> It effects a considerable advantage in the combustion of the furnace.

The only advantage accruing must obviously be due to the presence of moisture—the formation of water gas, and it is indeed remarkable that this combination of an exhaust steam jet and a centrifugal fan was patented by one of the severest critics of the steam jet blower, which, on the other hand, is always designed to use live steam, and that usually at high pressures.

Such figures as are available all go to show that the combustion is more perfect where steam jet blowers are in use. Care has been taken to include authentic figures only, and the analyses here quoted may be accepted as correct.

As is well known, the nearer the air supply is kept to the quantity theoretically required for combustion, the higher is the percentage of CO_2 (carbonic oxide). The test for CO_2 is now generally accepted as being the standard test for determining the efficiency of combustion.

As it is useful in comparing results obtained with the two systems of draught production to know the air pressure in the ashpits (in inches of water), and also the rate of combustion, these figures are included in each case, (see Tables, pp. 152, 153).

The comparative figures in the following tabular statement are worth careful study; they very clearly show that for perfect combustion the Destructor working with steam jet blower draught has the advantage. It is only possible to take into consideration such figures as are complete and authentic. It is true that the tests are but few in number, but they cover long as well as short periods, forced and easy working, and air pressures from 1⅛″ to 3·1″. Further, four distinct types of Destructors are represented, and on the whole it may be submitted that fair comparison can be made.

It will be observed that some tests for CO_2 were made at Warrington, in 1894, these were probably the first tests of the kind ever conducted in connection with Destructors. The analysis of the gases of combustion is a comparatively new departure in connexion with the Destructor practice. Such analyses were never heard of in connection with the old low temperature Destructors, and in the light of modern practice it is easy to see what imperfections such analyses would have laid bare.

Concerning the excellent percentage of CO_2 in every case with steam jet blower draught, perhaps the Rochdale results are especially noteworthy, these very high figures being obtained *with all the doors open eight inches.* This but serves to prove what has been contended for years past by those who have closely studied the matter, that it is possible to so regulate the forced draught and chimney pull, that a perfect balance of the gases is secured, and with this condition existent in the cell cold air cannot enter even with the doors wide open.

This may be readily tested in a simple but conclusive manner by holding a handkerchief loosely in front of the open door: it will remain perfectly motionless if the gases are balanced by

STEAM JET BLOWER DRAUGHT.

Table Showing the Percentage of CO_2 in the Gases of Combustion.

Town.	Date.	Duration Test.	Rate of Combustion.	Ashpit Pressure.	Average % CO_2.	Average % CO.	Average % Oxygen.	Apparatus Used.
Oldham . . .	May, 1898	24 hours	29 lb.	$1\frac{1}{6}$ in.	5 samples 8·60 15·50 18·10 8·50 13·30	 none ,, ,, ,, ,,	 10·90 3·90 1·40 10·70 6·30	Orsat.
*Rochdale . . .	May 20, 1895	95 in ordinary work	50 lb.	$1\frac{1}{8}$ in.	18·90 17·36 (2 tests)	Nil — —	·96 1·90	Orsat.
Lancaster . . .	February 7, 1902	$12\frac{1}{2}$ hours	$59\frac{1}{2}$ lb.	1·75 in.	15·5	—	—	Orsat.
Nelson . . .	February 19 to March 16, 1901	1 month $473\frac{1}{2}$ hours	29 lb.	1·50 in.	13·16	—	—	Orsat.
,, . . .	April 25, 1901	8 hours	$68\frac{1}{2}$ lb.	$2\frac{3}{8}$ in.	(30 readings) 14·40	—	—	,,
,, . . .	December 20, 1900	$9\frac{1}{2}$ hours	57 lb.	1·85 in.	12·21	—	—	,,
Hereford . . .	May 4, 1898	10 hours	54·88 lb.	1·45 in.	15·56 14·92	(20 readings) Nil	(20 readings) 5·40	Econometer.
	,, 5 ,,	$10\frac{1}{4}$,,	51·52 lb.	1·37 in.	16·84 16·83	(16 readings) Nil	(16 readings) 3·54	Orsat.
	,, 6 ,,	10 ,,	54·75 lb.	1·82 in.	16·27 16·38	(14 readings) Nil	(14 readings) 3·74	

* All doors open 8 inches.

FAN DRAUGHT.

Table Showing Percentage of CO_2 in the Gases of Combustion.

Town.	Date of Test.	Duration of Test.	Rate of Combustion per Square Foot.	Average Ashpit. Pressure Inches of Water.	Average % of CO_2.	% of CO.	Average % of Oxygen.	Apparatus Used.
St. Helens . . .	April 10, 1900	7 hours 20 min.	103 lb.	3·1 in.	(21 readings) 10·4	—	(20 readings) 9·16	Orsat.
Blackburn . . .	May 15, 1901	7 hours 40 min.	34·66 lb.	—	11·87	—	—	Orsat.
Warrington .	June 30, 1894	10 hours	59 lb.	2 in.	7·2	No trace	11·8	—
Metropolitan Borough of Wandsworth	February, 1903	120 hours	68·4 lb.	2·55 in.	7·93	25	12·25	Orsat.

proper regulation of the forced draught. If this balance does not exist, whatever system of forced draught is in use, cold air will enter when the doors are opened, the combustion, i.e. the percentage of CO_2, will suffer accordingly, and if the simple handkerchief test be applied, this, instead of hanging vertically inactive, will be sucked in the open door immediately.

Like the Rochdale figures, the Hereford figures are also of much interest, in this case the percentage of CO_2 being tested by means of the Econometer, as well as the Orsat apparatus. An Econometer is still in daily use at Hereford, giving a constant record of CO_2 in the gases. Further, at Hereford this remarkably high percentage of CO_2 is obtained, notwithstanding the fact that cold air is supplied to the blowers for combustion, while in the case of the latter installations included in the table such as Lancaster and Nelson, hot air was used.

Combustion and the Air Supply.

There can be no doubt that the more closely the cardinal principles governing combustion are adhered to, the better are the results obtained. Of course, the whole question of design and proportion is also closely involved, and demands careful attention, or it is impossible to obtain satisfactory results.

It has already been observed that the modern American Destructor is very unsatisfactory, and that this may be largely attributed to lack of knowledge and experience in design. Had Destructors in this country not been designed by those properly qualified, it is quite possible that our position would be but little better than that in America. This particular class of work, however, has always been recognized as a distinct branch of engineering, and this to a large extent goes to explain why our failures have been but few, compared with the many failures in America.

So long as the qualified and experienced engineer is recognized as being alone fitted for this special work, so long shall we progress. Even in more modest furnace work, again and again it has been shown that the inexperienced will not do, and that to engage one who is not a specialist is to court disaster.

Combustion in furnaces may be simply expressed as controlled chemical combination of the elements—carbon and hydrogen—in the refuse or fuel, with the oxygen of the atmosphere.

It may be also well to observe at the outset that unless perfect combustion is obtained, it is impossible to operate a Destructor satisfactorily, this must be the case whether the Destructor is a Destructor pure and simple, or whether the power is utilized.

Notwithstanding the absolute necessity for perfect combustion, it is a fact that five out of every six Destructor works in this country are without any apparatus for analysing or testing the gases of combustion. The composition of the gases is unknown; in many instances even where Destructors have been in operation for from ten to twenty years it is safe to say that the gases have never been tested.

In spite of this, any inquiry as to the possibility of imperfect combustion would only lead to an invitation to look into the cell, or main flue, perhaps to gaze at the chimney top. This may be satisfactory, or it may not, certainly it cannot be compared with actual analysis; a mere glance through an inspection hole, or even into an open door, can but very inadequately convey what is actually taking place in the way of effective combination of dissimilar elements. Again, even close scrutiny of the chimney top, while satisfying the layman, is but a poor index as to what is taking place in the cells.

It is of the highest importance that the air supply be so regulated that the excess of air supplied for combustion shall be as low as possible, closely conforming to theoretical requirements. Where this matter has received careful attention in connection with large steam power installations within recent years, a remarkable advance has been made, and a point of efficiency has been reached which is almost incredible.

When similar methods have been suggested in connection with Destructor installations it has been observed that such a high efficiency is not necessary, and that while it is perfectly reasonable to thus ensure the highest economy with coal, which is often costly to purchase, no such methods are worth serious consideration when refuse is being burned, because of its low calorific value.

Such a line of argument is not so reasonable as it may at first sight appear. If refuse is recognized as possessing a fuel value, it is surely worth while to ensure the yielding up of its maximum calorific power. It is a question of inefficient *v.* efficient combustion, *firstly*, and even as a Destructor pure and simple it is smportant that the combustion should reach the highest efficiency, while at the same time such a condition is essential for the best possible results in power production.

It is only by careful attention to the air supply that real efficiency can be attained, and the maximum efficiency is of great importance with the modern Destructor in order to render the same self-supporting.

Owing to the provision of very high and powerful chimneys, with the early Destructors the excess of air passing through the cells must in many cases have been enormous. With 2 per cent. only of CO_2 in the gases of combustion, the loss of heat would be about 65 per cent., owing, of course, to the heat taken up by the excessive volume of air supplied. With 9 per cent. of CO_2 in the gases the loss in this way would only be 15 per cent, and with 14·5 per cent. of CO_2 registered, the loss would be reduced to 10 per cent. To show a percentage as high as 14·5 per cent. constantly would be excellent practice, but nothing more than should be aimed at and insisted upon as being evidence of efficient combustion.

The diagram prepared by the late Mr. Bryan Donkin (see Fig. 36) serves to clearly show the loss of heat resulting from an excess of air as indicated by the percentage of CO_2 in the gases of combustion.

The two methods of analysis for determining the percentage of CO_2 in the combustion gases are, briefly, the gravimetric method, with which the percentage is determined by weight, and the volumetric method, giving the percentage by volume. The latter system, although demanding chemical knowledge, is more extensively used and gives very accurate results, the most popular apparatus being that known as the "Orsat."

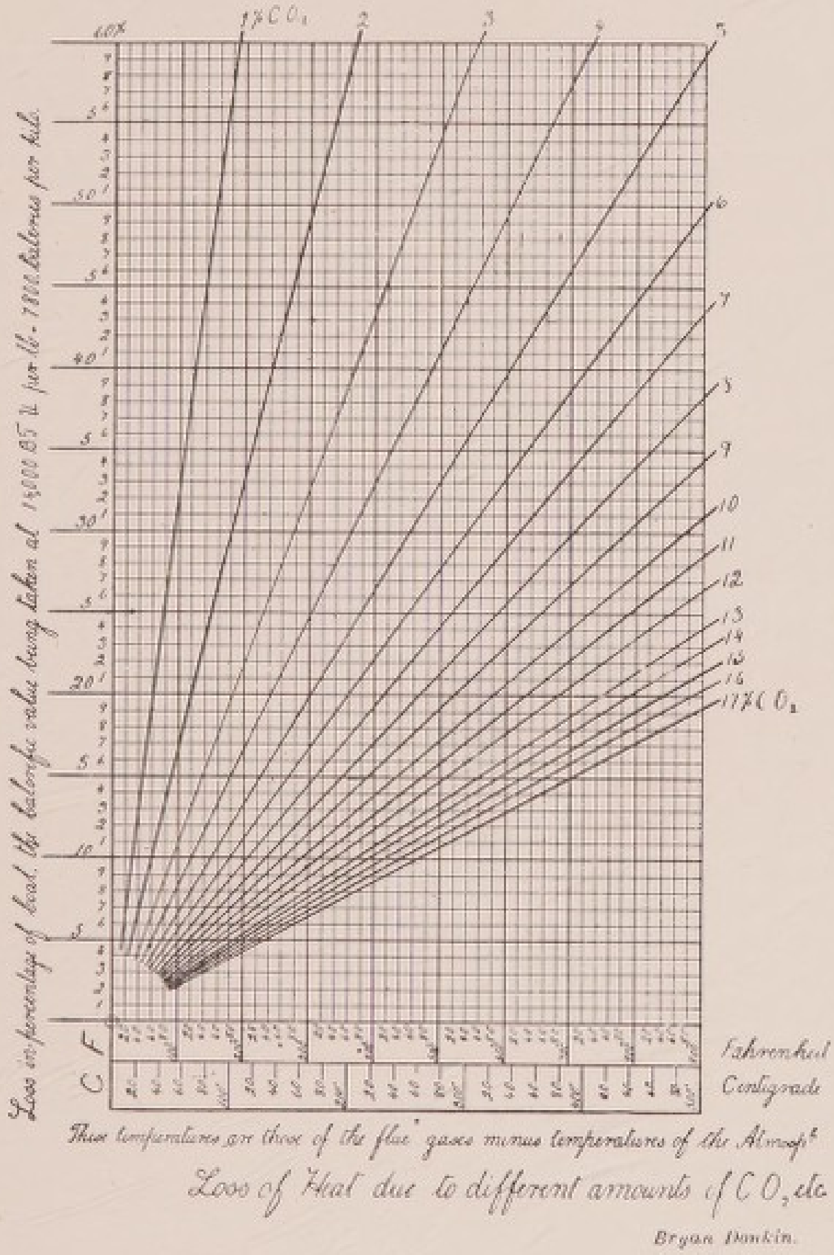


FIG. 36.

The gravimetric method is perhaps best represented by the "Econometer," an instrument which gives a constant reading of the percentage of CO_2 on a dial, and requires but very little attention.

A number of these instruments are in use in various parts of the country, in connection with steam boilers, and when tested with the Orsat apparatus for CO_2 the results practically agree.

THE USE OF HOT AIR FOR COMBUSTION.

The employment of heated air for combustion is perhaps one of the most useful departures in recent years in Destructor practice. While the real utility of this innovation is more manifest with the power Destructor, than with the Destructor pure and simple, there can be no doubt that in the case of the latter it is exceedingly beneficial.

The heating of air has been effected by two distinct methods only up to the present, the first being by means of side air-boxes, this system being peculiar to the Horsfall type of Destructor, and the regenerative system of air heating, first introduced with the Meldrum Destructor.

The two systems are entirely different in principle, the Horsfall air-boxes being placed on the sides of the firebars in the cell, firstly to prevent clinker adhering to the brickwork, for which purpose they are very effective, secondly to receive the air direct from the blast flue, and distribute the same under the grate.

It is obvious that the air, in its passage through the air-boxes, must have a cooling effect on the metal, in this way facilitating clinkering from the sides and protecting the walls of the cell; but unfortunately although this system has been in use for many years, no records are available as to the temperature to which the air is heated in passing through the air-boxes.

With Meldrum's Regenerative system the whole volume of hot gases, after leaving the boiler, is intercepted and caused to pass vertically downwards through a battery of staggered cast-iron pipes, the cold air for combustion circulates around the outer surface of the regenerator pipes, and is induced by the steam jet blowers to travel through a conduit connecting direct to the ashpits, where it is forced through the fire by the blowers.

A somewhat similar system of air heating has been adopted with the "Heenan" Destructor as part of Howden's system of forced draught, which has been employed so extensively with marine boilers.

It is well known that hot air has remarkable absorbent properties, and herein lies one great advantage in its use with the

Destructor, it rapidly absorbs moisture; so effective indeed has the regenerative system proved to be in this respect, that the drying hearth has been entirely dispensed with.

While the use of hot air not only dispenses with the necessity for a drying hearth with its perpetual distillation process, it enables very wet refuse to be readily dealt with without any difficulty, and this is very essential with the power Destructor, because for instance in the case of a sewage works, in time of flood or abnormal rainfall, when the pumping work would be much heavier, the refuse also being unduly wet, would be less useful as fuel.

With wet refuse on the drying hearth, and the forcing of the fires to meet the extra demand for steam, and cold air only available for combustion, the danger is that while the amount of steam required is three times that required for normal pumping, under the very unfavourable conditions it may be difficult to obtain even normal evaporation from the boiler.

The results obtained with the regenerative system have been in every way satisfactory, clearly proving that the combustion is more perfect, the temperature higher and more easily maintained. These features are perhaps more readily appreciated in connection with a power installation, but at the same time it must not be forgotten that such favourable conditions of high temperature working with but little fluctuation ensure perfect cremation, a vitreous clinker and an immunity from nuisance.

By the rapid absorption of moisture, the ignition point is reached so much earlier, and thus the whole cell is brought into an active state more quickly than can possibly be the case when hot air is used. Further, the air supply for combustion with hot air approaches more closely to the quantity theoretically required than is the case with cold air.

A few actual figures will doubtless be of interest, as showing the difference in the temperature of air for combustion, entering and leaving the regenerator; the former temperature may be taken as being approximately the temperature of the atmospheric air in the building at the time of the test, and accordingly represents the temperature at which the air would have been supplied to the cells had the regenerator not been in use.

Town.	Date.	Duration of Test.	Average temperature of Air entering Regenerator.	Average temperature of Air leaving Regenerator.
Darwen .	Sept. 30, 1899	48 hours	62° Fahr.	328° Fahr.
Nelson .	Dec. 20, 1900	9½ hours	Average of 19 readings, 64° Fahr.	346° Fahr.
Nelson .	Feb. 19 to March 16 1901	473½ hours continuous		243° Fahr.
Nelson .	April 25, 1901	8 hours	Average of 29 readings, 82° Fahr.	394° Fahr.
Lancaster .	Feb. 7, 1902.	12 hours 26 min.	62° Fahr.	478° Fahr.

These figures will serve to clearly show that the air for combustion in its passage through the regenerator chamber is highly heated, and as this heat is abstracted from the gases after they have passed the boiler, it is so far a net gain, as unless an economiser be installed, the volume of the heated gases would pass direct from the boiler to the chimney.

Experience has clearly shown that a Destructor supplied with hot air usually discharges the gases even from an amply large boiler at a sufficiently high temperature not only to heat the air supply passing through the regenerator chamber, but also to efficiently heat the boiler feed water in an economiser.

It will thus be seen that not only is the initial or cell temperature considerably higher when hot air is used, but the fluctuations in temperature are confined within much narrower limits, and lastly, the ultimate temperature must obviously be higher. The ultimate temperature or the temperature beyond the boiler is a matter of importance, because, as has been already observed, the waste gases are of value for other purposes after actual steam raising.

Chapter XIV

SPECIAL POINTS IN DESIGN FOR SECURING AND MAINTAINING HIGH TEMPERATURE AND STEADY STEAMING

IN a critical analysis of design and construction it becomes necessary to separate Destructors into at least two distinct groups. *Firstly*, we have single cell systems represented by the "Horsfall," the "Fryer," the "Warner," and the "Baker" patents.

By single cell systems is meant any arrangement of cells either in single row, or back to back, in a block, or arranged with a boiler between every two cells. In short every arrangement of Destructor cells which does not provide for the intermingling of the gases from two or more cells, either in the cell or cells, or in a combustion chamber common to both, or all of the cells.

In the second group must be placed all systems embodying in a lesser or greater degree the principle of "mutual assistance." In this group we have Meldrum's system of "continuous grate." and also their Improved Beaman & Deas type, which has always been known as a system of erecting cells "in pairs," with a combustion chamber common to each pair of cells; Heenan's system of "Twin Cells" also having a common combustion chamber for one or two pairs of cells; and lastly the "Sterling" destructor, likewise designed on "the pair" principle, and having a central combustion chamber.

Although divided into distinct groups, a great variety in design will be found in each group. It is unnecessary to discuss the details of design here, the special features of each make being described in another chapter.

As already indicated, each group embraces various makes, embodying two distinct principles. A careful study of the matter has led the author to the conclusion that the principle here defined is to a far greater extent responsible for the varying degrees of efficiency than mere details in design and construction.

It has been said that it is impossible to secure a high temperature in the cell; this is an erroneous idea—it is quite possible to secure and maintain a high temperature in the cell, but this can only be effected by designing the cell in such a manner that it shall never be idle. With systems conforming to this principle the highest degree of mutual assistance is embodied, and theoretically such systems should be the most perfect as Destructors, because of the maintenance of a high temperature *in the cell*, and most efficient as power producers, because such maintenance of high temperature *in the cell* ensures a constant supply of hot gases to the boiler, the temperature of the gases being high and well maintained.

Following on similar lines, the types which next most closely approach the principle of "mutual assistance" are cells erected in pairs, but in the case of these there is a distinct difference, each cell is idle for clinkering and charging alternately, and it is therefore impossible to maintain a high temperature constantly in either of the cells, but the principle of design, and the alternate system of charging and clinkering ensures the maintenance of a high temperature in the combustion chamber, which as already pointed out is common to a pair of cells.

With all systems of single cells, whether the cells are arranged in single row, back to back, or on either side of a boiler, each cell, *as a cell*, is isolated and entirely distinct from its neighbour. In the ordinary alternative system of working, an idle cell is in turn of necessity next to an active cell, and we may assume that in the case of the former, after clinkering and charging, the temperature will be fully 1,000° Fahr. below that of its active neighbour.

Out of a battery of four such cells, three may be in full work while one is being clinkered and charged, but the inactive cell can derive no benefit from its active neighbour on either side, excepting in so far as the whole volume of gases intermingle in a common main flue *beyond the cells*.

Ten years since Sir Alex. R. Binnie and Dr. Shirley F. Murphy, in their report to the London County Council on Refuse Destructors, expressed their opinion as follows—[1]

> In our opinion any arrangement which makes it possible for the imperfectly heated gases from drying refuse to escape into the flue without being compelled to pass through the hottest part of the furnace is an imperfect one. It is true that such gases may be completely burned by subsequent exposure to the heat of a cremator, but the most satisfactory and economical method appears to be to secure the most complete combustion possible *in the cell itself*.

The foregoing report, while showing that the value of the front exhaust was fully appreciated, clearly carries with it a further meaning. It is suggested that the most complete combustion possible should be secured *in the cell itself*. Precisely, and to ensure this it is of the utmost importance to secure and maintain a high temperature *in the cell itself*.

Too much importance cannot be attached to the question of complete combustion *in the cell*. The safeguards beyond the cell may be ample, and in every way satisfactory, but it is of primary importance that we begin at the beginning. If complete combustion be secured in the cell, then it matters not what may, or may not, happen beyond the cell in the main flue, combustion chamber, or immediately under the boiler tubes as the case may be. That the intermingling of the gases in the main flue may not be entirely satisfactory in maintaining a continuity of high temperature in the case of smaller installations is very obvious to the close student of design, and as a very large number of installations in this and other countries must necessarily be but small, the question is one of considerable importance.

[1] See *Report on Dust Destructors to the London County Council*, dated May 10, 1903. By Sir Alexander Binnie and Dr. Shirley F. Murphy, M.O.H.

Mr. Frank Watson, A.M.I.C.E., in a paper read at Dublin in August, 1898, remarked as follows—[1]

> It is found that when a considerable number, *say six cells or more*, are combined in one block, the mixing of the gases from the various furnaces ensures a very steady and very high temperature in the main flue, and it is therefore always found advisable to construct the furnaces in blocks in this manner rather than to divide them up and put boilers between them.

This would appear to clearly emphasize what has already been said concerning the vital importance of ensuring complete combustion in the cell itself, whether the installations be large or small.

In thus making close comparison there is no intention to unduly criticize any particular make of Destructor or to direct invidious comparison between any two makes. The issue is broader, it is a question of principle and design, a question of suitability for most effectually securing a continuity of high temperature within the cells. Mr. Frank Watson's statement which I have already quoted is in itself an admission of the weakness referred to.

Too much attention cannot be given to the actual work *within the cell;* there the work should be done, and if the cell temperature is well maintained we need not trouble about what may happen beyond the cell. Continuity of high temperature is demanded as the working condition of the cell; we may point to a main flue or a combustion chamber, even as many years since we were invited to look at the cremator, to see evidence of heat, when we failed to see such evidence in the cell.

It has been said that each single cell—one of a row or block—should not be considered as distinct in itself, but as part of a whole. While it is true that each single cell discharges its gases into a main flue common to the whole, yet this is the one and only point of connexion. *As a cell*, each cell is distinct, and separate from the cell on its right or left, and it is impossible for one cell, as a cell, to derive any assistance from any other cell in

[1] See Paper read by Mr. Frank Watson, A.M.I.C.E., at Dublin Congress of the Royal Institute of Public Health, August, 1898.

the row or block as the case may be, excepting in so far as the whole volume of gases commingle in a main flue beyond the cells.

In the case of the two makes with which the principle of "mutual assistance" has been most fully developed, the drying hearth has been entirely dispensed with. With Heenan's "Twin Cell" the drying process takes place in each cell alternately, and with Meldrum's "continuous grate" the drying process is carried on in different parts of the one cell from end to end successively, as charged.

The striking difference between these two makes and single cells will be at once apparent; in the former case, the drying or evaporation of moisture is more rapid; further, instead of slow distillation of volatile gases, the process is accelerated and the volume of low temperature volatile gases, at all times very small by comparison with the very large volume of high temperature gases present, must quickly ignite in the cell.

The drying hearth, as distinct from the grate proper, is an integral part of the cell in every system of single or isolated cells. It therefore follows that, in addition to cremating its charge of refuse, each cell has another function, and one which is to some extent antagonistic to the main purpose. Owing to the presence of a quantity of ordinary refuse on the drying hearth in the cell, there must be a definite loss in temperature owing to the constant absorption of heat by the escaping gases distilled from the drying hearth.

Each single or isolated cell is therefore called upon to fulfil two objects at the same time, viz., drying or slow distillation of volatile gases, and cremation or combustion. The former is a constant process in *every such cell*, the latter process being broken by the intervals of burning down, or reduced activity during clinkering, and charging.

While it will be obvious that a dry charge pulled from the drying hearth is so far beneficial, it must be equally clear that the dry charge is only obtained at a sacrifice of the cell temperature as a whole, and therefore the drying hearth is by no means so advantageous as is commonly supposed.

An easy continuity of high temperature working being a matter of supreme importance, even if the *desideratum* be cremation pure and simple, it might be reasonably urged that in order to secure the first essential, it would be worth while, if found necessary, to make a sacrifice in another direction. It will, how-

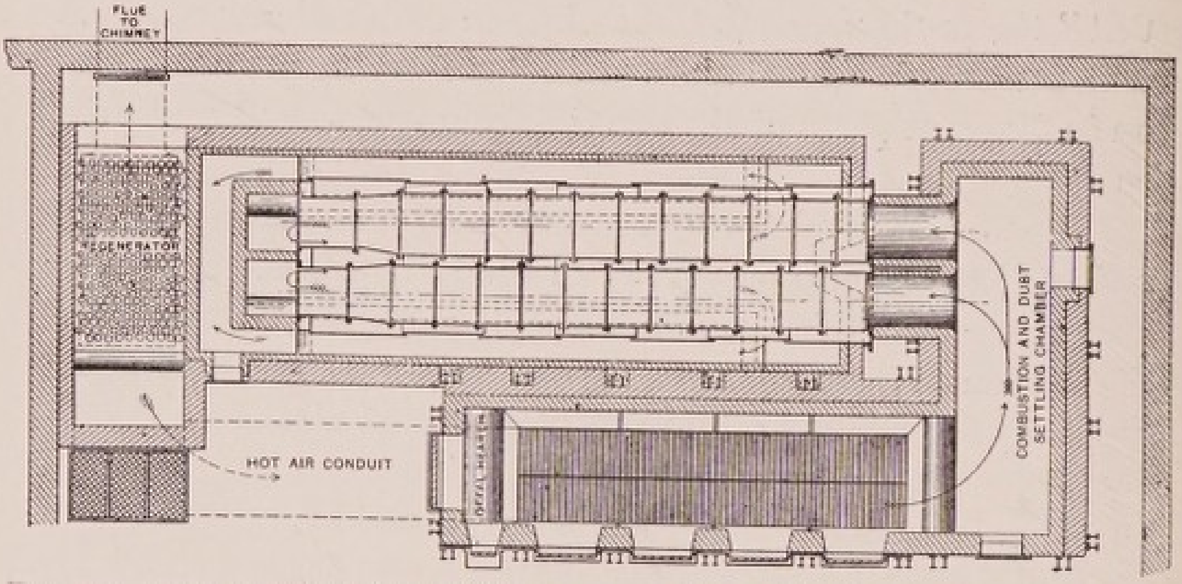


Fig. 37. Meldrum's Patent "Continuous Grate"—the equivalent of four ordinary cells. The gases have a sideway motion into the Combustion Chamber, thence to the Boiler.

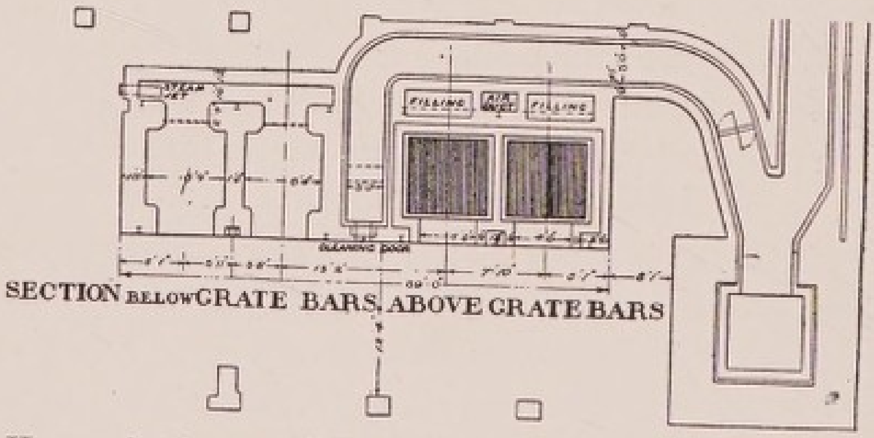


Fig. 38. Heenan's Patent "Twin-Cell"—the equivalent of two ordinary cells. The gases usually have a sideway motion into the Combustion Chamber, thence to the Boiler.

ever, be readily observed that in effectually securing an easy continuity of high temperature working, no sacrifice is involved either directly or indirectly, but, on the other hand, the gain is very material and comprehensive.

Firstly.—Owing to the minimum of fluctuation in the cell temperature, the cell as a structure suffers less, being subjected to the minimum of strain from expansion and contraction.

Secondly.—Nuisance, in the way of escaping noxious fumes, is absolutely impossible.

Thirdly.—The continuity of high temperature working is of the highest importance when the Destructor is combined with a power plant, because—

(*a*) The maximum evaporative efficiency is secured, and

(*b*) The steam pressure is kept steady, which is desirable in every case where the power is fully utilized, but imperative where steam is supplied to an electricity works.

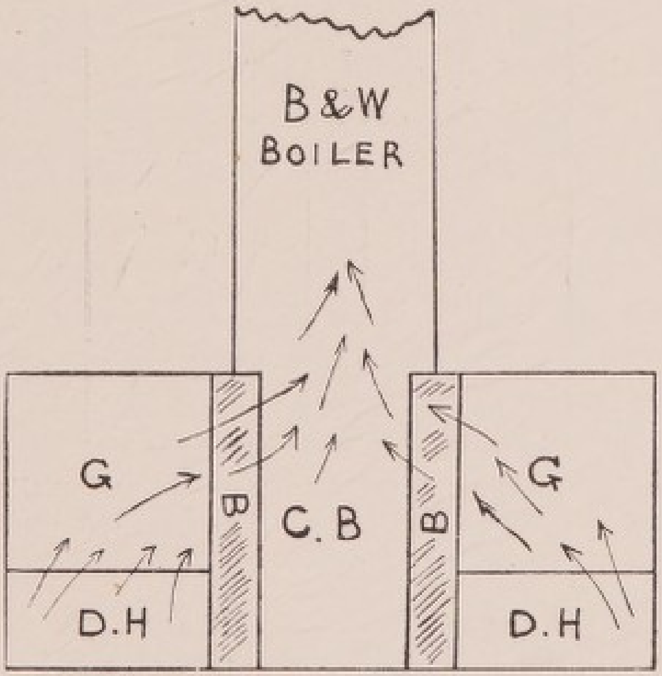


Fig. 39. The Sterling "Pair-Cell" System, with Combustion Chamber arranged centrally, the gases passing from the right and left hand cells into the Combustion Chamber, thence to the Boiler.

Steadiness in steam pressure is only possible when the gases coming into contact with the heating surface of the boiler are steady in temperature, and so, to go back to the beginning, steady temperature of the gases at the boiler is only possible by ensuring steady temperature of the gases *in the cell or cells* as the case may be.

Those who may consider that too much stress is laid upon the necessity for perfect combustion *within the cell*, should not forget that if unconsumed gases once reach the chimney, nothing can be done to avoid nuisance, such gases being heavier than air will certainly descend after cooling.

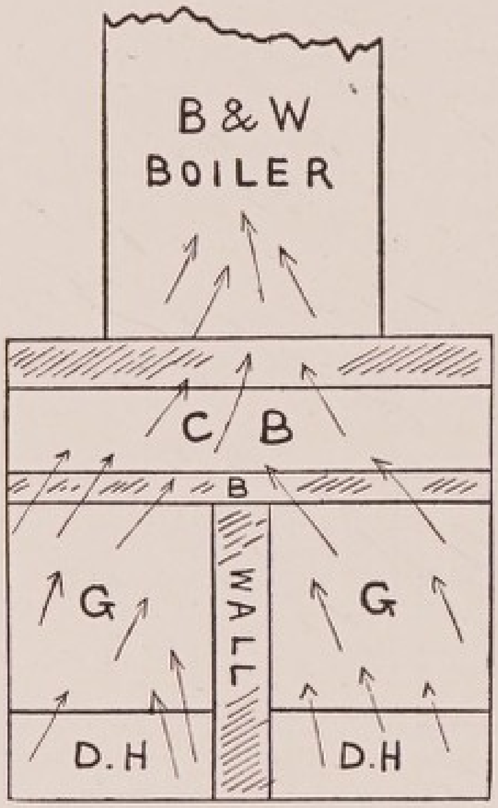


FIG. 40. MELDRUM'S "BEAMAN & DEAS" TYPE "PAIR-CELL" system. The gases passing from the right and left hand cells into the Combustion Chamber behind, thence to the Boiler.

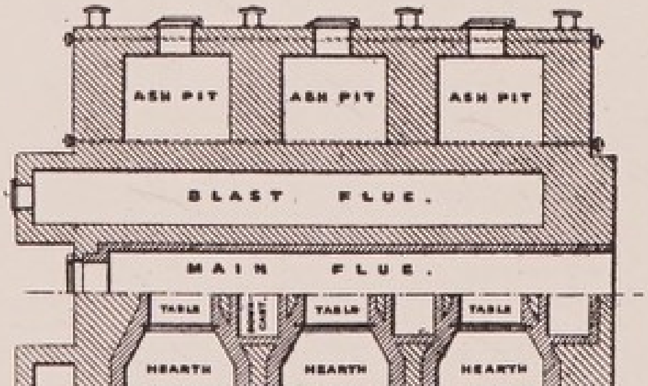


FIG. 41. HORSFALL'S TOP FED TYPE, arranged back to back, in a block, the boiler or boilers being placed at the right hand end of the main flue. Each cell is separate and distinct, the gases therefrom leaving at the front and passing into the main flue at the back, thence to the boiler.

Having this clearly in mind, and realizing its importance, is it not advisable to begin at the beginning, aiming at an *initial high temperature?* If this be done, then nuisance is rendered

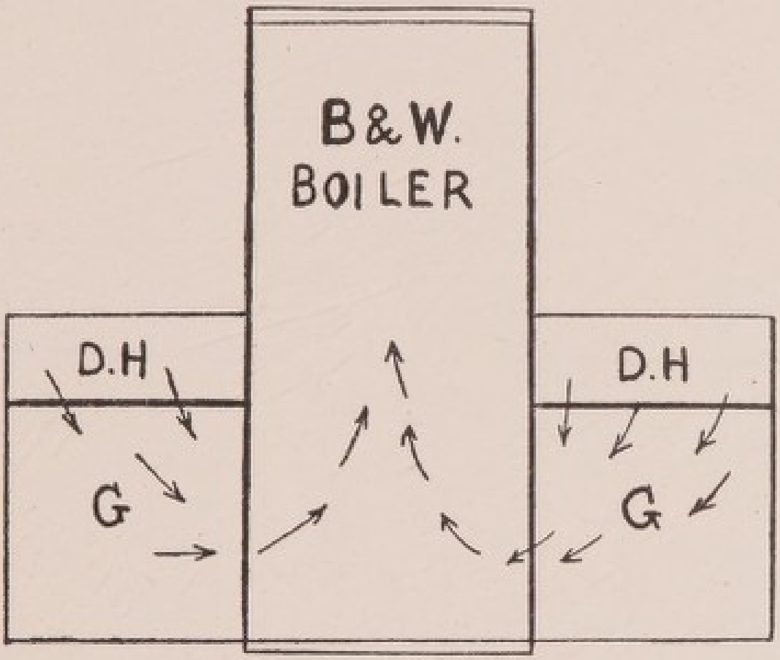


FIG. 42. FRYER'S "IMPROVED" TOP FED TYPE—a Babcock & Wilcox boiler being set between two cells. The gases upon leaving the cells come into immediate contact with the boiler tubes.

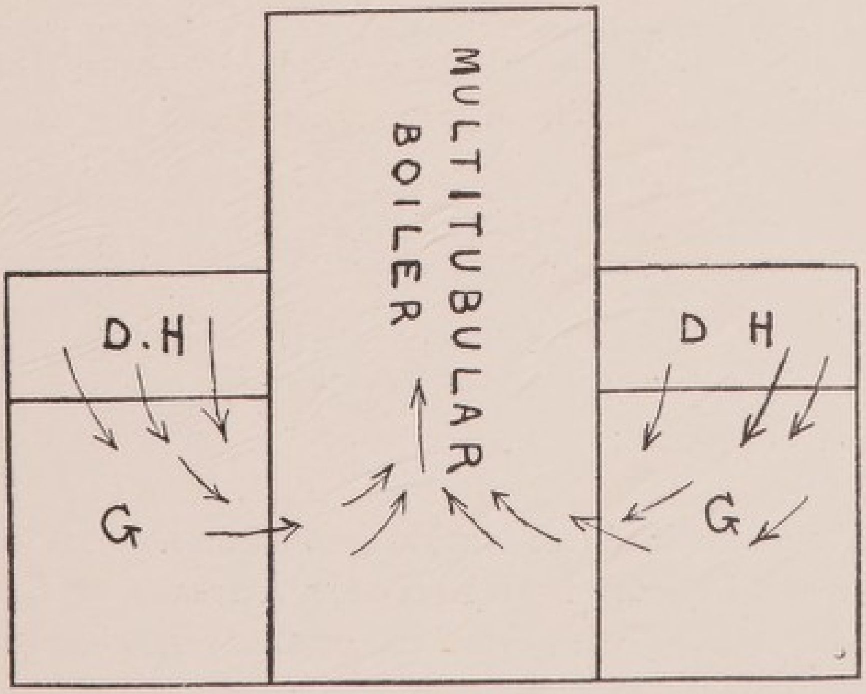


FIG. 43. WARNER'S "PERFECTUS" TOP FED TYPE, a Multitubular boiler being set between two cells. The gases upon leaving the cells come into immediate contact with the boiler.

absolutely impossible, and the theoretical advantages of such a principle are fully realized in practice.

Figs. 37 to 44 are in plan, and for the most part diagrammatic only, but they will serve to show the salient features in design

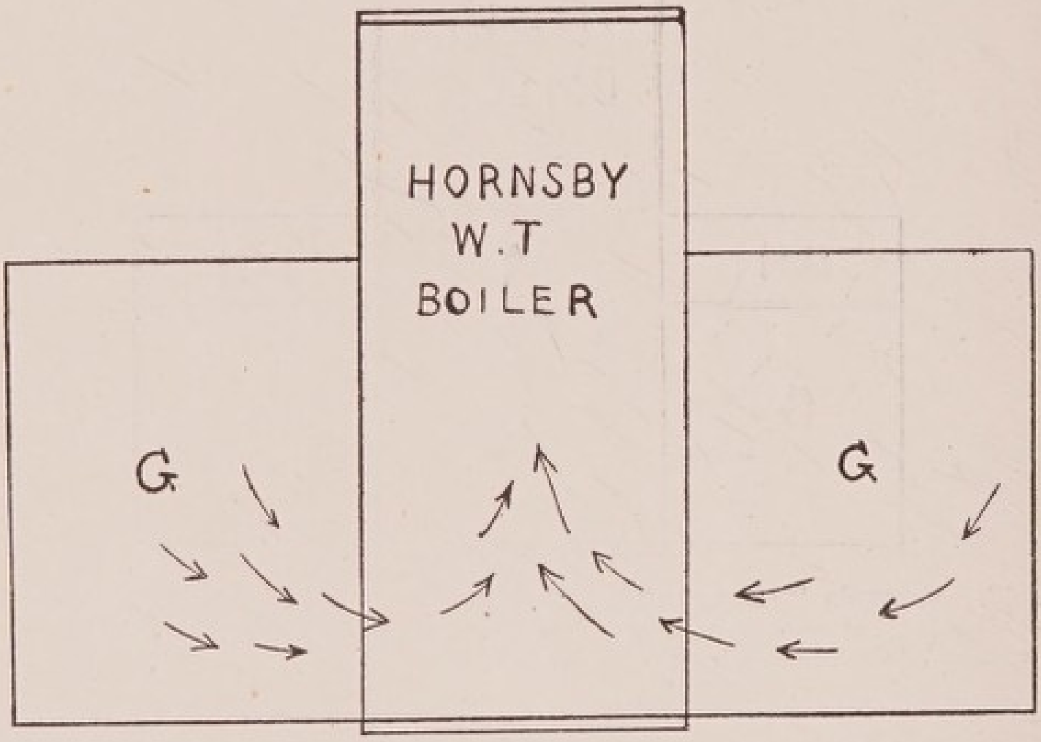


FIG. 44. BAKER'S "IMPROVED" TOP FED TYPE, a Hornsby boiler being set between two cells. The gases upon leaving the cells come into direct contact with the boiler tubes.

G. = Grate.
D.H. = Drying Hearth.
C.B. = Combustion Chamber.
B. = Bridge.
The arrows in each case indicate the course of the gases from the cell to the boiler.

which have for their object " mutual assistance." In the case of the single cell systems it will be observed that no combustion chamber is provided, with three different systems the gases from a pair of divided or isolated cells commingle when immediately under the boiler.

Taking the four systems in the other group, it will be observed that with two makes the gases must commingle in the cell, and still further in the combustion chamber, while with the two other makes in this group the provision of a common combustion chamber ensures the intermingling of the gases before the boiler is reached.

Chapter XV

THE COMPARATIVE ADVANTAGES OF VARIOUS TYPES OF STEAM BOILERS FOR USE WITH DESTRUCTORS

THIS work would be incomplete without some reference to the boiler question. A careful perusal of all the available literature on the subject would seem to indicate a strange reluctance upon the part of the various writers to express any decided views concerning boilers.

Generally speaking, the choice lies between Lancashire and Water Tube boilers. A number of Cornish boilers are used for small installations, and also not a few Multitubular boilers, but boilers of the latter type are unsuitable and inefficient, and are no longer adopted in connection with modern high temperature Destructor installations.

An effort has been made to introduce "Dry Back Marine" or "Fire Tube" boilers, but this type has not yet been tried, neither Municipal authorities nor Destructor makers apparently caring to make the experiment. Although this type of boiler would undoubtedly prove to be more efficient than the multitubular type, yet serious and constant trouble would undoubtedly be experienced, owing to the rapid accumulation of dust in the tubes. Further, as at present designed, it may be gravely doubted whether anything like sufficient area would be available for the passage of the gases from a Destructor of reasonable size.

Referring to the multitubular boilers in use with the Destructor at Ashton-under-Lyne, Mr. Neville Applebee wrote as follows :—

"The $3\frac{1}{2}$ inch fire tubes in the mulitubular boilers get rapidly choked and seriously reduce the effective heating surface."[1]

Even if the area will permit of a reasonably large volume of gases being passed through the fire tubes, the question of dust deposit has still to be faced. In spite of all reasonable attention, the heating surface is never clean and wholly exposed for many hours at a time.

In considering the question of suitable boilers it will therefore be clear that the choice must be between Water Tube, Lancashire, and Cornish boilers. As already observed, however, the use of Cornish boilers is limited to small installations such as Destructors combined with sewage works, the steam being used for pumping purposes, and the work usually being of a steady character.

For work of this kind, the Cornish boiler is very suitable, in fact it would be difficult to improve upon the results obtained, and so far as one is able to judge, under such circumstances, nothing would be gained by substituting water tube boilers for Cornish boilers. In larger combined sewage and Destructor works, Lancashire boilers have been mostly installed, and experience has shown that this type of boiler is well adapted for the work.

The more critical test of the boiler is in connection with the combined Destructor and electricity works, but it will frequently be found exceedingly difficult to make comparison between water tube and Lancashire boilers, owing to the great variety of working conditions. It may, for example, be reasonably submitted that fair comparison cannot be made between the results obtained with one water tube boiler working in connection with a four grate unit Destructor of the hand fed type and another water tube boiler working in connection with four single cells of the top fed type. The difference in boiler efficiency may be entirely due to the radical difference in the design of the two Destructors, and this being so, it would be manifestly unfair to adversely criticize the performance of the boiler.

[1] See the *Electrician*, December 5, 1902.

While the reader may with advantage compare the various steam pressure diagrams herein reproduced, it would be idle to pretend that these diagrams are conclusive, nevertheless, such charts clearly emphasize the general superiority of the Lancashire boiler for steady steaming. The steam pressure charts cover a wide variety in design and, likewise, a variety of working conditions, but every chart here included represents ordinary working conditions, and is therefore of value for purposes of comparison.

In studying the diagrams, the student must be impressed with the unsteady steaming shown with water tube boilers. It will be observed that in some cases the percentage of fluctuation is very serious indeed.

To briefly summarize the comparative advantages of water tube and Lancashire boilers. In the case of the former, it is possible to instal a greater amount of heating surface in a given space, and a greater absorption of radiant heat is ensured than is the case with the Lancashire boiler. Then the question of space is often a very serious one, more particularly, perhaps, in London, and in other large cities and towns where land is valuable.

The Lancashire boiler has large steam and water space and also possesses the merit of extreme simplicity, both of which are features of great importance. The large steam and water space is of the highest utility, making as it does for steady steaming, which is essential where the power is being used for electrical purposes.

The water tube boiler while being a rapid steam raiser, is also a rapid steam loser, possessing but a limited amount of steam and water space. On the other hand, the Lancashire boiler, by reason of its large storage capacity for steam and water, has a goodly reserve of power, which is of immense value in connection with the power Destructor, being a most useful set off against possible fluctuations in the quality and condition of the refuse, and also laxity on the part of the men, as will happen occasionally.

One of the highest authorities on steam boilers in this country, Mr. C. E. Stromeyer, M.I.C.E., recently expressed the following opinion concerning the comparative advantages of various types of steam boilers :—[1]

> I will conclude by remarking that, as matters stand at present, Lancashire boilers with economisers are doubtless the most efficient as regards economy and upkeep, but they occupy much floor space. Marine boilers, of course without economisers, are nearly as efficient, and seem to require practically no repairs. They occupy about half as much floor space as Lancashire boilers, but cost considerably more. "Economic" and Water Tube boilers are practically on a level as regards economy and floor space. In both cases the heavy brickwork is a constant source of loss through air admission.

While it is true that Mr. Stromeyer's remarks specifically refer to boilers fired with coal, yet his conclusions are equally applicable to boilers fired with Refuse Destructor gases. In the latter case, however, marine type and "Economic" boilers would necessarily be less efficient for reasons already explained, i.e. the constant choking up of the tubes with dust.

It is unnecessary to deal at any length here with the question of feed water, it being now clearly recognized that where the water is of a sedimentary nature a water purifying apparatus must be installed with a water tube boiler, and where the comparative cost of Lancashire and water tube boilers is being considered, the cost of such apparatus should be added to that of the latter type.

That there is a field for both types of boiler is beyond question ; each has advantages not possessed by the other, and likewise disadvantages. For many small electricity undertakings the water tube boiler will always be popular, lending itself as it does to supplementary coal firing, and thus in the early days of small electricity undertakings saving the cost of at least one separate coal fired boiler.

As with the type of draught, so with the type of boiler, the subject will always be a controversial one, but alike in both cases all the advantages are by no means on the one side.

[1] *The Choice of a Steam Boiler.* By C. E. Stromeyer, M.I.C.E., Chief Engineer, Manchester Steam Users' Association. See *Proceedings of Civil and Mechanical Engineers' Society*, 1903.

Chapter XVI

REFUSE DESTRUCTORS IN THE METROPOLITAN BOROUGHS, LONDON

COMPARATIVELY speaking, very slow progress is being made in the Metropolitan Boroughs in the final and sanitary disposal of refuse. In so large a city this is to be regretted, the more so, perhaps, when it is borne in mind that the other methods of disposal in vogue are very costly, and generally speaking unsatisfactory.

It cannot be deemed satisfactory when large Metropolitan Boroughs inflict their filth upon other smaller communities in Urban Districts, and such a method does not even possess the saving grace of economy. The system is most expensive, and it has been clearly demonstrated wherever Destructors have been erected, with the exception of Battersea, that the cost of disposal has been materially reduced.

In the case of Battersea, it is not the system which is at fault. The Destructor was erected some fifteen years since, on a site which has in the course of time proved to be anything but central. The Battersea of to-day is so thickly populated, and has so extended in other directions, that the Destructor site which fifteen years ago was reasonably central, is now in a corner of a large Borough, and so the cartage cost has increased alarmingly.

With this single exception the destruction of refuse within the Borough where it is produced has been beneficial to the ratepayers financially, although they may not always recognize it as such.

A glance at Fig. 45 will at once make clear the actual progress which has been made up to the present. It is safe to say that ten years hence it will be possible to present a very different chart. So increasingly difficult is it becoming to get rid of London's waste that the Destructor is generally recognized to be the only solution. It is quite certain that if it were not possible to inflict the filth upon Urban communities, the London of to-day would be far better equipped with Destructors than is the case.

Fig. 45.

The Metropolitan Boroughs.

D=Destructor in use.
DE=Destructor combined with electricity works in use.
Hatched Sections=Boroughs without Destructors.

There are distinct signs that the present method of mere riddance will have to cease. It is becoming increasingly evident that small Urban communities strongly object to being made the dumping ground of the stale filth of London, and when these small communities adopt Destructors to deal with their own waste, as they are now rapidly doing, it is only reasonable to expect that difficulties will arise, and that the available dumping grounds for London's filth will gradually diminish, as is indeed the case already.

A = Date of Erection.
B = Make and Type of Destructor.
C = Number of Cells.
D = Number and Type of Boilers.
E = Height of Chimney.
F = Type of Draught used.
G = Purpose for which Power is used.
H = Weight of Refuse Destroyed Daily.
I = Labour Cost per Ton of Refuse Destroyed.
J = Average Number of Board of Trade Units Generated, per Ton of Refuse Destroyed.

E.W. = Destructor combined with Electricity Works.
S.W. = Destructor combined with Sewage Works.
E.W.S.W. = Destructor combined with both Electricity and Sewage Works.

BATTERSEA—POPULATION, 168,907.

A . . .	1888.
B . . .	Fryer's top fed.
C . . .	12.
D . . .	1 Multitubular.
E . . .	180 feet.
F . . .	Natural draught only.
G . . .	Clinker crushing, etc.
H . . .	60 tons.
I . . .	2*s*.

BERMONDSEY—POPULATION, 130,486.

TWO INSTALLATIONS.

	1.	2. E.W.
A .	Rotherhithe, 1899.	Bermondsey, 1902.
B .	Meldrum's "Beaman & Deas" top fed.	Sterling top fed.
C .	2	6[1]

[1] It has recently been decided to erect two additional cells.

D .	1 Babcock & Wilcox.	3 Babcock & Wilcox.
E .	150 feet.	150 feet.
F .	Fan.	Fan.
G .	Fan engine, Works Lighting, and Disinfector	Electric Lighting and Public Baths.
H .	25 tons.	80 tons.
I .	1s.	—

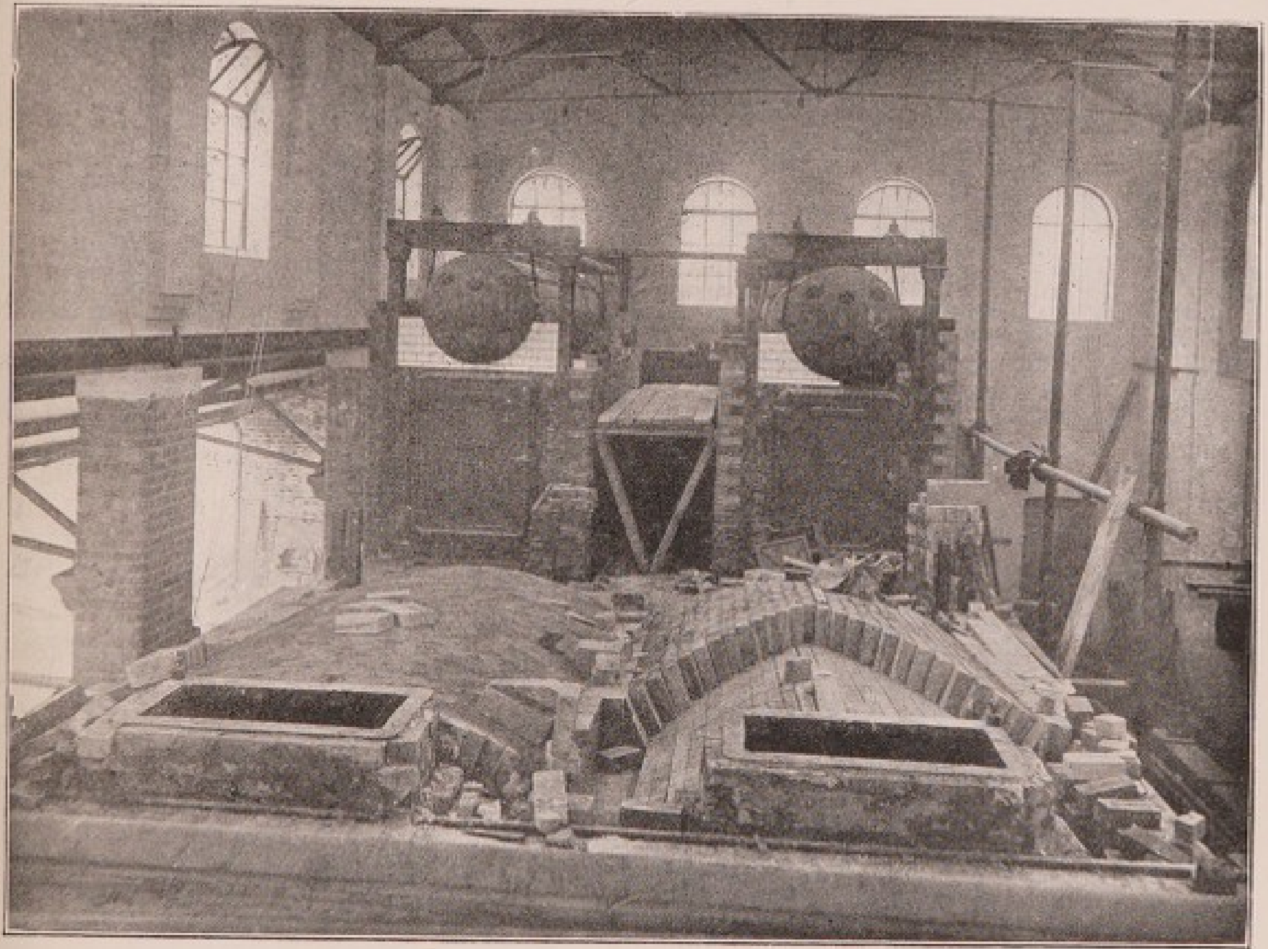


Fig. 46. Rotherhithe Destructor.
In Course of Erection.

The three Babcock & Wilcox boilers in connection with the Destructor are arranged for coal firing, either in conjunction with or independently of the gases from the Destructor, while additional coal fired boilers are also installed.

The power equipment of the station is as follows:—three Willans' engines, direct coupled to three Thames Iron Works

Dynamos, of a total capacity of 375 K.W. Tudor cells are also provided, having a capacity of 24 K.W. for 6 hours.

This combined works has a very successful record, largely due to the excellent day load. The following details are taken from a report covering the first nine months' working, ending in March, 1903.

The steam supplied to the Public Baths effected a saving in wages and coal of £541. The sum of £272 was saved by destroying trade refuse as compared with the previous cost of barging this material away. A portion of the clinker was utilized for making paving flags at a cost of £427. To purchase a similar quantity of flags would have cost £1,521. Some 600 tons of clinker was also used for making concrete at a saving of £58.

Figure 46 is a view of Meldrum's Beaman & Deas type of Destructor in course of erection at Rotherhithe.

City of London—Population, 37,705.

Letts Wharf Destructor.

A . . .	1884.
B . . .	Fryer's top fed.
C . . .	10.
D . . .	1 Multitubular.
E . . .	150 feet.
F . . .	Natural draught only.
G . . .	Hoist, and chaff cutting.

During the year 1902 the Destructor was in constant use both day and night, with the exception of stoppages, totalling 84¼ days, for repairs and flue cleaning. 26,245 loads of refuse were destroyed, yielding a residuum of 4,737½ loads of clinker and ashes.

Negotiations are just now being concluded for the purchase of 130 acres of land at Hornchurch Marshes, near Barking, having a river frontage of 1,700 feet. This land, which will cost the city £23,411, will be used as a Refuse tip.

FINSBURY—POPULATION, 101,463.

TWO INSTALLATIONS.

	1	2
A .	St. Luke's, 1899.[1]	Phoenix Wharf, 1899.
B .	Horsfall's top fed.	Baker's top fed.
C .	6.	2.
D .	1 Multitubular, 14 ft. by 8 ft.	1 Hornsby Water Tube.
F .	Steam Jet Blowers	Fan.
G .	Clinker Crusher, Mortar Mill, Works Lighting.	Fan Engine only.
H .	50 tons.	15 tons.[2]
I .	8½*d*.	

Some details of analytical tests of the gases taken both from the main flue and chimney at installation No. 2 (Baker's Destructor) are here given :—

GASES FROM MAIN FLUE (5 samples), analysed by Mr. J. Kear Colwell, F.I.C., March 7, 1902.

No. of Sample . . . Time of Collection . .	A. 3.50 p.m.	B. 4.5 p.m.	C. 4.20 p.m.	D. 4.45 p.m.	E. 5.5 p.m.
Pyrometer reading .	515° F.	550° F.	550° F.	550° F.	560° F.
Carbon Dioxide . .	7·0%	5·6%	4·3%	5·9%	7·6%
Carbon Monoxide .	0·0%	0·0%	0·0%	0·0%	0·0%
Oxygen	12·2%	12·0%	14·3%	12·0%	11·0%
Nitrogen	80·0%	82·4%	81·4%	82·0%	81·4%
Olefines and Heavy Hydrocarbons .	0·4%	0·0%	0·0%	0·0%	0·0%
Marsh Gas . .	0·4%	0·0%	0·0%	0·0%	0·0%
Percentage of Free Air	58·1%	57·1%	68·1%	57·1%	52·3%

[1] This installation replaced a six-cell plant of another make erected in 1895.

[2] A sorting process is carried on at these works, and the weight of material destroyed daily varies considerably. Only paper, cardboard, straw, garbage, etc., is destroyed, the heavy material being abstracted.

GASES FROM CHIMNEY (6 samples), analysed by Mr. J. Kear Colwell, F.I.C., February 26, 1902.

No. of Sample . . Time of Collection .	A. 1.30 p.m.	B. 2.20 p.m.	C. 3.20 p.m.	D. 4.5 p.m.	E. 4.30 p.m.	F. 5 p.m.
Pyrometer reading .	350° F.	410° F.	410° F.	410° F.	430° F.	440° F.
Carbon Dioxide .	5·1%	5·7%	1·8%	3·2%	3·6%	5·0%
Carbon Monoxide .	0·4%	0·0%	0·0%	0·0%	0·0%	0·0%
Oxygen . . .	14·2%	13·4%	14·8%	14·4%	14·0%	13·8%
Nitrogen . . .	79·9%	80·9%	83·2%	82·4%	82·0%	81·0%
Olefines and Heavy Hydrocarbons	0·4%	0·0%	0·2%	0·0%	0·4%	0·2%
Marsh Gas . .	0·0%	0·0%	0·0%	0·0%	0·0%	0·0%
Percentage of Free Air	67·6%	63·8%	70·5%	68·6%	66·6%	65·7%

E.W. FULHAM—POPULATION, 145,000.

A . . . 1901.
B . . . Horsfall's top fed.
C . . . 12.
D . . . 6 Babcock & Wilcox.
E . . . 100 feet.
F . . . Steam Jet Blowers.
G . . . Electric Lighting.
H . . . 100 tons.
I . . . 1*s.* 6·88*d.*[1]
J . . . 26·62.[1]

The six water tube boilers working in connection with the Destructors are arranged in a battery between two blocks of cells. These boilers are also equipped with mechanical stokers and forced draught, so that the boilers may be coal-fired either independently of or in conjunction with the Destructor gases.

Three boilers of the dry back marine type have since been installed for coal-firing only. Green's economisers are also provided in two batteries of 96 pipes each.

The power equipment of the station is as follows—Three Musgrave slow speed, compound engines, total H.P., 1500, direct coupled to three two-phase General Electric Company's Oerlikon Dynamos ; total capacity, 900 K.W.

[1] Average for the year 1902.

Mr. A. J. Fuller, the Borough Electrical Engineer, recently prepared a report for the Electricity Committee, reviewing the operation of the Destructor for the year 1902. A few extracts from this report will doubtless be of interest—

Total weight of Refuse burned	30,000 tons.
Total weight of Clinker barged away . .	16,000 ,,
Cost per ton for barging	3·7*d.*
Labour cost per ton of Refuse burned . .	1*s.* 6·88*d.*
Repairs cost per ton of Refuse burned . .	2·02*d.*
Management costs per ton of Refuse burned .	1·44*d.*
Average number of electrical units generated per ton of Refuse burned	26·62.

Some details of an evaporative test in connection with the Destructor are here given—

Date of Test	December 17, 1901.			
Duration of Test	16 hours.			
Number and Type of Cells . .	12 Horsfall Cells "Back-to-back," "Top-fed"			
Total Grate Surface . . .	360 square feet.			
System of Forced Draught . .	Horsfall Co.'s Patent Steam Blowers.			
Nature of Refuse	House and Market.			
Number and Type of Boilers . .	Six "Water Tube."			
Economiser—Number of Tubes .	Two Economisers, each 96 Pipes.			
	tons	cwt.	qrs.	lb.
Total quantity of Refuse burned . .	83	18	0	0
Total quantity of Refuse burned per cell per 24 hours. . . .	10	9	3	0
Total quantity of Refuse burned per sq. ft. of grate per hour . .	32·6 lb.			
Tons per man per shift . . .	6	19	3	2
Total Water evaporated . . .	96	17	0	20
,, ,, ,, per hour .	6	1	0	8
,, ,, ,, per sq. ft. of heating surface per hour . .	1·8 lb.			
Total Water evaporated per lb. of refuse from and at 212° F. or 100° C.	1·3 lb.			
Mean Steam Pressure . . .	137 lb.			
,, Feed Temperature . . .	48·5.			
,, Main Flue Temperature . .	1,800° F.			
,, Temperature behind boilers .	350° F.			

The general arrangement of the installation may be seen by referring to Figure 47. It will be observed that the boilers are all set in a battery, while the cells are arranged in two groups of six each, back to back.

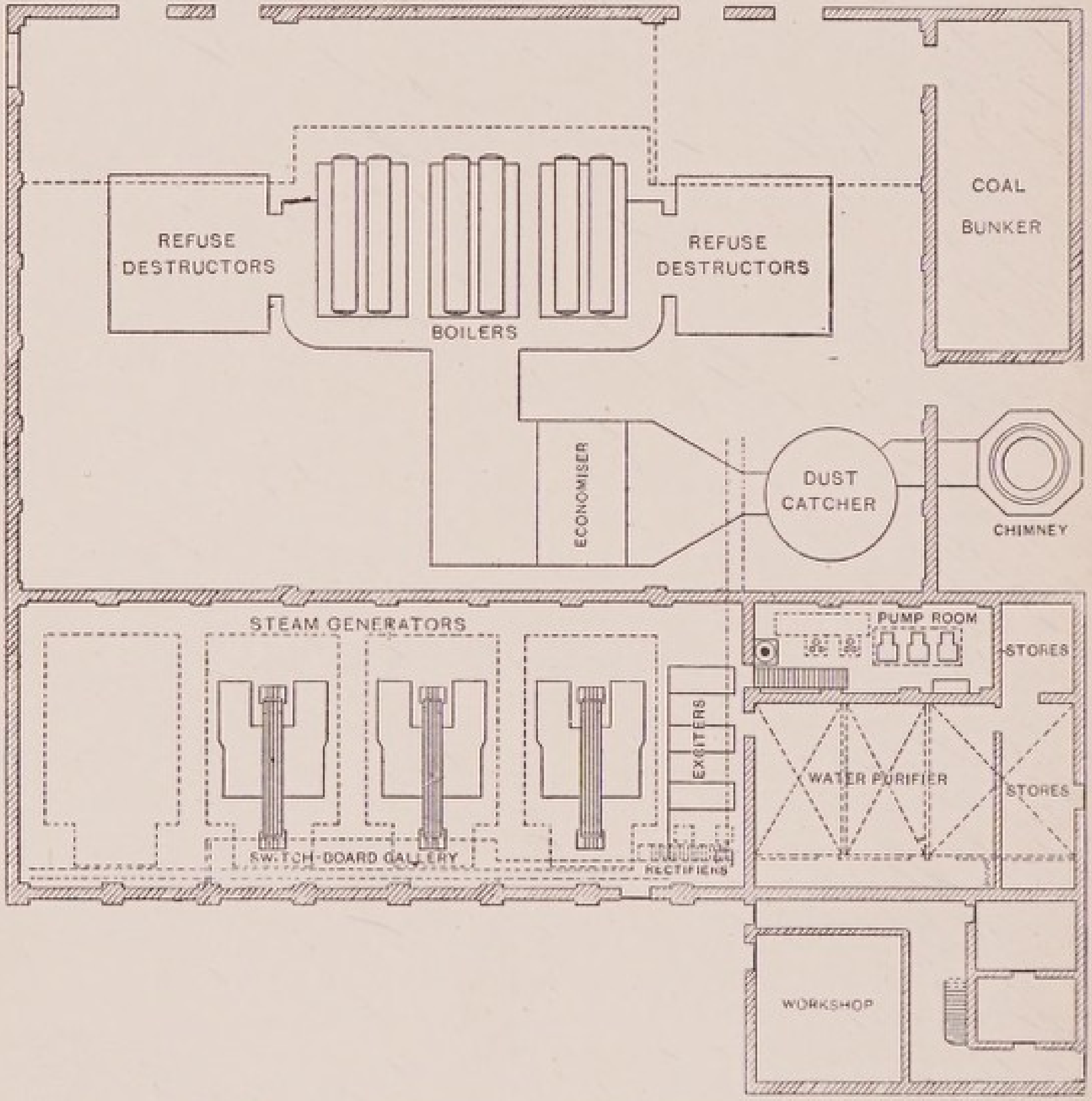


FIG. 47. FULHAM COMBINED DESTRUCTOR AND ELECTRICITY WORKS. Plan.

E.W. HACKNEY—POPULATION, 219,288.

A . . . . 1902.
B . . . . "Sterling" top fed.
C . . . . 12.
D . . . . 3 Babcock & Wilcox.
E . . . . 200 feet.

F . . .	Fans.
G . . .	Electric lighting.
H . . .	120 tons.[1]
I . . .	1*s.* 7·1*d.*[1]

Details of an evaporative test are here given—

Date	December 4 and 5, 1902.
Barometer	30·21 to 30·54.
Atmospheric Temperature . .	29° F. to 36° F.
Weather	Fine.
Character of Fuel	Unscreened Ashbin Refuse.
Number of Cells used . . .	12.
Number of Boilers used . . .	3.
Economiser—Number of Tubes .	288.
Duration of Test	19 hours.
Average hours worked per cell . .	17·9.
Refuse burned—Total tons . .	133 tons 15 cwt. 1 qr. 21 lb.
,, ,, ,, lbs. . . .	299,649.
,, ,, per cell hour . .	1,393 lb.
,, ,, per cell per 24 hours	14·8 tons.
Feed Water Temperature—Suction Tank	51·8° F.
Feed Water Temperature leaving Economiser	220·6° F.
Water evaporated—Total actual .	34,751 galls.
,, ,, ,, ,, .	347,510 lb.
,, ,, per hour . .	18,290 lb.
Average Steam Pressure above atmosphere	184 lb.
Water evaporated per pound of Refuse —actual	1·159 lb.
Water evaporated per pound of Refuse from and at 212° F.	1·415 lb.
Temperature of Flue Gases in main flue before economiser . . .	537° F.
Temperature of Flue Gases in main flue after economiser	335° F.
Average Air Suction at foot of shaft in inches of water	1·04.
Average Air Pressure at Fan Outlets	5·60 inches.
Average Air Pressure in Ashpits .	2·23 ,,
Units (Kilowatt hours) generated from refuse steam during test, Engines running non-condensing, actual .	7,247.

[1] Average for year ending March 31, 1903.

Average units per hour, actual non-condensing	381.
Average hourly E.H.P. actual non-condensing	511.
Units generated per ton Refuse burnt, actual non-condensing . . .	54·19.
Total units used for forced draught during test	553.
Percentage used for forced draught of actual total power raised from Destructor Steam, non-condensing	7·63.
Units per ton Refuse for Fans . . .	4·13.
Total units consumed in elevating Refuse	39·70.
Units per ton of Refuse	0·296.

The complete figures for the first year's working, ending March 31, 1903, are here given and will be found of interest—

Analysis of Accounts for year ended March 31, 1903.

I.—Statement of Capital.

Amount of Loans Sanctioned.	Amount Borrowed.	Amount Repaid.	Capital Expenditure.
£29,900	£29,900	£1,268	£39,224

II.—Destructor Records.

1. Quantity of Refuse destroyed	34,006	tons.
2. Largest Quantity destroyed in one day . .	186	,,
3. Smallest Quantity destroyed in one day . .	41	,,
4. Average Quantity destroyed daily . .	120	,,
5. Bye-Product—		
Clinker, Fine Ash, and Flue Dust . . .	11,578	,,
Tins, Cans, and Scrap Iron	120	,,
Total	11,698	,,
6. Total Quantity of Water evaporated and utilised by Electricity Department . . .	41,411,970	lbs.
7. Total Quantity of Water evaporated per lb. of Refuse	·54	,,

III.—Revenue.

	Amount.	Per Ton of Refuse Destroyed.
	£	*d.*
1. Revenue from supply of steam to Electricity Department	2,272	16·0
2. Sundry Receipts	8	·1

	Amount.	Per Ton of Refuse Destroyed.
3. Balance being net cost to Public Health Department of destruction of Borough Refuse	£ 5,020	d. 35·4
Total Revenue	£7,300	51·5d.

IV.—Expenditure.

	Amount.	Per Ton of Refuse Destroyed.
	£	d.
1. Oil, Waste, Water, and Stores . .	61	·4
2. Electricity for Lighting and Power . .	660	4·7
3. Wages of Workmen	2,708	19·1
4. Repairs and Maintenance . . .	48	·3
5. Clinker Disposal	747	5·3
6. Management Expenses	304	2·1
	£4,528	31·9
7 Interest on Loans	944	6·7
8. Sinking Fund	1828	12·9
Total Expenditure	£7,300	51·5d.

The fuel cost per unit generated is given as ·48*d*., and the total costs 1·03*d*. The load factor, 15·88%, is likely to improve, and this will, of course, widen the scope of usefulness for the Destructor.

Hampstead—Population, 81,942.

A . . . . 1888, 1890, and 1897.
B . . . . Fryer's top fed.
C . . . . 14.
D . . . . None.
E . . . . Two chimneys, each 120 feet.
F . . . . Natural draught only.
G . . . . No power available.
H . . . . 100 tons.

KENSINGTON—POPULATION, 176,623.

A . . .	[1]
B . . .	Warner's top fed.
C . . .	22.
D . . .	Two Multitubular.
E . . .	150 feet.
F . . .	Fans.
G . . .	Works purposes only.
H . . .	150 tons.

The estimated total cost of this plant is £30,513 6*s.* 0*d.*, and included in the scheme is a disinfector station, laundry, and foreman's house and offices.

LAMBETH—POPULATION, 301,895.

A sixteen cell Destructor, of the improved Fryer type, was erected here in 1900 by the South London Electricity Corporation, Limited. It was intended to utilize the power for electric lighting, eight Babcock & Wilcox boilers being provided, each boiler being set between a pair of cells, but after a few months' working the destructor was stopped, and has not been operated again up to the present time.

POPLAR—POPULATION, 168,838.

A . . .	1898.
B . . .	Warner's top fed.
C . . .	14.
D . . .	1 Multitubular.
E . . .	150 feet.
F . . .	Fan.
G . . .	Fan engine, clinker crusher and mortar mill.
H . . .	96 tons.
I . . .	1*s.* 10½*d.*

The cost of this installation was about £8,400, exclusive of the cost of the site and the chimney.

[1] This installation is not likely to be completed until the end of 1904.

St. Pancras—Population, 235,284.

A . . .	1894 and 1895.
B . . .	Warner's top fed.
C . . .	18.
D . . .	1 Hornsby, water tube.
E . . .	207½ feet.
F . . .	Fans.
G . . .	Fan engine, clinker crusher and mortar mill.
H . . .	100 tons.
I . . .	1*s.* 1¾*d.*

The total cost of this installation was £21,000, exclusive of the cost of the site, but including the cost of heavy retaining walls. A considerable quantity of mortar is made, for which there is a steady demand at 5*s.* per ton.

E.W. Shoreditch—Population, 118,705.

A . . .	1897.
B . . .	Fryer's improved top fed, including Boulnois, Wood & Brodie's patents.
C . . .	12.
D . . .	6 Babcock & Wilcox.
E . . .	150 feet.
F . . .	Fans.
G . . .	Electric lighting.
H . . .	100 tons.
I . . .	2*s.* 3·3*d.*

The total cost of the installation, exclusive of site, was £20,527. The average electrical output per ton of refuse destroyed taken over one year is given as 20 units. The electrically driven fans for providing forced draught use four units per ton of refuse destroyed, while 5 units per ton of refuse handled is used by the electric hoists and tipping trucks.

This installation has been the subject of much discussion, but not a little of the criticism has been based upon erroneous ideas. It is but fair to state this, and to point out that with the plant now installed, having a total capacity of nearly 2,500 K.W., it would be impossible for any Destructor to supply but a fraction of the total power required.

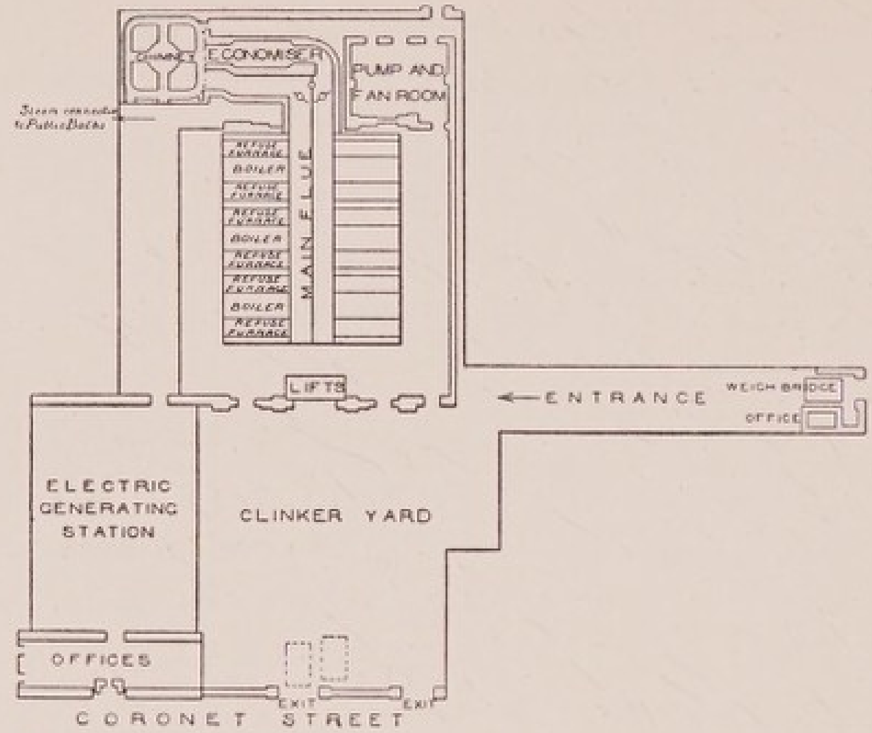


Fig. 48. Shoreditch Combined Destructor and Electricity Works. Plan.

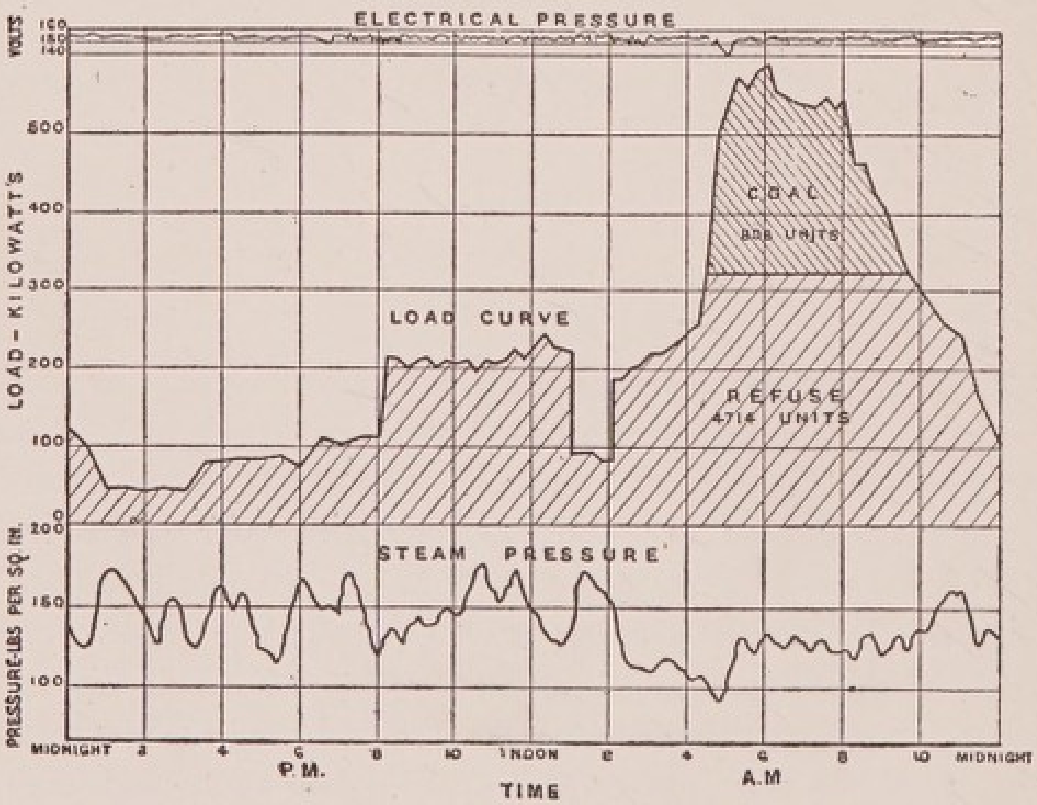


Fig. 49. Results of Test, January 10, 1899.

The question of design has already been fully discussed in another chapter, and although this must effect the general efficiency yet the fact remains that at Shoreditch, as in every other combined works, the maximum benefit from the Destructor could

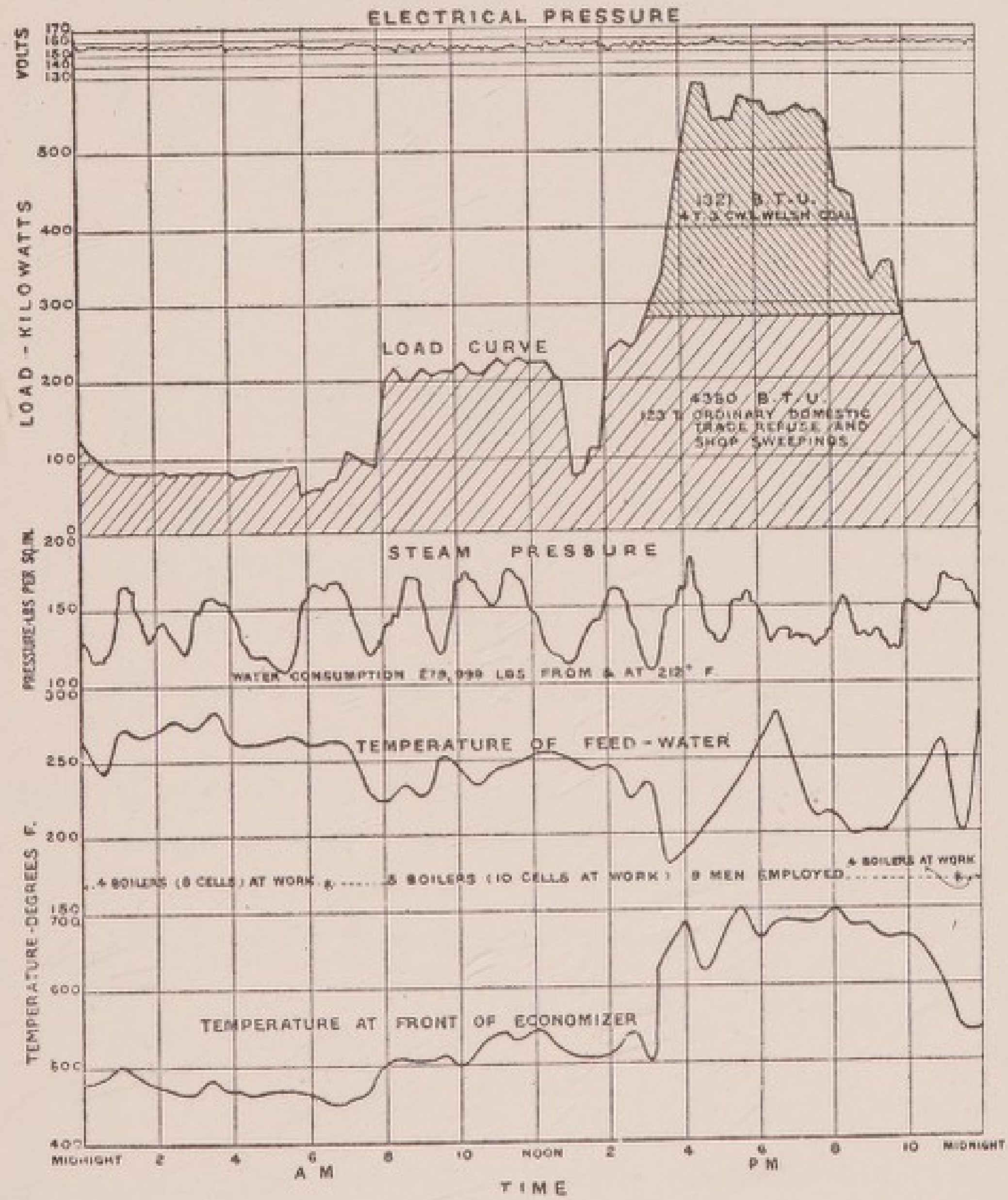


Fig. 50. Results of 24-Hour Test, December 6, 1898.

only reasonably be expected during the first year or two of operation.

Apart altogether from the power aspect, the refuse is disposed of more cheaply than under the old system of riddance which, owing to the difficulties of disposal, becomes increasingly expensive year by year. It is but fair to bear in mind that even if the amount of power produced has fallen short of expectations yet Shoreditch possesses a system of final and sanitary disposal which might well be emulated by many other Metropolitan Boroughs, who continue at huge expense to inflict their filth on other communities.

The general arrangement of the Shoreditch installation, which will, however, be familiar to many readers, is shown in Fig. 48, while Figs. 49 and 50 are of interest as combined diagrams.

STEPNEY—POPULATION, 298,548.

A . . .	1900.
B . . .	Fryer's improved top fed.
C . . .	12.
D . . .	6 Babcock & Wilcox.
E . . .	180 feet.
F . . .	Fans.
G . . .	Electric lighting.
H . . .	165 tons.
I . . .	1*s.* 4·9*d.*
J . . .	32.

The cells are arranged in single row, and the works are kept in a very clean condition. The total cost of the installation was £17,740, 16*s.* 0*d.*, exclusive of the site. In addition to the Destructor boilers, three supplementary coal fired boilers of the Babcock & Wilcox type are provided. The power equipment of the station is as follows :—5 Willans engines, and 6 Mather & Platt dynamos, having a total capacity of 1,220 K.W., also 260 Tudor cells, of 800 ampère hours' capacity.

Some interesting figures, extracted from the accounts for the year ending March 31, 1902, are here given.

ELECTRICITY GENERATED.

From steam taken from the boilers of the Refuse Destructor . .	868,546	Board of Trade units
From steam raised in coal fired boilers	279,758	,, ,, ,,
Total	1,148,304	,, ,, ,,

Cost of Steam

	£	s.	d.
Total cost for steam from Refuse Destructor boilers, 868,546 B.T.U. at ·3*d*. . . . . (or about 3 B.T.U. for 1*d*.)	1,085	13	8
Steam raised in coal fired boilers, 279,758 B.T.U. (equals ·84*d*. per unit.)	989	6	1

Fig 49, which is a reproduction from a steam pressure chart, is of interest for purposes of comparison, not only with diagrams obtained with Lancashire boilers, but also with others here reproduced from combined works, where the general design of the plant differs from that at Stepney.

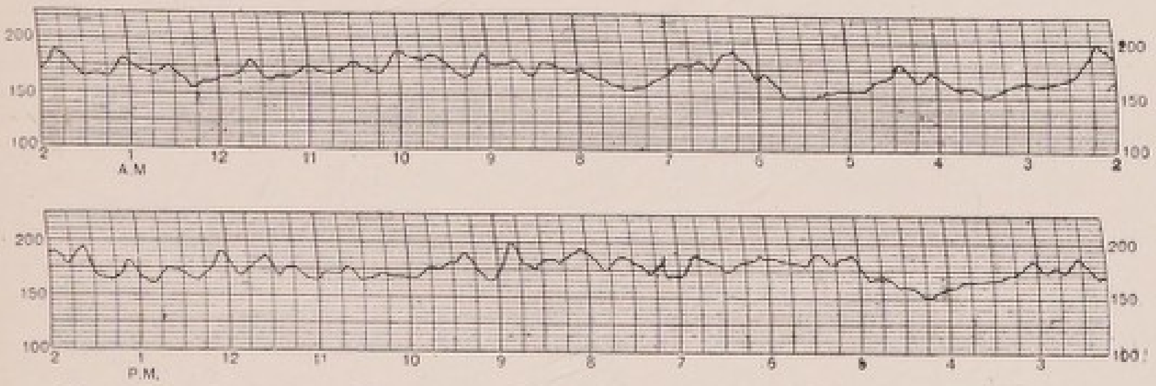


Fig. 51. Stepney Combined Destructor and Electricity Works.
Steam Pressure Diagram.

Wandsworth—Population, 232,030.

A . . . . 1899.
B . . . . Meldrum's Beaman & Deas top fed, direct charged.
C . . . . 4.
D . . . . 1 Babcock & Wilcox.
E . . . . 150 feet.
F . . . . Fan.
G . . . . Works purposes only.
H . . . . 70 tons.
I . . . . $7\frac{1}{2}d$.

The cost of this installation was £5,005, including the chimney, but not including the inclined roadway. The complete details of a test of 120 hours' duration are here given; this test was carried out under ordinary working conditions, and mainly with a view to ascertaining the actual value of the Wandsworth refuse for power producing purposes. The whole of the clinker is readily disposed of at the works at 1*s*. 9*d*. per cubic yard, the purchasers carting the same away themselves.

METROPOLITAN BOROUGH OF WANDSWORTH

Result of Six Days' Continuous Test (February 2 to 7, Inclusive) at the Destructor Depôt, Lower Tooting

Particulars.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Totals.
Time of Start	9.25 a.m.	—	—	—	—	—	—
,, ,, Finish	—	—	—	—	—	9.25 a.m.	—
Duration of Test	14 hrs. 35 min.	24 hours	24 hours	24 hours	24 hours	9 hrs. 25 min.	120 hours
Weather	Very cold	Very cold	Moderately cold	Mild	Mild	Mild	—
Type of Furnace	B. & D.	B. & D.	B. & D.	B. & D.	B. & D.	B. & D.	Beaman & Deas
,, ,, ,, Charging Apparatus							Marten's Patent
No. of Cells or Grates	2	2	2	2	2	2	2
Effective Grate Area (per cell 25 sq. feet)	50	50	50	50	50	50	50 sq. ft.
Type of Boiler	B. & W.	B. & W.	B. & W.	B. & W.	B. & W.	B. & W.	Babcock&Wilcox
Heating Surface of Boiler	1,619 sq. ft.	1,619 sq. ft.	1,619 sq. ft.	1,619 sq. ft.	1,619 sq. ft.	1,619 sq. ft.	1,619 sq. ft.
Total Weight of Refuse including Tins—183 tons 12 cwt.—411,264 lb.	60,368 lb.	74,116 b.	78,652 lb.	86,352 lb.	87,444 lb.	24,332 lb.	411,264 lb.
Weight of Tins—728 lb.	107 ,,	131 ,,	140 ,,	153 ,,	155 ,,	42 ,,	728 ,,
No. of Times No. 1 Furnace Charged	8	11	11	13	12	3	58
No. of Times No. 2 Furnace Charged	8	11	12	12	12	4	59
Average Weight of each Charge	3,766 lb.	3,354 lb.	3,420 lb.	3,453 lb.	3,643 lb.	3,444 lb.	3,509 lb.
Weight of Refuse burned—183 tons 5 cwt. 2 qrs.	60,261 lb. app.	73,985 lb. app.	78,512 lb. app.	86,199 lb. app.	87,289 lb. app.	24,290 lb. app.	410,536 ,,
Weight of Refuse burned per hour	4,132 ,, ,,	3,082 ,, ,,	3,271 ,, ,,	3,591 ,, ,,	3·637 ,, ,,	2,578 ,, ,,	3,421 ,,
Weight of Refuse burned per sq. ft. Grate per hour	82·06 ,, ,,	61·06 ,, ,,	65·42 ,, ,,	71·7 ,, ,,	72·7 ,, ,,	51·5 ,, ,,	68·4 ,,
Weight of Refuse burned per sq. ft. of Boiler Heating Surface per hour	2·5 ,, ,,	1·93 ,, ,,	2·02 ,, ,,	2·2 ,, ,,	2·2 ,, ,,	1·5 ,, ,,	2·1 ,,
Residuals— tons. cwt. qrs.							
Clinker 68 16 0	—	—	—	—	—	—	154,112 ,,
Flue Dust 1 12 3	—	—	—	—	—	—	3,668 ,,
Ashpit Dust 0 18 3	—	—	—	—	—	—	2,016 ,,
Total 71 7 2	—	—	—	—	—	—	159,796 ,,
Proportion of Clinker to Refuse burned	—	—	—	—	—	—	37%
Proportion of Flue Dust to Refuse burned	—	—	—	—	—	—	·8 of 1%
Proportion of Ashpit Dust to Refuse burned	—	—	—	—	—	—	·4 of 1%
Total							38·2
Weight of Water Evaporated	56,062 lb. app.	67,911 lb. app.	83,991 lb. app.	92,019 lb. app.	92,019 lb. app.	27,881 lb. app.	419,883 lb.

Weight of Water Evaporated Average per hour (actual)	3,844 lb. app.	2,339 lb. app.	3,500 lb. app.	3,834 lb. app.	3,834 lb. app.	2,960 lb. app.	3,499 lb.
Weight of Water Evaporated from and at 212° F.	4,766 ,, ,,	3,509 ,, ,,	4,340 ,, ,,	4,754 ,, ,,	4,754 ,, ,,	3,670 ,, ,,	4,338 ,,
Weight of Water Evaporated per lb. of Refuse (actual)	·93 ,, ,,	·91 ,, ,,	1·07 ,, ,,	1·06 ,, ,,	1·06 ,, ,,	1·15 ,, ,,	1·02 ,,
Weight of Water from and at 212° F.	1·15 ,, ,,	1·12 ,, ,,	1·32 ,, ,,	1·32 ,, ,,	1·32 ,, ,,	1·42 ,, ,,	1·24 ,,
Weight of Water per sq. ft. H. S. from and at 212° F.	2·9 ,, ,,	2·1 ,, ,,	2·6 ,, ,,	2·9 ,, ,,	2·9 ,, ,,	2·2 ,, ,,	2·6 ,,
Maximum Temperature at Boiler Inlet	About 2,000°	About 2,000°	About 2,000°	About 2,000°	About 2,000°	About 2,000°	Copper melted in ½ min.
Approximate Average Temperature at Boiler Inlet	1,629·5° F.	1,639° F.	1,714° F.	1,746° F.	1,744° F.	1,764° F.	1,698° F.
Maximum Temperature at Boiler Outlet	710° F.	715° F.	750° F.	725° F.	750° F.	765° F.	765° F.
Average Temperature at Boiler Outlet	619° F.	638·3° F.	648·22° F.	658·9° F.	660° F.	655° F.	637° F.
Maximum Temperature at Chimney Base	690° F.	700° F.	725° F.	725° F.	740° F.	725° F.	740° F.
Average Temperature at Chimney Base	596·82° F.	573·2° F.	649·1° F.	651·48° F.	657·5° F.	648° F.	629° F.
Average Ashpit Pressure (No. 1 Furnace)	2·5 in.	2·23 in.	2·653 in.	2·604 in.	3·0 in.	3·0 in.	2·66 in.
Average Ashpit Pressure (No. 2 Furnace)	2·44 ,,	2·04 ,,	2·48 ,,	2·28 ,,	2·75 ,,	2·675 ,,	2·44 ,,
Average on Nos. 1 and 2 Furnaces	2·49 ,,	2·135,,	2·56 ,,	2·44 ,,	2·87 ,,	2·83 ,,	2·55 ,,
Maximum Ashpit Pressure (No. 1 Furnace)	3·5 ,,	3·25 ,,	4·0 ,,	3·5 ,,	5·25 ,,	4·25 ,,	5·25 ,,
Maximum Ashpit Pressure (No. 2 Furnace)	3·0 ,,	3·12 ,,	4·0 ,,	3·0 ,,	4·5 ,,	4·5 ,,	4·5 ,,
Maximum Pull in Flue at Boiler Outlet	—	—	·5625	·5625	·5625	·5625	·56
Minimum Pull in Flue at Boiler Outlet	—	—	·5	·375	·5	·5	·468
Average Pull in Flue at Boiler Outlet	—	—	·531	·531	·531	·562	·538
Maximum Pull at Chimney Base	·5	·375	·812	812	·812	·812	·5
Minimum Pull at Chimney Base	·375	·312	375	·625	·625	·687	·687
Average Pull at Chimney Base	·437	·375	468	·687	·75	687	·498
CO_2 in Flue Gases	CO_2 | O. | CO.	CO_2 | O. | CO.	—	CO_2 | O. | CO.	CO_2 | O. | CO	—	·567
Highest Reading	12·7 | 17·8 | ·6	8·3 | 18·4 | ·65	—	11·2 | 17·4 | ·3	14·6 | 10·9 | ·4	—	—
Lowest ,,	2·6 | 7·9 | ·1	1·7 | 12·1 | ·4	—	3·8 | 9·8 | ·1	9·5 | 5·5 | ·2	—	—
Average ,,	7·4 | 12·3 | ·2	4·1 | 16·1 | ·52	—	8·2 | 12·67 | 1	12·2 | 8·06 | ·18	—	—
Average Temperature of Feed Water	56·5° F.	44·7° F.	44·4° F.	44·3° F.	44° F.	44° F.	46° F.

WESTMINSTER—POPULATION, 182,977.

A	1900.
B	Horsfall's top fed direct charged.
C	6.
D	1 Babcock & Wilcox.
E	90 feet.
F	Steam Jet Blowers.
G	Works purposes only.
H	72 tons.
I	11·5*d*.

The cost of this installation as originally arranged was about £10,000. The complete details of a test conducted by Mr. J. W. Bradley, M.I.C.E., the city engineer of Westminster, are here given :

Date of Test	December 2 to 4, 1902.
Duration of Test . .	$45\frac{1}{4}$ hours.
Number of cells in use .	6.
Total grate area . . .	252 square feet.
Nature of Refuse . .	House, trade and market.
Number of Firemen and average wage per day . .	9 Stokers at 35*s*. each per week. 4 Topmen at 27*s*. 6*d*. each per week.
Number, size and type of boiler	1 Babcock & Wilcox, with 1,426 sq. ft. of heating surface.
Total weight of Refuse burned	138 tons 15 cwt. 1 qr. —310,828 lb.
Total weight of Refuse burned per cell per 24 hours .	12 tons 5 cwt. 1 qr. 8 lb. = 27,476 lb.
Total weight of Refuse burned per square foot of grate per hour	27·2 lb.
Labour cost per ton of Refuse burned	11·5*d*.
Percentage of Clinker and Ash	24·9 per cent.
Mean Steam Pressure . .	125 lb.
Mean Feed Temperature .	48° F.
Mean Main Flue Temperature	Over 2,000° F.
Mean Temperature behind boilers	500° F.

Woolwich—Population, 117,178.

Two Installations.

	1. Woolwich.	2. Plumstead. E.W.
A . .	1893.	1903.
B . .	Fryer's top fed.	Meldrum's front hand fed.
C . .	6.	12 grates.
D . .	—	3 Babcock & Wilcox.
E . .	160 feet.	80 feet.
F . .	Natural draught only.	Steam jet blowers.
G . .	—	Electric lighting.
H . .	30 tons.	80 tons.

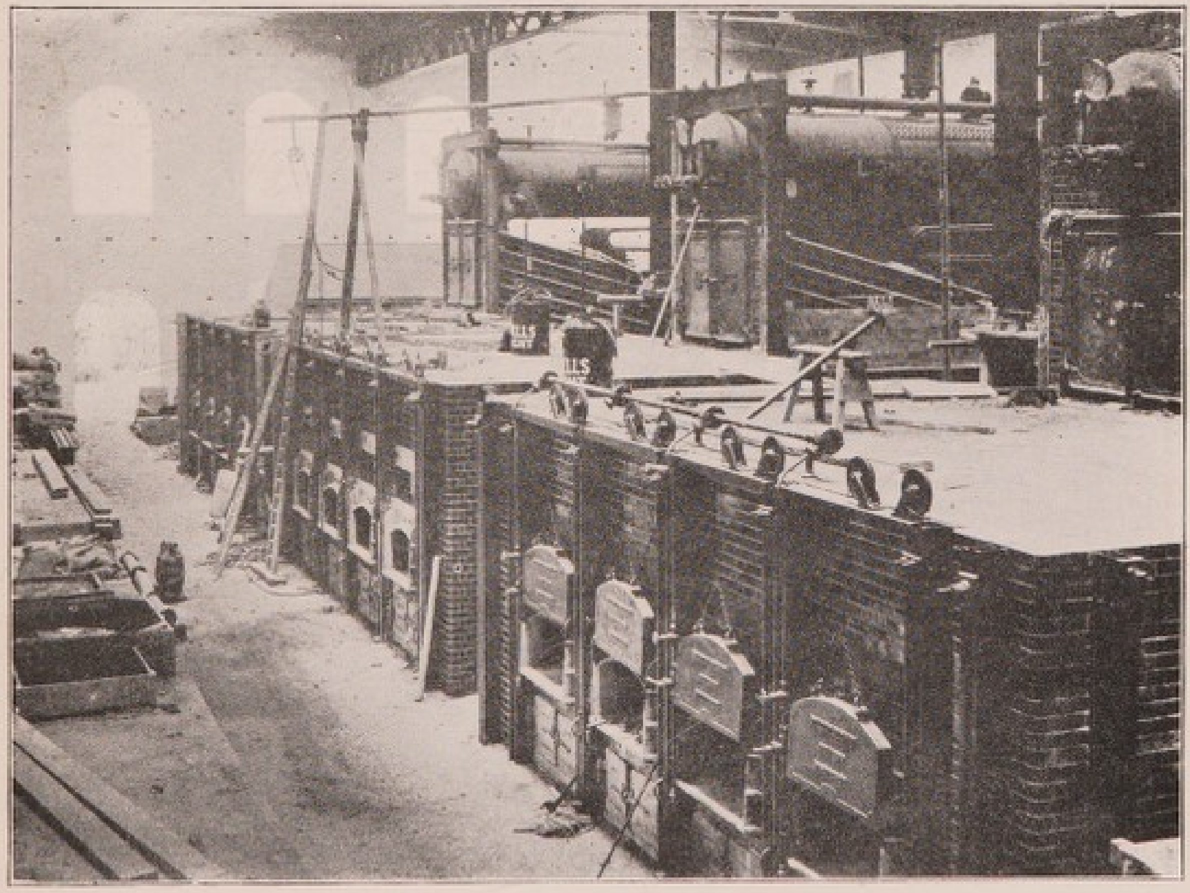


Fig. 52. Woolwich (Plumstead) Destructor.
In Course of Erection.

Installation No. 2 is one of the largest Destructors yet erected in this country in combination with an electricity works, and it is of a very comprehensive character.

Fig. 52 shows the Destructor cells and boilers in course of erection, while Fig. 53 is an external view of the buildings.

A clinker brick-making plant, and also a clinker flag press, both designed by Messrs. Alexander, of Leeds, are provided, and will serve to utilize the clinker.

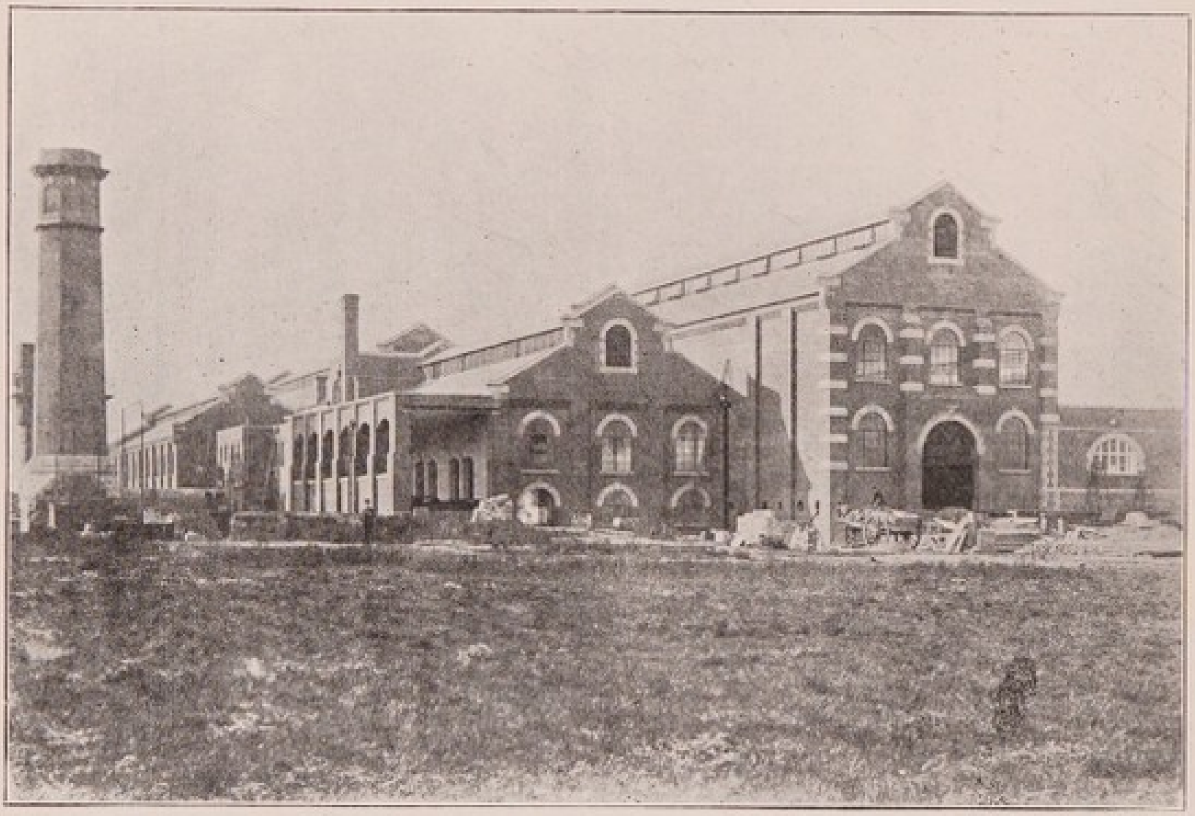


FIG. 53. WOOLWICH (PLUMSTEAD) COMBINED DESTRUCTOR AND ELECTRICITY WORKS.

View of Buildings.

Chapter XVII

REFUSE DESTRUCTORS IN ENGLAND AND WALES

ACCRINGTON MUNICIPAL CORPORATION—POPULATION, 43,122.

E.W.

A	1900.
B	Horsfall top fed in single row.
C	6.
D	2 Lancashire, 30 ft. × 8 ft.
E	250 feet.
F	Steam jet blowers.
G	Electric lighting.
H	60 tons.
I	1*s.* 5*d.*
J	25.

IN connection with this installation, a somewhat novel departure from the usual practice was made, by arranging supplementary coal fired grates between the cells and the boilers, so that the boilers might if desired be fired with coal in addition to the Destructor gases, or in the event of non-delivery of refuse coal could be used for the Destructor boilers, even if the cells were idle.

While this practice has become quite common with water tube boilers the arrangement had not hitherto been tried with the Lancashire type of boiler.

In addition to the two Lancashire boilers in connection with the Destructor, one Lancashire boiler is also installed for coal firing alone. Among the Destructor accessories is a complete screening and crushing plant for turning the clinker into a marketable product. The total cost of the Destructor, buildings and chimney, but exclusive of the site, was about £8,000.

The power equipment of the Electricity Works comprises 5 Willans & Robinson & Browett Lindley engines, the total H.P. being 970; the engines are direct coupled to 5 Johnson & Phillips, and Lancashire Dynamo Company's Dynamos, having a total capacity of 580 K.W. Chloride batteries are also provided, having a capacity of 750 ampère hours.

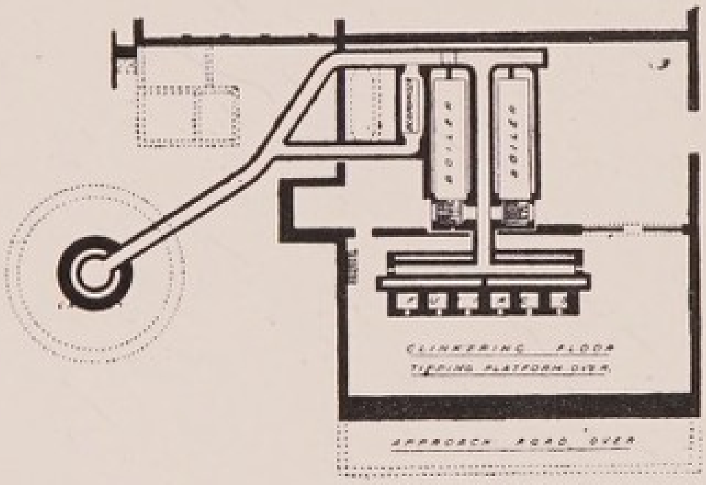


FIG. 54. ACCRINGTON COMBINED DESTRUCTOR AND ELECTRICITY WORKS. Plan.

The figures of a month's log are here given, as also some details of the official test.

Fig. 54 shows the general arrangement of the cells, boilers and supplementary coal fired grates, between the cells and the boilers.

Accrington Corporation. Electricity and Destructor Works.

Log for the Month of November, 1901.

1901.	Units generated.			Units delivered: total for Week.	Refuse for Week in lb.
November 1					
,, 2					
,, 3	Sunday.	Destructors not working.			
,, 4		493			
,, 5		844			
,, 6		593	Total		
,, 7		686	for		
,, 8		825	week,		
,, 9		845	4,286	2,457	548,464
,, 10	Sunday.	Destructors not working.			
,, 11		715			
,, 12		802			
,, 13		624			
,, 14		794			
,, 15		895			
,, 16		984	4,814	2,780	555,100
,, 17	Sunday.	Destructors not working.			
,, 18		504			
,, 19		908			
,, 20		720			
,, 21		782			
,, 22		835			
,, 23		944	4,693	3,090	535,920
,, 24	Sunday.	Destructors not working.			
,, 25		644			
,, 26		745			
,, 27		791			
,, 28		865			
,, 29		919			
,, 30		1,039	5,003	3,311	492,772
			18,796	11,638	2,132,256

lb. Refuse per unit generated—112·9 lb.

Most units generated in one day, 1,039 units.

Highest load observed during month, 472 Ampères at 235 volts. 148·6 Electrical H.P.

Total units generated for 24 days, 18,796.

Average per day, 783 units.

OFFICIAL TEST

Date of Test	April 11 and 12, 1901.
Duration of Test . . .	22 hours.
Number and type of Cells . .	6 Cells, single row, top fed.
Total Grate Surface . .	180 square feet.
Nature of Refuse . . .	Unscreened, ashpit, house, trade and market.
Number and type of boilers .	1 Lancashire, 30 ft. × 8 ft. diameter.
Total heating surface . .	About 1,000 square feet.
Total quantity of Refuse burned	117,846 lb.
Total quantity of Refuse burned per cell per 24 hours. .	21,424 lb.
Total quantity of Refuse burned per cell per hour . .	892 lb.
Total quantity of Refuse burned per sq. ft. of grate per hour	29·7 lb.
Cost of Labour per ton burned .	——
Total Water evaporated . .	135,624 lb.
,, ,, ,, per hour	6,164 lb.
,, ,, ,, per lb. of Refuse burned at Feed Temp.	1·15 lb.
Total Water evaporated per lb. of Refuse calculated from and at 212° F.	1·39 lb.
Total amount of Residual, Clinker, ashpit dust, flue dust .	41,955 lb.
Percentage of Residual to Refuse burned	35·5 per cent.
Mean Steam Pressure . .	185 lb.
,, Feed Temperature . .	50° F.
,, Main Flue Temperature .	2,000° F.
,, Temperature behind boilers	500° F.

ALDERSHOT URBAN DISTRICT COUNCIL—CIVIL POPULATION, 14,248.

S. W.

A	1901.
B	Meldrum's front hand fed.
C	4 Grates.
D	2 Cornish, 14 ft. × 4 ft. 3 in.
E	70 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	11 tons.
I	1*s*. 1*d*.
Actual annual saving in coal cost	£300.

This is one of the few installations in this country where Destructor cells have been adapted to existing boilers and chimney. The two Cornish boilers had been previously fired with coal for twenty years. Since the Destructor was erected no coal whatever has been used, and this in spite of the fact that in time of storm the normal flow (750,000 gallons) has been frequently trebled.

In addition to the saving in fuel cost, an additional economy has been effected by the utilization of the clinker on the bacteria beds, coke and coke breeze having previously been purchased for filtration purposes.

The total cost of the Destructor installation, including the necessary structural alterations involved, was about £1,200. The additional cost of burning refuse as compared with the labour cost for burning coal, previous to the installation of the Destructor, is given as 3½*d.* per ton of refuse destroyed.

Ashton-under-Lyne Municipal Corporation—Population, E. W. 43,890.

A	1901.
B	Horsfall top fed.
C	6.
D	2 Multitubular.
F	Steam Jet Blowers.
G	Electric traction.
H	30 tons.
I	11·66*d*.

Four Lancashire boilers are also installed, which are fired with coal alone, one of these boilers being always in use, at the same time as the Destructor fired boilers.

A serious mistake was made in selecting multitubular boilers for a combined station of this character, and the experiment is not likely to be repeated. A common steam main being used for both the Destructor boilers and the coal fired boilers, it is therefore impossible to accurately determine the number of electrical units generated from the refuse, but Mr. Neville Appelbee, the

Electrical Engineer, considers the combination of the Destructor with the electricity works to be serviceable.

The power equipment comprises 3 Browett-Lindley vertical compound engines, and 2 Bellis engines, the total H.P. being 2,000, with Sayers and Siemen's dynamos direct coupled, having a total capacity of 1,200 K.W.

The following figures for the second year's working (1902) are interesting :—

Load Factor	17·11 per cent.
Fuel Cost	·69 per unit.
Works ,,	1·18 ,, ,,
Total ,,	1·48 ,, ,,
Net Profit	£278.

ASTON MANOR MUNICIPAL CORPORATION—POPULATION, 77,310.

TWO INSTALLATIONS.

	1.	2.
A	1892.	1901.
B	Fryer top fed.	Sterling top fed.
C	8.	4.
D	1 Multitubular.	2 Babcock & Wilcox.
E	165 feet.	Same chimney used.
F	Steam Jet Blowers.	Fans.
G	—	Works purposes generally, clinker crusher, mortar mill, lighting and engine.
H	75 tons.	
I	11d.	11d.

ATHERTON URBAN DISTRICT COUNCIL—POPULATION, 16,211.

A	1902.
B	Heenan back fed.
C	2.
D	1 Water Tube.
E	90 feet.
F	Fan.
G	Supplied to an adjoining laundry.
H	15 tons.

BANGOR MUNICIPAL CORPORATION—POPULATION, 11,770.

E. W.

A	1900.
B	Meldrum's " Beaman & Deas " top fed.
C	2.
D	1 Hornsby Water Tube.
E	80 feet.
F	Fan.
G	Electric lighting.
H	Winter months = 8 tons. Summer ,, —9·5 ,,
I	1s. 4d.
J	20.

One Hornsby Water Tube boiler is also installed for supplementary coal firing as may be necessary. Owing to the Destructor cells being erected after the boilers and generating plant had been installed, it was not possible to place the Destructor in the most suitable position for securing the maximum benefit from the same for power production. It is, therefore, not surprising to find that the average number of electrical units generated per ton of refuse destroyed is given as 20 only.

The power equipment of the electricity works comprises 3 Willans engines, the total H.P. being 450; these are direct coupled to dynamos of Messrs. Fowler & Hall's make, the total capacity of the same being 270 K.W.

BARRY URBAN DISTRICT COUNCIL—POPULATION, 27,000.

A . .	1901.
B . .	Sterling top fed.
C . .	2.
D . .	1 Babcock & Wilcox—1,741 sq. ft. of heating surface.
E . .	150 feet.
F . .	Fan.
G . .	Mortar mill, fan engine, works lighting.
H . .	25 tons.
I . .	About 1s. 3½d.

The cost of Destructor and boiler was £2,763, chimney £1,805; the total cost, including buildings and site, being £8,541.

BARROW IN FURNESS, MUNICIPAL CORPORATION—POPULATION, 57,586.
E. W.

A Destructor of the "Heenan" back fed type is now in course of erection here, comprising two twin cells, and one Lancashire tube boiler. The power will be fully utilized for electrical purposes.

BATH MUNICIPAL CORPORATION—POPULATION, 49,821.

A . . .	1895 and 1899.
B . . .	Warner's top fed.
C . . .	10.
D . . .	1 Multitubular, 14 ft. × 8 ft.
E . . .	165 feet.
F . . .	Fan.
G . . .	Clinker crusher, mortar mill and fan engine.
H . . .	45 tons.
I . . .	1*s.* 3*d.*

Originally a low temperature Destructor, it was found necessary about two years since to apply forced draught to the cells, and also to carry out other improvements, involving an expenditure of over £2,000. The original cost of the installation, exclusive of site, was £6,906.

BATLEY MUNICIPAL CORPORATION—POPULATION, 30,321.

	1.	2. E.W.
A . . .	1887 and 1891.	Not yet commenced.
B . . .	Fryer top fed.	Horsfall back fed.
C . . .	6.	3.
D . . .	1 Multitubular.	1 Lancashire.
F . . .	—	Steam Jet Blowers.
G . . .	Works only.	Electric lighting.
H . . .	15 tons.	—
I . . .	1*s.* 6*d.*	—

BECKENHAM URBAN DISTRICT COUNCIL—POPULATION. 26,000.
E. W.

A . .	1900.
B . .	Horsfall back fed.
C . .	3.

D . .	1 Babcock & Wilcox—1,426 sq. ft. of heating surface.
E . .	120 feet × 5 ft. 6 in., internal diameter.
F . .	Steam Jet Blowers.
G . .	Electric lighting.
H . .	24 tons.
I . .	1*s.* 9*d.*

Three additional coal fired Babcock & Wilcox boilers of similar capacity to that already mentioned are provided, and also a Green's Economiser. The power equipment of the station comprises 2,200 H.P., and 1,100 H.P. Bellis engines, direct coupled to a 2,120 K.W. and 1·60 K.W. Fowler Alternators, also one Browett Lindley engine direct coupled to a Johnson & Phillips Alternator of 250 K.W. capacity.

As coal fired boilers are also used during the load, it has not been determined what power is actually produced from the combustion of the refuse. Unfortunately the Destructor cells in this instance, as at Bangor, were not erected sufficiently close to the boilers to secure the best results in power production.

Some details of an evaporative test carried out in September, 1902, are here given—

Date of Test . . .	September 19 and 20, 1902.
Duration of Test (started from cold) . .	18½ hours burning, 16½ evap.
Number and type of Cells .	Three cell. Single row, back fed.
Total Grate Surface . .	90 feet square.
System of Forced Draught .	Horsfall Co.'s Patent Steam Blower.
Nature of Refuse . .	House, shop and much garden.
Number of Firemen and average wage per day .	Four at 5*s.*
Number and type of Boilers	Two Water Tube.
Total quantity of Refuse burned . . .	25 tons 1 cwt. 3 qrs. 4 lb.
Total quantity of Refuse burned per cell per 24 hours . . .	10 tons 17 cwt.
Total quantity of Refuse burned per square foot of grate per hour .	34 lb.
Total Water evaporated .	28 tons 5 cwt. 1 qr. 8 lb.
,, ,, ,, per hour	1 ton 14 cwt. 1 qr. 1 lb. = 3,837 lb.

Total Water evaporated per square foot of heating surface per hour .	1·34 lb.
Total Water evaporated per lb. of Refuse from and at 212° F. or 100° C. .	1·512 lb.
Mean Steam Pressure .	145 lb.
,, Feed Temperature (Tank)	57° F.
,, Main Flue Temperature	1,700° F.

A few extracts from the official figures of the first year's working (1902) are here given :—

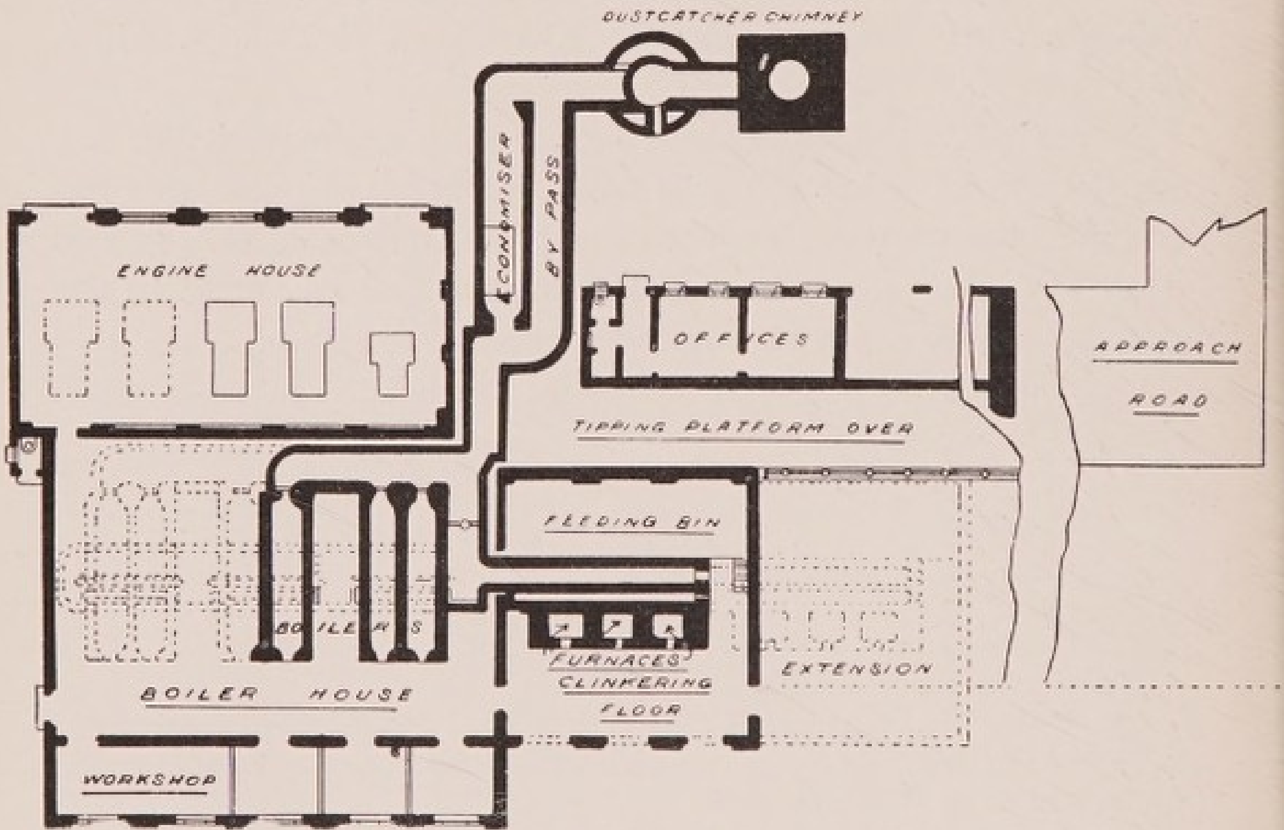


Fig. 55. Beckenham Combined Destructor and Electricity Works. Plan.

Load factor	12·51 per cent.
Fuel cost	1·75*d.* per unit.
Works ,, ...	2·45*d.* ,, ,,
Total ,, ...	3·16*d.* ,, ,,
Deficit	£696.

Fig. 55 illustrates the general arrangement of this installation It will be observed that additional cells will be erected on the right and additional boilers on the left, which arrangement must operate seriously against the general efficiency.

BIRKENHEAD MUNICIPAL CORPORATION—POPULATION, 111,102.
TWO INSTALLATIONS.

	1	2
A . .	1894	1896
B . .	Fryer top fed	Warner top fed
C . .	12	12
D . .	1 Multitubular 1 Babcock & Wilcox	1 Multitubular
E . .	180 feet	180 feet
F . .	Steam Jet Blowers	Fans
G . .	Mortar mills and forced draught	Mortar mills and forced draught
[1] H . .	90 tons	90 tons
I . .	10·21*d.*	10·21*d.*

Mortar sells freely at 6*s.* 6*d.* per ton and yields a fair profit. The total expenditure in connection with the two installations, but exclusive of cost of the site, was £22,774.

BIRMINGHAM MUNICIPAL CORPORATION—POPULATION, 522,204.
FOUR INSTALLATIONS.[2]

	1 Shadwell Street	2 Montague Street	3 Rotton Park St.	4 Montgomery St.
A	1877	1879	1879	1899
B	Fryer top fed	Own design	Own design	Fryer Improved top fed
C	4	47		12
D	16 Multitubular and 2 Galloway			2 Lancashire
E	140 feet	260 feet	200 feet	195 feet
F	—	—	—	Fans
G	Screening and Poudrette shop	mixing manure, plant, mortar machinery	driving mills, work-	Electric lighting of works
H	Total 400 Tons			
I	—	—	—	9·82*d.*

[1] Twelve Cells only are in operation at one time.

[2] Additional installations are now contemplated.

As will be observed, Birmingham is well equipped for the final and sanitary disposal of its refuse. It is true that a large number of the cells in use do not conform to modern requirements, many having been in use for upwards of twenty years, but large modern installations are being erected as circumstances warrant, and doubtless in course of time the original cells, having served their purpose, will be dismantled and replaced by modern cells.

It is interesting to observe that during the year 1902, no less than 120,000 tons of refuse was destroyed, and that 5,805 tons of rough clinker and 4,806 tons of screened clinker were sold to contractors.

BLACKBURN MUNICIPAL CORPORATION—POPULATION, 129,216.

FOUR INSTALLATIONS.

	1	2	3	4. W.W.
A	1879, 1890 and 1900	1900	1901	1903
B	Fryer top fed	Meldrum's front hand fed	Heenan's back fed	Heenan's back fed
C	10	2 grates	6	8
D	1 Multitubular	1 Lancashire	2 Water tube	2 Lancashire
E	300 feet	75 feet	156 feet	150 feet
F	—	Steam Jet Blowers	Fan.	Fan
G	Mortar mills	Municipal work shops machinery	Supplied to gas works	Water pumping
H	40	15	30	45
I	10*d.*	11*d.*	10½*d.*	—

The cost of installation No. 2 was £1,200, as against £9,000 for No. 3 installation, and a proportionally higher sum for installation No. 4. The first installation cost £10,724.

It should be noted that steam power is supplied to the Gas Works, which adjoin Destructor No. 3. For this steam the Gas

Committee pay a Scavenging Committee the sum of £300 per annum.

Some interesting details of an evaporative test with this plant are here given :—

Date of Test	May 15, 1901.
Duration	7 hours 40 minutes.
Cells in use	4 – 2 twin cells.
Total grate area	120 square feet.
Total heating surface of boiler	2,400 square feet.
Type of boiler	Heenan's Patent Water Tube.
Total Refuse burned	31,682 lb.
Total Refuse burned per hour average	4,159·8 lb.
Total Refuse burned per square foot grate per hour	34·66 lb.

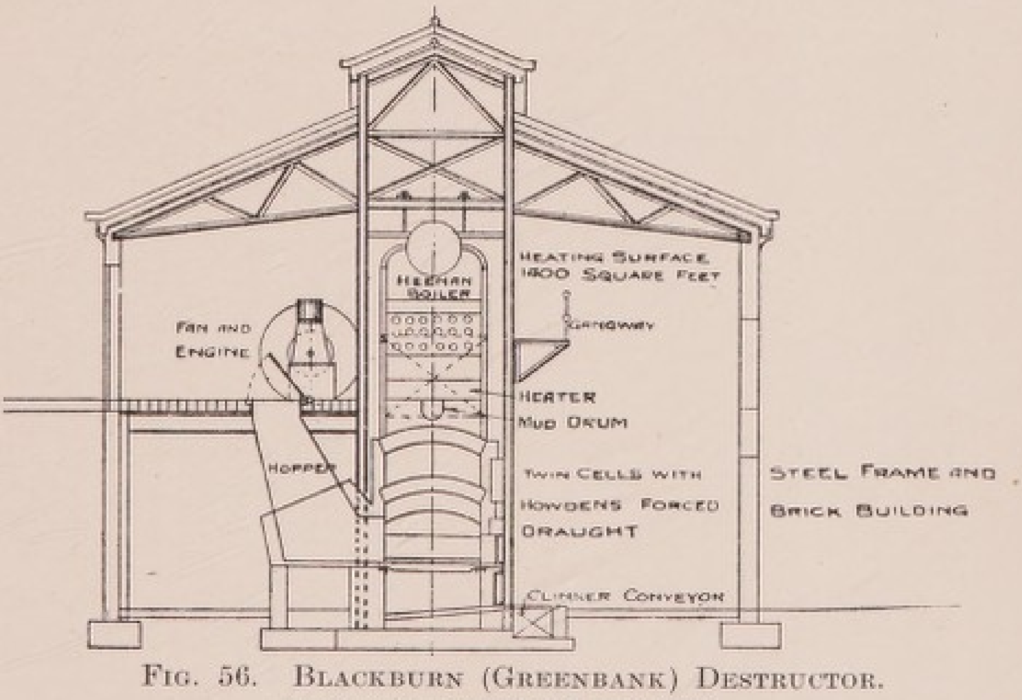


FIG. 56. BLACKBURN (GREENBANK) DESTRUCTOR.
Cross Section through Cells and Boiler.

Refuse burned per cell per hour	1,015 lb. or 9 cwt. 0 qr. 7 lb.
Rate of burning capacity per cell per 24 hours	10 tons 17 cwt. 2 qr. 0 lb.
Total clinker and fire ash	10,052 lb.
Percentage of clinker and fine ash to charged refuse	25·5 per cent.
Temperature of combustion chamber	1,800° F.
Temperature at chimney base	700° F.
Temperature of feed-water in tank	59° F.

Temperature of feed-water after leaving exhaust steam heater	116·5° F.
Temperature of charging floor .	70° F.
Temperature of clinkering floor .	79° F.
Average steam pressure . .	122·3 lb.
Total water evaporated . .	36,221 lb.
Total water evaporated per hour .	4,724·7 lb.
Total water evaporated per hour per square foot heating surface	1·96 lb.
Total water evaporated per lb. of refuse actual . . .	1·135 lb
Total water evaporated per lb. of refuse from and at 212° F. .	1·297 lb.
Percentage of CO_2 (approximately)	11·87 per cent.

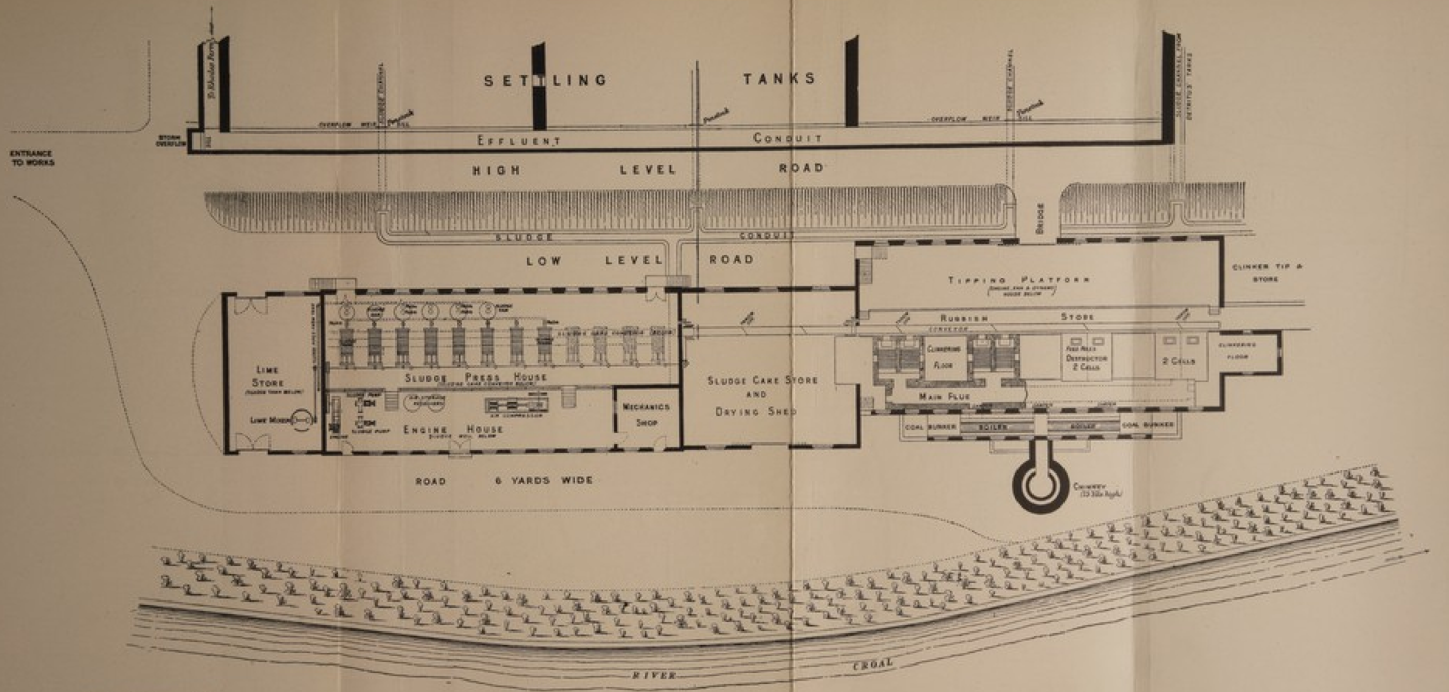
Fig. 56 is a cross section through the boiler, cells and hopper at No. 3 installation, which, however, has been somewhat modified since.

Blackpool Municipal Corporation—Population, 50,330.
Four Installations.

E. W.

	No. 1	No. 2	No. 3	No. 4
A	1890	1896	1899	1903
B	Fryer top fed	Horsfall top fed	Mason's gasifier top fed	Horsfall's direct charged
C	8	4	2	6
D	1 Multitubular	1 Multitubular	1 Vertical	2 Babcock & Wilcox
E	—	116 feet	—	200 feet
F	—	Steam Jet Blowers	Steam Jet Blowers	Steam Jet Blowers
G	—	—	—	Electric Lighting
H	—	32 tons	8 tons	—
I	—	1*s.* 6½*d.* including supervision	—	—

With a population varying from 50,000 to 120,000 in the season. ample destroying capacity is demanded, and it will be observed



SCALE—16 feet–1 inch.

FIG. 57. HACKEN COMBINED DESTRUCTOR AND SEWAGE WORKS, BOLTON.
General Plan.

that at Blackpool, with its many and varied attractions, sanitation has been kept carefully in mind.

As showing the class of refuse which has to be dealt with during the season, it is interesting to note that no less than two tons of paper is collected every day within a half mile radius of the Town Hall. The fourth Destructor installation will undoubtedly prove to be very superior in every respect to those previously erected.

BOLTON MUNICIPAL CORPORATION—POPULATION, 171,082.
FOUR INSTALLATIONS.

	No. 1	No. 2	No. 3	No. 4. S.W.
A	1881	1888	1901	1902
B	Fryer top fed	Local design	Horsfall back hand fed	Meldrum Beaman & Deas top fed
C	8	10	8	8
D	1 Multitubular 1 Lancashire 30 ft. × 7 ft.	2 Multitubular 1 Lancashire 30 ft. × 7 ft.	2 Babcock & Wilcox	2 Babcock & Wilcox
E	180 feet	195 feet	Same chimney	225 feet
F	—	—	Steam Jet Blowers	Fan
G	Mortar Mills	Mortar Mills	Forced draught and Mortar Mills	Sewage Pumping, etc.
H	40 tons	50 tons	59 tons	Refuse and sludge
I	10*d.*	10*d.*	—	—

Some details of an evaporative test with (No. 3) Horsfall's Destructor at Wellington Yard are here given :—

Date of test	August 2, 1902.
Duration of test	$22\frac{1}{4}$ hours.
Number of cells used	8.
Total grate area of cells	240 square feet.
Number and type of boilers used	2 Babcock & Wilcox.
Total heating surface of boilers	2,852 square feet.

Weight of Refuse destroyed per cell per hour	1,078·28 lb.
Weight of Refuse destroyed per square foot of grate surface per hour	35·67 lb.
Water evaporated per lb. of Refuse, from and at 212° F.	·8 lb.
Mean Steam Pressure	116·5 lb.
Highest temperature in main flue	2·000° F.
Percentage of residue to refuse destroyed	37·3 per cent.

The general arrangement of Meldrum's Destructor (No. 4) at Hacken Sewage Works will be seen by referring to the block plan (Fig. 55). This is the most modern and complete installation in this country for dealing with Sewage Sludge.

The sludge is pressed and so reduced to one fifth of its original bulk, but when ready for destruction still contains sixty per cent. of moisture. Two thirds of sludge are destroyed to one third of refuse, and from this mixture sufficient power is obtained to operate the pumping plant, sludge presses, lime mixers, conveyor plant, and also for the electric lighting of the works and the manager's house, 10 arc lamps and 44 incandescent lamps being provided for this purpose.

Some interesting figures are available which will serve to clearly show how the two old Destructors in Bolton have been operated profitably, as the result of the great demand for mortar produced from the clinker.

The following statement, for the year 1901, and referring to the old Destructors only, will doubtless be of interest:

Total quantity of refuse destroyed—33,528¾ tons.
Wellington Yard Destructor, mortar making.
Made and sold—

		£	s.	d.
7,350 tons	"Common" mortar at 5s. per ton	1,837	10	0
346 ,,	"Special" ,, 6s. 8d. ,, ,,	115	6	8
7,696 ,,		£1,952	16	8
	Cost of Mortar making	1,376	4	11
	Balance	£576	11	9

Back o' The Bank Destructor, mortar making,
Made and sold—

	£	s.	d.
5,881 tons "Common" mortar at 5s. per ton .	1,470	5	0
$288\frac{3}{4}$,, "Special" ,, ,, 6s. 8d. ,, .	95	5	0
	1,565	10	0
Cost of mortar making	1,106	0	0
Balance	£459	0	0

SUMMARY.

Total weight of mortar made and sold . . $13,865\frac{3}{4}$ tons.

	£	s.	d.
Total revenue from sales	3,518	6	8
Total cost of manufacture	2,482	4	11
Net profit from sales	1,037	11	9

The profit on the manufacture and sale of the mortar, according to the above figures, is such as to provide for the greater proportion of the labour cost in connection with the destruction of over 33,500 tons of refuse. Nor are the results obtained during the year 1901 exceptionally good, for in 1897, after paying the wages cost, and also for lime and water, tools, and current repairs, the sales of mortar yielded a net profit of £1,360 0*s.* 2*d.*, which sum sufficed to pay the whole of the wages in connection with the Destructors while still leaving a balance of £120 15*s.* 6*d.*

Ten mortar mills are in constant use, the mortar is in great demand, and, as will be observed, at a paying figure. While perhaps this case is without parallel, yet in every case where mortar is being made and sold, a profit is being realized.

BOOTLE MUNICIPAL CORPORATION—POPULATION, 58,566.

A	1893.
B	Local design; modified Fryer.
C	12.
D	1 Multitubular, 14ft. × 8 ft.
E	170 feet.
F	—
G	Clinker crusher and mortar mills.
H	50 tons.
I	$11\frac{1}{2}$*d.*

The total cost of this installation was £9,000. The clinker is fully utilized, a Musker Flag plant being installed in addition to the mortar mills.

BOURNEMOUTH MUNICIPAL CORPORATION—POPULATION, 47,003.

A	1887 and 1891.
B	Warner's top fed.
C	6.
D	None used.
E	150 feet.
F	Natural draught only.
G	No power available.
H	30 tons.
I	9*d*.

This is one of the few remaining installations in this country working with natural draught alone. Additional cells are badly needed, and these should be of the modern high temperature type.

BRADFORD MUNICIPAL CORPORATION—POPULATION, 279,767.

FOUR INSTALLATIONS.

	No. 1 Hammerton Street	No. 2 Cliffe Road	No. 3 Southfield Lane	No. 4. E.W. Sunbridge Road
A	1897	1891	1902	1903.
B	Horsfall top fed	Fryer top fed	Horsfall top fed	Horsfall top fed
C	12	8	6	12
D	2 Multitubular each 11 ft. × 8 ft.	—	—	2 Babcock & Wilcox, marine type
E	180 feet	180 feet	180 feet	—
F	Steam Jet Blowers	Steam Jet Blowers	Steam Jet Blowers	Steam Jet Blowers
G	Works purposes	Works purposes	Works purposes	Electricity
H	120 tons	—	—	120 tons
I	9*d*.	—	—	—

Installation No. 1, known as Hammerton Street Destructor, originally comprised a twelve cell plant of another make erected in 1880 and 1882. Nine years later forced draught was added to the twelve cells, which in 1897 were rebuilt by the Horsfall Company.

This installation secured great prominence owing to the enterprise and unceasing labour of the late Mr. John McTaggart, the well known Cleansing Superintendent of Bradford. Mr. McTaggart's work will be long remembered in Bradford, tending as it did to revolutionize Refuse Disposal, more particularly perhaps in the economic utilization of the residuum.

Some details of an evaporative test with this plant are here given :—

Date of test	June 24 to July 7, 1900.
Number of cells	12.
Type	Horsfall's back to back.
Duration of test	278 hours.
Nature of fuel	Midden, market and dry refuse.
Number of men employed	12 furnace men, 6 chargers.
Wages	Furnace men 28*s.*, chargers 25*s.*
Total quantity of refuse burned	2,896,320 lb. =1,293 tons.
Total quantity of refuse burned per cell per 24 hours	20,837 lb. =9·3 tons.
Total cubic feet of refuse burned per cell per 24 hours	543 feet.
Total quantity of refuse burned per cell per hour	868 lb.
Total quantity of refuse burned per square foot of fire grate per hour	34 lb.
Cost of labour per ton destroyed	9*d.*
Total weight of water evaporated	2,153,000 lb.
Total weight of water evaporated per hour	7,774 lb.
Total weight of water evaporated per cell per hour	645 lb.
Water evaporated per lb. of refuse burned	·743 lb.
Water evaporated per lb. of refuse burned from and at 212° F.	·882 lb.
Weight of clinker produced	817,516 lb. = 364·96 tons.
Weight of fine ash produced	26,936 lb. = 12·02 tons.

Weight of flue dust produced .	5,992 lb. =2·67 tons.
Total weight of residuals . .	850,444 lb. =379·65 tons.
Percentage of residuals . .	29·36 per cent.
Steam pressure maintained (by recorder)	60 lb.
Temperature of feed-water . .	60° F.
Temperature of gases in main flue	1,800° F.
Temperature of gases at chimney bottom	1,000° F.
Average air pressure (water gauge)	$\frac{7}{8}$ in.
Total I.H.P. per hour at 20 lb. .	387·2
Total I.H.P. per cell continuously .	32·2
I.H.P. hours per ton burned . .	83·2

Summary of Weights of Refuse taken during Test.

	Tons	cwt.	qrs.
Left in pit to start with	15	0	0
1,358 loads of ashpit refuse	1,174	15	1
61 loads of market refuse	47	19	3
80 loads of light refuse	31	3	0
447 tradesmen's carts, averaging 2 cwt. each .	44	2	0
	1,313	0	0
Less quantity left in pit	20	0	0
Total	1,293	0	0

	cwt.	qr.
Average weight of one load of ashpit refuse . .	17	1
Average weight of one load of market refuse . . .	15	3
Average weight of one load of light refuse . . .	7	3

	lb.
One cubic foot of ashpit refuse weighs	42·2
One cubic foot of market refuse weighs	22·6
One cubic foot of light refuse weighs	19·2

During the test the power generated was utilized in the following manner :

	£	s.	d.
306 tons 13 cwt. 2 qr. of mortar made and sold, value .	82	8	6
442 tons of crushed clinker sold	14	14	8
245 square yards of concrete flags manufactured, value	38	15	10
3 tons 3 cwt. 3 qr old tins sold, value . . .	0	15	11
About 4 tons of fish guano manufactured . .	12	0	0
	£148	14	11

The whole of the water evaporated was measured through a Kennedy water meter, fixed direct to the boiler.

FIG. 58. BRADFORD (HAMMERTON STREET) DESTRUCTOR.
View on top of Cells showing the Charging Operation.

ANALYSES OF CHIMNEY GASES FROM HAMMERTON STREET DESTRUCTOR, BRADFORD, BY MR. F. W. RICHARDSON, F.I.C., F.C.S., CITY ANALYST OF BRADFORD.

Date.	1 June 29	2 July 24	3 August 3, 1900
Carbon dioxide . . .	4·62	6·12	3·82 per cent.
Carbon monoxide . .	1·88	none	3·78 ,, ,,
Sulphur oxides . . .	—	traces	none
Oxygen	14·68	15·40	16·40 ,, ,,
Nitrogen	78·82	78·48	76·00 ,, ,,

At installation No. 3 (Southfield Lane) a considerable quantity of screened clinker and mortar is sold, as is also the case at Hammerton Street (No. 1); and at the latter works a flag plant is also in operation, which is capable of turning out some 200 paving flags per day.

At installation No. 4 (Sunbridge Road) the twelve cell plant is just now in course of erection, and will replace nine old cells. The power will be fully utilized for generating electricity, the makers guaranteeing an output of 1,000,000 units per annum from 120 tons of refuse daily. Assuming that the working days number 300, this would give an output per ton of refuse destroyed of rather less than 28 units, which figure should be reached without difficulty.

Fig. 58 clearly shows the method of charging at the No. 1 Hammerton Street Destructor, top fed type; the intake to the blast flue will be observed immediately behind the chargeman.

BRENTFORD URBAN DISTRICT COUNCIL—POPULATION, 15,163.

S. W.

A . . . 1900.
B . . . Fryer's improved, with Messrs. Boulnois, Wood & Brodie's patents.
C . . . 4.
D . . . 2 Babcock & Wilcox.
E . . . 150 feet.
F . . . Fan.
G . . . Sewage pumping, 600,000 gallons per 24 hours, also electric lighting of the works, stables and yard.
H . . . 14 tons.

BRIDPORT MUNICIPAL CORPORATION—POPULATION, 5,944.

The Council have recently decided to erect a small Destructor of the Horsfall type.

BRIGHTON MUNICIPAL CORPORATION—POPULATION, 124,539.

A . . .	1896.
B . . .	Fryer's Improved, including Messrs. Boulnois & Brodie's patents.
C . . .	12.
D . . .	1 Multitubular, 12 ft. × 8 ft.
E . . .	200 feet.
F . . .	Fan.
G . . .	Mortar mill and fan engine.
H . . .	72 tons.
I . . .	1*s*. 7*d*. per ton.

This Destructor was originally arranged to work with natural draught, but about two years since it was found advisable to add forced draught at a cost of about £1,791.

The mortar, made from three parts of clinker to one part of lime, is disposed of at a small profit. A considerable quantity of clinker is used for road foundations, and to further utilize this product it is proposed to erect a clinker brickmaking plant. Exhaustive inquiries concerning the utilization of clinker for brickmaking were made both in this country and on the Continent.

BRISTOL MUNICIPAL CORPORATION—POPULATION, 328,842.

A	1892.
B	Fryer top fed.
C	16.
D	1 Multitubular, 12 ft. × 8 ft.
E	180 feet.
F	Steam jet blowers—8 cells. Natural draught—8 cells.
G	Forced draught, mortar mills, etc.
H	108 tons.
I	11½*d*. per ton.

The cost of the Destructor installation was as follows :—

	£
Foundations	2,909
Destructor, cremator, approach road and offices . .	6,820
Chimney	1,689

A clinker crusher and two mortar mills with 7 ft. pans are installed to deal with part of the clinker, also a Musker Flag plant. During the year ending March 25, 1902, the clinker was disposed of as follows :—

14 tons of mortar sold at 7*s.* 6*d.* per ton.
1,777 ,, ,, ,, used by the Corporation.
2,635 ,, ,, screened ashes sold at 1*s.* 8*d.* per ton.
28 ,, ,, ,, ,, used by the Corporation.
343 ,, ,, rough ashes sold at 1*s.* per ton.
170 ,, ,, breeze sold at 1*s.* 3*d.* per ton.
143 ,, ,, ,, used by the Corporation.
849 ,, ,, clinker for road foundations sold at 1*s.* per ton.
1,324 ,, ,, ,, used by the Corporation.
2,239 ,, ,, ,, carted to tips.
1,029 ,, ,, ,, used for concrete flags and artificial stone dressings.

About 97 yards super of paving flags are produced daily in 9 hours at a cost of 2*s.* 6*d.* per yard, exclusive of repairs and depreciation. Slabs and building dressings are also made in wooden moulds by hand at a cost of 2*s.* 4*d.* per yard super.

Burnley Municipal Corporation—Population, 97,044.
Two Installations.

		E. W.
	1.	2.
A . .	1898.	1902.
B . .	Meldrum's Beaman & Deas top fed.	Meldrum's front hand fed.
C . .	1 Babcock & Wilcox.	1 Lancashire, 30 ft. × 8 ft.
D . .	2.	4 grates.
F . .	Fan.	Steam jet blower.
G . .	Electric lighting.	Electric lighting.
H . .	30 tons.	40 tons.

In addition to the boilers in connection with the Destructors, 3 Lancashire boilers, each 28 feet long and 7 feet 6 inches in diameter, are installed for coal firing. The power equipment of the station is as follows :—5 compound condensing engines, with 5 Elwell Parker and E.C.C. dynamos direct coupled, having a total capacity of 960 K.W., also Tudor cells of 500 ampère hours capacity.

[1] BURSLEM MUNICIPAL CORPORATION—POPULATION, 38,766.

A	1889.
B	Fryer top fed.
C	4.
D	1 Multitubular.
E	80 feet.
F	Fan.
G	Fan engine only.
H	25 tons.
I	1*s.* 5*d.*

BURTON-ON-TRENT MUNICIPAL CORPORATION — POPULATION, 50,386.

TWO INSTALLATIONS.

	1.	2.
A	1901.	1899.
B	Fryer top fed.	Meldrum front hand fed.
C	4.	2 grates.
D	1 Multitubular.	1 Cornish, 20 ft. × 6 ft.
E	144 feet.	Same chimney used.
F	—	Steam Jet Blowers.
G	Works purposes only.	Lighting works, water pumping, clinker crushing.
H	25 tons.	20 tons.
I	1*s.* 4*d.* per ton.	1*s.* 4*d.* per ton.

The installation here is of peculiar interest; the accompanying report by Mr. G. T. Lynam, the Borough Engineer, will serve to show how the Fume Cremator was "converted" into a two grate unit Destructor, a novel departure, but apparently amply justified by the results obtained.

[1] It has recently been decided to erect a second Destructor to deal with 10,000 tons of refuse per annum. The power will be fully utilized for electrical purposes.

County Borough of Burton-on-Trent

Corporation Destructor

The first portion of the Destructor, consisting of four cells, tipping platform, approach road, boiler and engine room, sheds and chimney, were erected by Messrs. Manlove, Alliott & Co., in 1890, at a cost of £4,800.

These cells are capable of destroying about 8,600 tons of refuse per annum. The quantity of clinker and ash remaining is about one-third of the bulk put into the furnaces.

About a year and a half ago a new furnace was erected by Messrs. Meldrum Bros., and the following is an epitome of the tests which were completed in April, 1900. It was feared that with forced draught to the new cells, the efficiency of the old ones would be seriously interfered with, but, as a matter of fact, the loss was not very great after certain difficulties as to the arrangement of the flue dampers were overcome.

At the first test, with the ordinary staff of men working 16 hours on the new furnace and twenty-four hours on the old, the former destroyed 15 tons 4 cwt. 3 qrs., or 19 cwt. per hour. The four old cells destroyed 27 tons 11 cwt. 1 qr., or nearly 23 cwt. per hour.

At the second test, which lasted 24 hours, the Meldrum cells destroyed 25 tons 8 cwt., or 2 cwt. per hour, which is equal to 44·8 lb. of refuse destroyed per square foot of grate area per hour. At the same time, the old cells destroyed 23 tons 15 cwt. 3 qrs., or 19 cwt. 3 qrs. 8 lb. per hour, equal to 22·2 lb. per square foot per hour. For this test four additional men were employed.

A third test made with the new furnace working to its full capacity resulted in 131 tons 14 cwt. being consumed in 120 hours, or 21·95 cwt. per hour, equal to 44·5 lb. of refuse per square foot of grate surface, the proportion of clinker resulting being 25·5 per cent.

As Messrs. Meldrum's guarantee was to destroy not less than 15 tons of refuse per 24 hours, the result of the test shows that they have exceeded that amount by 75·5 per cent.

A new Cornish boiler, 20 feet by 6 feet, has been fixed, the old one having proved to be much too small to deal with the great heat now produced.

It is proposed now to add to the works an electrical installation for lighting the stables and workshops adjoining, and a plant for pumping water for washing night soil pans. A stone breaker for breaking clinker and other material has recently been fixed. If further use can be found for the steam, there is little doubt that there is sufficient heat for a second boiler of the size above stated.

The total cost of the addition of the Meldrum furnace, with alteration to flues, new bye-pass, and the incidental work in connection with the alterations, has been about £540.

The following facts will be of interest, but they relate only to the old cells :—

	£	s.	d.
Total cost of working for 12 months ending March 31, 1900, was equal to 2*s.* 1*d.* per ton burned . .	930	7	5
Wages for same period were equal to 1*s.* 5½*d.* per ton burned	645	4	7
Repairs to machinery	9	13	8
,, ,, firebars	20	0	10
,, ,, buildings	70	3	0

The weight of the refuse consumed at present is about 200 tons per week, and the average amount of wages is £13 10*s.*, equal to 1*s.* 4*d.* per ton. The number of men employed is 8, divided into 2 day shifts of 3 men each, and a night shift of 2 men when the Meldrum furnaces are not used.

George T. Lynam,
Borough Engineer and Surveyor.

Town Hall, June 13, 1901.

Bury Municipal Corporation—Population, 58,028.

Two Installations.

S. W.

	1.	2.
A . .	1897.	1901.
B . .	Warner top fed.	Horsfall top fed.
C . .	6.	6.
D . .	3 Multitubular.	2 Babcock & Wilcox.
E . .	180 feet.	—
F . .	Fan.	Steam jet blowers.
G . .	Works purposes.	Sewage pumping.
H . .	—	40 tons.
I . .	—	10·8*d.*

A few details of an evaporative test made by Mr. Watson, the Electrical Engineer, are here given :—

Duration of test	4 hours.
Number of cells in use . . .	6.
Total refuse destroyed . . .	9 tons 1 cwt.
,, water evaporated per hour .	2,700 lb.
Temperature of feed water . .	50° F.
Evaporation per lb. of refuse . .	·532 lb.

Complete details of a test with installation No. 2 are here given :—

Date of test	March 10 to 11, 1902.
Duration of test	24 hours
Number and type of cells	6 Horsfall cells, back to back.
Total grate surface	180 square feet.
Nature of refuse	Unscreened house, wet ashpit, garden and market.
Number and type of boilers	2 Babcock & Wilcox.
Total heating surface	2,852 square feet.
Total quantity of refuse burned	129,360 lb.
Total quantity of refuse burned per cell per 24 hours	21,560 lb.
Total quantity of refuse burned per cell per hour	898 lb.
Total quantity of refuse burned per square foot of grate per hour	29·9 lb.
Tons per man per watch	5 tons 15 cwt.
Cost of labour per ton burned	10·8*d*.
Total water evaporated	98,728 lb.
Total water evaporated per lb. of refuse calculated from and at 212° F.	·94 lb.
Total water evaporated per square foot of heating surface per hour	1·4 lb.
Mean steam pressure	121·8 lb.
Mean feed temperature	50° F.
Mean main flue temperature	1,800° F.
Mean temperature behind boilers	500° F.

BUXTON MUNICIPAL CORPORATION—POPULATION, 10,181.
S.W.

A	1891.
B	Fryer top fed.
C	4.
D	—
E	150 feet.
F	—
G	No power available.
H	12 tons.
I	11*d*.

CAMBRIDGE MUNICIPAL CORPORATION—POPULATION, 38,398.

A	1899.
B	Fryer's improved, including Messrs. Boulnois, Wood & Brodie's patents, top fed.

C . . 6.
D . . 3 Babcock & Wilcox.
E . . 175 feet.

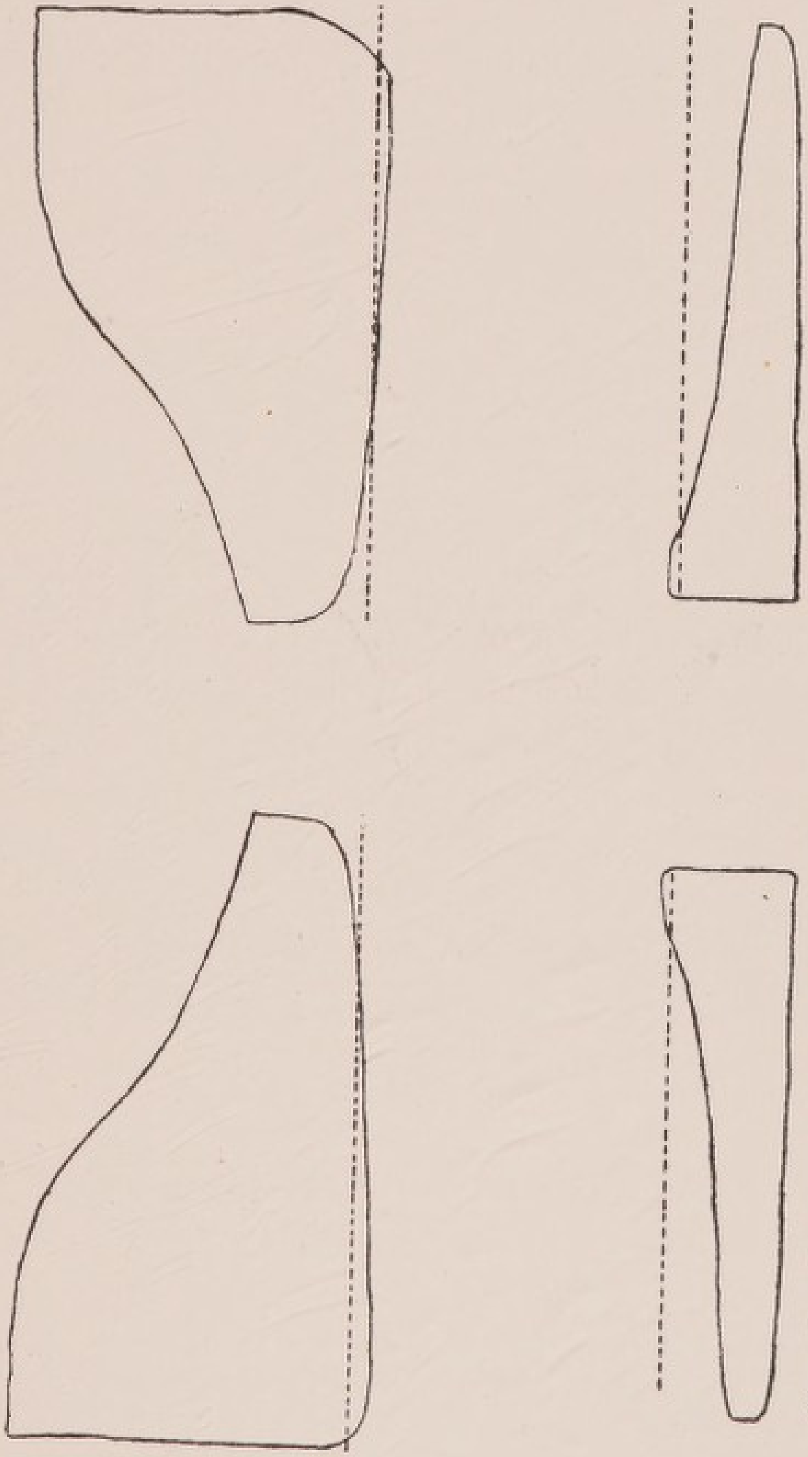


Fig. 59. Indicator Diagrams, Cambridge Combined Destructor and Sewage Works.

F . . Fan.
G . . Sewage pumping.
H . . 35 tons.
I . . 1*s*. 3*d*. including supervision.

The total cost of the Destructor, boilers, building and chimney was £10,177. The dry weather flow of sewage is 2,000,000 gallons, this volume having to be lifted 43 feet. The pumping plant comprises two 80 H.P. tandem compound condensing pumping engines.

The indicator diagrams here reproduced (see Fig. 59) are very interesting as showing what work has been accomplished

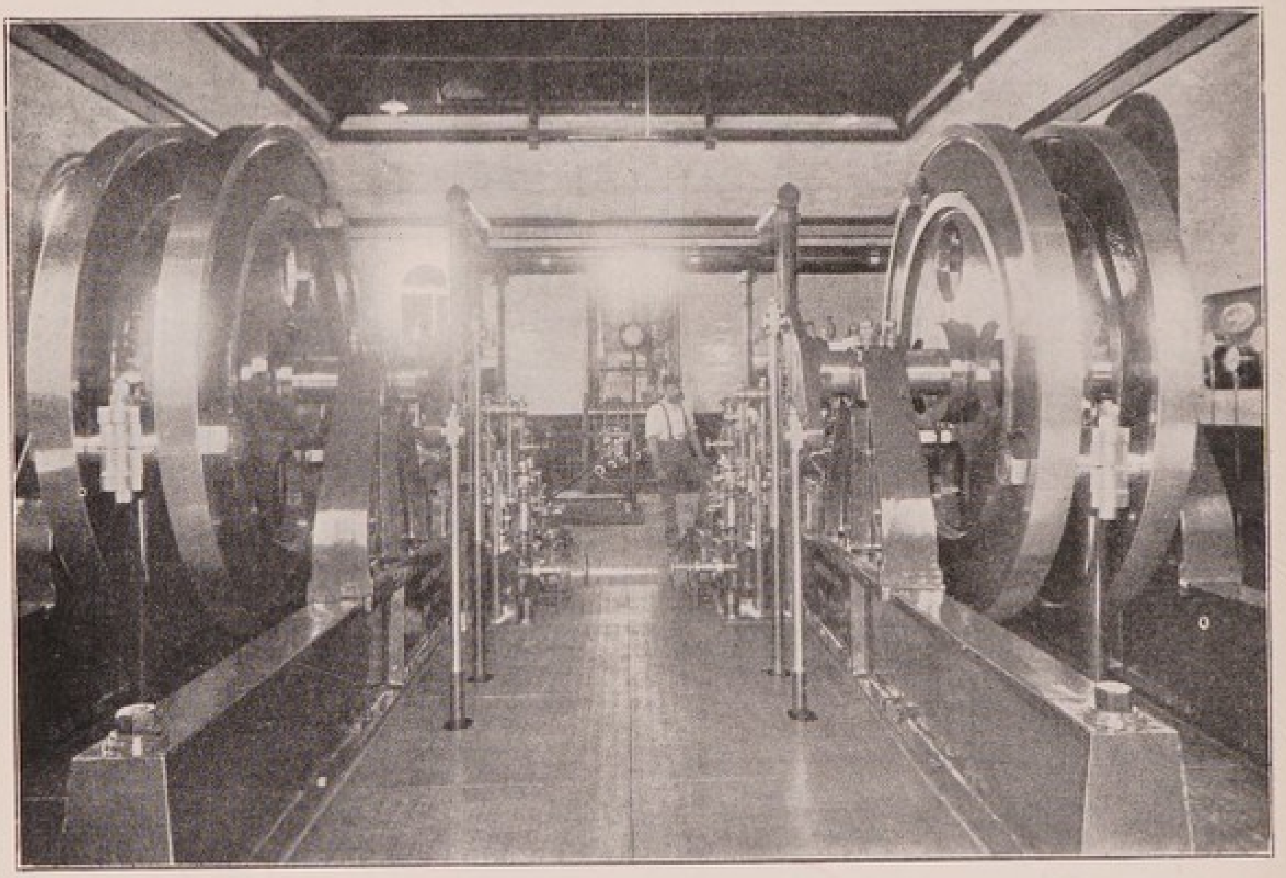


FIG. 60. COMPOUND CONDENSING PUMPING ENGINES, CAMBRIDGE COMBINED DESTRUCTOR AND SEWAGE WORKS.

with this plant, while Figs. 60 and 61 respectively clearly show the pumping engines and cells and boilers.

The *calculations of power* (see Fig. 59) are as follows—

Diameter of cylinders, 26 in., 48 in. .	Stroke 4 ft.
Steam on boiler	78 lb.
Vacuum	25 in.
Strokes per minute	$13\frac{1}{2}$.
Mean P. in H.P. cylinder . . .	57·2 lb.
,, ,, L.P. ,, . . .	7 lb.
I.H.P. in H.P. ,, . . .	99·38 } —140·78 I.H.P.
I.H.P. in L.P. ,, . . .	41·4 }

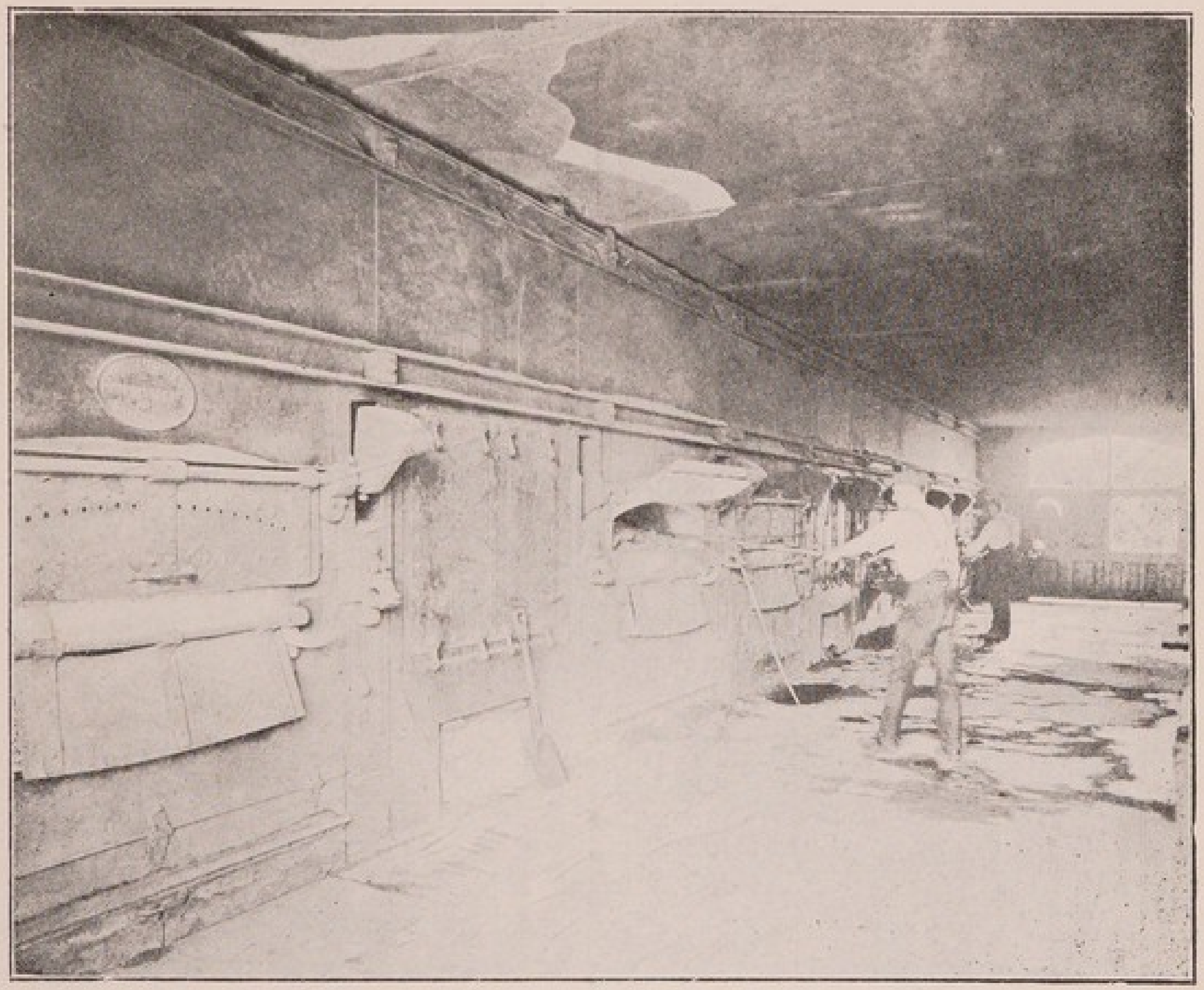


FIG. 61. DESTRUCTOR CELLS AND BOILERS, CAMBRIDGE COMBINED DESTRUCTOR AND SEWAGE WORKS.

CANTERBURY MUNICIPAL CORPORATION—POPULATION, 24,868.
E. W.

A	1899.
B	Meldrum's Beaman & Deas, top fed.
C	2.
D	1 Babcock & Wilcox.
E	150 feet.
F	Fan.
G	Electric lighting.
H	20 tons.
	s. d.
I	1·986.

Four Lancashire boilers for supplementary coal firing are provided in a separate boiler house, and the power equipment of the station is as follows :—4 high speed enclosed engines and 4 dynamos direct coupled, of a total capacity of 600 K.W. Also 280 Chloride R. type cells, capacity 630 ampère hours.

Some details of the official evaporative test of the Destructor are here given.

Official test at Canterbury Destructor and Electricity Works with Meldrum's Beaman and Deas Patent Destructor.

Quality of refuse	Dry and of average quality.
Duration of test	$8\frac{3}{4}$ hours.
Average temperature of feed-water	123° F.
Average boiler pressure	125 lb. per square inch.
Refuse consumed	29,400 lb.
Water evaporated	41,300 lb.
Water evaporated per lb. of refuse under actual conditions	1·4 lb.
Water evaporated per lb. of refuse from and at 212° F.	1·58 lb.
Water evaporated per lb. of refuse from feed-water at 60° F.	1·28 lb.
Refuse burned per hour	3,360 lb.
Water evaporated per hour	4,717 lb.
Rate of burning per day of 12 hours	18 tons.
Weight of clinker	5 tons 3 cwt.

It is interesting to compare the figures of the official test with the following figures which cover a period of 200 working hours :—

Total weight of refuse destroyed	256 tons.
Average rate of combustion per hour	1·28 tons.
Total water evaporated (actual)	552,480 lb.
Average evaporation per lb. of refuse destroyed (actual)	·986 lb.
Average evaporation per hour	2,762 lb.

Cheltenham Municipal Corporation—Population, 49,439.

A	1890.
B	Fryer top fed.
C	8.
D	1 Multitubular.
E	160 feet.
F	—
G	Mortar mills and disinfector.
H	40 tons.
I	7·6*d*.

CHESTERFIELD—POPULATION, 27,185. S.W.

A	1901 and 1902.
B	Horsfall back hand fed.
C	4.
D	2 Babcock & Wilcox.
E	—
F	Steam jet blowers.
G	Sewage pumping.
H	25 tons.
I	7·6*d*.

This installation has been very successful. The clinker is crushed and utilized on the Bacteria Beds.

CLECKHEATON URBAN DISTRICT COUNCIL—POPULATION, 15,250. E. W.

A	1902.
B	Meldrum front hand fed.
C	4 grates.
D	2 Lancashire, each 26 ft. × 7 ft. 6 in.
E	120 feet.
F	Steam jet blowers.
G	Electric traction.
H	12 tons.
I	—
J	35.

The working pressure of the boilers is 180 lb., steam being supplied to the engines at 160 lb. pressure. In addition to regenerators for heating the air supply for combustion, a Green's Economiser of 192 pipes is also provided.

The equipment of the power station is as follows :—

3 Bellis high speed engines, and 3 Johnson Lundell dynamos, direct coupled, having a total capacity of 450 K.W., also 270 E.P.S. cells—capacity 400 ampère hours.

The main load at present is for traction purposes, the Council having an agreement with the British Electric Traction Company, by which all energy required will be supplied from the Council's station.

The agreement provides for a minimum supply of 400,000 units per annum at 1½*d*. per unit, that is the Company will pay £2,500 per year to the Urban District Council. The next 100,000 units will be charged at 1·4*d*. per unit, and all in excess of this at 1·3*d*. per unit. This is generally considered by all concerned to be a fair price, enabling all standing station charges to be met, but giving no undue profit to the Council. Briefly, such an agreement allows Cleckheaton to possess its own electricity undertaking without risk of its being any burden on the rates.

Colne Municipal Corporation—Population, 23,000.

E. W.

A	1899.
B	Meldrum's Beaman & Deas top fed.
C	2.
D	1 Babcock & Wilcox.
E	210 ft. × 6 ft., internal throughout.
F	Fan.
G	Electric lighting.
H	18 tons.
I	10½*d*.
J	20.

The following report by Mr. H. C. Sugden, the Health Superintendent, of the first nine months' working of this installation, will doubtless be of interest.

Refuse Destructor.

This important undertaking commenced working in March last, and for the nine months ending December 31, 1899, it burnt the following refuse :—

Loads of refuse		3,489	
Loads of garbage		43	
Total		3,892	
	Tons	cwt.	qrs.
Weight of ashes	3,083	1	22
Weight of garbage	49	18	0
Total	3,132	19	2

The number of actual working fan hours of the furnaces amounts to 1,767, showing a consumption of refuse amounting to 1 ton 15 cwt. 1 qr. per two cells per hour. This, in my opinion, is a very good result, when we take into consideration that in summer we only average 55 tons per week of 48 fan hours, while in the winter our consumption amounts to an average of 98 tons per week of 48 fan hours.

There is no doubt that if there were sufficient refuse in the town to keep the Destructor working night and day, the consumption would be materially increased, as the furnaces in the morning are practically cool, this necessitating the first few loads taking longer to burn than those at a later period of the day.

I should like to draw your attention to the enormous waste of steam, which could undoubtedly be used for some purposes to create a slight revenue.

On January 26, 1900, Mr. Cooper, the electrical engineer, and I took a test to gauge the amount of horse power which at present is not utilized for any purpose.

Duration of test . . .	9½ hours.
Steam pressure . . .	90 lb.
Temperature of feed-water .	100° F.
Water evaporated . . .	17 tons 1 cwt. 3 qr. or 38,276 lb.
Water evaporated per lb. of refuse burned . . .	1 lb. of water.
Horse-power, on a basis of 20 lb. steam per I.H.P. .	203 H.P. per hour.

The test, in comparison with sixteen Destructors in various parts of the country, shows exceedingly well, and, as I said before, if the furnace did not cool during the night more favourable results would be acquired. Comparing the work of the last few months, I find that it is now being done with greater economy and despatch. The men have now got quite used to their work, and appear to be content.

Considering the financial side of the Destructor, the cost of burning runs out somewhat as follows :—

	s.	*d.*	
Cost of burning (labour only)	0	10½	per ton.
Sinking fund and interest	1	1	,, ,,
Cost of carting, office, etc.	2	1	,, ,,
This makes a total cost of refuse burned .	4	0½	,, ,,

The cost of the installation was as follows:

	£	s.	d.
Land and ground rent	2,000	0	0
Chimney	2,025	0	0
Buildings	1,450	0	0
Approach road	1,110	0	0
Destructor and boiler	1,190	0	0
Office and weighbridge	400	0	0
Engine and mess-room	500	0	0
Boundary wall	450	0	0
Clinker crushing plant and engine	450	0	0
	£9,675	0	0

Wishing to fully utilize the power available from the Destructor, it was decided to instal a Parson's turbine, and steam is now supplied to a 150 H.P. Parson's Turbo Generator, which generates at 480 volts for lighting, and 500 to 550 volts for traction. It is run at 3,300 revolutions.

The additional plant at the electricity works is as follows: One Lancashire boiler and Green's economiser, one Bellis engine direct coupled to a Greenwood and Batley's multipolar dynamo, the total capacity being 260 K.W., also 270 P.T.L. York cells; capacity 60 ampère hours.

The clinker from the Destructor is crushed and graded, a portion being utilized for mortar making, but the greater part is sent to the sewage works for use on the bacteria beds instead of coke, which was formerly employed.

Croydon—Population, 137,000.

The Corporation have recently decided to erect a Destructor of the "Warner Perfectus" type on a site known as Brimstone Barn.

It is also proposed to erect two other Destructors in the immediate future on other sites, with a view to keeping the cartage cost as low as possible.

Dartford Urban District Council—Population, 18,643.

E. W. & S. W.

A	1903.
B	Meldrum improved top fed.
C	2 grates.
D	1 Lancashire, 30 ft. × 8 ft.
E	120 feet.
F	Steam jet blowers.

G	Electric lighting and sewage pumping.
H	20 tons.
I	Not yet determined, the Destructor only having recently been started.

A Sugden Superheater is set in the downtake at the back of the boiler to give a moderate superheat, while beyond the superheater is the regenerator, for heating the air for combustion, and also a Green's Economiser for heating the boiler feed water. A Bruun Lowener Water Softener is also installed and arranged to deliver a supply of hot water to the economiser.

The power will be fully utilized for sewage pumping and electric lighting, and it is anticipated that the daily collection of refuse will give sufficient steam not only for the operation of the sewage pumps, but also for the electric lighting until the demand for current seriously increases.

Two additional Lancashire boilers of the same size as the Destructor boiler are installed in a separate boiler house, and these will be coal fired as may be found necessary. The power equipment of the electricity works comprises two Reavell engines, direct coupled to two General Electric Company's dynamos, the total capacity being 250 K.W. A storage battery has been installed by Messrs. Ashmore, Benson, Pease & Co., and has a capacity of 250 ampère hours.

Darwen Municipal Corporation—Population, 40,000.

E. W.

A	1899.
B	Meldrum front hand fed.
C	8 grates.
D	2 Lancashire, each 30 ft. × 8 ft.
E	240 feet.
F	Steam jet blowers.
G	Electric traction and lighting.
H	35 tons.
I	1s.
J	33.

For the year ending March 31, 1901, the following interesting figures are available. The average evaporation per pound of refuse destroyed over a total quantity of 10,000 tons was actually 1·25 lb. of water. During the same period the total cost of coal, water and stoking to the Electricity Department was £1,200. With their separate coal fired boilers the Electricity Department evaporated 2,940,000 gallons of water during the year, while the boilers in connection with the Destructor, from refuse alone, evaporated 2,520,000 gallons of water during the same period, this being a *net* quantity after deducting the proportion of steam supplied for the forced draught blowers.

On the basis of £1,200, as the cost of evaporating 2,940,000 gallons of water with the coal fired boilers, the 2,520,000 gallons of water evaporated by the Destructor boilers has a value of £1,050; that is, had there been no available power from the refuse, the Electricity Department would have paid £1,050 extra for water, coal and labour charges, so that clearly this amount in the gross, was saved by the combination.

The figures quoted are reliable, the water being supplied to the electricity works and the Destructor works through separate meters. Two supplementary coal fired boilers are provided in a separate boiler house. The power equipment is as follows:— Four Bellis engines, and two Siemens', one Mather and Platt, and one Bruce Peebles dynamos, direct coupled, having a total capacity of 900 K.W. Also 250 Tudor cells of 600 ampère hours' capacity, maximum discharge 250 ampères.

Some extracts from the returns for the second year's working are of interest:—

Load factor	12·12 per cent.
Fuel cost	·65*d*. per unit.
Works "	1·10*d*. " "
Total "	1·34*d*. " "
Net profit	£217.

Some details of an evaporative test with the Destructor are here given:—

Date of test	April 5, 1900.
Duration of test (2 p.m. to 10 p.m.) . .	8 hours.

Kind of fuel burned	Unscreened ashpit refuse.
Total refuse burned (15 tons 15 cwt.) . .	35,280 lb.
Refuse burned per hour (1 ton 19 cwt. 1 qr. 14 lb.)	4,410 lb.
Refuse burned per square foot of grate per hour	52·5 lb.
Total water evaporated (4,903·5 gallons) .	49,035 lb.
Water evaporated per hour (612·94 gallons)	6,129·4 lb.
Water evaporated per lb. of refuse, actual .	1·39 lb.

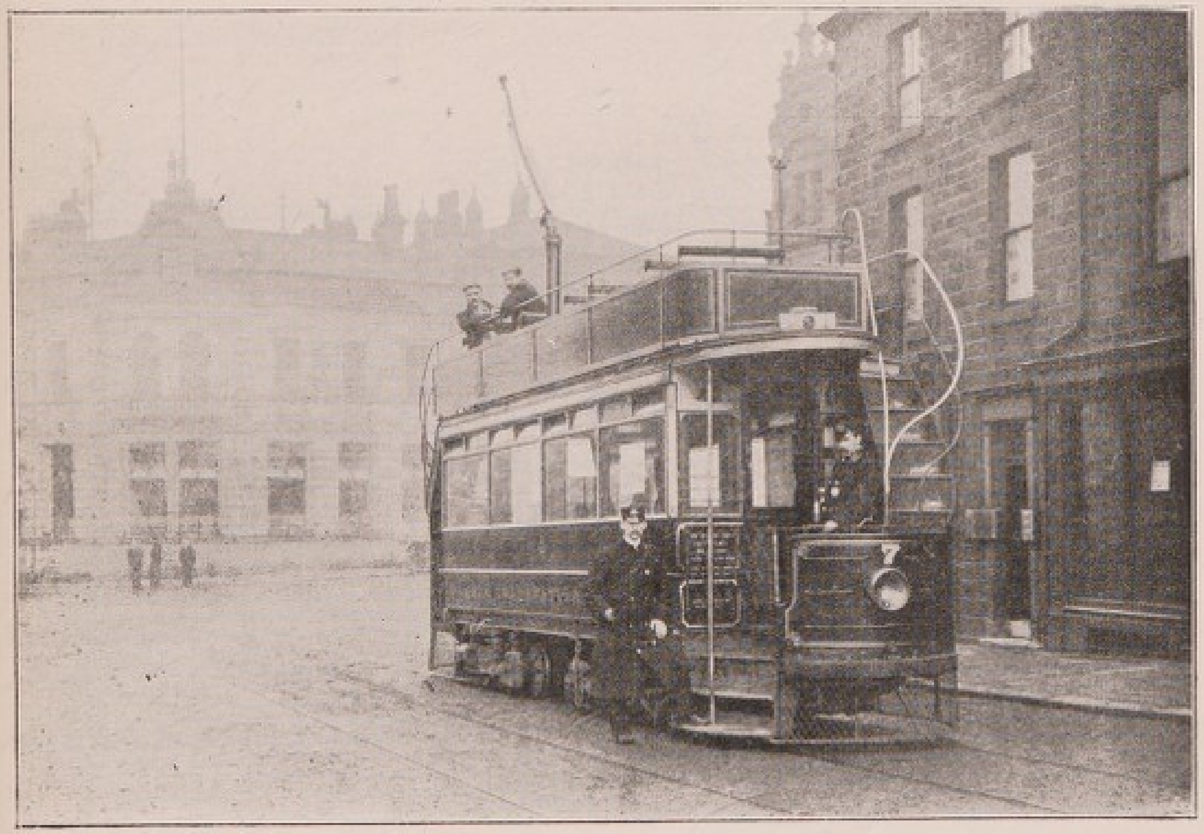


FIG. 62. DARWEN COMBINED DESTRUCTOR AND ELECTRICITY WORKS. ELECTRIC CAR.

Water evaporated per lb. of refuse, from and at 212° F.	1·71 lb.
Total weight of clinker and ash (4 tons17 cwt. 2 qrs. 16 lb.	10,936 lb.
Percentage of clinker and ash . . .	31 per cent.
Average steam pressure	195 lb.
Temperature of feed-water . . .	40° F.
Temperature of hot air feed . . .	291·6° F.
Temperature in combustion chamber (by copper test)	2,000° F.

ANALYSIS OF FLUE GASES.

Percentage of carbonic acid (CO_2) (36 readings)	14·13 per cent.
Percentage of free oxygen (O) (35 readings)	6·21 per cent.
Percentage of carbonic oxide (CO) (35 readings)	*Nil.*

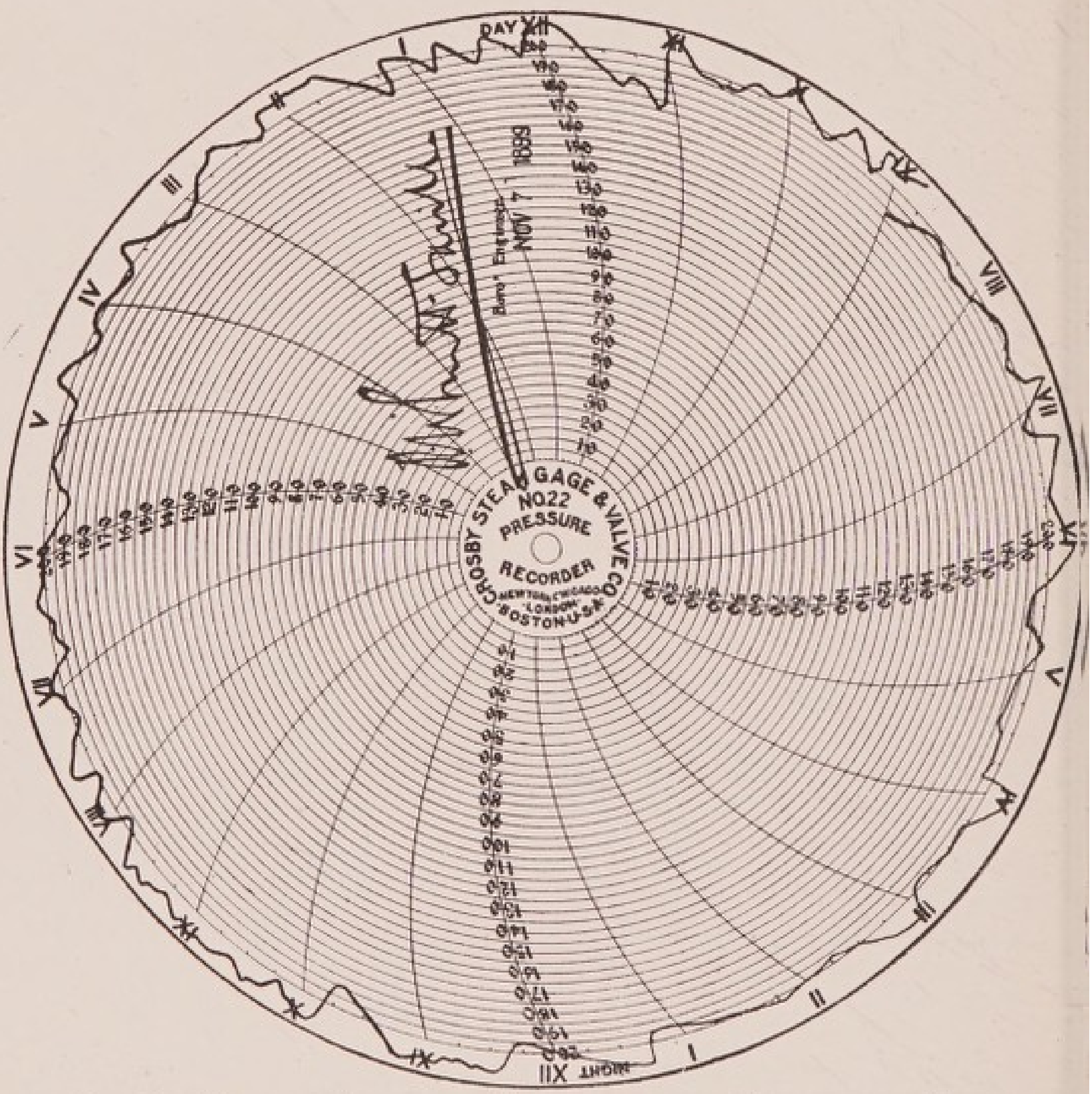


FIG. 63. DARWEN COMBINED DESTRUCTOR AND ELECTRICITY WORKS. STEAM PRESSURE RECORDER DIAGRAM.

Fig. 62 shows one of the electric cars which are in operation for 18 hours daily between Darwen and Blackburn, the current being generated by steam from the Destructor boilers. It will be interesting to the still doubting councillor to compare this illustration with say Figs. 2, 3, 5 and 6. Fig. 63 is a reproduction of a steam pressure recorder diagram.

DERBY MUNICIPAL CORPORATION—POPULATION, 113,863.
TWO INSTALLATIONS.

	1.	2.
A	1882.	1898.
B	Fryer top fed.	Warner top fed.
C	6.	6.
D	—	1 Multitubular, 10 ft. × 6 ft.
E	160 feet.	Same chimney used.
F	—	Fan.
G	—	Fan engine and elevator.
H	50 Tons.	—
I	—	—

DEWSBURY MUNICIPAL CORPORATION—POPULATION, 28,060.

A	1898.
B	Meldrum's Beaman & Deas top fed.
C	2.
D	1 Babcock & Wilcox.
E	90 feet.
F	Fan.
G	Fan engine and mortar mill.
H	28 tons.
I	13·75*d*.

A considerable quantity of mortar is made, which sells freely at 7*s*. per ton, yielding a fair profit.

EALING MUNICIPAL CORPORATION—POPULATION, 33,040.
S.W.

A	1883. Three extensions since.
B	Fryer, Warner and Ealing model, all top fed.
C	10.
D	3 Multitubular.
E	143 feet.
F	Fan.
G	Sewage pumping, sludge pressing, etc., for approximate details see below.[1]
I	—

Estimated saving in coal cost per annum, £300.

Mr. Chas. Jones, M.I.C.E., the Surveyor, has done yeoman service for many years past, in popularizing the Refuse Destructor, and his name will always be remembered and honoured by the sanitarian.

The clinker is all fully utilized. Mr. Jones has always claimed that he could make good use of every pound of clinker.

[1] Air compressors for sludge pressing	25 H.P.
Forced draught	14 ,,
Sludge pump and slab plant	8 ,,
Engines for operating lime mixers and agitators in tanks	12 ,,
3 steam pumps aggregating	20 ,,
Total	79 H.P.

EASTBOURNE MUNICIPAL CORPORATION—POPULATION, 43,337.
S. W.

A	1890.
B	Fryer top fed.
C	6.
D	2 Multitubular.
E	150 feet.
F	Natural draught only.
G	—
H	35 tons.
I	—

A six cell modern Destructor of the improved Fryer type is now in course of erection, with three Babcock and Wilcox boilers, one boiler being set between each pair of cells. The power will be fully utilized for working the air compressing plant in connection with Shone's ejectors. This Destructor will displace the original plant as described above, but the same chimney will be used.

EAST HAM URBAN DISTRICT COUNCIL—POPULATION, 100,000.
S. W.

A	1903.
B	Meldrum's special type front hand fed.
C	2.

[1] A considerable quantity of sludge is destroyed with the refuse.

D	1 Babcock & Wilcox.
E	—
F	Steam jet blowers.
G	Sewage pumping.
H	—
I	—

This plant is now in course of erection; it is merely an experimental installation, preliminary to the erection of a complete Destructor plant.

Refuse will be burned in special designed furnaces installed under a large Babcock and Wilcox boiler, and also in connection with a large Lancashire boiler. This course has been decided upon as the result of some experiments carried out on similar lines with East Ham refuse a few months since.

While undoubtedly a considerable amount of power may be obtained, the system cannot be generally recommended, mainly because power production and not perfect cremation is the inevitable result.

Eccles Municipal Corporation—Population, 34,369.

S. W.

A	[1]
B	Meldrum's front hand fed.
C	4 grates.
D	2 Lancashire, each 28 ft. × 7 ft.
E	95 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	30 tons.
I	[1]

Elland Urban District Council—Population, 10,412.

E. W.

A . . .	1903.
B . . .	Meldrum's improved top fed and front fed.
C . . .	3 grates.

[1] This installation, which will also comprise machinery for clinker utilization, will not be completed until early in 1904.

D . . .	1 Lancashire, 30 ft. × 8 ft.
E . . .	—
F . . .	Steam jet blowers.
G . . .	Electric lighting.
[1]H . . .	10 tons.
I . . .	This installation has only recently been opened.

EPSOM URBAN DISTRICT COUNCIL—POPULATION, 10,915.

S. W.

A	[2]
B	Meldrum's front hand fed.
C	4 grates.
D	2 Cornish, each 16 ft. × 6 ft.
E	60 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	10 tons.
I	[2]

FLEETWOOD URBAN DISTRICT COUNCIL—POPULATION, 12,082.

E. W.

A	1900.
B	Meldrum's Beaman & Deas top fed.
C	2.
D	1 Babcock & Wilcox.
E	—
F	Fan.
G	Electric lighting.
H	12 tons.
I	—

One additional boiler is installed for coal firing, and also a Green's Economiser. The power equipment of the electricity works is as follows :—Two Willans engines, total H.P. 200, direct coupled to two four pole Johnson and Phillips dynamos, of a total capacity of 600 ampère hours.

The detailed figures of the official test are here given.

[1] A proportion of sewage sludge is also being destroyed.

[2] This installation will not be completed until early in 1904.

Test of Meldrum's Beaman and Deas Type of Destructor at the Electric Light Station, Fleetwood.

Date of test	September 28, 1900.
Duration of test	8 hours.
State of weather	Fine.
Kind of fuel	Unscreened ashpit refuse (very wet).
Number of cells	2.
Area of each grate	25 square feet.
Type of boiler	Babcock & Wilcox.
Heating surface of boiler . . .	1,426 square feet.
Total weight of refuse burned, 14 tons 7 cwt. 2 qrs. 20 lb. . . .	32,220 lb.
Weight burned per hour, 1 ton 15 cwt. 3 qrs. 23 lb.	4,027 lb.
Weight burned per square foot grate, per hour (50 square feet) . .	80·5 lb.
Total weight of clinker and ash, 4 tons 13 cwt. 1 qr. 0 lb. . . .	10,444 lb.
Percentage of clinker and ash . .	32·4 per cent.
Total water evaporated . . .	31,952 lb.
Water evaporated per hour . .	3,994 lb.
,, ,, ,, lb. of refuse, actual	·916 lb.
Water evaporated per lb. of refuse from and at 212° F. including economiser	1,191 lb.
Water evaporated per square foot heating surface	2·8 lb.
Temperature of feed-water at tank .	59° F.
Temperature of feed-water from economiser	239° F.
Average steam pressure . . .	135 lb.
Average air pressure	$2\frac{1}{2}$ in.
Temperature of combustion chamber by copper test	2,000° F.
Temperature in main flue before economiser	622° F.
Temperature in main flue after economiser	356° F.
Average chimney pull . . .	$\frac{3}{8}$ in.

It rained heavily on three consecutive days immediately preceding the test, and the quality of the refuse was exceedingly bad.

FOLKESTONE MUNICIPAL CORPORATION—POPULATION, 30,690.

The Corporation have lately decided to erect a Destructor of the Horsfall back shovel fed type at a total estimated cost of £14,000.

GARSTON (CITY OF LIVERPOOL)—POPULATION, 18,710.
E. W.

A	1901.
B	Meldrum front hand fed.
C	3 grates.
D	1 Babcock & Wilcox.
E	—
F	Steam jet blowers.
G	Electric traction.
H	25 tons.
I	—

The power is fully utilized for electric traction, and although no official returns are available, it is stated that the power production is highly satisfactory.

Two Lancashire boilers for coal firing alone are installed in a separate boiler house. The power equipment of the electricity works is as follows:—Two Browett Lindley engines, total H.P. 140, direct coupled to two Siemens shunt wound dynamos, total capacity 87 K.W., also a storage battery of 232 W.P.S. cells, having a total capacity of 400 ampère hours.

GLOUCESTER MUNICIPAL CORPORATION—POPULATION, 47,955.
E. W.

A	1902.
B	Heenan back fed.
C	4.
D	2 Babcock & Wilcox.
E	—
F	Fan
G	Electric lighting.
H	25 tons.
I	10*d.*
J	35.

The supplementary coal fired boiler plant comprises four Lancashire boilers, each 30 feet long, and 8 feet in diameter, with a Green's Economiser. Sufficient steam is provided by the Destructor boilers to charge the batteries which light the city during the night.

The power equipment of the station is as follows :—One 250 H.P. Bellis engine, and one 500 H.P. engine of the same make, also one Willans engine of similar capacity. Four 150 K.W. Silvertown dynamos, and two 75 K.W. Mather and Platt dynamos. The storage cells number 280 of the E.P.S. type.

Gosport Urban District Council—Population, 28,887.
S. W.

The Council have just decided to erect a two-cell Destructor of the Horsfall type, at the new sewage works, in front of two existing boilers of the Lancashire type. The estimated cost of the Destructor installation is given as £1,100.

Gorton Urban District Council—Population, 28,000.
S. W.

It has recently been decided to erect a Destructor of the Horsfall type at the Council's sewage outfall works, at an estimated cost of £8,816.

Grantham Municipal Corporation—Population, 17,598.

A	1903.
B	Fryer's improved top fed.
C	2.
D	1 Lancashire.
E	80 feet.
F	Steam jet blowers.
G	Forced draught and disinfector.
H	—
[1]I	—

[1] These works are now in course of erection.

GRAYS URBAN DISTRICT COUNCIL—POPULATION, 15,834.

E. W.

A	1901.
B	Meldrum front hand fed.
C	2 grates.

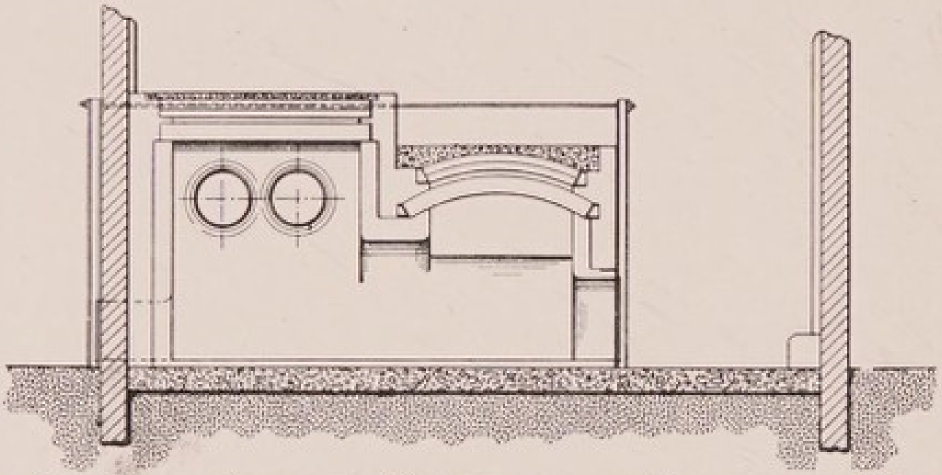


FIG. 64. GRAYS COMBINED DESTRUCTOR AND ELECTRICITY WORKS

Sectional Elevation.

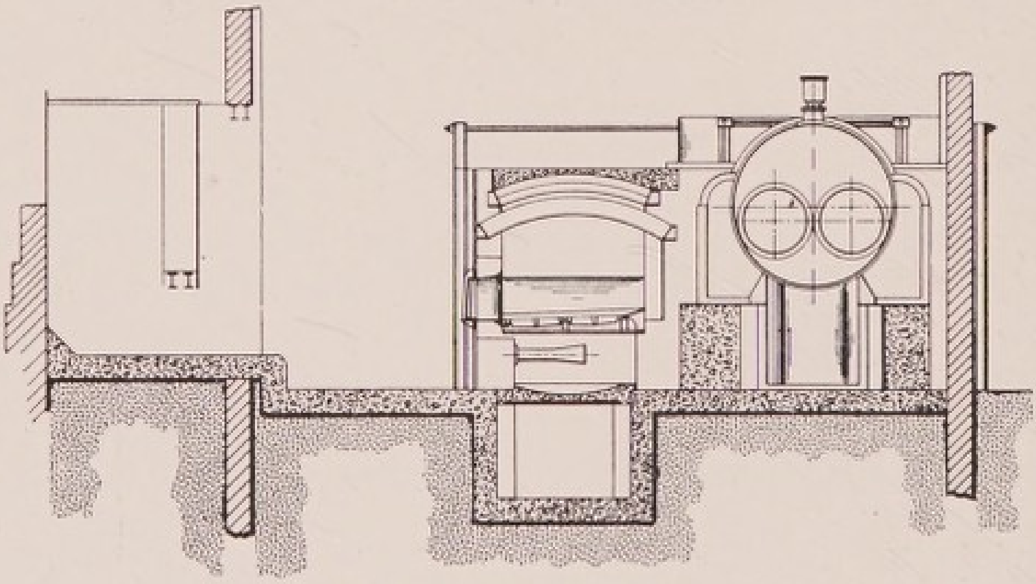


FIG. 65. GRAYS COMBINED DESTRUCTOR AND ELECTRICITY WORKS.

Sectional Elevation.

D	1 Lancashire, 20 ft. × 7 ft.
E	100 feet.
F	Steam jet blowers.
G	Electric lighting.
H	8 tons.
I	10*d*.
J	33.

Two supplementary coal fired boilers are installed in a separate boiler house. The power equipment of the station comprises the following :—Two Reavell engines, total H.P., 300, direct coupled to two British Schuckert four-pole dynamos of a total capacity of 200 K.W. Also 260 D.P. cells having a total capacity of 350 ampère hours.

Some details of the official test of the Destructor are here given.

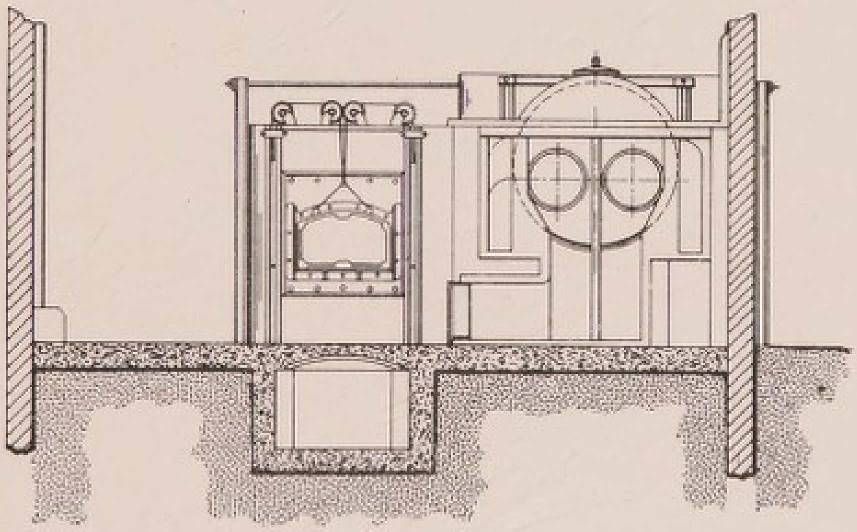


FIG. 66. GRAYS COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
Sectional Elevation.

TEST OF MELDRUMS PATENT "SIMPLEX" REFUSE DESTRUCTOR AT THE COUNCIL'S ELECTRICITY WORKS, GRAYS THURROCK, ESSEX.

E. D. LONG, ESQ., A.I.E.E., ENGINEER.

Date of test	January 23, 1902.
Duration of test (starting from cooled furnace)	7 hours.
Grate area	50 square feet.
Boiler, Lancashire, 20 ft. × 7 ft., heating surface	600 square feet.
Economiser, 128 tubes, heating surface .	1,408 square feet.
Refuse delivered (including pots, tins, etc., not deducted from total) . . .	26,684 lb.
Refuse consumed per hour	3,812 lb.
Refuse consumed per square foot grate per hour	$76\frac{1}{4}$ lb.

Total water evaporated . . . . . 27,100 lb.
,, ,, ,, per hour . . . $3{,}871\frac{1}{2}$ lb.

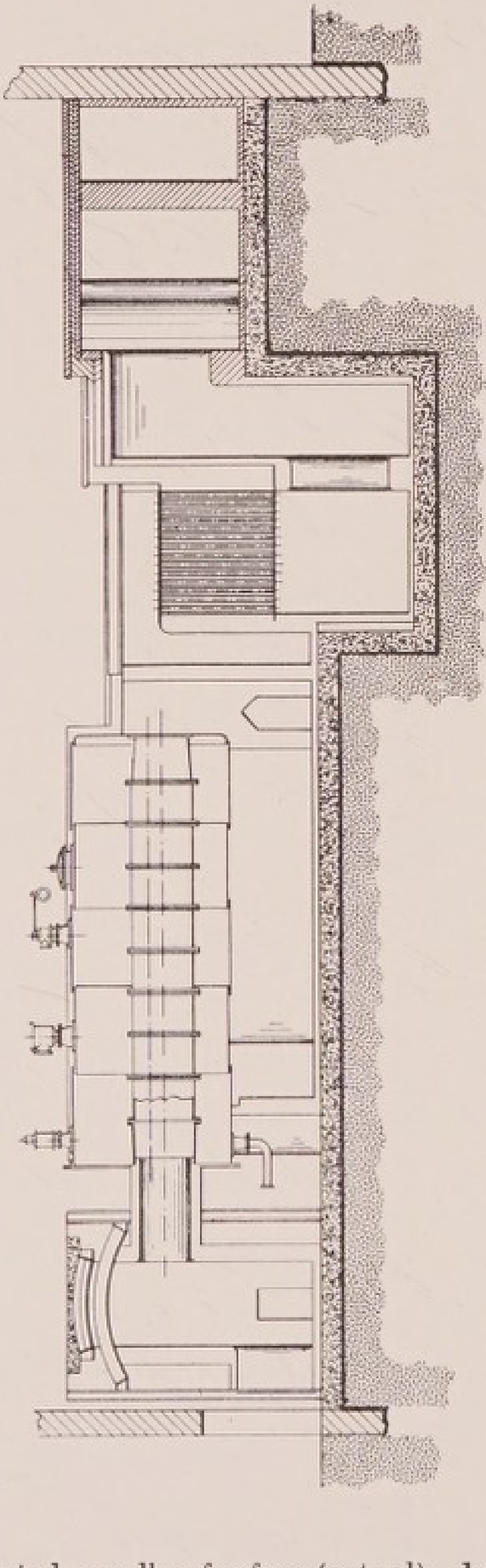


Fig. 67. Grays Combined Destructor and Electricity Works.
Longitudinal Elevation.

Water evaporated per lb. of refuse (actual) 1·01 lb.

Water evaporated per lb. of refuse from and at 212° F. . . . . . . 1·22 lb.

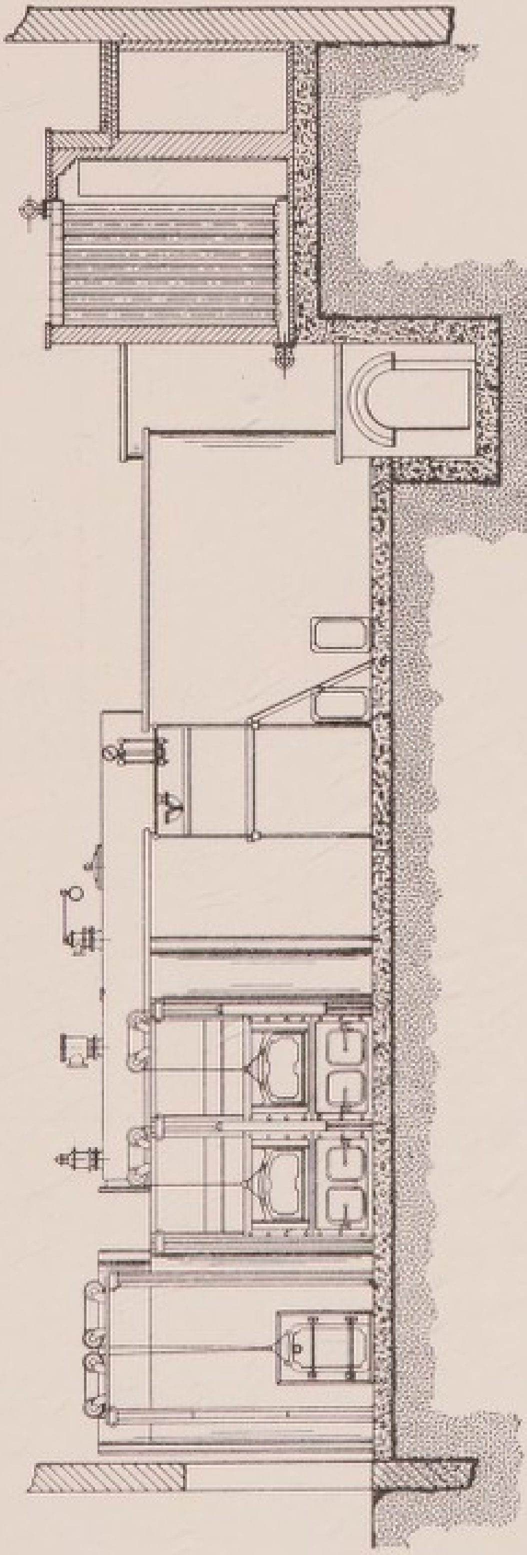


FIG. 68. GRAYS COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
Front Elevation.

Temperature of water entering economiser 50° F.
" " leaving economiser, average . . . . 299° F.

Average steam pressure, per square inch .	144 lb.
Total heat units in steam generated . .	4,544,554.
Heat units from economiser	967,750.

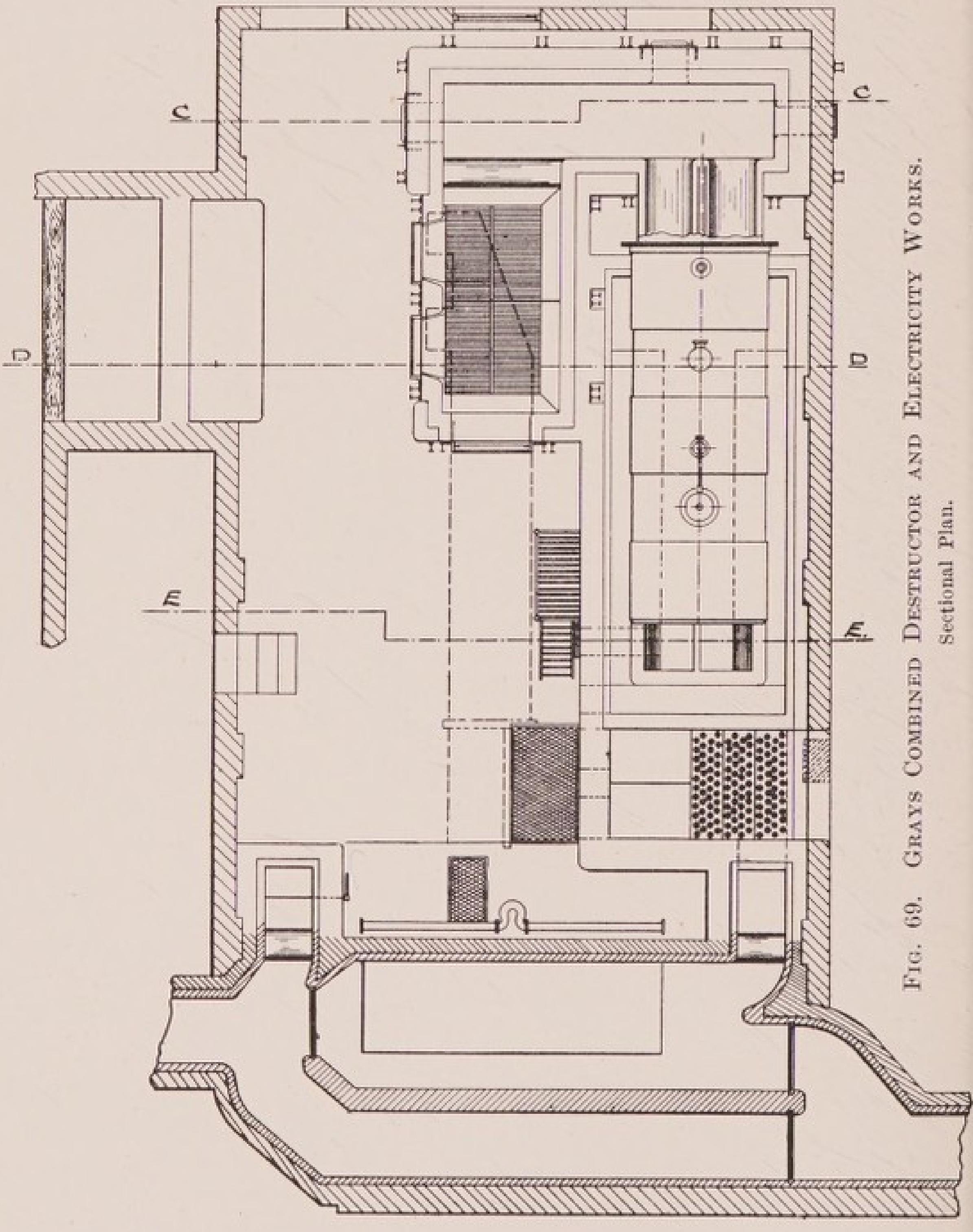


Fig. 69. Grays Combined Destructor and Electricity Works.
Sectional Plan.

Percentage of total heat from economiser .	21·2.
Board of Trade units generated during last 4½ hours	272.

Board of Trade units generated per ton of refuse, besides blowing off . . .	35·5.
Board of Trade units generated during 3 hours, steam blowing off . . .	215.
Board of Trade units generated per ton of refuse during 3 hours . . .	42·4.

The general arrangement of this small Destructor installation will be clearly followed by referring to Figs. 64 to 69.

Gravesend Municipal Corporation—Population, 27,196. E. W.

A	1903.
B	Sterling top fed.
C	4.
D	1 Babcock & Wilcox.
E	125 feet.
F	Fan.
G	Electric lighting.
H	25.
I	—

Three supplementary coal fired boilers are provided, and the power equipment of the station is as follows :—Three Alley and Maclellan engines direct coupled to three Lancashire dynamos, the total capacity being 600 K.W., also a 50 K.W. motor generator set by the Lancashire Dynamo Co., balancers and boosters.

A storage battery of Verity Cells is provided, having a total capacity of 630 ampère hours.

Great Grimsby Municipal Corporation—Population, 63,318. E.W.

A . . .	1903.
B . . .	Horsfall back hand fed.
C . . .	4.
D . . .	1 Babcock & Wilcox.
E . . .	180 feet.
F . . .	Steam jet blowers.
G . . .	Clinker crusher, mortar mill and electric lighting.
H . . .	30 tons.
I . . .	—

GREAT YARMOUTH MUNICIPAL CORPORATION—
POPULATION, 51,250.

A	1902.
B	Fryer's improved top fed.
C	10.
D	1 Multitubular, 60 H.P.
E	204 feet.
F	Natural draught only.
G	—
H	78 tons.
I	—

The total cost of this installation was £14,000, although the estimated cost was £5,000 less than this figure. Very serious difficulties with the foundations explain the serious excess on the estimate.

HANDSWORTH URBAN DISTRICT COUNCIL—POPULATION, 52,921.

A	1901.
B	Warner top fed.
C	8.
D	2 Multitubular.
E	200 feet.
F	Sturtevant fans.
G	Fan engine only.
H	50 tons.
I	$10\frac{3}{4}d.$

HANLEY MUNICIPAL CORPORATION—POPULATION, 61,599.

A	1902.
B	Horsfall top fed.
C	8.
D	2 Lancashire, each 30 ft. × 8 ft.
E	120 feet.
F	Steam jet blower.
G	Not used at present, but it is intended to supply steam to the electricity works.
H	60 tons.

HARTLEPOOL MUNICIPAL CORPORATION—POPULATION, 22,737.

A	1901.
B	Warner top fed.
C	6.

D	3 Multitubular.
E	150 feet.
F	Fan.
G	Fan engine only.
H	20 tons.
I	11*d*.

The total cost of the installation (exclusive of the cost of the site) was £5,100 ; of this sum £2,692 was expended upon the buildings, inclined roadways and chimney.

Fig. 70 shows an accumulation of refuse on top of the cells, from whence it is charged through the hopper into the cell as required.

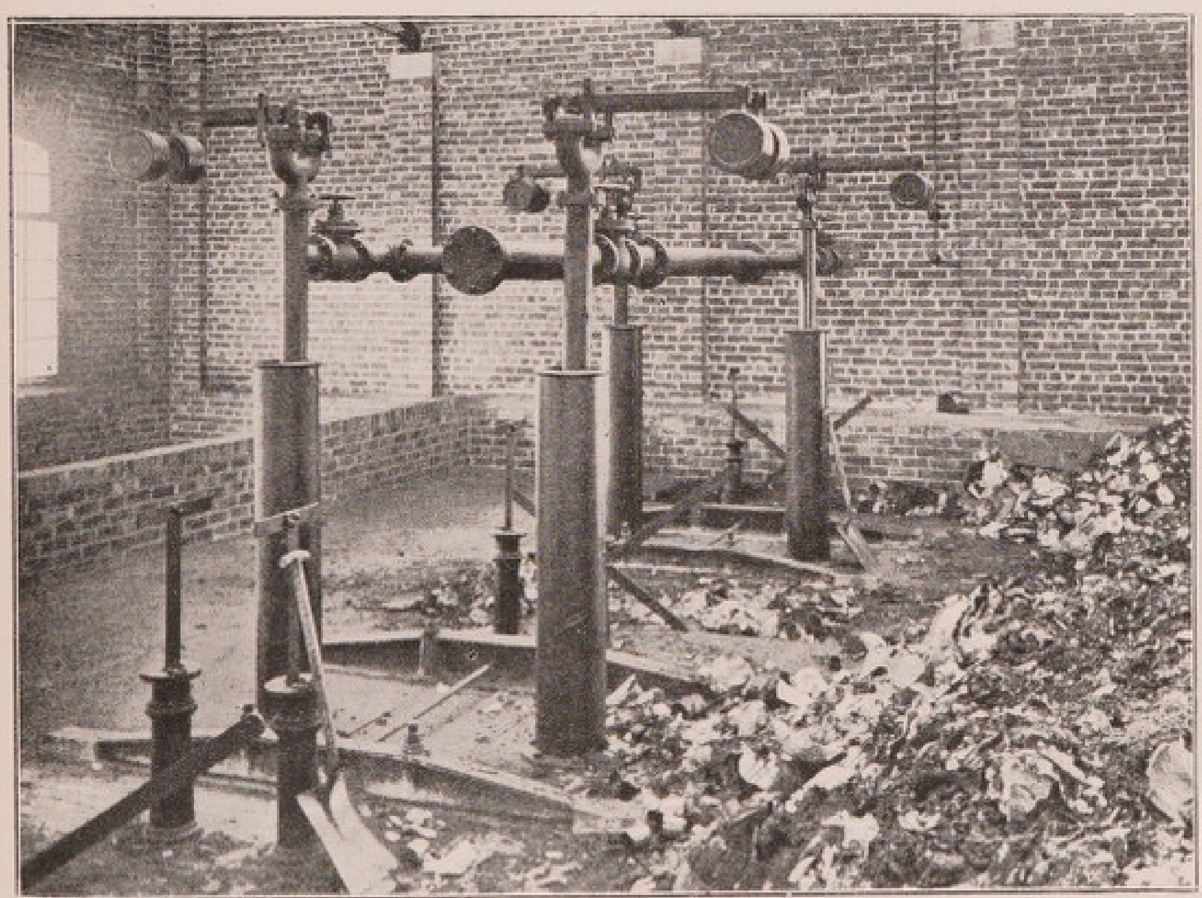


FIG. 70. HARTLEPOOL DESTRUCTOR.
View showing Hopper Levers and Refuse on Top of Cells.

HASTINGS MUNICIPAL CORPORATION—POPULATION, 65,528.

A	1889.
B	Fryer top fed.
C	4.
D	2 Multitubular.
E	130 feet.

F	Fan.
G	Pumping salt water, and also for Disinfector.
H	36 tons.
I	1*s.* 6¾*d.*

HECKMONDWIKE URBAN DISTRICT COUNCIL—POPULATION, 11,000.

TWO INSTALLATIONS.

	1.	2.
A . . .	1883.	1900.
B . . .	Fryer top fed.	Horsfall back hand fed.
C . . .	3.	2.
D . . .	1 Multitubular	1 Babcock & Wilcox.
E . . .	—	105 feet.
F . . .	[1] Steam jet blower.	Steam jet blower.
G . . .	—	Works purposes only.
H . . .	—	11 tons.
I . . .	—	1*s.*

HEREFORD MUNICIPAL CORPORATION—POPULATION, 21,328.

S. W.

A	1897.
B	Meldrum front hand fed.
C	4 grates.
D	2 Galloway, each 22 ft. × 6 ft. 6 in.
E	45 feet.
F	Steam jet blowers.
G	Sewage pumping, etc.
H	10 tons.
I	9*d.*

This installation has been remarkably successful, and it possesses several interesting features. It is one of the few works where Destructor cells have been adapted to existing boilers previously fired with coal. The same chimney is also used, and being only 45 feet in height and 2′ 3″ internal diameter, is probably the smallest Destructor chimney in this country.

The works are situated in close proximity to excellent residential property. The cost of the Destructor has been long since recouped by the saving of the coal bill.

The total weight of refuse produced in Hereford is about 25 tons, and it is interesting to note that 10 tons only, collected as

[1] Added in 1893.

close as possible to the works, suffices to provide the whole of the power required at the sewage works.

Complete details of the official tests are here given :—

Date of test	May 4, 1898	May 5, 1898	May 6, 1898
Duration of test . . .	10 hours (7 a.m. to 5 p.m.)	$10\frac{1}{4}$ hours (7.15 a.m. to 5.30 p.m.)	10 hours (7 a.m. to 5 p.m.)
Kind of fuel burned . .	Unscreened ashpit refuse.	Unscreened ashpit refuse.	Unscreened ashpit refuse.
Total weight of fuel burned .	19,768 lb.	19,012 lb.	19, 712 lb.
Weight burned per hour .	1,976 „	1,855 „	1,971 „
Weight burned per sq. ft. of grate area per hour .	54·88 „	51·52 „	54·75 „
Total weight of clinker and ash	6,699 „	6,804 „	5,040 „
Percentage of clinker and ash .	33·88%	35·7%	25·56%
Percentage of moisture . .	24·5%	27·0%	25·0%
Total water evaporated . .	26,254 lb.	25,570 lb.	29,800 lb.
Water evaporated per hour .	2,625 „	2,494 „	2,980 „
Water evaporated per lb. of refuse, actual . . .	1·32 „	1·34 „	1·51 „
Water evaporated per lb. of refuse from and at 212° F.	1·58 „	1·60 „	1·82 „
Temperature of feed-water .	48°	48°	48°
Average steam pressure . .	70 lb.	70·2 lb.	70·92 lb.
Average steam pressure at blowers . . .	64·37 „	64·55 „	65·21 „
Average air pressure under grates by water gauge .	1·45 in.	1·37 in.	1·82 in.
Chimney pull, by water gauge	$\frac{3}{8}$ „	$\frac{3}{8}$ „	$\frac{3}{8}$ „
Temperature in combustion chamber, by copper test .	Over 2,000° F.	Over 2,000° F.	Over 2,000° F.
Temperature of waste gases, leaving damper . .	25 Readings, 611·5° F.	36 Readings, 638·8° F.	41 Readings, 715·12° F.
Percentage of carbonic acid (CO_2) by Econometer .	25 „ 15·56%	39 „ 16·84%	41 „ 16·27%
Percentage of carbonic acid, Orsat app. . . .	20 „ 14·92%	16 „ 16·83%	14 „ 16·38%
Percentage of free oxygen (O). Orsat app. . . .	20 „ 5·40%	16 „ 3·54%	14 „ 3·74%
Percentage of carbonic oxide (CO), Orsat app. . .	20 „ nil.	16 „ nil.	14 „ nil.
Size of boiler, 22 ft. × 6 ft. 6 in., with two flues, each 2 ft. 6 in. Area of grate 36 square feet .	During above test the sludge presses and liming plant worked the whole time. Both sewage pumps worked from 7 o'clock to 10.50; after that one pump only. Steam in excess was blown off.	The sludge presses and liming plant were running the whole time. Both pumps from start to 11.30; then one pump till 3.45; then both again to the finish. Steam in excess was allowed to blow off.	The sludge presses and liming plant worked the whole time of test. Two pumps worked from 7 o'clock to 11·20; then one pump for the remainder of time. Steam in excess was allowed to blow off.

One-and-a-half Million Gallons of Sewage is pumped per day of ten hours, on an average, to a height of 36 feet.

The clinker is utilized on the bacteria beds; this is one of the very few works of the kind where the gases of combustion are being constantly analysed.

HEYWOOD MUNICIPAL CORPORATION—POPULATION, 25,461.

S. W.

A	1902.
B	Meldrum front hand fed.
C	2 grates.
D	1 Lancashire, 20 ft. × 7 ft.
E	90 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	25 tons.
I	—

HOLYHEAD MUNICIPAL CORPORATION—POPULATION, 10,079.

E. W.

A	—
B	Meldrum front hand fed.
C	2.
D	1 Babcock & Wilcox.
E	120 feet.
F	Steam jet blowers.
G	Electric lighting.
H	10 tons.
I	—

This installation is not likely to be completed until early in 1904.

HORBURY URBAN DISTRICT COUNCIL—POPULATION, 6,736.

S. W.

A	1903.
B	Horsfall back hand fed.
C	2.
D	2 Cornish.
E	50 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	6 tons.
I	Works now in course of erection.

HORNSEY MUNICIPAL CORPORATION—POPULATION, 77,938.

A . . .	1889, 1893 and 1895.
B . . .	Warner top fed.
C . . .	12.
D . . .	1 Multitubular.
E . . .	217 feet.
F . . .	Fan.
G . . .	Clinker crusher, mortar mill and fan engine only.
H . . .	75 tons.
I . . .	9*d.*[1]

The cost of this installation is given as £9,628, but this is exclusive of the cost of the forced draught apparatus which was added about two years since, mainly owing to difficulties experienced in dealing with trade refuse.

During the year 1902, a total of 20,648 tons of refuse was passed through the Destructor, this weight being made up as follows :—

House refuse	20,374 tons.
Vegetable refuse	230 ,,
Fish offal	44 ,,

It is interesting to note that the quantity of refuse disposed of at these works seven years ago was only 10,092 tons per annum.

In addition to a clinker crusher and mortar mill, a Musker Flag plant has also been installed, and a considerable portion of the clinker is utilized.

HUDDERSFIELD MUNICIPAL CORPORATION—POPULATION, 95,047.

TWO INSTALLATIONS.

	1.	2. S. W.
A .	1891–92.	1898.
B .	Fryer top fed.	Horsfall back hand fed.
C .	10.	2.
D .	1 Multitubular, 11 ft. × 7 ft.	2 Cornish, each 22 ft. × 5 ft.
E .	180 feet.	—
F .	—	Steam jet blowers.

[1] This has possibly been increased since forced draught was added to the cells.

G	Works purposes.	Sewage pumping and sludge pressing.
H	50 tons.	20 tons.
I	10½*d*.	—

HULL MUNICIPAL CORPORATION—POPULATION, 240,739.

TWO INSTALLATIONS.

	1.	2.
A	1882.	1902.
B	Fryer top fed.	Horsfall top fed.
C	6.	12.
D	1 Multitubular.	2 Babcock & Wilcox.
E	180 feet.	110 ft. × 7 ft. 6 in., internal diameter.
F	Steam jet blowers.[1]	Steam jet blowers.
G	Works purposes only.	Forced draught, hoist and works lighting.
H	45 tons.	90 tons.
I	1*s*. 3*d*.	—

HUNSTANTON URBAN DISTRICT COUNCIL— POPULATION, 1,893.
W. W.

A	1899.
B	Meldrum front hand fed.
C	2 grates.
D	1 Cornish.
E	50 feet.
F	Steam jet blowers.
G	Water pumping.
H	3½ tons.
I	1*s*.

The installation is of much interest, not only because it is the smallest Destructor yet installed in this country, but owing to the fact that from the combustion of some 3½ tons of refuse daily, sufficient steam is produced to operate a modern water pumping plant.

The Destructor installation is very complete, comprising a two grate unit Destructor erected in front of a high pressure Cornish boiler, with which a Schwoerer Superheater is provided, and also

[1] Added in 1896.

a Meldrum regenerator for heating the air supply for combustion. The whole plant with its combination for power production affords a remarkable object lesson to small seaside and health resorts.

HYDE MUNICIPAL CORPORATION—POPULATION, 32,766.

S. W.

TWO INSTALLATIONS.

	1.	2.
A . .	1893.	1903.
B . .	Warner top fed.	Meldrum front hand fed.
C . .	4.	6 grates.
D . .	1 Multitubular.	1 Lancashire, 30 ft. × 8 ft. 6 in.
E . .	180 feet.	Same chimney.
F . .	Meldrum's steam jet blowers to 1 cell.[1]	Steam jet blowers.
G . .	Mortar Mills, etc.	Sewage pumping.
H . .	24 tons.	30 tons.
I . .	1*s.* 2*d.*	—

Installation No. 2 will displace No. 1, and the power will be fully utilized for sewage pumping.

IPSWICH MUNICIPAL CORPORATION—POPULATION, 66,630.

E. W.

A	1903.
B	Meldrum front hand fed.
C	4 grates.
D	1 Lancashire, 30 ft. × 8 ft.
E	175 feet.
F	Steam jet blowers.
G	Electric lighting and traction.
H	40 tons.
I[2]	—

The Destructor installation is part of a very comprehensive scheme just now approaching completion, Professor Kennedy being the consulting engineer.

The whole of the available steam from the Destructor boiler

[1] Added in 1900.

[2] Works not yet in operation.

will be utilized for generating electricity, and to obtain the maximum advantage therefrom, it is likely that the refuse will be destroyed within sixteen hours daily instead of throughout the whole twenty-four hours.

The Destructor will be complete in every respect, the Lancashire boiler will work at a pressure of 200 lb. to the square inch, and a Musgrave Dixon Superheater will be fixed in the downtake, a Green's Economiser and Regenerator being also provided.

KETTERING URBAN DISTRICT COUNCIL—POPULATION, 300,000.
E. W.

A	1904.
B	Meldrum front hand fed.
C	2 grates.
D	1 Lancashire, 28 ft. × 7 ft. 6 in.
E	150 feet.
F	Steam jet blowers.
G	Electric lighting.
H	30 tons.
I[1]	—

This is part of a combined scheme now being carried out under the supervision of Professor Kennedy at an estimated total cost of £42,375.

KING'S NORTON AND NORTHFIELD URBAN DISTRICT COUNCIL—POPULATION, 57,120.

A Destructor of the "Heenan" type is now in hand for this Council.

KINGSTON-ON-THAMES MUNICIPAL CORPORATION—POPULATION, 34,375.

A	1903.
B	Meldrum's, Beaman & Deas' direct charged.
C	2.

[1] Works not yet in operation.

D	1 Babcock & Wilcox.
E	150 feet.
F	Fan.
G	Works purposes only.
H	30 tons.
I[1]	—

The cost of the Destructor and boiler was £3,050, this being exclusive of the cost of the foundations, buildings and chimney, the total estimated cost being £8,370.

The direct charging arrangement for tipping direct from the carts is Marten's patent, made by Messrs. Meldrum Bros., Ltd. The same system of charging has been in use at the Tooting Destructor (Metropolitan Borough of Wandsworth) for three years past with very satisfactory results.

LANCASTER MUNICIPAL CORPORATION—POPULATION, 40,329.

E. W.

A	1901.
B	Meldrum front hand fed.
C	8 grates.
D	2 Lancashire, each 30 ft. × 8 ft.
E	—
F	Steam jet blowers.
G	Electric traction.
H	30 tons.
I	1*s.* 4*d.*

In addition to the Destructor boilers, three supplementary coal fired boilers are provided, these being also of the Lancashire type, 30 feet long and 8 feet in diameter. Green's Economisers are also installed, as also with the Destructor boilers.

The power plant comprises:—Four Willans engines direct coupled to four dynamos, the total capacity being 420 K.W. One 200 K.W. Westinghouse set, and 120 Epstein cells.

Details of the official test of this Destructor are here given.

[1] Works not yet in operation.

Lancaster Corporation Destructor.

Result of Test.

Date of test	February 7, 1902.
Duration of test	12 hours 26 min.
Number of cells	4.
Grate area	100 square feet.
Type and size of boiler . . .	Lancashire, 30 ft. × 8 ft.

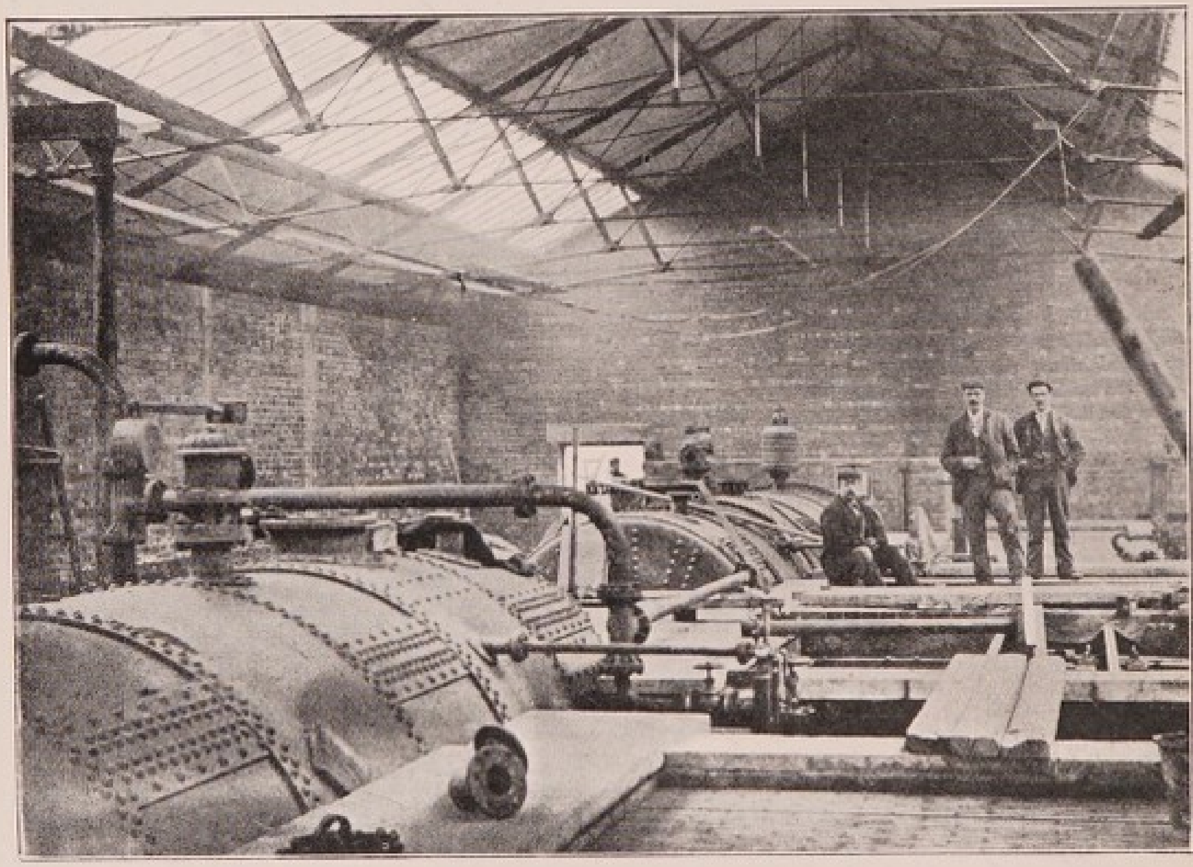


Fig. 71. Lancaster Combined Destructor and Electricity Works.
View of Boilers.

Refuse consumed (total)	33 tons 9 cwt. 1 qr.
Refuse consumed in pounds . . .	74,929 lb.
Water evaporated, total (actual). .	9,938 gallons.
,, ,, per hour (actual) .	799 gallons.
,, ,, per lb. of refuse (actual) . . .	1·33 lb.
,, ,, per hour from and at 212° F.	982 gallons.
Water evaporated per lb. of refuse from and at 212° F.	1·63 lb.

Average steam pressure	164 lb.
,, temperature of feed-water .	40·5° F.
Weight of clinker	25,498 lb.
Percentage of clinker	34 per cent.
Average percentage of carbon dioxide in flue gases	15·5 per cent.
Temperature of combustion chamber .	Over 2,000° F., as copper could always be melted.
Maximum temperature of combustion chamber	Unknown: melted nickel 2,650° F.
Average temperature of gases leaving boiler	995° F.
,, temperature of gases leaving economiser	520° F.
Average temperature of heated air from Regenerator	478° F.

Fig. 71 is a view on top of the cells at Lancaster during course of erection. This view should be of interest to the student, clearly showing as it does the prominence of steam boilers in connection with the modern Destructor.

Leamington Municipal Corporation—Population, 26,888.
S. W.

A	1903.
B	Horsfall back hand fed.
C	6.
D	2 Lancashire, each 30 ft. × 7 ft. 6 in.
E	90 ft. × 5 ft. internal diameter.
F	Steam jet blowers.
G	Sewage pumping.
H	25 tons.
I	—

The sewage is pumped to the sewage farm a mile and a half distant, the lift being from 80 to 120 feet. The chimney was previously used for coal fired boilers.

LEEDS MUNICIPAL CORPORATION—POPULATION, 428,968.
FOUR INSTALLATIONS.

	No. 1 Burmantofts	No. 2 Armley Road	No. 3 Kidacre St.	No. 4 Meanwood Rd.
A . .	1876, 1883 & 1887	1877, 1884 & 1886	1891 & 1894	1895
B . .	Fryer top fed	Fryer top fed	Horsfall top fed	Horsfall top fed
C . .	14	12	16	8
D . .	1 Babcock & Wilcox	1 Multitubular	2 Multitubular	2 Babcock & Wilcox
E . .	120 feet	120 feet	144 feet	240 feet
F . .	Steam jet blowers.*	Steam jet blowers.†	Steam jet blowers.	Steam jet blowers.
G . .	Forced	draught purposes	and only.	Works
H . .	—	—	—	—
I . .	$10\frac{1}{4}d.$	$10\frac{1}{4}d.$	$10\frac{1}{4}d.$	$10\frac{1}{4}d.$

* Added in 1887. † Added in 1894.

FIG. 72. LEEDS (MEANWOOD ROAD) DESTRUCTOR.
View of Building.

As will be observed, Leeds is very well provided for, having a total number of fifty cells, nearly half of which are of modern design, while the remainder are equipped with forced draught. The total cost of the various installations is given as £48,525, including the cost of the sites.

Fig. 72 is an external view of the more recently erected plant (No. 4) at Meanwood Road.

LEICESTER MUNICIPAL CORPORATION—POPULATION, 211,581.

FOUR INSTALLATIONS.

	No 1 Needham Street	No. 2 Mill Lane	No. 3 Lero	No. 4 West Humberstone
A . .	1890	1893	1894	1902
B . .	Fryer top fed	Borough Surveyor's design, top fed	Borough Surveyor's design, top fed	Fryer's improved Boulnois, Wood & Brodie's, top fed
C . .	6	6	6	6
D . .	3 Multitubular	1 Multitubular	1 Multitubular	3 Babcock & Wilcox
E . .	160 feet	180 feet	180 feet	180 feet
F . .	Fan	Fan	Fan	Fan
G . .	Supplied to an adjoining engineering works	Clinker crusher, mortar mill and works lighting	Works purposes	Works purposes
H . .	45 tons	45 tons	45 tons	—
I . .	$8\frac{1}{4}d.$	$8\frac{1}{4}d.$	$8\frac{1}{4}d.$	—

The estimated cost per cell of the first three installations is given as follows :

No. 1. Needham Street	£1,116 per cell	Including buildings, chimney and machinery.
No. 2. Mill Lane .	£1,345 ,, ,,	
No. 3. Lero . .	£1,475 ,, ,,	

Some particulars of the refuse disposed of at the above three works during the year 1902 will doubtless be of interest.

Destructors	House Refuse		Trade Refuse		Meat Tons	Mat-tresses
	Loads	Tons	Loads	Tons		
No. 1. Needham Street .	12,266	13,489	320	101	80	472
No. 2 Mill Lane . .	13,878	13,472	904	273	74	290
No. 3. Lero . . .	12,034	13,181	1,361	587	280	246

No. 4 Installation, known as West Humberstone destructor, will undoubtedly prove to be a distant advance on those previously erected. The estimated total cost of this plant is given as £6,755 19*s*. 0*d*.

In thus so completely equipping this important town with destructors, an excellent example has been set for the benefit of many large provincial towns. Mr. E. G. Mawbey, M.I.C.E., Leicester's eminent Borough Engineer and Surveyor, has done wisely in erecting four separate installations in different parts of so large a town, thus greatly expediting the collection and also keeping the collection cost within reasonable limits.

At the various works, a number of mortar mills are installed and a considerable quantity of mortar is made which yields a fair profit. At the West Humberstone Works, a flag plant has been provided.

Leigh Municipal Corporation—Population, 40,001.

The Council have recently decided to instal a destructor of the " Horsfall " type.

Levenhsulme Urban District Council—Population, 11,435.

A two cell destructor of the " Heenan " type is now in hand for this Council, the estimated cost of the same being £4,500.

Leyton Urban District Council—Population, 98,999.

S. W.

A . . . . . 1898.
B . . . . . Meldrum's " Beaman & Deas " type, top fed.
C . . . . . 8.

D	2 Babcock & Wilcox.[1]
E	150 feet.
F	Fan.
G	Sewage pumping.
H	60 tons.[2]
I	1*s.* 7*d.*

LIVERPOOL MUNICIPAL CORPORATION—POPULATION, 710,737.
FOUR INSTALLATIONS.

	No. 1	No. 2	No. 3	No. 4 E. W.
	Charter's St.	Rathbone Rd.	Toxteth Park.	Cobb's Quarry
A .	1891 & 1893.	1893.	1895.	1900.
B .	Fryer's top fed.	Fryer's top fed.	Fryer's improved top fed.	Fryer's improved top fed.
C. .	24.	6.	8.	8.
D .	1 Multitubular 11 ft. × 8 ft. 1 Stirling water tube.	—	1 Multitubular, 12 ft. × 7 ft.	4 Babcock & Wilcox.
E .	170 feet.	—	180 feet.	200 feet.
F .	—	—	—	Fans.
G .	Mortar mills, clinker crusher, works lighting, etc.	—	Works only.	Electric traction.
H .	Total	about	300	tons.
I .	—	—	—	$8\frac{1}{4}$*d.*

Under the control of Mr. J. A. Brodie, M.I.C.E., the destructor installations in Liverpool have been developed and possess a very satisfactory record, more especially perhaps installation No. 4, known as Cobb's Quarry.

Some 30 electric cars are operated daily by power produced from the refuse, and the sale of electrical energy to the Electricity

[1] The Council have recently decided to instal an additional boiler in connection with the Destructor at an estimated cost of £1,335.

[2] Refuse and pressed sludge.

Department yields a handsome return to the Cleansing Department, the price paid being ·35*d.* per unit.

Some details of an evaporative test made with the destructor at Cobb's quarry are here given.

St. Domingo Destructor, Liverpool.

	Tons.	cwt.	qr.	lb.
Total refuse burnt in 8 cells in 24 hours	123	16	0	0
Note.—Twenty-three tons were burnt in 6 hours, between 12 midnight and 6 a.m. The boilers were not in work during this period. The heat passed through the flues direct to the chimney	23	0	0	0
Refuse burnt in 8 cells in 18 hours	100	16	0	0
,, ,, 8 cells per hour	5	11	0	0
,, ,, per cell per hour	0	13	3	14
,, ,, per square foot of grate area per hour	62·16 lb.			

Total quantity of water evaporated in 18 hours	262,460 lb.
,, ,, ,, ,, per hour	14,581 lb.
,, ,, ,, ,, per lb. of refuse burnt	1·173 lb.

Output of Electricity in 18 Hours.

(The output is restricted at present to the requirements of the Tramways Department.)

No. 1 Engine	1,650 units,	for tramways.
No. 2 ,,	1,779 ,,	,,
No. 3 ,,	234 ,,	for public lighting.
	3,663 ,,	

A further destructor of the improved "Fryer" type is now in course of erection at "Laverock Bank," the power from which will be fully utilized for electrical purposes.

This installation, together with additional cells not included in the tabular statement, will comprise in all some 65 cells, so that Liverpool may claim to be well equipped for final and sanitary disposal of its refuse.

The clinker is fully utilized for a variety of purposes, a considerable quantity of mortar is made, as also some 300 paving flags daily, while some thousands of tons of clinker were used for concrete for the bridges and roads over St. George's Dock etc.

In the future it is likely that considerable quantities of clinker will be used in the construction of artizans' dwellings. The experiments in this direction now being conducted by Mr. Brodie are referred to elsewhere. With the absorption of Garston, possessing its own destructor, Liverpool is, on the whole, splendidly equipped; and it must be admitted that the progress which has been made, all tends to clearly show the weakness and inefficiency of the whole system of sending the refuse out to sea.

LIVERSEDGE URBAN DISTRICT COUNCIL—POPULATION, 13,980.

A	1900.
B	Horsfall's back hand fed.
C	2.
D	1 Babcock & Wilcox.
E	90 ft. , 3 ft. 6 in. internal diameter.
F	Steam jet blowers.
G	Forced draught, and works purposes only.
H	13 tons.
I	—

LLANDUDNO URBAN DISTRICL COUNCIL—POPULATION, 9,310. E. W.

A	1898.
B	Meldrum's "Beaman & Deas" top fed.
C	4.
D	2 Babcock & Wilcox.
E	120 feet.
F	Fan.
G	Electric lighting.
H	15 tons.
I	1*s.* 3¼*d.*
J	32.

In addition to the destructor boilers, 4 Babcock and Wilcox boilers are also provided for supplementary coal firing, also a Green's Economiser.

The power equipment of the station is as follows :—3 Bellis-

Silvertown two-pole under type dynamos, 1 Allen-Silvertown four-pole dynamo, 2 Allen-Crompton Multipolar machines, 150 k.w. each, total H.P. 1,100, also 250 Pritchett & Gold's cells of 250 ampère hours capacity.

The total cost of the destructor was £6,032, of which sum £1,085 has already been repaid. A few figures extracted from the statement for the third year of operations are of interest.

Load factor	8·24 per cent.
Fuel cost	·69*d.* per unit.
Works „	1·35*d.* „ „
Total „	1·97*d.* „ „
Net profit	£679.

It is also worthy of note that this combined works has paid from the first year of operation.

Longton Municipal Corporation—Population, 35,815.
Two Installations.

	No. 1	No. 2
A	1887.	1895.
B	Fryer's top fed.	Warner's top fed.
C	4.	2.
D	1 Multitubular.	1 Multitubular.
E	150 feet.	Same chimney used.
F	—	Fan.
G	Works purposes only.	Works purposes only.
H	35	tons.
I	11*d.*	11*d.*

Loughborough Municipal Corporation—Population, 21,508.
Two Installations.

	1.	2. S.W.
A	1896.	1903.[1]
B	Coltman's.	Fryer's top fed.
C	1.	2.

[1] Now in course of erection.

D	1 Elephant.	1 Babcock & Wilcox.
E	80 feet.	Same chimney.
F	Fan.	Fan.
G	Sewage pumping.	Sewage pumping.
H	20 tons.	—
I	1*s.* 2*d.*	—

LOWESTOFT MUNICIPAL CORPORATION—POPULATION, 29,850.

A	1899.
B	Horsfall's back hand fed.
C	4.
D	1 Babcock & Wilcox.
E	120 ft. × 6 ft. 6 in. internal diameter.
F	Steam jet blowers.
G	8 H.P. engine for mortar mill, and forced draught.
H	28 tons.
I	11½*d.*

The clinker sells freely at 8*d.* per load at the Works; a portion is converted into mortar and sells freely at 5*s.* per load.

LYTHAM URBAN DISTRICT COUNCIL—POPULATION, 7,185.

A	1902.
B	Meldrum's front hand fed.
C	2 grates.
D	1 Cornish, 20 ft. × 6 ft. 6 in.
E	50 ft. × 3 ft. 9 in. internal diameter.
F	Steam jet blowers.
G	Sewage pumping and works lighting.
H	10 tons.
I	8*d.*

An external view of the Lytham Works is shown in Fig. 73. The writer is indebted to Mr. A. J. Price, the Surveyor, for this photograph. The whole of the steam power required at these works is obtained from refuse alone, the dry weather flow of sewage being 800,000 gallons daily, this volume being lifted by Gwynne's centrifugal pumps. Power is also supplied for driving a 7-brake horse power Robey vertical high speed engine and dynamo for works lighting purposes, 6 arc lamps and 24.16 C.P. incandescent lamps being provided. The whole combined scheme was carried out well within the estimate of £10,560, and reflects great credit upon Mr. A. J. Price, Surveyor to the Urban District Council.

FIG. 73. LYTHAM COMBINED DESTRUCTOR AND SEWAGE WORKS.
View of Building.

MANCHESTER MUNICIPAL CORPORATION—POPULATION, 543,872.

A	First in 1876, with several extensions since.
B	Fryer's old type, and Whiley.
C	[1] 14 and 28.
D	15.[2]
E	200 feet.
F	See below.[3]
G	Mortar mills, works purposes, screening, etc.
H	—
I	—

[1] It has recently been decided to erect a 2-cell Meldrum Destructor at the Sewage Works.

[2] Meldrum's forced draught and grates fitted to the 12 original cells.

[3] The boilers are mostly of the Galloway type, and are not set in connection with the destructors. Sorted refuse is burned in the boiler furnaces.

It is interesting to note that the first destructor cells ever erected in this country were installed at the Water Street Depôt of Manchester Corporation. The first two cells are illustrated in Fig. 1.

For some years past an extensive system of sorting and utilization has been employed in Manchester, the destructors and boilers therefore only deal with a proportion of the civic waste.

E. W.

MANSFIELD MUNICIPAL CORPORATION—POPULATION, 21,445.

A	1903.
B	Heenan's back fed.
C	6.
D	2 Babcock & Wilcox.
E	150 feet.
F	Fan.
G	Electric lighting.
H	20 tons.
I	—

Three Lancashire boilers for supplementary coal firing are provided in addition to the destructor boilers. The power equipment of the station comprises high speed triple expansion condensing engines direct coupled to compound multipolar generators. The station is laid out for a total capacity of 1,000 k.w. including a large storage battery.

E. W.

MEXBOROUGH URBAN DISTRICT COUNCIL—POPULATION, 10,430.

A	1902.
B	Meldrum's front hand fed.
C	3 grates.
D	1 Lancashire, 24 ft. × 7 ft. 6 in.
E	120 feet.
F	Steam jet blowers.
G	Electric lighting.
H	20 tons.
I	11*d*.

One supplementary coal fired boiler of the Lancashire type, of similar size to the destructor boiler, is provided, the working pressure of both boilers being 150 pounds, steam being supplied to the engines at 140 pounds pressure.

The power equipment of the station is as follows: Two coupled sets capable of developing 50 k.w. at 440 to 480 volts at a speed of 550 revolutions per minute; there is also a Balancer Booster consisting of four machines coupled together.

Adjoining the engine room is the accumulator room containing 250 cells, having an output of 500 ampère hours at a 10 hour rate or 450 ampère hours at a 5 hour rate.

The public lighting consists of 213 street lamps each containing 2 16-C.P. lamps, and fitted with prism globes, also 15 enclosed arc lamps of 500 C.P. each. The public lighting replaces 139 gas lamps of lower candle power, which formerly cost the Council £400 per annum.

The total cost of the combined installation, including the site, was about £18,800. The total works cost per unit generated is given as 1·98*d*. The Electricity Committee pay the Sanitary Committee ·7*d*. per unit generated, the latter paying the cost of stokers and coal, also the interest and depreciation on the destructor.

E. W.

MORECAMBE MUNICIPAL CORPORATION—POPULATION, 11,798.

A	1902.
B	"Sterling" top fed.
C	4.
D	1 Lancashire.
E	126 feet.
F	Fan.
G	Electric lighting and mortar mills.
H	11 tons.
I	1*s*. 0⅛*d*.[1]

MOSS SIDE URBAN DISTRICT COUNCIL—POPULATION, 26,677.

A . . .	1902.
B . . .	Horsfall's top fed.
C . . .	6.

[1] This figure applies to the official test of 12 hours.

D . . .	2 Babcock & Wilcox.
E . . .	90 ft. ×5 ft. internal.
F . . .	Steam jet blowers.
G . . .	Works purposes, clinker crushers, mortar mills.
H . . .	26 tons.
I . . .	8*d*.

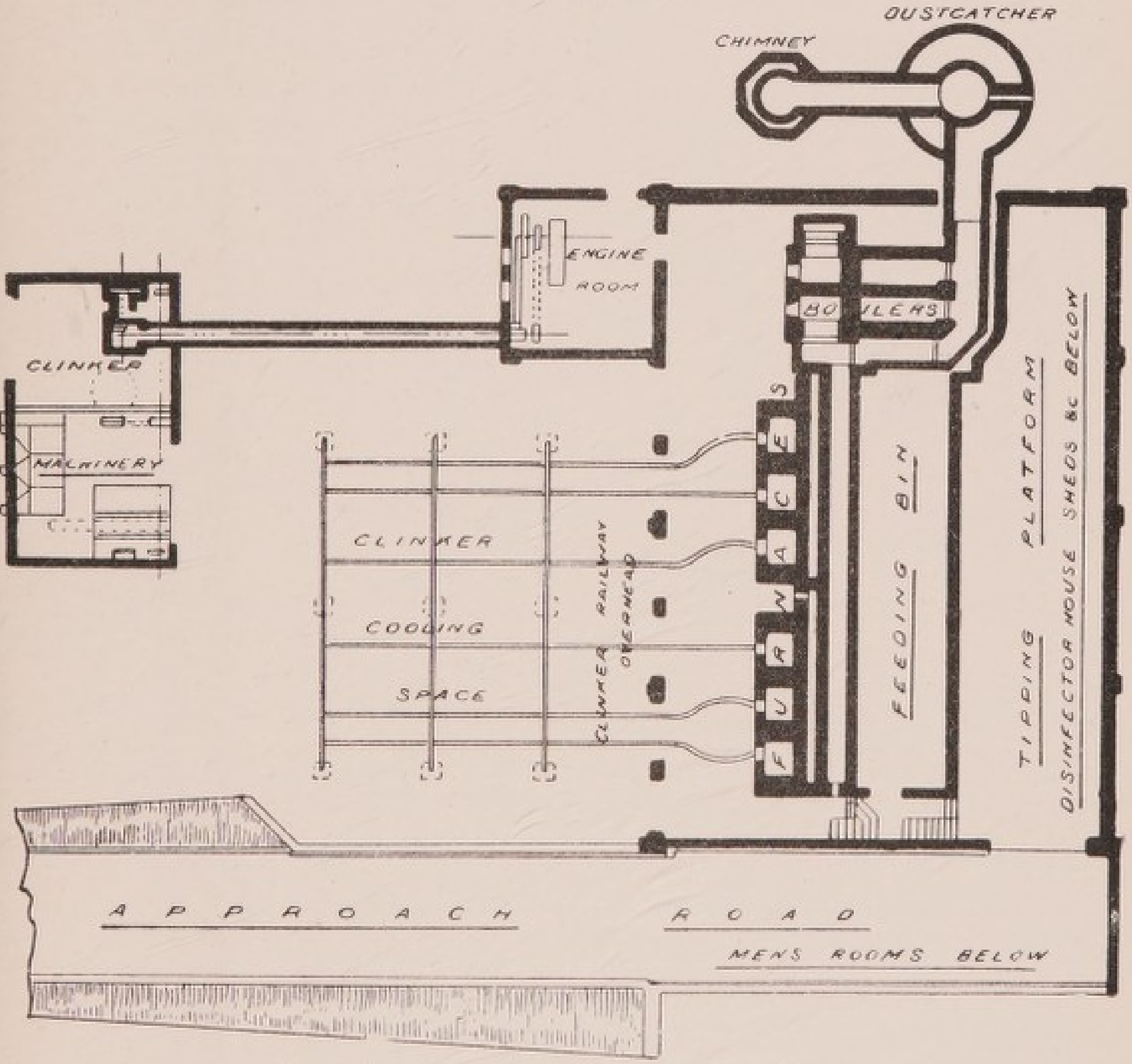


FIG. 74. MOSS SIDE DESTRUCTOR. Plan.

This is one of the best examples of this particular type of Destructor in this country, and it is to be regretted that the power cannot be fully utilized.

The general arrangement of the plant will be seen by referring to Fig. 74. Only four cells are used at one time. The total cost of the installation was £10,300. The mortar made sells freely at

4*s*. 6*d*. per ton, and the clinker, rough and screened, at 6*d*. and 3*s*. per ton respectively.

A complete clinker crushing and screening plant is installed, which absorbs about 25 H.P. during the day for driving, while at night a 20 k.w. dynamo is in use for works lighting purposes, but these, together with the forced draught blowers, offer the only outlet at present for power utilization.

E. W.

NELSON MUNICIPAL CORPORATION—POPULATION, 32,816.

A	1900.
B	Meldrum's front hand fed.
C	4 grates.
D	1 Lancashire, 30 ft. × 8 ft.
E	180 feet.
F	Steam jet blowers.
G	Electric traction.
H	30 tons.
I	1*s*.
J	40.

Here the destructor was erected well in advance of the electricity works, but a number of tests under varying conditions and over extended periods, carried out by the Health Superintendent, Mr. J. A. Priestley, quite satisfied the authorities that the combination would be advantageous.

The writer is indebted to Mr. J. A. Priestley for the interesting charts and diagrams reproduced in Figs. 75, 76 and 77.

One interesting feature introduced in connection with the destructor was the offal charging hopper and hearth, so arranged that this most objectionable refuse is readily charged without handling, and is placed in such a position in the cell that the fumes as driven off must pass over 100 square feet of active fire before reaching the combustion chamber and boiler. This effective method of dealing with offal will be readily followed by referring to Fig. 78.

Two 30′ × 8′ Lancashire boilers, for supplementary coal firing are provided in addition to the destructor boiler. The power equipment of the station is as follows :—3 Willans' engines, of 300

NELSON DESTRUCTOR

8 HOURS TEST

DIAGRAM OF TEMPERATURE IN COMBUSTION CHAMBER

TAKEN WITH A CALLENDAR'S ELECTRICAL RECORDING PYROMETER.

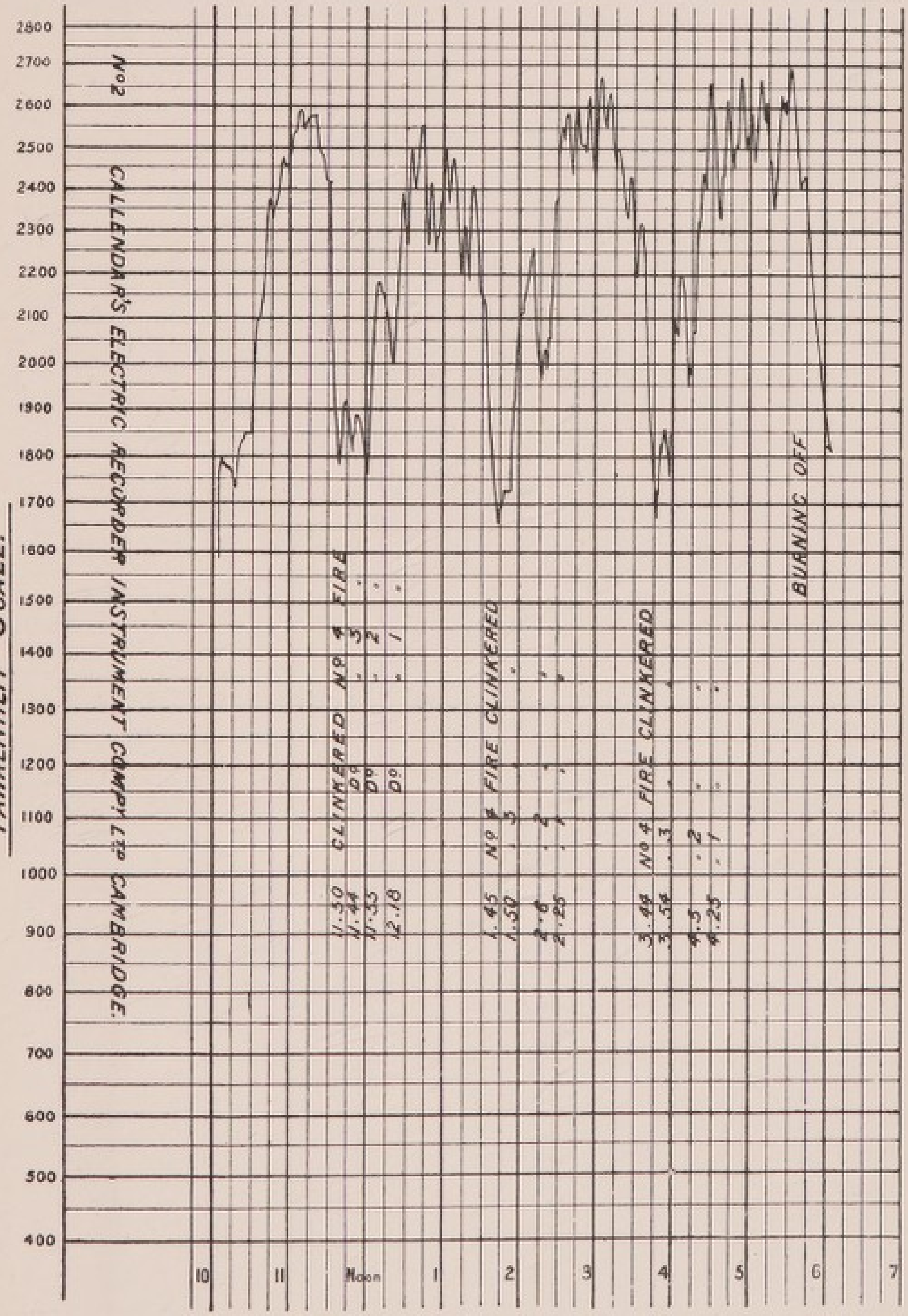


FIG. 75.

H.P. each, and 3 Bruce Peebles dynamos each 200 k.w., also 240 Tudor cells.

Details of three evaporative tests are here given, and as these were made under entirely different conditions, they are worth careful study and comparison.

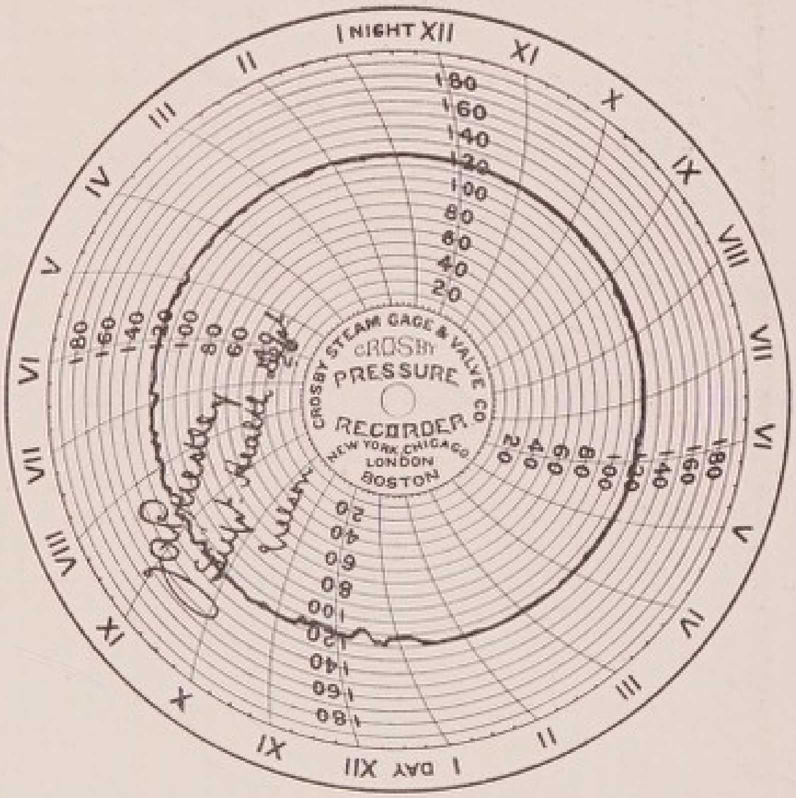
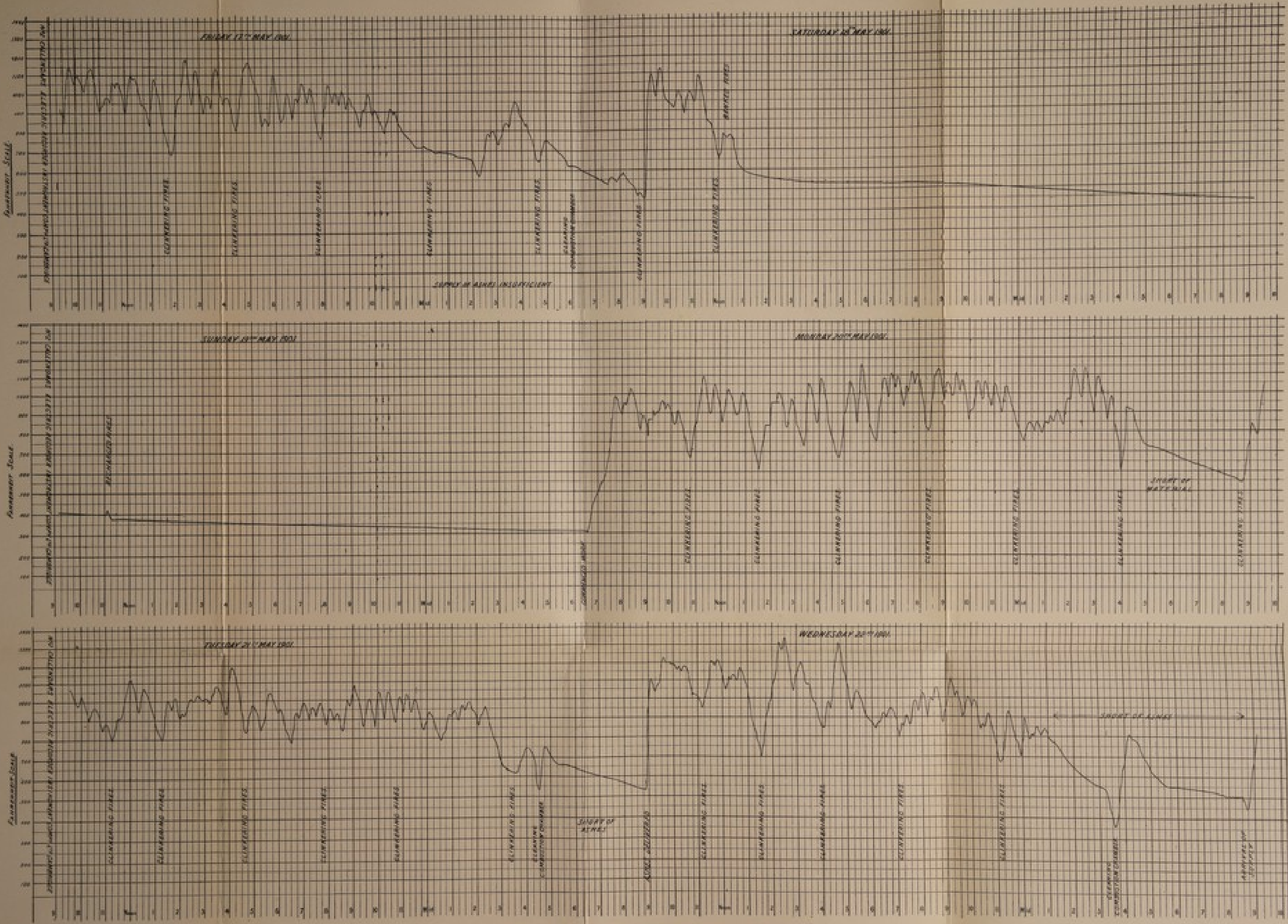


Fig. 76. Nelson Combined Destructor and Electricity Works.
Steam Pressure Recorder Diagram.

Test A.

Result of Test made at Nelson Destructor, 20th December, 1900.

Duration of test	$9\frac{1}{2}$ hours.		
Number of cells	4.		
Total grate area	100 sq. ft.		
Boiler, Lancashire, 30 ft. × 8 ft. heating surface	986 sq. ft.		
Refuse consumed—	Tons.	cwt.	qr.
Unscreened ashpit refuse	22	18	3
Greens and light refuse	1	4	0
Slaughter house offal	0	1	0
	24	3	3



—— NELSON DESTRUCTOR ——

DIAGRAM OF TEMPERATURE IN DOWNTAKE OF LANCASHIRE BOILER TAKEN WITH A CALLENDARS ELECTRICAL RECORDING PYROMETER.

FIG. 77.

J A Priestley
Supt Health Dept
Nelson

Refuse other than ashes	5 per cent.
Refuse consumed, total	54,180 lb.
,, ,, per hour	5,703 lb.
,, ,, per square foot grate area per hour	57 lb.
Water evaporated	,, 68580 lb.
,, ,, per hour actual	7,220 lb.
,, ,, ,, from and at 212° F. average	8,650 lb.
,, ,, ,, ,, ,, maximum	9,380 lb.
,, ,, ,, per lb. of refuse, actual	1·266 lb.
,, ,, ,, ,, ,, from and at 212° F.	1·516 lb.
,, ,, ,, per sq. ft. heating surface per hour from and at 212° F.	8·77 lb.

FIG. 78. NELSON COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
View of Cell and Offal-Charging Hopper.

Average steam pressure	118 lb.
Weight of clinker remaining	11,473 lb.
Percentage of clinker to refuse consumed	21·18 per cent.
,, organic matter in clinker	Nil.
,, CO_2, average	12·21 per cent.
,, ,, highest reading	18·20 ,,
,, ,, lowest reading, clinkering	6·40 ,,

Average temperature of feed water	63·4° F.
,, ,, combustion chamber, 17 readings	2,200° F.
Highest ,, ,, ,, melting nickel	2,650° F.
Lowest ,, ,, ,, thermophone	1,570° F.
Average ,, in side flues, 24 readings	982° F.
,, ,, in main flue, 21 readings	596° F.
,, ,, air entering regenerator	64° F.
,, ,, air leaving regenerator, 19 readings	346° F.
,, ashpit pressure	1·85 inches.
,, vacuum in main flue	1·53 in.
,, ,, in blower boxes	·35 in.
,, ,, under regenerator, 10 a.m. to 1.40 p.m.	1·375 in.
,, ,, ,, ,, 1.40 to 7.30 p.m.	·545 in.
,, ,, in downtake, 10 a.m. to 1.40 p.m.	·875 in.
,, ,, ,, 1.40 to 7.30 p.m.	·375 in.
,, time taken to clinker one fire	5 min. 36 secs.
,, ,, between each clinkering	1 hr. 54 min.
Number of times each fire clinkered	Five.
Damper full open to 1.40 p.m., area	10·2 sq. ft.
,, partly closed after 1.40 p.m., area	5 sq. ft.

Analysis of Clinker Residue

Silica	40·6 per cent.
Lime	11·2 ,,
Alumina	18·5 ,,
Ferric oxide	22·8 ,,
Magnesia, manganese and alkalies	6·9 ,,
	100·0 ,,

Note.—Boiler was not clothed when this test was made.

Test B.

Result of Test at Nelson, 19th February to 16th March, 1901.

Duration of test	473½ hours.		
Number of cells	Four.		
Total grate area	100 sq. ft.		
Lancashire boiler, 30 ft. × 8 ft. heating surface	986 sq. ft.		
Refuse consumed	Tons	cwt.	qr.
Unscreened ashpit refuse	571	12	1
Light refuse	29	11	3
Vegetable refuse	9	0	3
Fish and slaughter house offal	16	18	0
	627	2	3
Pots, tins, etc., not burned	13	3	1
Net amount consumed	613	19	2

Refuse, other than ashes	9 per cent.
,, consumed, total	1,374,304 lb.
,, ,, per hour	2,902 lb.
,, ,, per sq. ft. grate area per hour	29 lb.
Water evaporated	2,125,980 lb.
,, ,, per hour, actual	4,490 lb.
,, ,, ,, ,, from and at 212° F.	5,379 lb.
,, ,, ,, lb. of refuse, actual	1·546 lb.
,, ,, ,, ,, ,, from and at 212° F.	1·850 lb.
Average steam pressure	120 lb.
Weight of clinker remaining	415,296 lb.
,, fine ashes from under grates	46,620 lb.
,, other residuals	68,992 lb.
Percentage of clinker to refuse consumed	30·20 per cent.
,, ashes	3·38 ,,
,, other residuals	5·10 ,,
,, CO_2, average	13·16 ,,
,, ,, highest reading	15·60 ,,
,, ,, lowest ,,	9·40 ,,
Average temperature of Feed-water	59·8° F.
,, ,, combustion chamber, 51 readings	1,959° F.
Highest ,, ,, ,,	2,462° F.
Lowest ,, ,, ,,	925° F.
Average ,, in side flues, 45 readings	654° F.
Highest ,, ,, ,,	825° F.
Lowest ,, ,, ,,	525° F.
Average ,, main flue, 43 readings	410° F.
Highest ,, ,, ,,	530° F.
Lowest ,, ,, ,,	320° F.
Average ,, downtake, 54 readings	1,070° F.
Highest ,, ,,	1,350° F.
Lowest ,, ,,	700° F.
Average ,, of heated air, 34 readings	243° F.
,, ashpit pressure, 43 readings	1·50 in.
,, vacuum in main flue, 39 readings	1·30 in.
,, in blower boxes, 36 readings	·20 in.
,, ,, under regenerator, 38 readings	·93 in.
,, ,, over ,, ,, ,,	·86 in.
,, ,, in air conduit, 34 readings	·11 in.

Maximum daily evaporation during test from and at 212°F.	1·96 lb.
Minimum ,, ,, ,, ,, ,,	1·64 lb.
Rainfall throughout test	2·2 in.
Proportion of steam produced used by forced blast	15 per cent

Test C.

Result of Test made at Nelson Destructor, 25th April, 1901.

Duration of test	8 hours.		
Number of cells	4.		
Total grate area	100 sq. ft.		
Lancashire boiler, 30 ft. × 8 ft. heating surface	986 sq. ft.		
Refuse consumed—	Tons	cwt.	qr.
Unscreened ashpit refuse	24	2	0
Greens and light refuse	0	18	1
Fish offal	0	2	0
	25	2	1
Pots, tins, etc., not burned	0	12	3
Net amount consumed	24	9	2

Refuse other than ashes	4 per cent.
,, consumed, total	54,824 lb.
,, ,, per hour	6,853 lb.
,, ,, per sq. ft. grate area per hour	68½ lb.
Water evaporated	91,600 lb.
,, ,, per hour, actual	11,450 lb.
,, ,, ,, from and at 212° F. average	13,442 lb.
,, ,, ,, ,, ,, maximum	16,162 lb.
,, ,, per lb. of refuse, actual	1·67 lb.
,, ,, ,, ,, from and at 212° F. average	1·96 lb.
,, ,, ,, ,, from and at 212° F. maximum	2·35 lb.
,, ,, per square ft. heating surface per hour from and at 212° F.	13·6 lb.
Average steam pressure	122 lb.
Weight of clinker remaining	15,932 lb.
,, fine ashes from under grate	1,008 lb.
Percentage of clinker to refuse consumed	29·06 per cent.
,, ashes ,, ,,	1·83 ,,
,, CO_2 average, 30 readings	14·40 ,,
,, ,, highest reading	19·80 ,,
,, ,, lowest reading, clinkering	4·80 ,,
Average temperature of feed-water	83° F.
,, ,, combustion chamber, recorder	2,227° F.
Highest ,, ,, ,,	2,693° F.
Lowest ,, ,, ,,	1,666° F.
Average ,, in downtake, 20 readings	1,306° F.

Average	in side flues, 28 readings	922° F.
Highest	,, ,, ,,	1,150° F.
Lowest	,, ,, ,, at commencement	562° F.
Average	,, in main flue, 29 readings	666° F.
Highest	,, ,, ,,	770° F.
Lowest	,, ,, ,, at commencement	500° F.
Average	,, air entering regenerator	82° F.
,,	,, air leaving ,, 29 readings	394° F.
,,	pressure in ashpits	$2\frac{3}{8}$ in.
,,	vacuum in main flue	1·78 in.
,,	,, in blower boxes	$\frac{1}{4}$ in.
,,	,, in air conduit	·20 in.
,,	,, under regenerator	1·40 in.
,,	,, over ,,	1·24 in.
,,	time taken to clinker one fire	7 min. 25 secs.
,,	,, between each clinkering	2 hrs. 7 min.
Number of times each fire clinkered		Three.
Damper full open, area		10·2 sq. ft.

Tests B and C are, so far as the writer is aware, record tests, the former being of one month's duration, under easy conditions, while the latter being under forced conditions over a short period clearly demonstrates the remarkable elasticity of the plant, as also putting on record a remarkable duty for a Lancashire boiler fired with destructor gases.

Newcastle-on-Tyne Municipal Corporation—Population, 215,328.

Two Installations.

	1.	2.
A	1885.	1891.
B	Fryer's top fed.	Warner's top fed.
C	6.	6.
D	None.	None.
E	150 feet.	Same chimney.
F	Natural draught only.	—
G	No power available.	
H	75 tons.	—
I	8·16*d*.	

The approximate cost per cell is given at £600. During the year 1902 a total of 29,536 tons of refuse was dealt with. This is one of the few remaining low temperature installations in this country, and is of course of insufficient capacity for dealing with the total amount of refuse now produced.

S. W.

NEWMARKET URBAN DISTRICT COUNCIL—POPULATION, 10,686.

A	Fryer's improved top fed.
C	2.
D	1 Babcock & Wilcox.
E	120 feet.
F	Fan.
G	Sewage pumping.
H	9 tons.
I	11*d*.

One supplementary boiler of the Cornish type is installed, for coal firing, as may be found necessary. The clinker is used for road foundation work.

E. W.

NORTHAMPTON MUNICIPAL CORPORATION—POPULATION, 87,021.

A	1903.
B	Heenan's back fed.
C	8.
D	2 Lancashire.
E	120 feet.
F	Fan.
G	Electric traction.
H	80 tons.
I	—

It is proposed to fully utilize the available power for generating electricity for traction purposes, but some few months must yet elapse before this part of the scheme will be complete. The cost of the destructor was £14,150. It is proposed to instal a flag plant for partial utilization of the clinker.

Fig. 79 is a cross section through the boiler, cells and flues; the chimney, originally arranged to be either 80 or 100 feet in height, was increased in height to 120 feet.

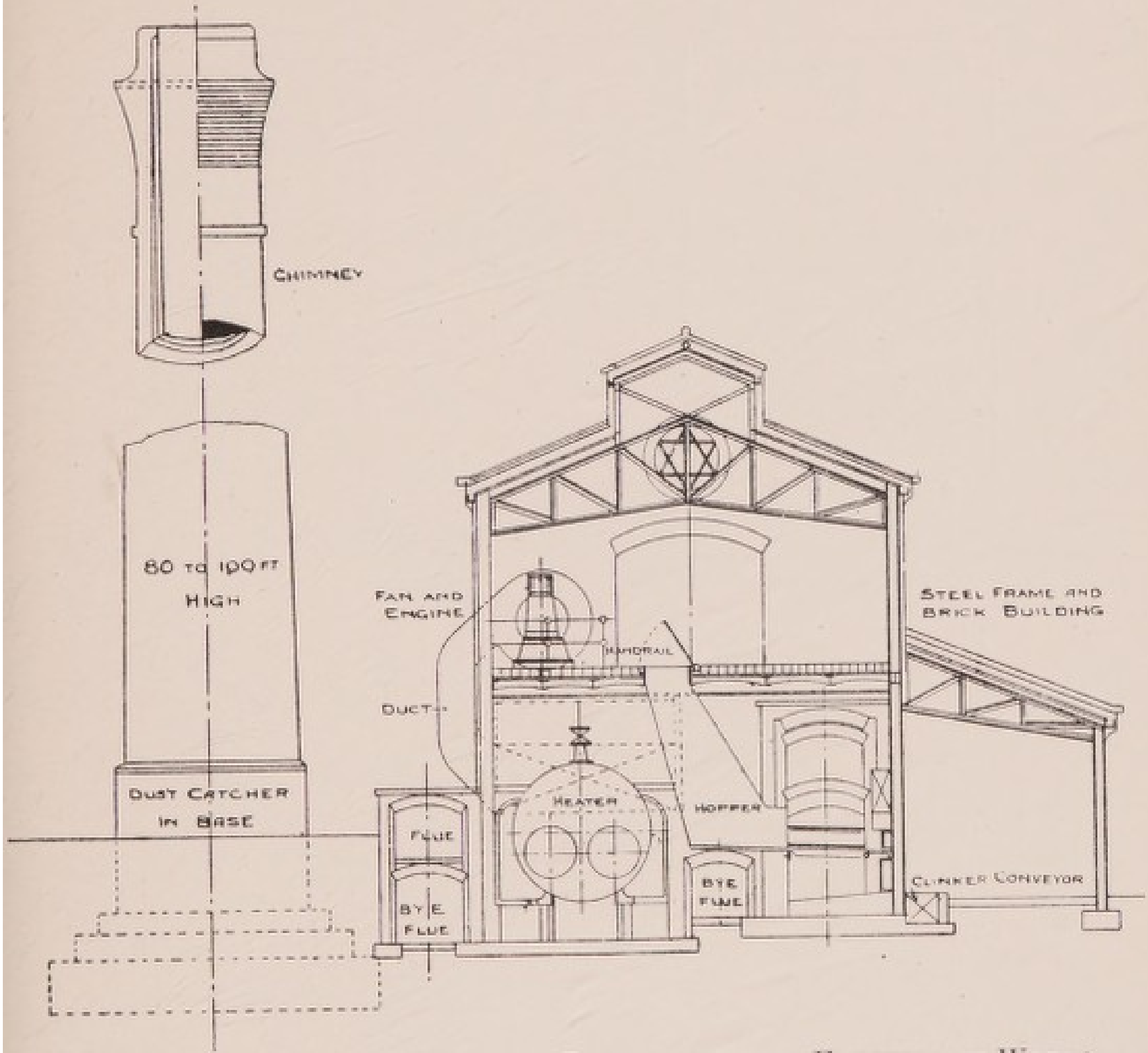


FIG. 79. NORTHAMPTON COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
Cross Section.

S. W.

NORWICH MUNICIPAL CORPORATION—POPULATION, 111,728.

A	1898 and 1903.
B	Horsfall's top fed.
C	4.
D	2 Babcock & Wilcox
E	100 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	30 tons.
I	—

NOTTINGHAM MUNICIPAL CORPORATION—POPULATION, 239,753.

THREE [1] INSTALLATIONS.

	No. 1	No. 2 Radford.	No. 3 Eastcroft. E.W.
A . .	1882.	1902.	1903.
B . .	Fryer's top fed.	Fryer's improved.	Fryer's improved.
C . .	5.	6.	12.
D . .	1 Multitubular.	—	—
E . .	160 feet.	—	—
F . .	Steam jet blowers.[2]	Fans.	Fans.
G . .	—	—	Electricity.
H . .	—	—	—
I . .	—	—	—

S. W.

NUNEATON URBAN DISTRICT COUNCIL—POPULATION, 15,246.

A	1901.
B	Meldrum's front hand fed.
C	3 grates.
D	2 Cornish.
E	70 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	15 tons.
I	10*d*.

The destructor cells were adapted to two existing Cornish boilers, which were previously fired with coal for many years ; the old chimney is also utilized. The refuse available is found sufficient to provide the whole of the power required for pumping the sewage, and no coal whatever is used. The clinker is partially used for mortar making.

[1] It has recently been decided to erect a fourth Destructor.

[2] Added in 1893.

E. W.

Oldham Municipal Corporation—Population, 137,238.

Three Installations.

	No. 1 Rhodes Bank.	No. 2 Hollinwood.	No. 3 Dunbar Street.
A . .	1891 and 1894.	1901.	1901.
B . .	Horsfall's back hand fed.	Horsfall's back hand fed.	Horsfall's back hand fed.
C . .	10.	8.	8.
D . .	2 Lancashire, each 30 ft. × 8 ft.	2 Lancashire, each 30 ft. × 8 ft.	2 Lancashire, each 30 ft. × 8 ft.
E . .	120 feet.	180 feet.	180 feet.
F . .	Steam jet blowers.	Steam jet blowers.	Steam jet blowers.
G . .	Works purposes & electric lighting.	Clinker crushers & mortar mills.	Public baths & washhouses.
H . .	Total	120 tons per	day.
I . .	$9\frac{3}{4}d.$	—	—

Installation No. 1 is of special interest as being the first destructor in this country, combined with an electricity works; it is also noteworthy as the first Horsfall destructor erected, and it is largely owing to the experience gained with this installation that the present Horsfall standard has been evolved.

Although 6 cells were erected in 1891, on this site, known as Rhodes Bank, it was some three years later when steam was first supplied for the generation of electricity, and this date marks the initiation of a combination which, although yet in its infancy, has made remarkable strides.

In connection with the two destructor boilers, a 96-pipe Green's Economiser is installed, the supplementary coal fired boilers being 8 in number, also of the Lancashire type, with which a Green's Economiser is also included.

The power equipment of the station comprises—10 Willans' engines, total H.P. 2160, 1 Parson's turbine, 400 H.P., and 11 bipolar dynamos, of a total capacity of 1582 k.w.

A few figures taken from the returns for the eighth year of operation (1902) are of interest—

Load factor	12·02 per cent.
Fuel cost	·71 per unit.
Works ,, ...	1·33 ,, ,,
Total ,, ...	1·75 ,, ,,
Net profit	£897.

At installation No. 2 (Hollinwood) a very complete plant is provided for clinker utilization, comprising clinker crushing and mixing machinery, and one of Messrs. Fielding and Platt's latest three-mould type hydraulic flag presses.

Padiham Urban District Council—Population, 12,005.

A	1901.
B	Horsfall's back hand fed.
C	3.
D	1 Lancashire, 28 ft. × 7 ft.
E	125 ft. × 4 ft. 6 in., internal.
F	Steam jet blowers.
G	Forced draught and works purposes only.
H	12 tons.
I	[1] 2*s*. 10*d*.

E. W.

Pontypridd Urban District Council—Population, 32,319.

A Destructor of the "Heenan" type is now in hand for this Council; it is likely that the power will be utilized for electrical purposes. The estimated cost of the installation is given as £12,062.

Plymouth Municipal Corporation—Population, 107,509.

A	1901.
B	Warner's top fed.
C	12.
D	6 Multitubular.
E	160 feet.
F	Fans.
G	—
H	100 tons.
I	—

[1] This high figure is attributed to the intermittent operation of the Destructor.

Preston Municipal Corporation—Population, 112,989.

Three Installations.

	No. 1 Moor.	No. 2 Marsh.	No. 3 E.W.
A . .	1886.	1892.	1903.[1]
B . .	Fryer's top fed single row.	Fryer's top fed, back to back.	Meldrum's front hand fed.
C . .	8.	20.	16 grates.
D . .	—	1 Multitubular.	4 Lancashire, each 30 ft. by 8 ft.
E . .	180 feet.	250 feet.	—
F . .	Natural draught.	—	Steam jet blowers.
G . .	—	—	Electric traction.
H . .	Total	108 tons.	80 tons.
I . .	1s. 0½d.	11¾d.	—

S. W.

Radcliffe Urban District Council—Population, 25,368.

A . . . 1902.
B . . . Meldrum's back hand fed.
C . . . 3 grates.
D . . . 1 Lancashire, 24 ft. × 7 ft. 6 in.
E . . . 150 feet.
F . . . Steam jet blowers.
G . . . Sewage pumping, operating sludge pressure, etc.
H . . . 26 tons.
I . . . 10*d*.

Ramsgate Municipal Corporation—Population, 27,686.

A . . . . . 1899.
B . . . . . Horsfall's back hand fed.
C . . . . . 4.
D . . . . . 2 Babcock & Wilcox.
E . . . . . 120 ft. × 5 ft., internal.
F . . . . . Steam jet blowers.
G . . . . . Forced draught and works purposes only.
H . . . . . 26 tons.
I . . . . . —

[1] This installation will not be completed until late in 1904. It is the largest destructor installation in the world, providing power for electrical purposes.

RAWTENSTALL MUNICIPAL CORPORATION—POPULATION, 31,053.

A	1902.
B	Heenan's back fed.
C	2.
D	1 water tube.
E	—
F	Fan.
G	Works purposes only.
H	28 tons.
I	—

E. W.

RHYL URBAN DISTRICT COUNCIL—POPULATION, 8,473.

A	1902.
B	Fryer's improved top fed.
C	4.
D	2 Babcock & Wilcox.
E	120 feet.
F	Fan.
G	Electric lighting.
H	16 tons.
I	1*s*. 4*d*.
J	15.

Two large Babcock and Wilcox boilers are also provided for supplementary coal firing. The power equipment of the station is as follows: 3 Compound single-acting three-crank engines, coupled direct to shunt wound multipolar dynamos, the engines being of Messrs. Alley & Maclellan's make, and the dynamos of the Lancashire Dynamos Company's make. The generating sets have an output of 165 k.w. at a speed of 380 revolutions per minute; a Hart's accumulator battery of 274 cells is also provided.

ROCHDALE MUNICIPAL CORPORATION—POPULATION, 83,114.

A	1894.
B	Meldrum's front hand fed.
C	4 grates.
D	2 Lancashire, 30 ft. × 8 ft.
E	250 feet.
F	Steam jet blowers.

G	Works purposes. About 120 H.P.
H	40 tons.
I	$7\frac{1}{2}d$.

Special interest attaches to this installation, firstly because it was the first Meldrum destructor erected, and secondly because here high pressure steam was first produced from refuse. As observed in another chapter, up to this time (1894) it had been urged that a steam pressure of 60 pounds to the square inch was the highest steam pressure obtainable with refuse as fuel. What Mr. Brookman was able to show at Rochdale nine years since has had far-reaching effects; in fact it is but fair to say that the demonstration at Rochdale initiated the modern combined plant, because the previously attained low steam pressure was alike useless for electrical purposes, or even modern sewage works.

Mr. Brookman, Rochdale's well-known Cleansing Superintendent and one of the highest authorities on refuse destructors living, has done not a little to popularize final and sanitary disposal. His work has always been of such a thorough and painstaking character, that it has contributed in no small measure to our British pre-eminence in this class of work.

Some details of three tests at Rochdale are here given, and they are worthy of careful perusal. (See Table, page 292.)

In addition to the destructor at Rochdale, 5 large Cornish boilers are provided; these are equipped with Meldrum forced draught furnaces, and burn a considerable quantity of refuse, the power from which is also fully utilized in connection with sanitary manure plant.

RHONDDA URBAN DISTRICT COUNCIL—POPULATION, 117,000.

A	1900.
B	Mason's gasifier.
C	2.
D	1 vertical.
E	—
F	Steam jet blowers.
G	None available.
H	16 tons.
I	2s. 7d.

Rochdale Destructor.

Test made at the Corporation Sanitary Works,

Under the supervision of F. W. Brookman, Esq., Resident Engineer.

Date of test	Mar. 1, 1895	Nov. 14, 1895.	Nov. 15, 1895.
Duration of test	6 hours.	$6\frac{1}{2}$ hours.	$6\frac{1}{2}$ hours.
Total refuse destroyed	11·4 tons.	13·75 tons.	14·3 tons.
Refuse burnt per hour	4,256 lb.	4,738 lb.	4,945 lb.
Refuse burnt per hour, per square foot of grate	47·3 ,,	52·6 ,,	54·9 ,,
Water evaporated per lb. of refuse	1·64 ,,	1·39 ,,	1·47 ,,
Equivalent evaporation, from and at 212°	1·97 ,,	1·68 ,,	1·78 ,,
Number of boilers used	Two.	One.	One.
Temperature of feed water	53° F.	52° F.	52° F.
Total water evaporated	42,072 lb.	42,900 lb.[1]	47,400 lb.[1]
Water evaporated per hour	7,012 ,,	6,600 ,,	7,290 ,,
Equivalent evaporation, from and at 212° F.	8,431 ,,	7,980 ,,	8,820 ,,
Average steam pressure per square inch	113 ,,	113 ,,	114 ,,
Percentage of (CO^2) in products of combustion	15·9	—	—
Percentage of (CO) in products of combustion	Nil.	—	—
Percentage of free oxygen	2·2	—	—
Labour cost per ton of refuse destroyed	$7\frac{1}{2}d.$	—	—

[1] It was found that some heat passed the damper and evaporated 60 and 54 gallons of water per hour respectively, in the stand-by boiler; these items were therefore included in the above figures.

ROTHERHAM MUNICIPAL CORPORATION—POPULATION, 54,348.

A	1892.
B	Fryer's top fed.
C	6.
D	[1] 1 Multitubular, 14 ft. × 7 ft.
E	130 feet.
F	Steam jet blowers.
G	Works purposes only
H	40 tons.
I	1s. 0½d.

ROYTON URBAN DISTRICT COUNCIL: POPULATION 14,881.

A	1983.
B	Warner's top fed.
C	4.
D	1 Multitubular, 12 ft. × 7 ft.
E	213 feet.
F	Natural draught only.
G	—
H	20 tons.
I	9½d.

ST. ANNE'S-ON-SEA URBAN DISTRICT COUNCIL—POPULATION, 6,807.

A	1900.
B	Warner's top fed.
C	2.
D	1 Multitubular.
E	—
F	Fan.
G	Forced draught and works lighting only.
H	6 tons normally.
I	1s. 4·1d.

E. W.

ST. HELENS MUNICIPAL CORPORATION—POPULATION, 87,385.

A	1899.
B	Meldrum's Beaman & Deas top fed.
C	4.

[1] It has recently been decided to instal a Lancashire boiler also.

D	2 Babcock & Wilcox.
E	200 feet.
F	Fan.
G	Electric traction.
H	32 tons.
I	1*s.* 2*d.*

The steam ranges from the destructor boilers to the engine room are so designed that two sets of each 125 k.w. can be run from the destructor boiler independently of the other boilers, or the destuctor boilers and supplementary coal fired Lancashire boilers can supply the whole range in parallel.

In each machine circuit a watt hour recorder meter is fixed, to meter the output from the generator. The usual practice is to drive one or both of the 125 k.w. sets from the destructor only for a part of the day, and later on, when more plant is required, to parallel both sets of boilers on the whole load.

Some figures extracted from the returns for the first year's working from March 31st, 1900, to March 31st, 1901, are of interest—

	Total for one Year	Average per Week
Weight of refuse destroyed . .	9,778 tons.	188 tons.
Electrical energy used for driving fans and other motors . .	70,000 units.	1,346 units.
Units generated by destructor boilers	365,000 units.	7,019 units.
Wages	£750.	£14 8*s.* 6*d.*
Weight of clinker produced . .	3,900 tons.	75 tons.
Value of mortar sold	£221 9*s.* 8*d.*	£4 5*s.* 2*d.*
Value of electrical units generated at ·3*d.* per unit	£450	£8 13*s.* 1*d.*

AVERAGES PER TON OF REFUSE DESTROYED.

Units generated exclusive of power used for 2 mortar mills and 1 steam winch	37·3
Units used on works	7·1

A few figures taken from the analysis of the accounts for the year ending March 31st, 1902, are interesting—

Labour factor	17·84 per cent.
Fuel cost per unit	·26*d*.
Works cost per unit	·65*d*.
Total ,, ,, ,, ...	1·04*d*.
Net surplus for year	£261.

Four supplementary coal fired boilers of the Lancashire type are provided, and the power equipment of the works is as follows :

6 Willans' engines ; total H.P. 2.220, and 6 multipolar dynamos direct coupled, total capacity 1,340 k.w. ; also a storage battery of 730 Chloride cells R. type.

Some details of the official test of the destructor are here given—

Date of test	April 10, 1900.
Duration of test (10.30 a.m. to 5.50 p.m.)	7 hours 20 mins.
State of the weather	Fine, windy.
Kind of fuel burned	Unscreened ashpit refuse.
Total weight of fuel burned . . .	16 tons 18 cwt. 2 qrs. = 37,912 lb.
Weight burned per hour	5,169 lb.
Weight burned per sq. ft. of grate area (50 sq. ft.)	103 lb.
Total weight of clinker and ash . .	5 tons 6 cwt. 1 qr. = 11,900 lb.
Percentage of clinker and ash . .	31·36 per cent.
Total water evaporated	48,216 lb.
Water evaporated per hour . . .	6,575 lb.
,, ,, per lb. of refuse, actual	1·27 lb.
,, ,, per lb. of refuse, from and at 212° F., including economiser	1·54 lb.
Temperature of water in tanks . .	46° F.
,, of feed water from economiser .	190° F.
Average steam pressure	132 lb.
,, air pressure under grates . . .	3·1 in.
Temperature in combustion chamber, by copper test	2,000° F.
Temperature in main flue, before economiser	537° F.
,, ,, ,, after economiser	358° F.
Percentage of CO_2, average for 21 readings .	10·4 per cent.
,, O, ,, ,, 20 ,, .	9·16 ,, ,,

Great credit is due to the late chief engineer, Mr. J. S. Highfield, for the very excellent results obtained at this combined works, which must rank as one of the most successful in this country.

St. Heliers, Jersey.

A	1899.
B	Horsfall's back hand fed.
C	3.
D	1 Babcock & Wilcox.
E	75 ft. × 4 ft. 6 in., internal.
F	Steam jet blowers.
G	Forced draught only.
H	15 tons.
I	—

During the first few months of working, nuisance was caused by the escape of offensive dust and fumes, and litigation ensued. This trouble was no doubt seriously contributed to by careless working and lack of efficient supervision.

Salford Municipal Corporation—Population, 220,957.

Five Installations.

	No. 1 Wilburn St.	No. 2 "Agecroft"	No. 3 Carey St.	No. 4 Wilburn St.	No. 5 Carey St.
A	1883.	1888.	1888.	1902.	1902.
B	Fryer's modified top fed.	Fryer's modified top fed.	Fryer's modified top fed.	Warner's top fed.	Warner's top fed.
C	12.	6.	6.	3.	6.
D	1 Multi-tubular.	—	—	1 Lancashire.	3 Multi-tubular.
E	180 ft.	180 ft.	180 ft.	same	chimney.
F	Natural	draught	only.	Fan.	Fan.
G	—	—	—	Forced draught works	and purposes.
H	—	—	—	—	—
I	—	—	—	—	—

S. W.

SALISBURY MUNICIPAL CORPORATION—POPULATION, 17,117.

A	1902.
B	Horsfall's back hand fed.
C	2.
D	2 Babcock & Wilcox.
E	120 ft. × 5 ft., internal.
F	Steam jet blowers.
G	Sewage pumping.
H	16 tons.
I	1*s.* 3*d.*

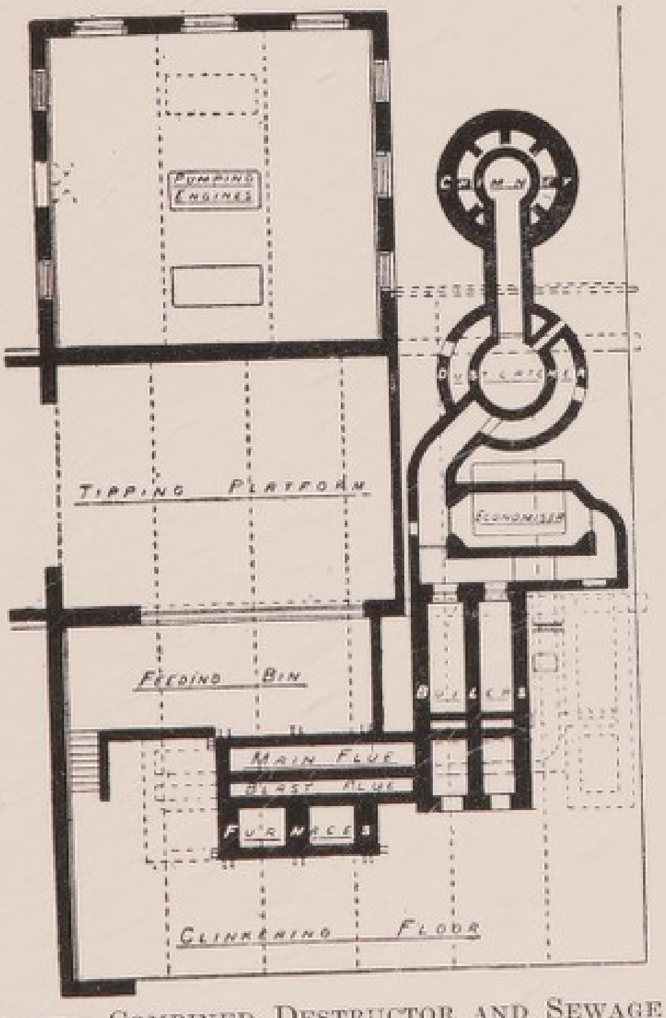


FIG. 80. SALISBURY COMBINED DESTRUCTOR AND SEWAGE WORKS. Plan.

The general arrangement of this installation will be seen by referring to Fig. 80. This destructor, being part of a modern scheme, is very complete, and an excellent example of its type.

Some interesting details of an evaporative test conducted by the National Boiler Insurance Co., Ltd., are here given—

Test of a Two-Cell Horsfall Destructor, carried out by the National Boiler Insurance Company, Limited, at Salisbury for the Salisbury Urban Sanitary Authority, April 16th and 17th, 1902.

General Particulars.

DESTRUCTOR.—With two cells, Horsfall's back fed type, each furnace having 30 square feet grate area. Worked under forced draught.

BOILERS.—Two Babcock and Wilcox boilers set in one battery. Each drum 3 feet diameter, 23 feet 7½ inches long, with 40 tubes 18 feet long. Fired by the waste gases from the Destructor. Total heating surface of both boilers, 1,800 square feet.

ECONOMISER.—One Green's economiser of 72 pipes. Total heating surface, 720 square feet.

Schedule of Principal Results.

Line.	Guarantees.			Results Obtained.		
A—Total refuse to be destroyed .	20 tons in 23 hours.			20 tons in 19 hours.		
B—Refuse to be burnt per sq. ft. of grate per hour . .	32 lb.			39·2 lb.		
C—Total evaporation of steam .	40,000 lb. in 23 hrs.			43,645·3 lb. in 19 hrs		
D—Water evaporated per lb. of refuse destroyed from and at 212° F. . . .	1 lb.			1·23 lb.		
	Max.	Min.	Aver.	Max.	Min.	Aver.
E—Boiler pressure—lb. per sq. in.	110	100	—	134	130	133
F—Temperature of feed water leaving economiser, deg. F.	280	250	—	226	191	214
G—Temperature in furnace, deg. F.	1,800	1,200	1,500	2,000	1,320	1,645
				Taken in combustion chamber.		

	Guarantees.	Results Obtained.		
		Max.	Min.	Avr.
H—Temperature deg. F. in main flue at inlet to No. 1 boiler .	About 1,600° F.	1,503	1,120	1,313
I—Temperature deg. F. in main flue at inlet to No. 2 boiler .	About 1,400° F.	1,323	810	965

OTHER OBSERVATIONS.

	Max.	Min.	Aver.
J—Temperature of flue gas deg. F. at economiser inlet	430	335	394
K—Temperature of flue gas deg. F. at economiser outlet	327	250	301
L—Average temperature of water pumped to economiser		50·5° F.	
M—Percentage of clinker(7 tons)obtained from the refuse		35 per cent.	
N—Weather		Fine.	

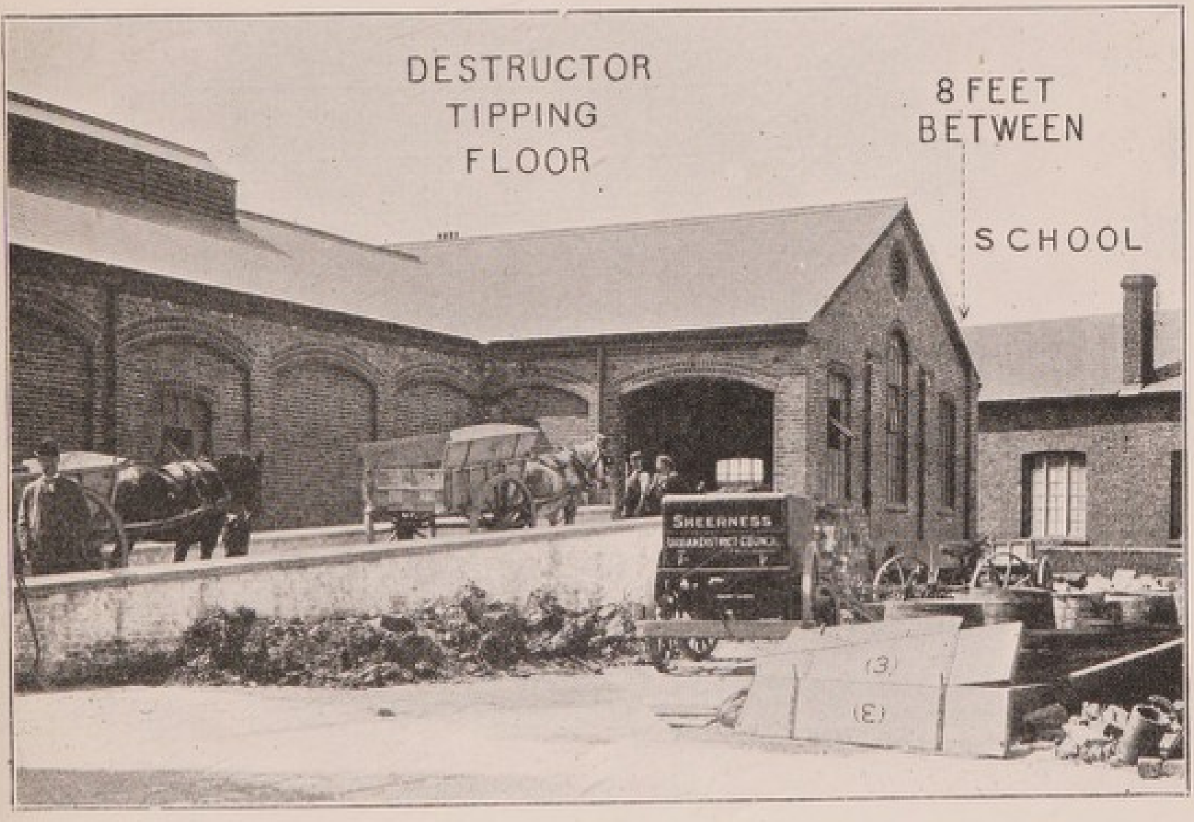


FIG. 81. SHEERNESS COMBINED DESTRUCTOR AND WATER WORKS.
View of Inclined Roadway and Building.

W. W.

SHEERNESS URBAN DISTRICT COUNCIL—POPULATION. 14,492.

A	1903.
B	Meldrum's front hand fed.
C	2 grates.
D	1 Lancashire, 26 ft × 7 ft.
E	90 feet.
F	Steam jet blowers.
G	Water pumping.
H	10 tons.
I	1*s*.

Figs. 81, 82 and 83 illustrate this plant, which is of more than ordinary interest. It is combined with the Council's water works on a remarkably central site. Sufficient power is obtained to operate the deep well pumps (about 70 H.P.) with the exception of Sundays, when, there being no collection of refuse, coal is used in a separate boiler.

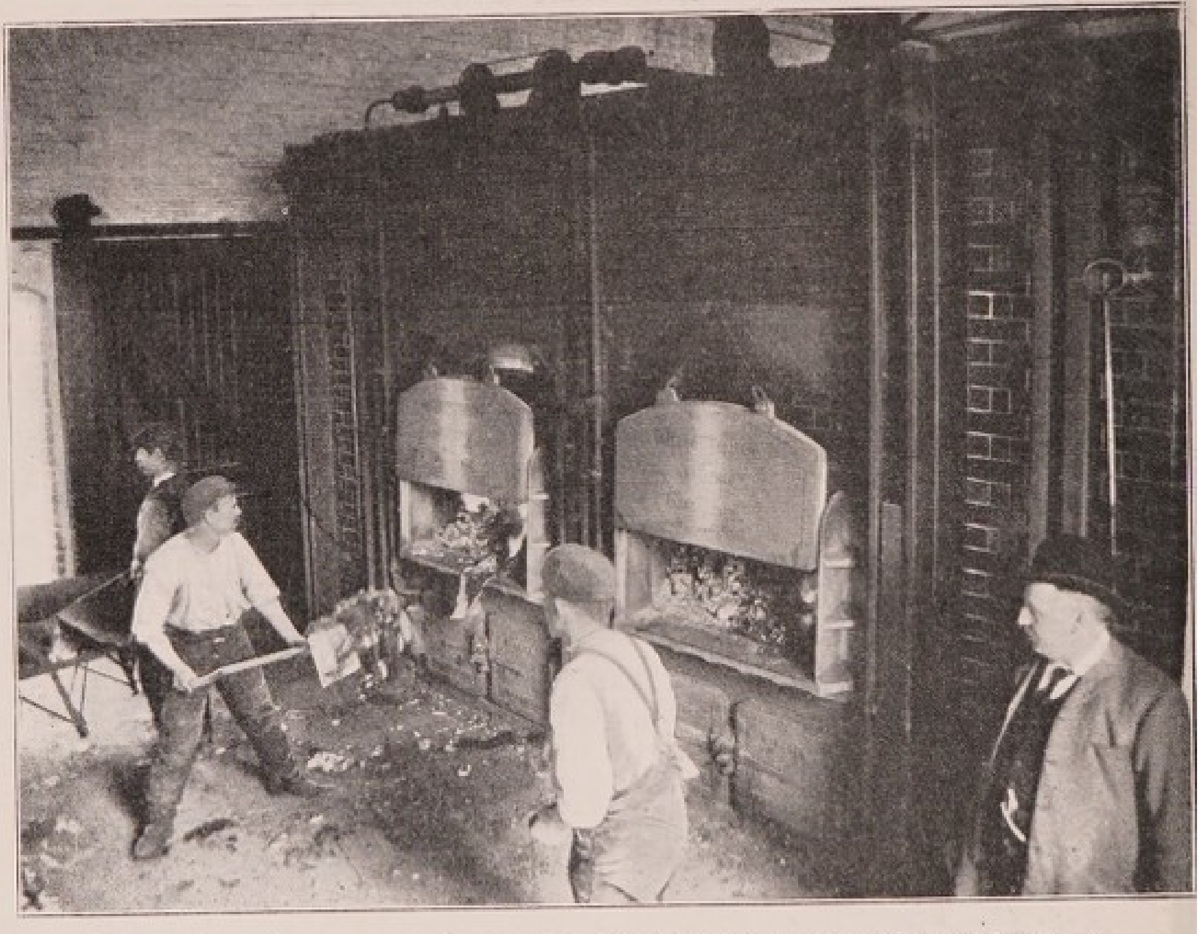


FIG. 82. SHEERNESS COMBINED DESTRUCTOR AND WATER WORKS.
View of Cells.

The total cost of the installation was about £3,500, and up to the present time, after six months' working, the average saving in fuel and collection cost has been over £17 per week.

It is anticipated that at the end of twelve months' working a saving of £1,000 will have been effected, and that the net economy as the result of the combination will be at least £600 per annum.

The external view of the works (Fig. 83) clearly conveys their remarkably central location. The chimney, 90 feet in height, was previously used for the coal fired boilers, and while being then

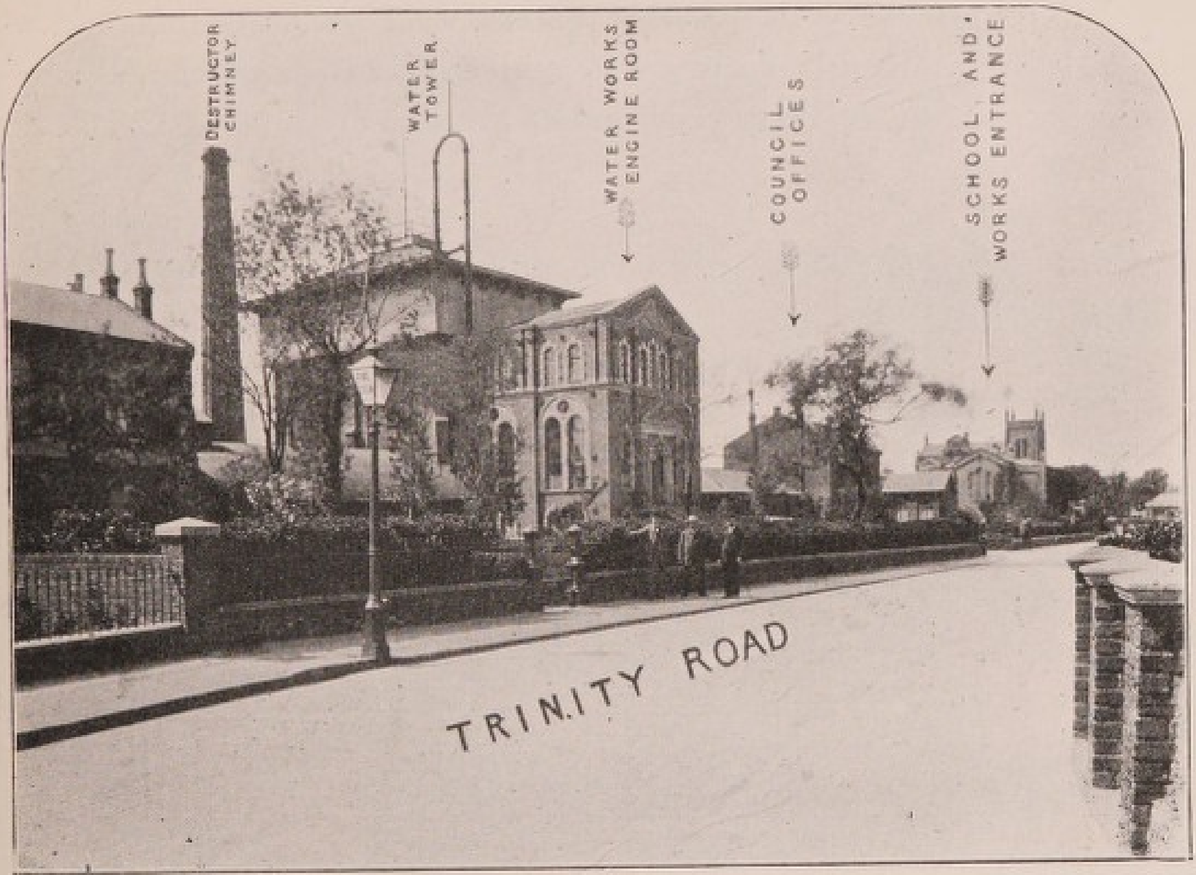


FIG. 83. SHEERNESS COMBINED DESTRUCTOR AND WATER WORKS.
View Showing the Unique Location of the Works.

notorious owing to the emission of black smoke, is now quite free from offence.

SHEFFIELD MUNICIPAL CORPORATION—POPULATION, 410,991.
TWO INSTALLATIONS.

	1. Lumley Street.	2.[1] Penistone Road.
A . .	1897 and 1901.	1903.
B . .	Warner's top fed.	Horsfall's top fed.
C . .	16 cells.	12 cells.
D . .	2 Multitubular.	2 Lancashires
E . .	180 feet.	—
F . .	Fan.	Steam jet blowers.
G . .	Forced draught and works purposes.	Forced draught and works purposes.
H . .	100 tons.	100 tons.
I . .	11½*d*.	—

1 Works not yet in operation.

In connection with installation No. 1, 2 mortar mills and a Musker hydraulic flag plant are provided, and a complete clinker utilization plant is being provided at Penistone Road destructor.

E. W., S. W.

SHIPLEY URBAN DISTRICT COUNCIL—POPULATION, 26,000.

A . . . . 1901.
B . . . . Meldrum's front hand fed.
C . . . . 4 grates.

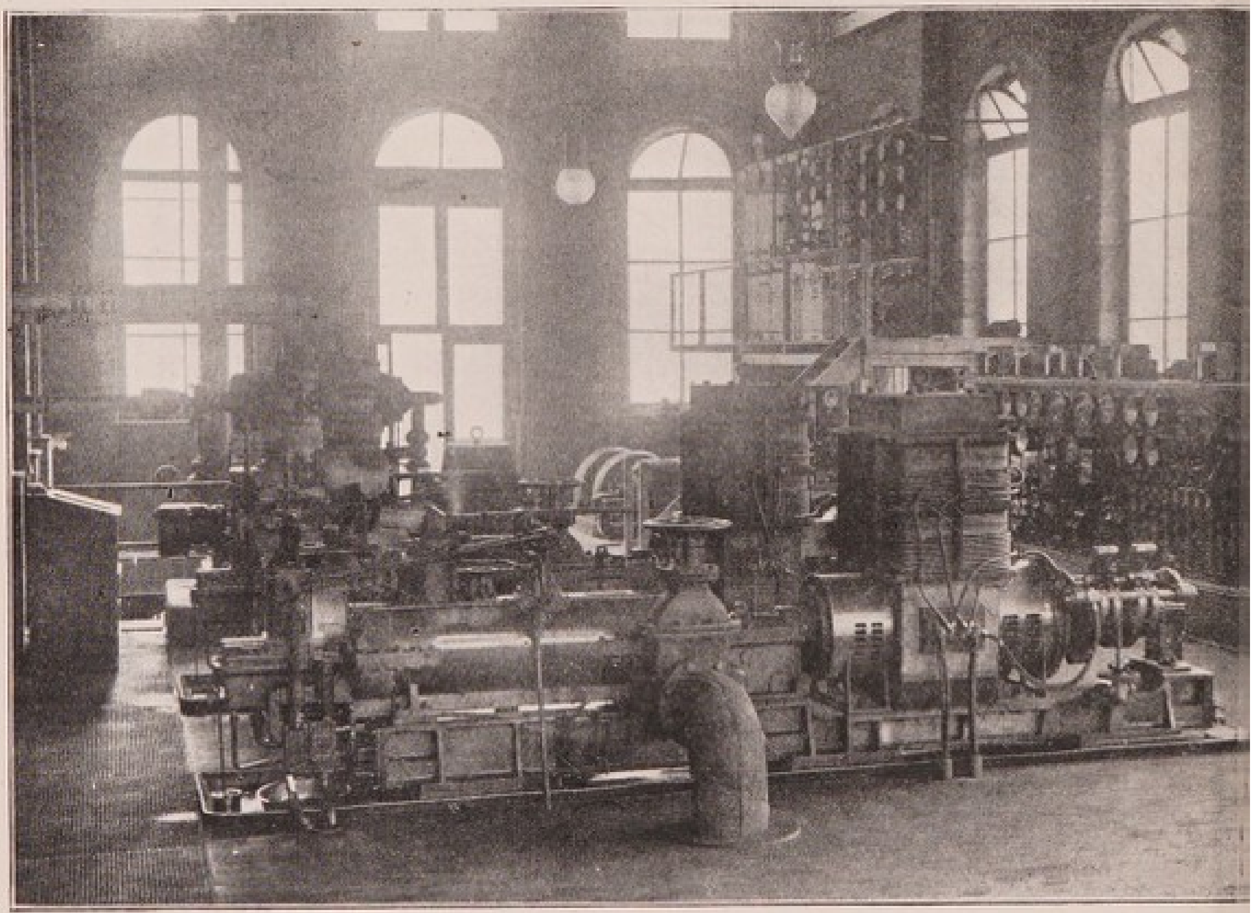


FIG. 84. SHIPLEY COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
View of Engine-room and Turbo Generators.

D . . . . 1 Lancashire, 30 ft. × 8 ft.
E . . . . 180 feet.
F . . . . Steam jet blowers.
G . . . . Electric lighting, traction and sewage pumping.
H . . . . 25 tons.
I . . . . $10\frac{1}{2}d.$
J . . . . 40.

In addition to supplying power for operating electrically driven sewage pumps, the destructor also gives a considerable amount of power, which is mainly used for the day load, motors and traction.

During the year ending March 31, 1903, 92542 units were used in the works for sewage pumping, works lighting, clinker crushing, etc., the total station costs being 1·368*d.* per unit, and the fuel cost ·372*d.* per unit.

Two supplementary Lancashire boilers are installed for coal firing, and the power equipment of the station comprises: 3 Parson's turbines, total capacity 720 k.w., and a storage battery of 260 B.P. T. and L. Company York cells.

Fig. 84 is a view of the engine room, showing the whole of the generating plant, as also the switchboards.

SMETHWICK—POPULATION, 54,539.

A	—[1]
B	Meldrum's improved top fed.
C	6 grates.
D	1 Lancashire.
E	150 feet.
F	Steam jet blowers.
G	Not yet decided.
H	55 tons.

About three years since a Mason's gasifier (2 cells) was erected, but this has not been used for some time past.

S. W.

SOUTHAMPTON MUNICIPAL CORPORATION—POPULATION, 107,833.

TWO INSTALLATIONS.

	1.	2.
A	1887.	1901.
B	Fryer's top fed.	Fryer's improved top fed.
C	6.	4.
D	1 Multitubular.	2 Babcock & Wilcox.

[1] This installation, which is estimated to cost £9,000, will not be completed until late in 1904.

E	160 feet.	Same chimney.
F	—	Fan.
G	—	Sewage pumping.
H	30 tons.	40 tons.
I	—	1*s.* 2½*d.*

The available power from installation No. 2 is fully utilized for sewage pumping, the dry weather flow being 4,000,000 gallons per 24 hours; the height of the lift is 18 feet.

SOUTHPORT MUNICIPAL CORPORATION—POPULATION, 48,083.

A	1901.
B	Horsfall's top fed.
C	6.
D	1 Lancashire, 30 ft. × 8 ft.
E	180 ft. × 7 ft. internal.
F	Steam jet blowers.
G	Gas works.
H	40 tons.
I	1*s.* 2*d.*

SOUTHWOLD MUNICIPAL CORPORATION—POPULATION, 2,800.

A	1900.
B	Ball's patent.
C	1.
D	None.
E	—
F	Natural draught only
G	No power available.
H	2 tons.
I	—

S. W.

STAFFORD MUNICIPAL CORPORATION—POPULATION, 20,894.

A	1898.
B	Fryer's improved top fed.
C	4.
D	2 Babcock & Wilcox.
E	135 feet.
F	Fan.
G	Sewage pumping.
H	20 tons.
I	1*s.* 4*d.*

The cost of the destructor and accessories, but exclusive of buildings and chimney, was £2,315.

STOCKTON-ON-TEES MUNICIPAL CORPORATION—POPULATION, 51,478.

A	1901.
B	Horsfall's back hand fed.
C	2.
D	Babcock & Wilcox.
E	130 ft. × 4 ft. internal.
F	Steam jet blowers.
G	Clinker crusher and mortar mill.
H	20 tons.
I	9*d*.

Six cells would be necessary to deal with the present collection of refuse, the bulk of which is still being tipped or disposed of to farmers.

The capital expenditure on the present plant was £3,091, exclusive of the cost of the site and included roadway, this being estimated at £700. The future extensions are estimated to cost £1,000 per cell.

E. W.

STOKE-ON-TRENT MUNICIPAL CORPORATION—POPULATION, 30,800.

A	1903.[1]
B	Meldrum's front hand fed.
C	6 grates.
D	2 Lancashire, 30 ft. × 8 ft.
E	120 feet.
F	Steam jet blowers.
G	Electric lighting.
H	30 tons
I	—

STOURBRIDGE URBAN DISTRICT COUNCIL—POPULATION, 16,302.

It has recently been decided to erect a destructor of the Horsfall type at a cost of £3,750.

[1] Now in course of erection.

STRETFORD URBAN DISTRICT COUNCIL—POPULATION, 30,436.

A	1899.
B	Meldrum's Beaman & Deas top fed.
C	2.
D	1 Babcock & Wilcox.
E	150 feet.
F	Fan.
G	Works purposes only.
H	18 tons.
I	1*s*. 4*d*.

S. W.

SUDBURY MUNICIPAL CORPORATION—POPULATION, 7,109.

A	1903.
B	Meldrum's front hand fed.
C	4 grates.
D	2 Cornish, 15 ft. × 5 ft.
E	80 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	5 tons.
I	—

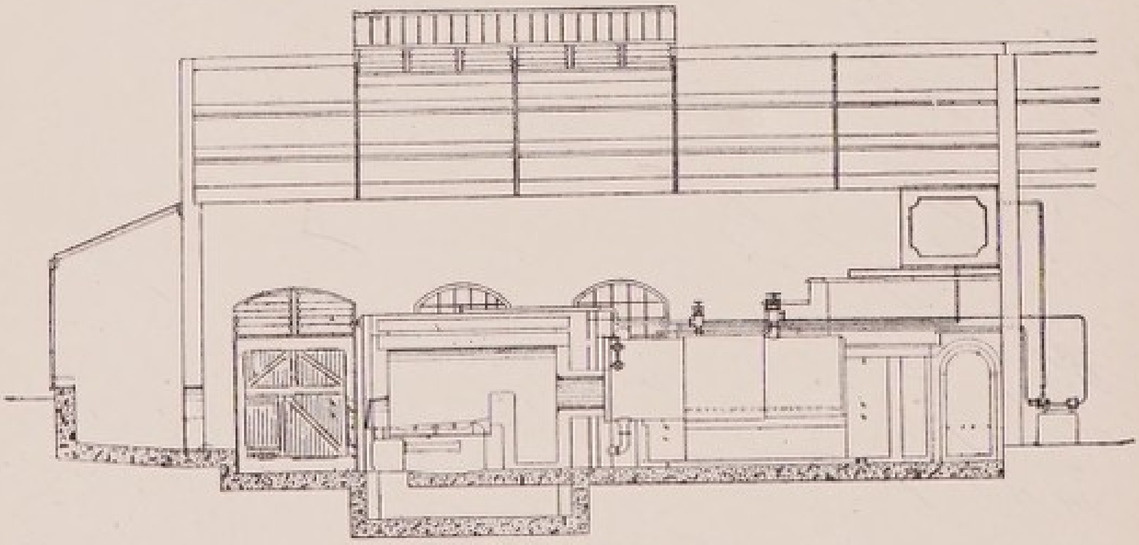


FIG. 85. SUDBURY COMBINED DESTRUCTOR AND SEWAGE WORKS.

This installation is of interest as being the smallest combined plant of the kind yet erected in this country. As such it affords a striking object lesson as to what may be done with such a

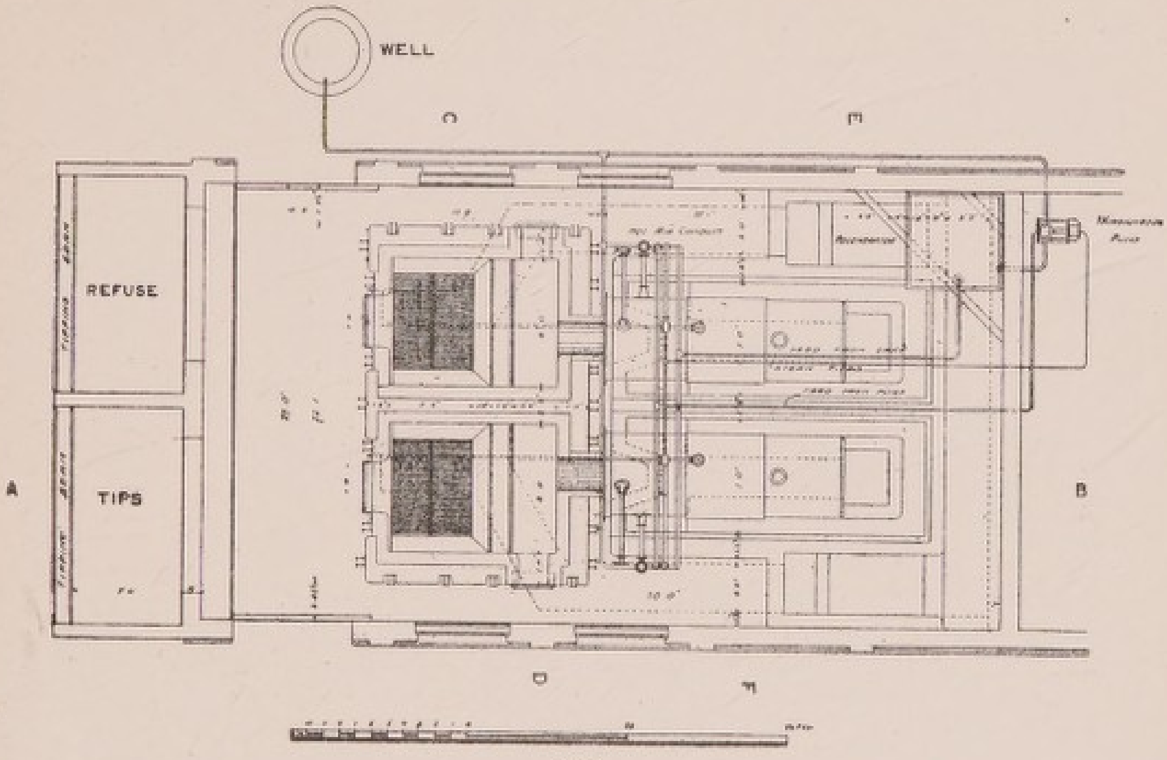


Fig. 86.

Sudbury Combined Destructor and Sewage Works.

small quantity of refuse. The clinker will be fully utilized for the bacteria beds.

The general arrangement of the destructor is shown in Figs. 85 and 86, and it will be observed that although only a small plant, it is yet complete in every respect.

Swansea Municipal Corporation—Population, 94,615.

An eight-cell destructor of Horsfall's top fed type is now in hand, the estimated cost of the same being £9,600.

S. W.

Taunton Municipal Corporation—Population, 21,078.

A	1903.
B	Horsfall's back hand fed.
C	4.
D	2 Babcock & Wilcox.
E	75 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	20 tons.
I	—

Fig. 87 is an external view of the works. The centrifugal

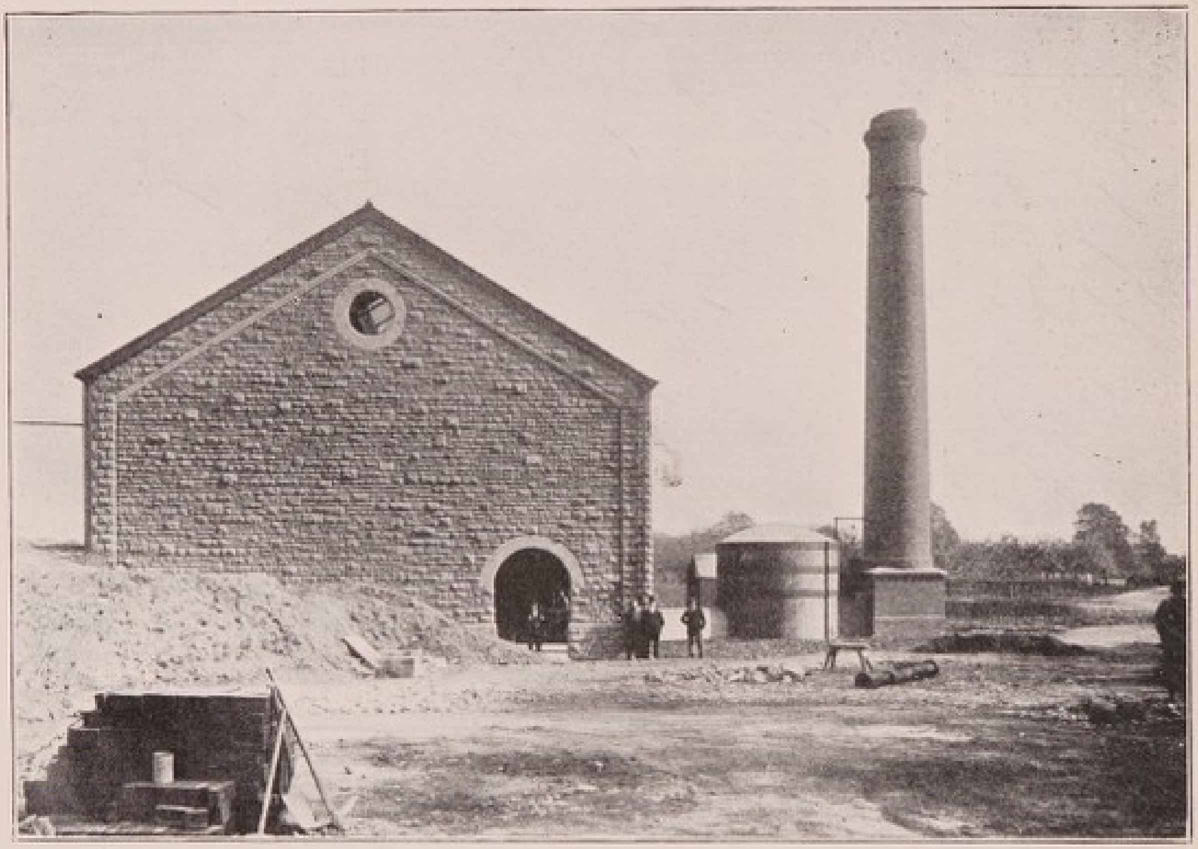


FIG. 87. TAUNTON COMBINED DESTRUCTOR AND SEWAGE WORKS.
External View, Showing Dust Catcher.

dust catcher will be observed between the building and the chimney.

TORQUAY MUNICIPAL CORPORATION—POPULATION, 33,625.

A	1899.
B	Warner's top fed.
C	4.
D	2 Multitubular.
E	150 feet.
F	Fan.
G	Works purposes only.
H	25 tons.
I	[1] $9\frac{1}{2}d.$

These works are situated in a hollow, and for the first year or two of operation the complaints concerning nuisance from escaping fumes were numerous and apparently well founded.

[1] This is a test figure.

Experts were, however, consulted by the Corporation, and the alterations suggested and adopted have had the effect of avoiding further trouble.

E. W.

TOTTENHAM URBAN DISTRICT COUNCIL—POPULATION, 106,800.

A	1903.
B	Warner's top fed.
C	10.
D	5 Multitubular.
E	180 feet
F	Fans.
G	Electric lighting.
H	80 tons.
I	—[1]

Fig. 88 is a block plan showing the general arrangement of this plant; it will be observed that each cell is provided with a separate fan for forced draught; this is a new departure, and while offering some advantages over the usual practice yet cannot on the whole be recommended.

E. W., S. W.

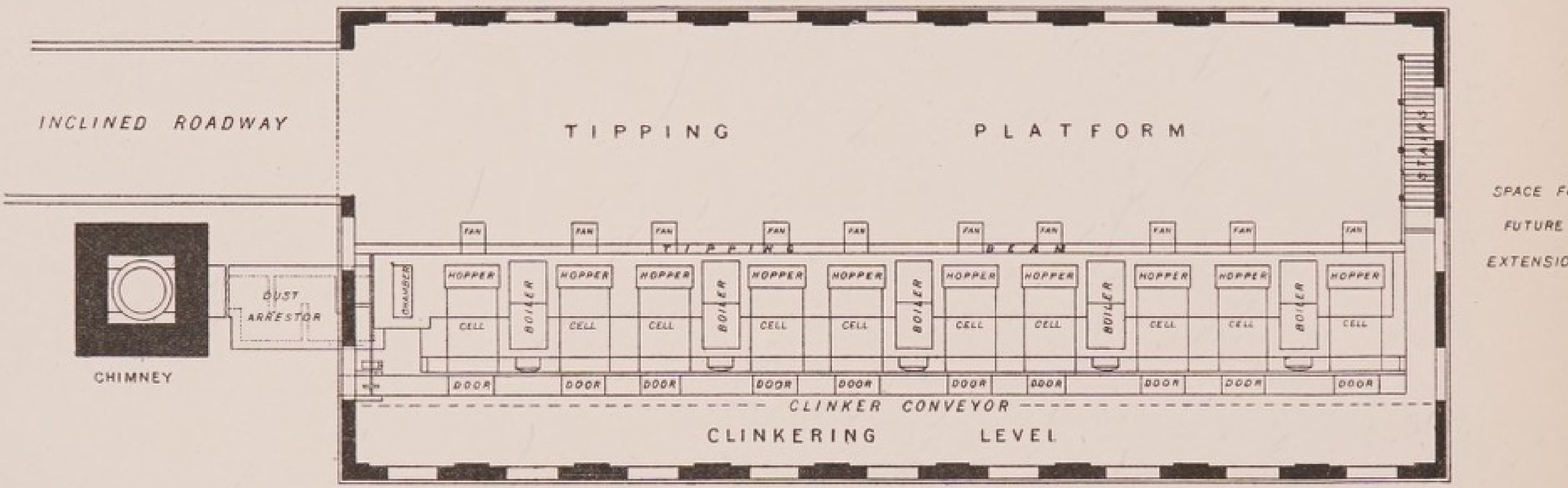
WAKEFIELD MUNICIPAL CORPORATION—POPULATION, 41,544.

TWO INSTALLATIONS.

	1.	2.
A . .	1898.	1902.
B . .	Fryer's improved top fed.	Heenan's back fed.
C . .	4.	2.
D . .	2 Babcock & Wilcox.	1 Lancashire, 24 ft. × 7 ft.
E . .	—	—
F . .	Fan.	Fan.
G . .	Electric lighting and sewage pumping.	
H . .	Total 40 tons.	

Five supplementary coal fired boilers are installed, these being of the Lancashire type each 30′ long and 8′ in diameter. The

[1] Works not yet in operation.



PLAN

Scale, 1/16 in. 1 ft.

Fig 88. Tottenham Destructor

power equipment of the station is as follows: 3 Horizontal slow speed engines, total H.P. 450; 3 fly-wheel alternators; 112 k.w. each; and 2,400 k.w. high speed vertical engines.

The Sanitary Committee pay the Electricity Committee 1*s*. 6*d*. per ton of refuse destroyed, the Electricity Committee providing 40 H.P. for operating the pumps for lifting the sewage into the settling tanks.

Some details of a test carried out with Installation No. 2 soon after its completion are here given—

Date of test	July 12, 1902.
Number of cells in use	2.
Total grate area	50 square feet.
Refuse consumed per hour	2,230 lb.
Refuse consumed per sq. ft. of grate surface per hour	44·6 lb.
Total water evaporated per hour	3080 lb.
Water evaporated per lb. of refuse destroyed from and at 212° F.	1·4 lb.

WALLASEY URBAN DISTRICT COUNCIL—POPULATION, 55,000.

A	1897.
B	Fryer's improved.
C	6.
D	No boilers.
E	160 feet.
F	Natural draught only.
G	No power available.
H	40 tons.
I	11*d*.

WALKER-ON-TYNE URBAN DISTRICT COUNCIL—POPULATION, 13,335.

A	1902.
B	Meldrum's front hand fed.
C	8 grates.
D	2 Cornish, each 15 ft. × 6 ft. 6 in.
E	90 feet.
F	Steam jet blowers.
G	Works purposes only.
H	30 tons.
I	$6\frac{3}{4}d$.

The details of the official test here given will serve to emphasize the serious mistake, even now frequently made, of not combining the destructor with some works where the power can be fully utilized.

Date	Nov. 25, 1902.
Time commenced	9.30 a.m.
Time finished	8.20 p.m.
Duration of test	10 hours 50 min.
Grate area	100 square feet.
Quantity of refuse destroyed, 30 tons 16 cwt. 1 qr.	69,020 lb.
Quantity of refuse destroyed per sq. ft. of grate area per hour	64 lb.
Residue—Clinker, 7 tons 9 cwt. 2 qr. Ashes, 0 ,, 11 ,, 0 ,,	17,976 lb.
Percentage of clinker	26 per cent.
Temperature of combustion chamber— Melted nickel 5 times. Fused and melted $\frac{1}{4}$-in. chain 4 times. Melted copper when cleaning out.	
Approximate maximum temperature	3,000° F.
Average temperature	Over 2,000° F.
Average temperature in side flue at back of setting	Over 1,400° F.
Average temperature in side flue, with combustion chamber door open	1,310° F.
Average temperature in bye-pass at entrance, with air inlets open	950° F.
Average temperature in bye-pass, with combustion chamber cleaning door open	875° F.
Average temperature in flue before regenerator	775° F.
Average temperature at chimney base	260° F.
Ashpit pressure	$1\frac{3}{8}$ in.
Pull before regenerator	$\frac{3}{8}$ in.
Pull after regenerator	$\frac{3}{8}$ in.
Pull in bye-pass	$\frac{7}{8}$ in.
Average steam pressure	90 lb.

HANDCOCK & DYKES, Consulting Engineers,
1, Victoria Street, Westminster, S.W.

Nov. 29, 1902.

NOTE.—It is worthy of remark that the occasion of the Walker test is the first on record where $\frac{1}{4}$-inch steel chain was fused and melted in the combustion chamber of a destructor furnace.

It will be observed that this official test was carried out to determine whether or not the Destructor could fulfil the guaranteed destroying capacity, but the figures are useful for other purposes, clearly showing as they do that a temperature can be reached and maintained such as was deemed impossible a few years since.

The following extract from the consulting engineer's report is of interest, clearly showing the serious loss in the case in question owing to the destructor not being combined with the electicirty works—

With the result of the test we are exceedingly pleased, as the plant has in every respect exceeded the requirements that we specified, and is working in a most satisfactory manner, there being no offensive gases given off either from the chimney or the furnaces, and there is almost an entire absence of smoke. It seems, however, a great pity to an engineer, or indeed to any one of an economical turn of mind, to see so much valuable power being wantonly thrown away, as the present plant has no arrangement for steam raising on a large scale. We were unable to test the amount of water which could be evaporated per ton of refuse, but from our experience of other destructors, and heat obtained in the furnaces, we have no hesitation in asserting that if suitable boilers were installed, each pound of refuse burnt in the destructor would provide $1\frac{1}{2}$ lbs. of high pressure steam over and above that required for the steam jets, etc. Now each unit burns 2·9 tons of refuse per hour, thus furnishing practically 10,000 lbs. of steam per hour, and allowing say 20 lbs. of steam per horse-power per hour would give 500 horse-power, which is considerably more than the power required to do all the lighting in Walker, and supplying the trams in addition. This is a sufficient answer to the critics who questioned the original proposals submitted, namely, to work the machinery in your proposed electric lighting station entirely by the heat provided by the refuse destructor.

At the present time actually 500 horse-power is being wasted for 12 hours per day, and it certainly seems a pity that as the supply company have to keep men at the destructor, and also men and machinery in their sub-station, that they could not utilize this heat by putting down steam engines alongside the destructor, as provided in our original plans, thus saving the coal required for 500 horse-power.

Warrington Municipal Corporation—Population, 64,242. Two Installations.

	1.	2. E. W.
A . .	1896.	1901.
B . .	Meldrum's Beaman & Deas top fed.	Meldrum's Beaman & Deas top fed.
C . .	4.	4.

D . .	2 Babcock & Wilcox.	2 Babcock & Wilcox.
E . .	120 feet.	—
F . .	Fan.	Fan.
G . .	Sanitary manure works.	Electric lighting.
H . .	30 tons.	34 tons.
I . .	1*s.* 1½*d.*	1*s.* 2*d.*
J . .	—	80.

Installation No. 1 was the first of its type in this country; at Installation No. 2 the works cost per unit generated in mid-winter when the refuse is of the highest calorific value is given as ·825*d.* per unit. This figure includes salaries and all incidental charges, but is exclusive of interest and sinking fund.

Four coal fired supplementary boilers of the Babcock and Wilcox type are provided, and the power equipment of the station is as follows: 4 Willans' engines, total H.P. 1760, direct coupled to 3 Bruce-Peebles' four-pole dynamos, and 1 E.E.M. Company's dynamo, total capacity 1,100 k.w. 262 Chloride cells are also installed, the capacity of the same being 800 ampère hours.

S. W.

WATFORD URBAN DISTRICT COUNCIL—POPULATION, 29,023.

A	1903.
B	Meldrum's front hand fed.
C	4 grates.
D	1 Lancashire, 30 ft. × 8 ft.
E	170 feet (Custodi's type).
F	Steam jet blowers.
G	Sewage pumping.
H	40 tons.
I[1]	—

E. W.

WELLINGBOROUGH URBAN DISTRICT COUNCIL—POPULATION, 18,142.

A	1900.
B	Mason's top fed.
C	1.
D	1 Stirling water tube.
E	100 feet.

[1] These works are not yet in operation.

F	Steam jet blowers.
G	Forced draught and electric lighting.
H	12 tons.

S. W.

WEST BRIDGFORD URBAN DISTRICT COUNCIL—POPULATION, 7,018.

A	1903.
B	Warner's top fed.
C	2.
D	1 Multitubular.
E	160 feet.
F	Fan.
G	Sewage pumping.
H	7 tons.

E. W.

WEST HARTLEPOOL MUNICIPAL CORPORATION—POPULATION, 62,627.

TWO INSTALLATIONS.

	1.	2.
A . . .	1901.	1903.[1]
B . . .	Horsfall's top fed.	Horsfall's top fed.
C . . .	6.	6.
D . . .	2 Babcock & Wilcox.	1 Babcock & Wilcox, marine type.
E . . .	—	—
F . . .	Steam jet blowers.	Steam jet blowers.
G . . .	Electric lighting and works purposes.	
H . . .	60 tons.	
I . . .	[2] $10\frac{1}{2}d.$	

About 80 H.P. is supplied to the electricity works from Installation No. 1, power being also used for operating a clinker crusher and mortar mill ; the mortar sells freely at 7*s.* 6*d.* per ton.

The capital cost of this plant was £7,646, exclusive of the cost of the site, but including the sum of £1,000 as part cost of the chimney, which is also used for the supplementary coal fired boilers.

[1] Now in course of erection.

[2] This figure applies to a test.

Three Lancashire boilers are provided for coal firing, and the power equipment of the station comprises the following: 6 Bellis compound high speed engines, direct coupled to 7 Crompton two-pole shunt wound dynamos, total capacity 500 k.w., and a storage battery of 260 Tudor cells, capacity 300 ampère hours.

Some details of an evaporative test in connection with the destructor are here given—

Date of test	January 17 to 18, 1902.
Duration of test (started from cold)	24 hours = 1 day.
Number and type of cells	6 cells, back to back, top fed.
Total grate surface	180 square feet.
System of forced draught	Horsfall Co.'s patent steam blowers.
Nature of refuse	Ashpit, house, and market.
Number and type of boilers	2 water tube.
Total quantity of refuse burned	55 tons 3 cwt. 1 qr. 0 lb.
Total quantity of refuse burned per cell per 24 hours	9 tons 3 cwt. 3 qr. 16 lb.
Total quantity of refuse burned per sq. ft. of grate per hour	28·6 lb.
Tons per man per shift	6 tons 2 cwt. 2 qr. 9 lb.
Total water evaporated	56 tons 15 cwt. 0 qr. 15 lb.
,, ,, ,, per hour	2 tons 7 cwt. 1 qr. 5 lb.
,, ,, ,, per sq. ft. of heating surface per hour	3·04 lb.
Total water evaporated per lb. of refuse from and at 212° F. or 100° C.	1·25 lb.
Mean steam pressure	166·4 lb.
,, feed temperature	50° F.
,, main flue temperature	2,190° F.
,, temperature behind boilers	400° F.

S. W.

WEYMOUTH MUNICIPAL CORPORATION—POPULATION, 19,831.

A	1903.[1]
B	Meldrum's front hand fed.
C	4 grates.
D	2 Cornish, 1 20 ft. × 5 ft. 6 in., 1 20 ft. × 6 ft. 6 in.

[1] Now in course of erection.

E	60 feet.
F	Steam jet blowers.
G	Sewage pumping.
H	16 tons.

Fig. 89 will serve to show the unique position of this destructor, which is being erected on the water side of the sewage works. One of the large open collection tanks will be covered by the boilers, and the air supply for combustion will be taken from the

FIG. 89. WEYMOUTH COMBINED DESTRUCTOR AND SEWAGE WORKS.
External View.

open tank through the covered tank and direct to the regenerator. This constant exhaust will have the effect of removing all foul gases.

The site is a very central one, and its advantage in reducing the cartage cost will be clearly seen by referring to the following tabulated statement, prepared by the Borough Surveyor, Mr. W. Barlow Morgan, for presentation to the Local Government Board at the inquiry.

Borough of Weymouth and Melcombe Regis Destructor.

Estimated annual cost and repayment of loans—

	£	s.	d.
Brickwork in destructor	1,750	0	0
Buildings	1,290	0	0
Road	160	0	0
	3,200	0	0
Loan for 20 years—			
Machinery and ironwork	1,400	0	0
	3,200	0	0
	4,600	0	0
Annual cost—			
£4,600 at 3 per cent.	138	0	0
Sinking fund $2\frac{1}{2}$ per cent—			
£3,200 at 30 years	72	12	9
£1,400 at 20 years	54	14	9
	265	7	6
Estimated annual saving to the rates—			
To present cost of coal used at pumping station	476	0	0
Estimated saving of 2 horses and 2 men per day. Collecting refuse (7*s.* 6*d.* per diem)	234	0	0
	710	0	0
To the value of 1,250 tons of clinker at 2*s.* 6*d.*	156	5	0
	866	5	0

Deductions—

	£	s.	d.	£	s.	d.
To interest and sinking fund	£265	7	6			
Increase in working staff (2 stokers at 24*s.* each per week)	124	16	0			
				390	3	6
				476	1	6

Nett assessable value . £99,650

Rateable value . . 92,000

1*d.* in the £ produces £356. £476 ÷ 1·33, say $1\frac{1}{4}$ in the £.

S. W.

WIMBLEDON URBAN DISTRICT COUNCIL—POPULATION, 45,000.

A	1900.
B	Meldrum's Beaman & Deas top fed.
C	4.
D	2 Babcock & Wilcox.
E	150 feet.
F	Fan.
G	Sewage Pumping.
H	54 tons.[1]
I	1*s.* 8*d.*

J Average number of electrical units generated per ton of refuse destroyed, 45.

FIG. 90. WIMBLEDON COMBINED DESTRUCTOR AND SEWAGE WORKS.
View of Cells in Course of Erection.

Five supplementary coal fired boilers of the Babcock and Wilcox type are also installed, the power equipment of the station being as follows: 5 Willans' engines, total H.P. 1800, 5 Crompton alternators, total capacity 1060 k.w.

[1] Two-thirds of refuse and one-third of sludge.

Fig. 90 shows this installation in course of erection. It is probably the only combined works yet erected where sewage sludge is destroyed with refuse, and the power production, as will be observed, is eminently satisfactory. It is worthy of note that for the year ending March 31, 1902, a net profit of £1,358 was realized.[1]

WINCHESTER MUNICIPAL CORPORATION—POPULATION, 20,919.
TWO INSTALLATIONS.

	1.	2.
A	1884.	1891.
B	Fryer's top fed.	Warner's top fed.
C	1.	2.
D	[2]	[2]
E	80 feet.	
F	Meldrum's steam jet blowers.[3]	
G	[2]	[2]
H	19 tons.	
I	10*d.*	

S. W.
WITHINGTON URBAN DISTRICT COUNCIL—POPULATION, 36,032.

A	1902.
B	Meldrum's front hand fed.
C	4 grates.
D	2 Lancashire.
E	—
F	Steam jet blowers.
G	Sewage pumping.
H	36 tons.
I	8*d.*

This is an excellent example of a modern combined works. The sewage is lifted by 1·19″, 1·15″ and 2·10″ Tangye centrifugal pumps. The two larger pumps are driven by compound engines of 68 and 35 H.P. respectively, while single 16 H.P. engines are provided for operating the two small pumps.

[1] Within the past year the Destructor has been combined with the Sewage Works on the same site.

[2] The gases are passed through a Green's economiser, and it is estimated that this effects a saving of £4 per week in the fuel bill at the sewage works.

[3] Added in 1897.

Twin air compressors of the high pressure double tandem type are installed; also Johnson's sludge pressing plant, having 42 chambers, and capable of pressing 8 tons of sludge at each charge.

E. W.

Wolverhampton Municipal Corporation—Population, 94,187.

A	1903.[1]
B	Fryer's improved top fed, including Boulnois, Wood & Brodie's patents.
C	8.
D	4 Babcock & Wilcox.
E	—
F	Fan.
G	Works purposes and electric lighting.
H	—
I	—[1]

S. W.

Worthing Municipal Corporation—Population, 22,617.

The Council have recently decided to erect a destructor of the "Heenan" type in combination with the sewage works. The estimated cost of the destructor, exclusive of excavation, foundations, buildings and chimney is £2,880. This is an interesting modern departure, the sewage being lifted at present by means of gas engines and three-throw pumps, and while the latter will be retained they will be steam driven, the steam being provided from the refuse.

E. W.

Wrexham Municipal Corporation—Population, 14,966.

A	1900.
B	Meldrum's front hand fed.
C	4 grates.
D	1 Lancashire, 30 ft. × 8 ft.
E	120 feet.
F	Steam jet blowers.
G	Electric lighting and traction.
H	35 tons.
I	—
J	38.

[1] Now in course of erection.

Two supplementary coal fired boilers of the Babcock and Wilcox type are installed, and the power equipment of the station is as follows: 3 Willans' engines, total H.P. 750, direct coupled to 3 Lancashire dynamos, total capacity 375 k.w., also 270 Chloride cells of 300 ampère hours capacity.

The log for two consecutive months' running is here given and is specially interesting, more particularly that of the second month, January, 1902, when no coal whatever was used even on Sundays.

Date.	Maximum Load in K.w.	Units Generated	Hours of Running Hrs. Mins.
Dec. 1, 1901 . .	Sunday.	Sunday.	Sunday.
,, 2 ,, . .	118·8	557	6 25
,, 3 ,, . .	114	658	6 30
,, 4 ,, . .	123·5	712	6 25
,, 5 ,, . .	121	646	6 40
,, 6 ,, . .	80·8	557	6 25
,, 7 ,, . .	133	803	7 25
,, 8 ,, . .	Sunday.	Sunday.	Sunday.
,, 9 ,, . .	133	622	6 30
,, 10 ,, . .	116·4	618	6 30
,, 11 ,, . .	123·5	931	9 35
,, 12 ,, . .	125·9	710	7 5
,, 13 ,, . .	90·3	489	7 5
,, 14 ,, . .	134·4	769	7 55
,, 15 ,, . .	Sunday.	Sunday.	Sunday.
,, 16 ,, . .	117·6	737	7 30
,, 17 ,, . .	118·8	600	6 40
,, 18 ,, . .	123·5	936	14 35
,, 19 ,, . .	135·4	966	10 30
,, 20 ,, . .	86·7	400	6 46
,, 21 ,, . .	148·8	756	7 30
,, 22 ,, . .	85·5 (Sunday)	279	3 25
,, 23 ,, . .	128·3	800	8 10
,, 24 ,, . .	137·8	816	7 30
,, 25 ,, . .	Christmas Day.	—	—
,, 26 ,, . .	No collection of refuse.	—	—
,, 27 ,, . .	No collection of refuse.	—	—
,, 28 ,, . .	134·4	748	8 0
,, 29 ,, . .	80·8 (Sunday)	248	3 40
,, 30 ,, . .	125·9	585	6 30
,, 31 ,, . .	112·8	818	9 10

January, 1902.	Max Load in K.w.	Units Generated.
Jan. 1, 1902	114	603
,, 2 ,,	118·75	557
,, 3 ,,	76	626
,, 4 ,,	134·4	816
,, 5 ,,	76	264
,, 6 ,,	116·375	671
,, 7 ,,	97·375	773
,, 8 ,,	114	613
,, 9 ,,	123·5	592
,, 10 ,,	85·5	471
,, 11 ,,	129·6	762
,, 12 ,,	76	274
,, 13 ,,	116·375	560
,, 14 ,,	111·625	534
,, 15 ,,	109·25	517
,, 16 ,,	121·125	621
,, 17 ,,	80·75	511
,, 18 ,,	134·4	814
,, 19 ,,	76	245
,, 20 ,,	114	638
,, 21 ,,	121·125	507
,, 22 ,,	121·125	513
,, 23 ,,	123·5	673
,, 24 ,,	85·5	369
,, 25 ,,	134·4	810
,, 26 ,,	83·125	256
,, 27 ,,	123·5	526
,, 28 ,,	125·875	542
,, 29 ,,	121·125	447
,, 30 ,,	118·75	481
,, 31 ,,	85·5	349
Feb. 1 ,,	140·125	708

Fig. 91 illustrates a steam pressure curve over an ordinary day's run, and fully bears out Mr. Sillery's contention that "the steam pressure is constant and easily controlled."

It is worthy of note that this destructor was in constant use for the whole year ending June 5, 1903, without being idle even for one day for cleaning or repairs, and that for the first three years of operation, which ended at the date already mentioned, not one penny had been spent upon repairs.

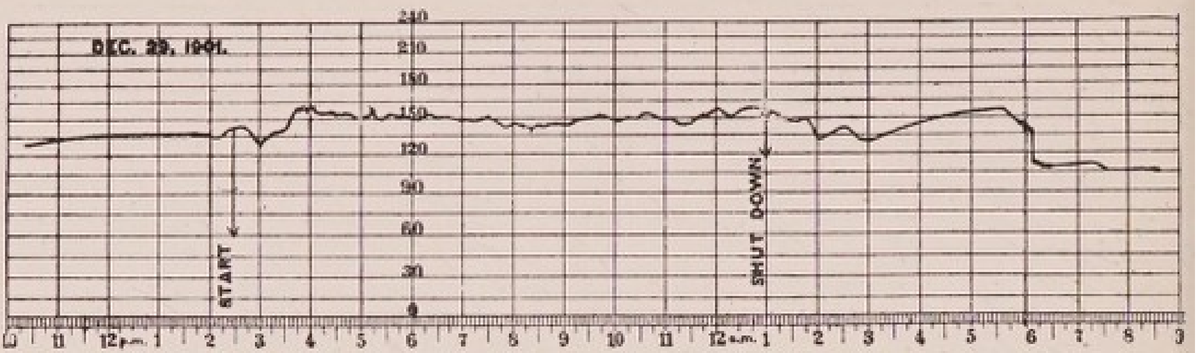


FIG. 91. WREXHAM COMBINED DESTRUCTOR AND ELECTRICITY WORKS.
Steam Pressure Diagram.

With the improved load factor during the past few months, the fuel cost per unit sold has been reduced to ·58*d*.

YORK MUNICIPAL CORPORATION—POPULATION, 77,914.

TWO INSTALLATIONS.

	1.	2.
A . . .	1895.	1898.
B . . .	Warner's top fed.	Fryer's improved top fed.
C . . .	6.	4.
D . . .	1 Multitubular.	2 Babcock & Wilcox.
E . . .	—	—
F . . .	Fan.	Fan.
G . . .	Works purposes only.	
H . . .	—	—
I . . .	—	—

Chapter XVIII

REFUSE DESTRUCTORS IN SCOTLAND AND IRELAND

Ayr Municipal Corporation—Population, 28,697.

E. W.

A	1903.[1]
B	Meldrum's front hand fed.
C	6 grates.
D	1 Babcock & Wilcox.
E	120 feet, Custodi's type.
F	Steam jet blowers.
G	Electric lighting.
H	30 tons.
I	—

The electricity works have been in operation for several years past, and the following coal fired boilers are installed: 4 of the Lancashire type, 2 Stirling water tube, and 1 Babcock and Wilcox.

The power equipment of the station is as follows: 8 Bellis, and 2 Marshall compound engines, 7 Siemens fly wheel alternators of 625 k.w. total output, 2 Bruce-Peebles' traction generators, 200 k.w. each, and 1 Siemens traction generator, 220 k.w.; a storage battery of E.P.S. cells is also provided.

Edinburgh Municipal Corporation—Population, 316,793.

A	1897.
B	Horsfall's top fed.
C	10 cells.
D	1 Multitubular, 14 ft. × 7 ft.
E	185 feet.
F	Steam jet blowers.
G	Forced draught.
H	60 tons.
I	*2s. 5½d.*

[1] Works now in course of erection.

Glasgow Municipal Corporation—Population, 781,000.

[1] Six Installations.

	No. 1 Crawford Street.	No. 2 St. Rollox.	No. 3 Kelvinhaugh.	No. 4 Haghill.	No. 5 Dalmarnock.	No. 6 Ruchill.
A	—	—	—	1898.	1901, 1903.	1902.
B	Own design.	Own design.	Own design.	Horsfall's top fed.	Meldrum's improved top fed.	Fryer's improved top fed.
C	11 cells.	10 cells.	9 cells.	5 cells.	16 grates.	8 cells.
D	—	—	—	1 Babcock & Wilcox.	3 Lancashire.	2 Lancashire. 30×8
E	250 feet.	250 feet.	300 feet.	250 feet.	250 feet.	200 feet.
F	—	—	—	Steam jet blowers	Steam jet blowers.	Fans.
G	—	—	—	Forced draught & works purposes.	Forced draught, works lighting, etc.	Forced draught & works purposes.
H	—	—	—	—	—	80 tons.

[1] A further installation is contemplated.

Some of the cells in Glasgow have been in use for over twenty years; the total weight of refuse destroyed daily varies considerably, as at some of the works only sorted refuse is destroyed, immense quantities being used for manurial purposes.

At the Dalmarnock works the clinker sells freely at 2*s.* 6*d.* per ton at the works, and is thus productive of a good revenue. It is stated that upwards of 20 tons of paper is collected every week, and at the present time one firm takes the whole of this material, paying the sum of £1,560 per annum for the same.

GOUROCK MUNICIPAL CORPORATION—POPULATION, 5,261.

A	1901.
B	Warner's top fed.
C	2.
D	1 Multitubular.
E	—
F	Fan.
G	Fan engine only.
H	5 tons.
I	10*d.*

GOVAN MUNICIPAL CORPORATION—POPULATION, 82,174.

A	1892, 1894 and 1900.
B	Warner's top fed.
C	16.
D	1 Multitubular.
E	120 feet.
F	Fan.
G	Fan engine and works purposes.
H	80 tons.
I	1*s.*

PAISLEY MUNICIPAL CORPORATION—POPULATION, 79,363.

A	1900.
B	Horsfall's top fed.
C	8.
D	1 Babcock & Wilcox.
E	180 feet.
F	Steam jet blowers.
G	Clinker crusher, mortar mills and forced draught.
H	62 tons.
I	9½*d.*

The total cost of this installation was £13,000; during the first eight months' working the sum of £236 5*s*. was realized from the sale of crushed clinker and mortar.

PARTICK MUNICIPAL CORPORATION—POPULATION, 54,298.

A	1902.
B	Fryer's improved top fed.
C	6.
D	3 Babcock & Wilcox.
E	153 feet.
F	Fans and steam jet blowers.
G	Electric lighting.
H	42 tons.
I	1*s*. 7⅛*d*.

The three Babcock and Wilcox boilers set between the destructor cells are arranged for supplementary coal firing as may be necessary, while one additional boiler of the same type is also provided for firing with coal alone.

The generating plant installed is as follows: 2 150 k.w. sets, 2 75 k.w. Bellis, Bruce-Peebles sets, and a Tudor storage battery of 184 cells.

The following figures for three months' working ending March 26, 1903, are of interest—

	£	*s*.	*d*.		*s*.	*d*.
Tons of refuse delivered						3,874
Expenditure—					Per ton.	
	£	*s*.	*d*.		*s*.	*d*.
Wages	308	13	8	=	1	7⅛
Interest and sinking fund	213	19	3	=	1	1¼
Stores	3	11	3	=	0	0¼
Total expenditure	£526	4	2	=	2	8⅝
Revenue—					Per ton.	
Steam sold to Electricity Department, being 104,816 units at ⅜*d*. per unit . . .	163	15	5	=	0	10
Clinker sold	7	13	2	=	0	0⅝
Balance, being cost to burgh of destroying refuse	354	15	7	=	1	10
Total revenue	526	4	2	=	2	8⅝

Average nearly 27 units generated per ton of refuse destroyed.

Port Glasgow Municipal Corporation—Population, 16,857.

A	1903.[1]
B	Meldrum's front hand fed.
C	4 grates.
D	1 Lancashire, 26 ft. × 7 ft. 6 in.
E	120 feet.
F	Steam jet blowers.
G	Not yet determined.
H	25 tons.
I	—

Belfast Municipal Corporation—Population, 348,965.

A	1901.
B	Warner's top fed.
C	12.
D	2 Multitubular.
E	150 feet.
F	Fans.
G	Fan engine only.
H	100 tons.
I	9*d.*

Dublin Municipal Corporation—Population, 265,000.

A	1894.
B	Fryer's top fed.
C	4.
D	1 Multitubular.
E	160 feet.
F	—
G	Mortar mill (12 H.P.)
H	26 tons.
I	9·9*d.*

The bulk of the refuse is taken out to sea and dumped. This system of disposal has long been recognized as unsatisfactory in the extreme, but owing to the enormous sums expended upon electric lighting and traction, there is a very evident reluctance upon the part of the authorities to embark upon any scheme of sanitary improvement in so far as refuse disposal is concerned.

[1] Works now in course of erection.

E. W.

PEMBROKE URBAN DISTRICT COUNCIL (DUBLIN)—
POPULATION, 25,524.

A	1900.
B	Horsfall's back hand fed.
C	4.
D	2 Babcock & Wilcox.
E	120 feet.
F	Steam jet blowers.
G	Electric lighting.
H	12 tons.
I	11¾*d.*[1]

Three supplementary coal fired boilers are installed, these being of the Lancashire type each 30′ × 7′, also a Green's economiser.

The power equipment of the station is as follows: 2 250 H.P. three-crank Easton, Anderson and Goolden engines, direct coupled to 4 75 k.w. Fynn dynamos, total capacity 300 k.w.; also 280 Chloride cells, capacity 800 ampère hours.

Details of an evaporative test in connection with the destructor are here given—

Date of test	June 1 and 2, 1900.
Duration of test	24 hours = 1 day.
Number and type of cells . .	Two cells single row Horsfall, back hand fed.
Total grate surface . . .	60 square feet.
System of forced draught . .	Horsfall Co.'s patent steam blowers.
Nature of refuse	Unscreened house, ashpit and garden.
Number and type of boilers . .	1 water tube.
Total quantity of refuse burned .	18 tons 0 cwt. 1 qr. 21 lb.
,, ,, ,, ,, per cell per 24 hours . . .	9 tons 0 cwt. 0 qr. 24 lb.
Total quantity of refuse burned per sq. ft. of grate per hour . .	28 lb.
Cost of labour per ton burned. .	11¾*d.*
Total water evaporated . . .	18 tons 0 cwt. 1 qr. 12 lb.
,, ,, ,, per hour .	15 cwt. 0 qr. 2 lb.
,, ,, ,, per sq. ft. of heating surface per hour .	2·3 lb.

[1] This figure applies to a test of 24 hours' duration.

Total water evaporated per lb. of refuse from and at 212°F. or 100C.	1·21 lb.
Percentage of clinker and ash to refuse burned . . .	34·4 per cent.
Mean steam pressure	120 lb.
,, feed temperature . . .	57° F.
,, main flue temperature . . .	1,800° F. to 2,000° F.
,, temperature behind boilers . .	600° F.

Two tables of evaporative tests in connection with destructors are here given, compiled by Mr. Frank Broadbent, M.I.E.E., of London, and Mr. J. A. Priestley, A. S.I., of Nelson, respectively.

In both cases the details given are sufficiently complete to make the figures of value for purposes of comparison. In many instances it will be found that the complete figures of the tests have been previously given, as also such particulars of the installations as the reader may find of interest in making more critical comparison.

EFFICIENCY TESTS OF DESTRUCTORS.

Compiled by Mr. Frank Broadbent, M.I.E.E.

Locality, and nature of refuse. (1)	Duration of tests. (2)	Type of boiler and grate area. (3)	Weight of refuse per sq. ft. of grate, per hour (average) (4)	Temperature in main flue or combustion chamber. (5)	Temperature of waste gases. (6)	Lbs. of water per lb. of refuse, from and at 212° F. (7)	Per cent. of CO_2 in waste gases (average). (8)
Accrington, ordinary town's refuse.	22 hours.	Lancashire, 180 sq. ft.	29·7 lb.	2,000° F.	500° F.	1·3 9lb. (E)	—
Ashton-under-Lyne, ordinary town's refuse.	24 hours (hot start)	Multitubular, 180 sq. ft.	31 lb., air pressure 1·25"	1,365° F. (max.) 1,241° F. (av.)	337° F.	0·783 lb. (E)	—
Bradford, unscreened midden and market refuse.	141 hours, ordinary working conditions.	Multitubular, 180 sq. ft.	28·5 lb., air pressure 0·6"	1,800° F.	900° F.	0·865 lb.	—
Do. do.	278 hours	Do.	34 lb.	Do.	Do.	0·882 lb.	—
Bury	4 hours.	Lancashire.	—	1,350° F.	—	0·65 lb. (E). (approx.)	—
Canterbury, town's refuse, dry	8·3 hours.	Water tube, 50 sq. ft.	77·7 lb., air pressure 3·625"	2,174° F. maximum	550° F.	1·51 lb. (E)	—
Do. do.	200 hours, ordinary working conditions.	Do.	57·5 lb.	Do.	Do.	0·986 lb. (E).	—
Colne, ashpit refuse . .	9·5 hours.	Water tube, 50 sq. ft.	50 lb.	Over 2,000° F. (maximum).	—	1·15 lb. (E)	—
Darwen, unscreened ashpit and slaughterhouse refuse.	48 hours.	Lancashire, 104·5 sq. ft.	28·5 lb.	Over 2,000° F. max.) 1,633° F. average).	585° F.	1·55 lb. (E).	—
Do. do.	8 hours.	do.	52·5 lb.	2,000° F.	—	1·71 lb. (E)	14·13 %
Farnworth, town's refuse (averaged) 24 per cent. moisture .	3½ hours.	Lancashire, 40 sq. ft.	42 lb.	Over 2,000° F. (maximum).	—	1·32 lb. (E)	—
Do. 26½ per cent. moisture	5½ hours.	Do.	37·5 lb.	Do.	—	1·35 lb. (E)	—
Do. (dry) 10 per cent. moisture	4¾ hours.	Do.	29·5 lb.	Do.	—	1·76 lb. (E)	—
Fleetwood, unscreened ashpit refuse (very wet).	8 hours.	Water tube, 50 sq. ft.	80·5 lb. air pressure 2¼".	Over 2,000° F. (maximum).	356° F.	1·191 lb. (E)	—
Grays Thurrock, unsorted ashbin refuse.	7 hours, starting warm	Lancashire, 50 sq. ft.	76·25 lb.	Over 2,000° F. (maximum).	Feed water from economiser 299° F.	1·22 lb. (E)	—
Hereford, unscreened ashpit refuse	10 hours.	Galloway, 90 sq. ft.	54·75 lb., air pressure 1·82".	Over 2,000° F. (maximum).	715° F.	1·82 lb. (E).	16·27 %
Huddersfield, 1 part sewage sludge 2 parts town's refuse.	24 hours.	60 sq. ft.	49 lb.	—	—	1·4 lb.	—
Lancaster	12 hours.	Lancashire, 100 sq. ft.	62 lb.	Over 2,000° F. (maximum).	520° F.	1·63 lb. (E).	15·5 %

Leyton, ⅔rds house refuse, ⅓rd sewage sludge (64·86 per cent. moisture).	12 hours.	Water tube, 100 sq. ft.	62·5 lb. air pressure, 2″.	Over 2,000° F. (maximum).	—	0·507 lb.	—
Llandudno, ordinary town's refuse.	Average working conditions.	Water tube, 100 sq. ft.	71·7 lb.	Do.	—	0·86 lb. (E).	—
Nelson, ashpit and slaughter house refuse.	8 hours.	Lancashire, 100 sq. ft.	68·5 lb., air pressure 2¾″.	2,693 F°. (max.) 1,306° F. (av.)	770° F. (max.) 666° F. (av.)	2·35 (max) (E). 1·96 (av.) (E).	19·8% (max.) 14·4% (av.)
Do.	473¼ hours, working continuously except week-ends.	Do.	29 lb., air pressure, 1·5″.	2,642° F. (maximum). 1,959° F. (average).	530° F. (maximum). 480° F. (average).	1·96 lb. (maximum). 1·85 lb. (average).	15·6% (maximum). 13·16% (average).
Oldham, unscreened ashpit refuse.	24	Lancashire 300 sq. ft.	24·76 lb. air pressure, 1·125″.	—	555° F.	1·06 lb. (E).	—
Rochdale, unscreened ashpit refuse.	6 hours, working conditions.	Lancashire, 90 sq. ft.	47·3 lb.	1,988° F. (maximum). 1,290° F. (minimum).	—	1·97 lb.	15·9%
St. Helens, unscreened ashpit refuse.	7·3 hours.	Water tube, 50 sq. ft.	103 lb., air pressure, 3·1″.	Over 2,000° F. (maximum).	358° F.	1·54 lb. (E).	10·4%
* Salford, unscreened refuse burned on the ordinary boiler grate.	14 hours.	Lancashire.	24·76 lb., air pressure, 1·125″.	—	—	2·28 lb.	Refuse very imperfectiy cremated.
Salisbury, unscreened ashpit refuse.	19 hours.	Water tube, 66 sq. ft.	39·2 lb.	1,760° F.	1,380° F.	1·18 lb.	—
Shoreditch, ashbin refuse .	5 hours.	Water tube.	60 lb.	—	—	0·96 lb.	—
Torquay, unscreened ashpit refuse.	3 hours (hot start).	Multitubular.	—	—	—	0·71 lb.	—
Torquay, summer—very light refuse.	3 hours.	Do.	—	—	—	0·33 lb.	—
Warrington, unscreened house refuse.	24 hours.	Water-tube, 100 sq. ft.	44·6 lb., air pressure 2·5″	Over 2,000° F. (maximum)	650° F.	1·3 lb. (E).	—
Do. (1½ refuse and 1 sludge).	5·75 hours	Do.	87 lb.	—	—	1·51 lb. (E).	—
West Hartlepool . . .	24 hours	Water-tube, 180 sq. ft.	28·6 lb.	2·190° F.	400° F.	1·25 lb.	—
Wimbledon, unscreened ashpit refuse—poor quality.	8·25 hours	Water-tube, 50 sq. ft.	77 lb. air pressure 2·5″.	—	—	1·006 lb.	—
Do. do. 2 parts refuse and 1 sewage sludge.	7 hours	Do.	82·5 lb. air pressure 2·5″.	—	—	0·639 lb.	—
† Rochdale, boiler slack, having a calorific value of about 12,500 B.T.U.	7·5 hours	Lancashire, 45 sq. ft.	32·2 lb.	—	—	7·33 lb.	—

(E) means that an economiser was used. * Not a real "destructor" test.

† A basis for comparison, the fuel being slack coal, not refuse.

DETAILS OF EVAPORATIVE TESTS IN CONNECTION WITH DESTRUCTORS.

Compiled by J. A. Priestley, A.S.I., Health Superintendent, Nelson.

Town.	Make of Furnace	Tests made by	Duration of Test.	Quality of Refuse.	Total Weight of Refuse burned.	Weight burned per hour.	Weight burn'd per sq. ft. grate area per hour.	Total Weight of Water Evaporated.	Water Evaporated per Hour.	Refuse, Actual Water Evaporated per 1 lb.	Same from and at 212° F.	Average Steam Pressure.	Temperature of Feed Water	Remarks.
			Hours.		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	°F.	
Rochdale . .	Meldrum	Mr. Brookman	6	Unscreened	25,536	4,256	47·3	42,072	7,012	1·64	1·97	113	53	2 boilers to 1 furnace
" . .	"	"	6¼	"	30,800	4,738	52·6	42,900	6,600	1·39	1·68	113	52	
" . .	"	"	6½	"	32,142	4,945	54·9	47,400	7,290	1·47	1·78	113	52	
Hereford . .	"	Mr. J. Parker	10	"	19,768	1,976	54·8	26,254	2,625	1·32	1·60	70	48	
" . .	"	"	10¼	"	19,012	1,855	51·5	25,570	2,494	1·34	1·62	70·2	48	
" . .	"	"	10	"	19,712	1,971	54·7	29,800	2,980	1·51	1·82	70·92	48	
Darwen . .	"	Mr. W. S. Saville	24	"	105,840	4,410	49	147,105	6,129	1·39	1·71	195	40	
" . .	"	"	48	"	143,091	2,981	33	211,774	4,412	1·48	1·55	183	185	
Nelson . .	"	Mr. J. A. Priestley	9½	"	54,180	5,703	57	68,580	7,220	1·26	1·51	118	63·4	
" . .	"	"	473½	"	1,374,304	2,902	29	2,125,980	4,490	1·54	1·85	120	59·8	
" . .	"	"	8	"	54,824	6,853	68·5	91,600	11,450	1·67	1·96	120	83	
Oldham . .	Horsfall	Lord Kelvin	24	"	71,320	2,972	29	78,900	3,287	1·16	1·39	128	57	
" . .	"	"	24	"	106,980	4,457	29	78,100	3,254	·73	·87	128	57	Hypothetical.
Bradford . .	"	Mr. Cox	141	"	721,280	5,115	34	523,000	3,709	·725	·87	60	50	
" . .	"	Mr. McTaggart	278	"	2,896,320	10,416	34	2,153,000	7,744	·743	·882	60	60	
Huddersfield .	"	Mr. Campbell	24	Two refuse, One sludge	70,560	2,940	58·8	83,040	3,460	1·17	—	69	cold	
Ashton-u.-Lyne	"		24	Unscreened	134,050	5,585	37	97,851	4,077	·729	·783	122·6	179·8	
Shoreditch . .	Manlove		5	"	75,092	15,018	60	72,225	14,445	·96	·96	—	212	
Torquay . .	Warners		3	"	5,076	1,692	—	3,000	1,000	·59	·70	81·2	56	2 boilers to 4 cells
Farnworth .	Heenan & Froude		4¼	Dry sample	5,040	1,186	29·5	7,500	1,785	1·48	1·76	120	60	
" . .	"		3½	Unscreened	5,880	1,680	42	6,500	1,857	1·10	1·32	120	58	
Loughborough	Coltman	Loughborough Engineer	10	"	14,653	1,465	52	30,590	3,059	2·02	2·46	65	36	Boiler over furnace
Moss Side .	Masons		24	"	13,552	565	35·25	—	—	—	—	—	—	
Warrington .	Beaman & Deas	Mr. F. F. Bennett	6	Radcliffe refuse	21,700	3,617	72	22,000	3,666	1·01	1·12	45	141·5	
" .	"	Huddersfield Engineer	5¾	One & half refuse, One sludge	25,088	4,363	87	32,000	5,565	1·27	1·51	—	65	
" .	"	Mr. G. Darley	24	Unscreened	53,544	2,231	44·6	61,344	2,556	1·14	1·31	68	104	
" .	"	Warrington Corporation	5½	"	18,509	3,173	63·4	27,791	4,766	1·5	1·68	53	135	
Leyton . .	"	Sir Douglas Fox		Two refuse, One sludge	74,956	6,246	62·4	31,920	2,660	·426	·50	105	65	
St. Helens .	"		7¼	Unscreened	37,912	5,169	103	48,216	6,575	1·27	1·54	132	46	
Canterbury	"	Mr. Hammond	8¾	"	29,400	3,360	67	41,280	4,717	1·40	1·59	132	125	
Fleetwood .	"	Medhurst & Lloyd	8	"	32,220	4,027	80·5	31,952	3,994	·99	1·19	135	59	Economiser in use.
Wimbledon .	"		8¼	"	31,794	3,853	77	27,287	3,307	·85	1·00	120	88	

Chapter XIX

REFUSE DESTRUCTORS ABROAD.

AMERICA.

AFTER perusing the recently expressed opinion of some American experts in the opening chapter, the reader will not expect to find any remarkable record of American practice in these pages.

Many American destructors or crematories might be described as also some few systems of reduction, but no good purpose would be served by so doing. So many destructors or crematories have failed in America, while so many now in use are admittedly unsatisfactory, that on the whole a description of past and present systems would possess but little if any educational value. The opinions of American experts already quoted very clearly explain the causes of failure in many cases, and of only partial success in others.

Concerning systems of reduction, it may be fairly submitted that their record is on the whole quite as unsatisfacfory as that of crematories. Although reduction still has many advocates, there is every reason to think that it will become increasingly unpopular, and at no distant date it is likely to be entirely abandoned. Reduction as a system possesses several highly unsatisfactory features. *Firstly*, only a small proportion of the total waste is dealt with. *Secondly*, it is a process inseparable from nuisance, and nuisance of such a character as has never been known in connection with even our earliest destructors. *Thirdly*, it involves the erection of a very costly plant. *Fourthly*, the cost of operation is very high. And *Lastly*, it should not be forgotten that the erection and operation of such plants have always been undertaken purely and simply as commercial ventures and not as sanitary necessities.

To no slight extent has the last named factor also exercised a pernicious effect upon systems of destruction by fire. The commercial element has always been too prominent. In this country, we frequently hear of the commercial element also, but only in so far as a municipality is anxious if possible to make a sanitary system pay its way.

There is clearly no comparison between this very laudable desire and that of the American contractor who contracts with a municipality to dispose of its refuse for a number of years on such terms as will at any rate ensure a profitable transaction for himself. The whole business partakes of a commercial and speculative nature which is unsatisfactory in the extreme.

Whatever may be said for or against company and municipality in questions of lighting or traction, it is clearly the duty of municipalities to deal with sanitary problems themselves. The contract system is unsatisfactory, and open to very serious abuse. It is safe to say that if sanitary problems were faced as they have been in this country, American practice would not only be interesting, but highly instructive.

Having dealt with the general design and construction of most of the American crematories[1] in a previous work, and as many of the various types therein described are no longer used, it would serve no useful purpose to again describe a number of crematories which are for the most part weak in design, and which have a very unsuccessful record.

To the British engineer it will doubtless be a source of satisfaction to know that in this particular branch of engineering we have nothing to learn from American design or practice.

Likewise the British sanitarian must observe with pleasure the premier position of his own country, viewing with amazement the utter disregard of elementary principles of sanitary science shown by our kinsmen across the Atlantic.

[1] See "*Refuse Disposal in America*, chapter xviii. *The Economic Disposal of Towns' Refuse.* By W. Francis Goodrich.

It is most difficult even if not impossible to compile anything like an accurate record concerning refuse disposal in American cities. Seeing that for the most part both crematories and reduction works are operated by companies under contract and not by municipalities, reliable data cannot be obtained.

The following report prepared by an expert, while being comprehensive and interesting, only serves to emphasize the very unsatisfactory condition of refuse disposal in America. The weight of opinion among experts is all against reduction systems; there are points in the reports of Mr. James G. Bayles here quoted *in extenso* which are distinctly in agreement with the opinions of other American experts previously quoted. In every case we have a frank admission of weakness—a clear indication that the whole question of refuse disposal has still to be faced.

Board of Estimate and Apportionment. City of New York.

Board Meeting at the Mayor's Office, City Hall, Tuesday, October 1, 1901.

Statement [1] presented by The Hon. Bird S. Coler, Comptroller.

The Comptroller presented the following—

James Bayles, M.E.Ph.D., Consulting Engineer for Public Utilities, Gas and Water Undertakings, Sanitation, etc.

New York Office, No. 338, Park Row Buildings,
October 2, 1901.

Hon. Bird S. Coler, Comptroller; Hon. Randolph Guggenheimer, President of the Council.

"Sir,—I hand you herewith a report which seems to conclude the first part of my work as expert for the city in the matter of the investigation and valuation for purposes of purchase of a plant of the New York Sanitary Utilization Company.

"The conditions were such as to impose upon me the conscientious obligation of advising that no steps be taken, looking to the expression of 'intention' on the part of the city to buy the plant.

"In the work done thus far I have not had opportunity to give the city the benefit of the investigation of other methods of garbage disposal which I deemed consistent with the duties I was instructed by you to perform. The subject is a large one, and information concerning it, as exact as can be compiled from the mass of more or less trustworthy

[1] Which was ordered on file.

official and unofficial data, should be at the command of the Board of Estimate and Apportionment. In outline, I may say that my study of the subject satisfies me that the garbage should be disposed of as gathered, without accumulation on scows and flotation, to a remote point where a great public nuisance may be maintained.

"I believe that the cost of disposing of the city's organic refuse can be materially reduced, and that very much better results than are now reached are possible, *if the idea of utilization is abandoned, and that of destruction by approved modern appliances is substituted.* I see no reason why this cannot be done at the dumps where the material is now collected, and without creating any greater nuisance than is inseparable from its receipts in carts. I believe the whole system now employed is crude, unscientific and expensive, and that New York is in a position to dispose of its organic refuse more expeditiously, cheaply and satisfactorily, than is done in any American city. The inquiry is a serious one, and without special authorization I do not deem it my duty to enter upon it.

"I await your further instructions.

"Respectfully,

"JAMES BAYLES.

"NEW YORK, *September* 30, 1901."

HON. BIRD S. COLER, Comptroller; HON. RANDOLPH GUGGENHEIMER, President of the Council.

"SIR,—As the result of my study and investigation of the question of the disposal of the garbage of New York and Brooklyn, and of the advantages or disadvantages to accrue to the city from the purchase of the Barren Island plant of the Sanitary Utilization Company, under the clause of the contract of 1896, which has been assumed to give the city the option of purchase, I advise that no steps be taken in the matter of giving the notice of 'intention' on behalf of the city, for which said clause provides.

"A consensus of legal opinion would probably show that what has been assumed to be an option conferred upon the city by the contract of 1896 is valueless. It would appear to have been so drawn as to admit of almost any interpretation which may be put upon it. As it was discussed at some length in my report of September 12, I probably do not need to go over the subject again, further than to say that subsequent conversation with the council of the Sanitary Utilization Company convinces me that if any one having authority to do so should give the required thirty days' notice of 'intention,' it would be interpreted as committing the city to the purchase of the plant, and might very well give rise to a costly litigation to compel its acceptance, whatever the showing of the Company's books as to the results of five years of operation under the best management obtainable.

"In the report referred to, I recommend that if the required notice could be given on behalf of the city without constituting an expressed or implied obligation to take the Barren Land plant, that course be taken, to the end that the Board of Estimate and Apportionment might be put in possession, by expert investigation, of the facts necessary to a decision, whether it is to the city's interest to own it or not.

"I am now convinced that this course is impracticable. The council for the Sanitary Utilization Company are disposed to avail themselves of every technical advantage of interpretation, and the directors are obviously unwilling to have any investigation made pending a decision on behalf of the city to purchase. I attribute this to the fact that the result of such investigation would convince any impartial person qualified to form a judgment that the business is one without attractions for private capital, and with fewer still for a municipality. Not having received any confidential information from the Sanitary Utilization Company, but a great deal from well-informed sources which imposed no obligations of confidence, I have no hesitation in saying that I believe the business has thus far been unprofitable to the Company. It has employed a large capital, it now calls for important and costly extension, and has made no return to the stockholders. I have no doubt the Company would be glad to sell the plant and business, but the hopelessness of finding a purchaser if opportunity is offered for investigation makes the management reluctant to entertain a proposition to open its books to inspection.

"From the business point of view, I am convinced that there is nothing in garbage utilization. Its two products are grease and tankage. After the most careful investigation, which I have had opportunity to make, I could not conscientiously advise the municipal authorities to undertake their manufacture even if the Barren Island plant were given to the city.

"At this date 'prime city tallow'—the best grade of grease material—is worth 6 cents a pound. This is very high, its normal price being about 4½ cents. Garbage 'grease' is black oil, in appearance more resembling asphalt varnish of low grade than any other material with which I can compare it. If a parity could be established between it and tallow, it would now be worth about 3½ cents, but, as a matter of fact, it is almost unsaleable. For this there are two reasons: it is an undesirable material, and the increased production and lower price of palm oil is displacing it from admixture with other material in uses which might be found for it if palm oil were scarce and dear. It is accumulating in store at the present, and if forced on the market, it must be sacrificed. With tallow high in price, and relatively scarce from the partial failure of the corn crop, the demand for it should be at a maximum, whereas it is at minimum. If the price of tallow holds, garbage grease should be nominally worth 2½ to 3½ cents, and only moderate quantities could be sold in this country even at that price.

"The export demand for this material is not steady dependence. I have been in conference with a dealer, an expert in grease, who has been several times to Europe to make a market for American garbage grease, and has always succeeded in doing so. He tells me, however, that owing to its low grade and dark colour, which exclude it from use in soap-making even in the cheapest grades of laundry soap, he has been unable to hold the business thus secured, and does not consider that the material can ever compete successfully as a commercial product with grease from other sources. Should the city become a producer of garbage grease, it would, no doubt, be possible for it to contract for its sale at a low price with a dealer willing to buy it speculatively, and carry it in stock where there was no market for it. The city could probably not produce it for two or three times its maximum market value, nor handle it commercially without heavy annual loss. The fire risk of a large quantity of this material is also very great.

"From the fertilizer dealers I learn that, while the dried material remaining after the grease and water has been expressed has a limited use as a dilutent of cheap fertilizers, it is the lowest grade material of its class. Its nominal value in bags at works is about 5 dollars a ton, but the demand for it fluctuates, and it will not bear transportation for any distance. Just now it is in very light demand, and a considerable quantity could be purchased at a price somewhat below its nominal market quotation. The reason the tankage of the Boston utilization plant is not saleable is probably that it will not bear transportation to a market where it is wanted. In the shape in which it is produced the farmer cannot use it profitably, even if it cost him nothing but cartage.

"There is also a technical side to the business of garbage utilization, which is known only to a few, and to command the experience which has been gained experimentally at so great a loss would undoubtedly cost the city a large sum in annual salaries.

"Garbage carries from 2 to 3 per cent of grease, accordingly to the season. Naturally it is lower in summer than in winter. To get it out by the process employed by the Sanitary Utilization Company is apparently a very simple matter, but it is really very difficult. If the 'cooking' is not just right, its separation is impossible. If the steam pressure is higher than it should be, the whole mass is reduced to pulp, in which condition it all passes through the straining cloths in the presses, and no subsequent separation is practicable. There are also conditions in which the grease forms an emulsion with the water, and will separate at any temperature. The care and management of a plant are also matters requiring the skill gained from experience, and even then its deterioration is rapid. The digesters are attacked by the acids and salts in the material treated, and are, at best, short-lived. It is impossible to tell what is going into them at any given time. Even the most complete qualitative analysis would fail to indicate what combinations are or may be formed during the cooking process. Disastrous explosions in different parts of the plant have occurred under conditions which rendered satisfactory explanations impossible. I have examined discarded tanks, which were honeycombed by energetic corrosion, and from their appearance outside and inside, I should consider working in a plant of this character an extra hazardous occupation.

"The record of utilization plants in this country and Europe, concerning which I have been at much pains to advise myself, has been generally successful. That a majority of the plants built for grease recovery have been destroyed by fire would be significant if they were insurable, which I am told they are not. Such fires have usually occurred when the companies owning the plants were *in extremis*. The combination of grease-soaked timbers and careless operation is a bad one from the fire risk viewpoint.

"In Vienna, where the system of garbage utilization originated, I am informed that it is not at present used, and I can learn of no similar plant in Europe which is operating successfully. In this country the history of the principal garbage utilization plants may hastily be reviewed as follows—

Denver.—Plant destroyed by fire after an unsuccessful run.

St. Paul.—Plant destroyed by fire, kindled by a mob as a protest against it as a public nuisance. It was supposed to be injurious to property interests in its vicinity; it was not rebuilt.

Buffalo.—Plant destroyed by fire after a period of unprofitable operation. It is now being rebuilt, but other than sound business considerations are said to have induced its replacement. The money losses in this enterprise are understood to have been heavy.

Chicago.—Plant destroyed by fire, and not rebuilt.

Milwaukee.—Plant destroyed by fire, and not rebuilt.

Detroit.—Plant crippled by fire, and rebuilt, but is understood not to have paid. The original capital of the company was wiped out. The inducement to rebuild is understood to have been an advantageous contract for the sweeping of the streets.

St. Louis.—Plant destroyed by fire, but rebuilt and now running in a small way. Holders of stock in the St. Louis Company tell me they have never received any returns on their investments.

New Bedford.—Plant burned out twice, but rebuilt, and now running in a small way.

Reading.—Undertaking not a success. I am informed that the capital of the company was wiped out in the losses of operation, and that it is now engaged in litigation with the city involving $100,000.

Pittsburg.—Plant now in operation. The original company failed, but the business was taken up by a concern which is engaged in the fertilizer industry. As to its financial history, since passing into the present ownership I have no information.

Syracuse.—Plant in operation, but it is understood that the company has made no money.

Paterson.—Plant was built by a strong company, with a liberal and broad-minded management. It was burned down, and was not rebuilt.

New Orleans.—Plant still standing, I believe, but the company which built it went into liquidation, having sunk its capital. Cincinnati, Indianapolis Philadelphia, and Boston have operative garbage utilization plants. The same is true of Washington, where the original investment, $200,000, was wiped out by the burning of the plant. New works were built, and are understood to be as satisfactory as any in the country.

"This is probably not a complete list of American plants of this general character, but it includes those of greatest prominence. In briefly outlining their history, I have summarized the best data obtainable, and believe that my information is correct. It is known to every one for whom the subject has interest that millions of dollars have been lost in efforts to make a commercial business of garbage utilization. It seems to have unusual attractions for investors, who are allured by the promise of the recovery of large profits from a waste material costing nothing, and in unfailing supply. In no instance have I found a situation warranting the belief that, as a business venture, the building of a utilization plant as a business undertaking has not illustrated what the late Senator Conkling described as 'the bright beginning and the bitter end of a halcyon and vociferous proceeding.' I am not prepared to say that the progress of the arts will not ultimately give us a method of extracting grease from garbage profitably, but of this, as of the gold in sea water, it may be truthfully said that it now costs more to get it than it is worth when recovered. The chemical industries furnish many like problems, and much value is wasted because it does not pay to save it.

"In my report of September 12 I described in sufficient detail the plant of the Sanitary Utilization Company on Barren Island. Should the city desire to engage in the business, I am not sure that it could begin to best advantage by buying that plant. It is experimental from the first, and has admittedly cost a great deal more than any conscientious appraiser could accept as its present valuation. The company has had to feel its way through a great many difficult problems, others confront it which are not yet solved, and notwithstanding the liberal compensation received from the city, the stockholders claim to have had no return in dividends. Further considerable investments in machinery are immediately necessary, and the replacement account must be burdensome. I think it doubtful if, for another year or two at least, its garbage contract will be satisfactorily profitable. I am assured that its operations under the five-year contract of 1896 were not.

"The principal argument advanced by the advocates of garbage utilization is based on the 'sanitary advantages' of this method of disposing of the organic waste of a city. Whether these advantages are more or less depends upon the method chosen as offering a standard of comparison. Utilization is unquestionably better than 'tipping' or dumping at sea, or allowing putrescible refuse to accumulate in cities and congest or clog the avenues of disposal. I am not at all sure, however, that it is the best, cheapest or safest way of disposing of the garbage of New York. Indeed, I am convinced that it is not. Certainly it is not the method the city should adopt in handling this material on its own account.

"It may not be outside the scope of my duties as a technical adviser to remind you that the longer New York remains dependent upon a private company, the higher the price it will have to pay to renew periodically its garbage disposal contracts. I think I may also venture the opinion that the more absolute its dependence upon such company, and the greater the amount of the material to be handled, the less satisfactory, from a sanitary point of view, will be the result.

"I respectfully recommend that the subject be taken up for investigation by the city, with a view to the preparation of an exhaustive report on the best and cheapest method of garbage disposal for New York, either by contract or as a municipal enterprise. Meanwhile, in view of the facts above stated, I advise that no steps be taken, looking to the possible purchase of the Barren Island plant of the Sanitary Utilization Company. If any possible value attaches to an option-of-purchase clause in a garbage contract, the clause conferring it should be so drawn as to mean something. Finally, if the Brooklyn contract is made for one year, the collection of the data necessary to a decision as to the measures necessary to be taken for the protection of the city's interests cannot be taken too soon.

"Respectfully,

"JAMES C. BAYLES, M.E., Ph.D."

Although patentees of American crematories are frequently loth to make the admission, it is nevertheless true that every attempt yet made to destroy garbage by fire has necessitated the use of a considerable weight of added fuel, and the cremator or secondary fire is an integral part of every crematory yet devised for dealing with garbage.

Fig. 92 is a longitudinal section of the "Dixon" crematory, a representative American type. It will be observed that not only are two coal fires provided, one at the end of the main destroying chamber and the other immediately underneath at the end of the evaporating chamber, but in addition a third fire, coke fed, is arranged at the chimney base.

Now those who are intimate with the composition of refuse in the South of England in midsummer are well aware that such refuse is in the main garbage, pure and simple; yet in spite of this no secondary fire or fuel is used, and in summer, as in winter, power is supplied for the various municipal purposes herein discussed. This cannot be disputed. Day by day the work goes on, and there are several examples, notably sewage works, where no other fuel but refuse has been used since the destructor was erected.

Notwithstanding the use of coal, coke, or other fuel in connection with American crematories, complaints concerning nuisance are frequent. It is true that within the past two or three years complaints have been less frequent, but possibly

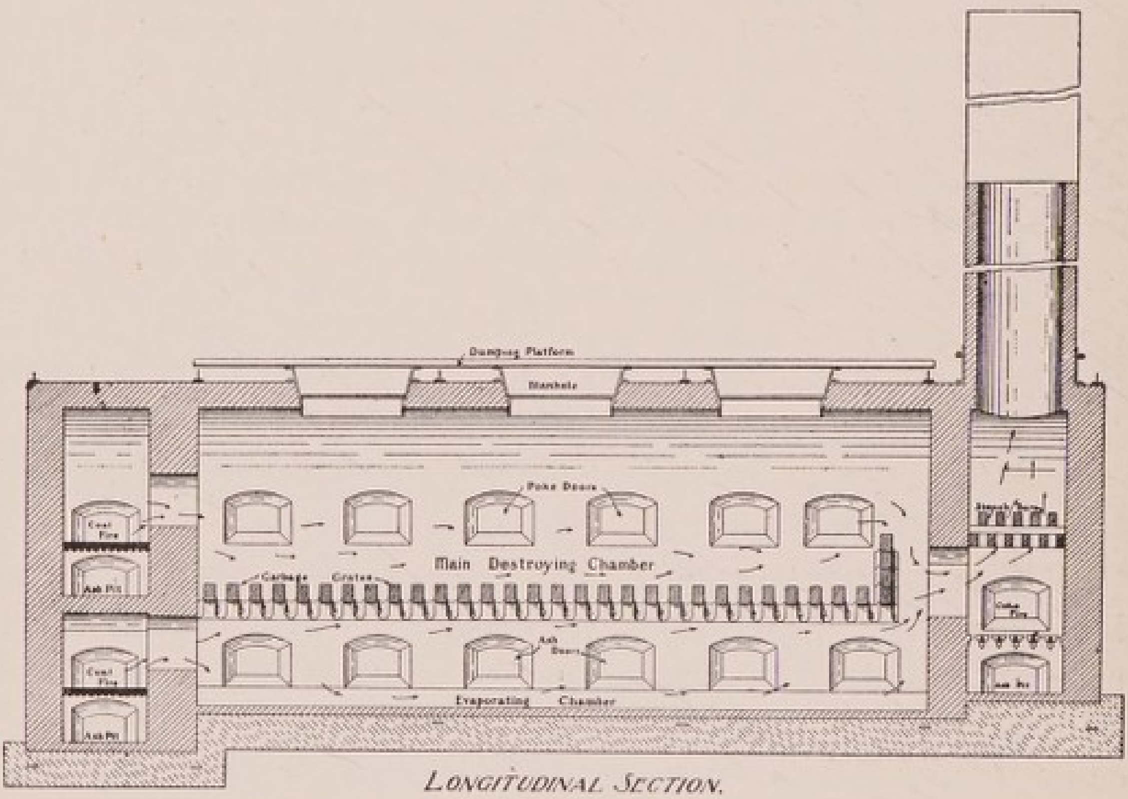


FIG. 92. THE DIXON CREMATORY.

this may be attributed either to the use of a larger proportion of added fuel, or increased vigilance. Certainly there has been no drastic improvement in design, or indeed any improvement which would tend toward the avoidance of nuisance, unless a good proportion of added or secondary fuel be used.

Owing to serious complaints of nuisance at Trenton, N.J., where a crematory of the "Davis" type is installed, a consulting engineer was engaged to investigate and report to the city authorities—*firstly*, as to the nature and extent of the trouble, and *secondly*, to make such recommendations as might be needed to improve the installation.

Complaints have been made concerning the escape of dust from the chimney, and it was also alleged that escaping sparks had been responsible for fires in the immediate neighbourhood of the works. As the result of investigation it was clearly proved that sparks were discharged from the chimney, and that they occasionally travelled a distance of 150 to 200 feet from the chimney.

The installation at Trenton comprises two "Davis" crematories, each consisting of a combustion chamber, a drying chamber (having an evaporating pan beneath), and also secondary fire grates. The works are situated in a thickly populated neighbourhood. The chimney is 120 feet in height, and is approached by a somewhat contracted main flue, in which is arranged a set of screens to intercept dust particles.

Presumably the Trenton plant may be considered as a modern example; if this be so, then it must be admitted that much remains to be done. When it becomes necessary to intercept dust by means of screens, a serious weakness in the design is at once manifest.

As the result of the investigation, recommendations [1] were made which if adopted would certainly tend to ensure satisfactory working thereafter, and it is interesting to observe that the various recommendations made are such as would be made by a competent engineer having experience of destructor work, thus at once emphasizing the soundness of the views expressed by such authorities as Mr. Rudolph Hering and Colonel Morse.

Some details of a test carried out with the Trenton installation are here given —

Results of Operation of the Garbage Crematory at Trenton, N.J., for One Week, August 4–9, 1902 (inclusive).

Total garbage burned	188·0 tons.
Garbage burned per day	31·3 ,,
Coal used on main fires	10·7 ,,
Coal used on auxiliary fires (estimated)	3·0 ,,
Total coal used	13·7 ,,

[1] See *Proceedings of the American Society of Civil Engineers*, vol. xxix., No. 1, January, 1903.

Coal used per day	2·3 tons.
Garbage burned per ton of coal	13·8 ,,
Approximate average time of operation per day .	14 hours.
Equivalent number of days of 24 hours . .	3·5 days.
Equivalent garbage burned per sq. ft. grate area per day of 24 hours	1,080 lb.
Equivalent amount of garbage burned per cell of 25 sq. ft. per day of 24 hours	13·5 tons.
Estimated total weight of clinker from garbage and coal grates	14 ,,
Estimated weight of ashes from ashpits . .	3 ,,
Percentage of ashes and clinker to garbage burned.	9·1 per cent.
Range of temperature of gases in chimney . .	600–1,000° F.
Percentage of moisture in garbage	81 per cent.
Corresponding water evaporated daily in furnaces	25·5 tons.
Quantity of coal required per day, to evaporate this water on a basis of 10 lb. of water per lb. of coal	2·5 ,,

Reduction v. Destruction.

As already observed, the former system only provides for the disposal of a comparatively small portion of a city's waste. To render such a system of disposal workable, it devolves upon the householder to keep the various classes of waste distinct, and in the collection of the waste, separate collections are demanded, because the bulk of the total waste has to be disposed of otherwise by the authorities. Fig. 93 illustrates the sorting of refuse at Boston, where a crematory of the Morse-Boulger type has also been erected.

The general average composition of the refuse of an American city would seem to conclusively show that sufficient material of good calorific value is collected to readily destroy the objectionable portion of the refuse, always providing of course that the *whole* be burned in an efficient destructor.

The refuse of an average American city is of the following composition—

	By weight.	By volume.
Garbage	13 per cent.	18 per cent.
Ashes	80 ,, ,,	57 ,, ,,
Rubbish	7 ,, ,,	25 ,, ,,
	100 ,, ,,	100 ,, ,,

Ordinary kitchen garbage consists approximately of—

	By weight.
Animal and vegetable matter	20 per cent.
Grease	3 ,, ,,
Water	70 ,, ,,
Rubbish, cans, rags, etc.	7 ,, ,,
	100 ,, ,,

It has been estimated that in a city such as New York, no less than 20 per cent. of recoverable coal is contained in the

FIG. 93. BOSTON REFUSE DISPOSAL WORKS. SORTING ROOM.

ashes collected from private houses and apartment houses. This being so, then it is a very strong argument in favour of the erection of destructors; such material would be found of immense value not only for effectually cremating the organic and objectionable waste, but in providing an immense amount of power for various municipal purposes.

According to the late Colonel G. E. Waring, jun.,[1] "city garbage from kitchens and markets consists of about 7 per cent. of

[1] See *Report on the Final Disposition of the Wastes of New York*. By George E. Waring, jun., Commissioner, 1896.

rubbish—cans, bottles, rags, etc., 70 per cent. water, 3 per cent. grease, and 20 per cent. of a mixture of animal and vegetable matter of a dry character.

"To cook the raw garbage and separate it into the four substances (i.e.) rubbish, water, grease, and fertilizer material, is the object of all garbage reduction or utilization systems.

"The rubbish has scarcely enough value to repay its separation, and the water has none at all. To get rid of these two substances, averaging 77 per cent. of the whole, is the expensive part of any reduction process."

It is beyond dispute that the cost per ton dealt with by a reduction system is very high, so high indeed that taking every factor into account it may be submitted that it would be possible for an average community to dispose of the *whole* of its waste for very little extra per ton than has been cheerfully paid for the disposal of a portion only.

In order to arrive at a basis for fair comparison, one must take into account the whole of the capital and standing charges for a reduction plant, not forgetting the depreciation, which must ever be a very serious item, because we are comparing the cost with that of a system which deals with the *whole* of the waste.

The assets must of course be allowed for, but it may be observed in this connection that such assets have up to the present not shown themselves to be of equal value to the assets from a modern destructor plant.

The costs in connection with a reduction plant usually cover the collection and transportation of the garbage, and it is but fair to point out that a modern destructor can be erected on a central site, such a site as ensures the minimum cost for collection, while on the other hand the reduction works cannot under any circumstances be erected within a city, and for purposes of argument we may therefore assume that the collection costs would be doubled.

Further, all available figures clearly show that even a first-class modern destructor, complete with steam boilers, can be erected for less money than a reduction works for a city of similar size, while in the case of the former the *whole* of the refuse is dealt with, and in the latter case the small percentage of garbage only is treated.

If we compare the cost for labour and materials per ton of material dealt with, the destructor again has the advantage. A greater variety of labour is required for the operation of a reduction works, and the proportion of skilled labour demanded compares badly with the destructor and its direct and simple process.

Having briefly reviewed the comparative economic aspect, we may now turn to the sanitary aspect. The former has been first dealt with because, as already pointed out, the reduction process has been for the most part regarded as a commercial venture.

In the first place, no system can be regarded as sanitary which does not provide for the disposal of the *whole* of the waste of a community without sorting. Even when the garbage is delivered at the reduction works, a system of hand sorting is essential.

Again, ample evidence is available to conclusively show that reduction works are usually productive of nuisance; in fact, the process would appear to be inseparable from nuisance, although it is claimed that a high standard of perfection has now been reached.

It is idle for the advocates of reduction to contend that the system is more profitable, commercially speaking, than destruction and power production. This can only be determined by making careful comparison between a reduction system and a modern destructor supplying power, paid for at a reasonable rate. Further, the clinker has to be taken into account, this frequently being a good source of revenue.

The modern destructor, as we understand the term, is unknown in America; the immense amount of power obtainable coincidently with the destruction process has yet to be realized, as also the value of the residuum and its ever widening sphere of usefulness.

It is not exaggeration to say that if it were possible to erect two large modern British destructors in New York, destroying sufficient refuse to operate about 200 electric cars for eighteen hours daily, reduction would at once become an impossible system. Separate collection of the waste and sorting would cease entirely, and destruction by fire would speedily become as popular as is the case in this country.

As already indicated, the commercial aspect has counted for much in the development of reduction, and it may be fairly assumed that the commercial aspect of destruction, once demonstrated, would appeal strongly to a people possessing no mean utilitarian record.

To the British student of the subject it must be obvious that the power aspect of refuse disposal alone is likely to induce a commercial people to abandon that *laisser faire* attitude concerning their filth, which is the most serious stumbling-block to sanitary progress.

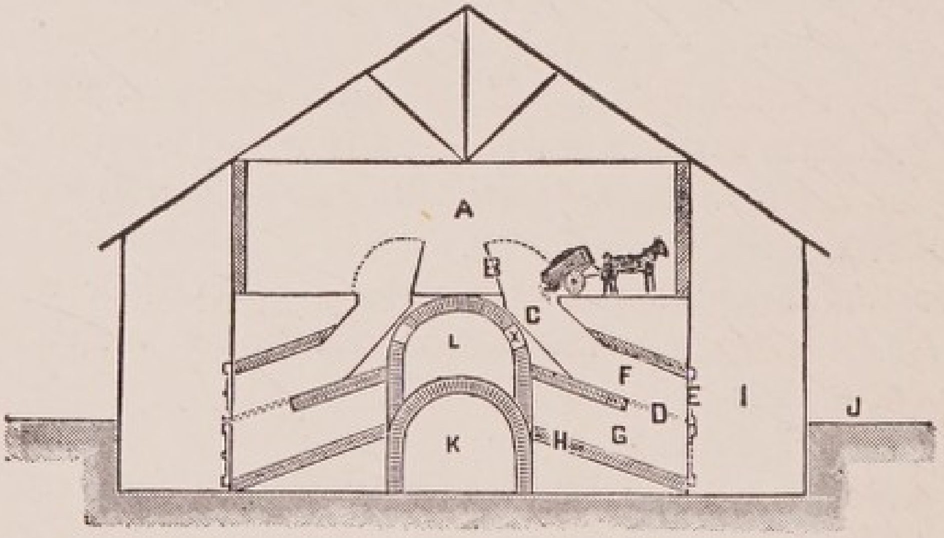


Fig. 94. Montreal Destructor, "Thackeray" Type.

CANADA.

Montreal—Population, 267,516.

The refuse of the Western district of this important Canadian city is destroyed in a destructor or incinerator of the Thackeray type. Fig. 94 is a cross-section of the Thackeray destructor as erected in Montreal. It will be observed that in design it is very similar to the original "Fryer" destructor. Twelve cells are provided, arranged back to back, each cell having a grate area of 72 square feet.

The chimney is 175 feet in height, and a fume cremator has been erected at the chimney base. Natural draught only is now used. Fan and steam jet blower draught have both been tried and abandoned. A steam boiler which was originally set at the chimney end of the main flue has been removed.

The destructor was erected in 1894 at a cost of $41,000, and has been in constant operation ever since. During the year 1901 13,659 tons of refuse was destroyed at a cost of $12,778, equal to about 93½ cents per ton of refuse destroyed.

ANALYSIS OF "HOUSEHOLD" REFUSE OF MONTREAL.[1]

	Summer.	Winter.
Kitchen waste . . .	65 per cent.	25 per cent.
Paper	15 ,, ,,	10 ,, ,,
Tin cans, bottles, old boots, rags, etc. . . .	10 ,, ,,	5 ,, ,,
Ashes	10 ,, ,,	60 ,, ,,

The high percentage of ashes in winter is of course due to the low temperature, the lowest temperature in the winter being given as 25° F., and the highest summer temperature 93° F. in the shade.

The author is indebted to Dr. Elzear Pelletier, of Montreal, for the foregoing information concerning the disposal of the refuse of that city.

SOUTH AMERICA.

BAHIA.

About a year since this municipality decided to erect three destructors to the design of Mr. Price Abell, a British engineer.

BUENOS AYRES (Argentine).

A small experimentary destructor was erected by Messrs. Baker about two years since.

GEORGETOWN (British Guiana).

A small destructor of the Fryer type was erected here several years since.

[1] Analysis made by Mr. J. E. Doré, Municipal Sanitary Engineer.

MANAOS (State of Amazonas).

A three-cell Colwell destructor was erected here by Messrs. Baker in 1901; two Hornsby water tube boilers were provided, these being set between the cells.

PARA (Brazil).

Some twelve years ago a small destructor of the Fryer type was erected here, followed a few years later by a Horsfall destructor of the top fed type.

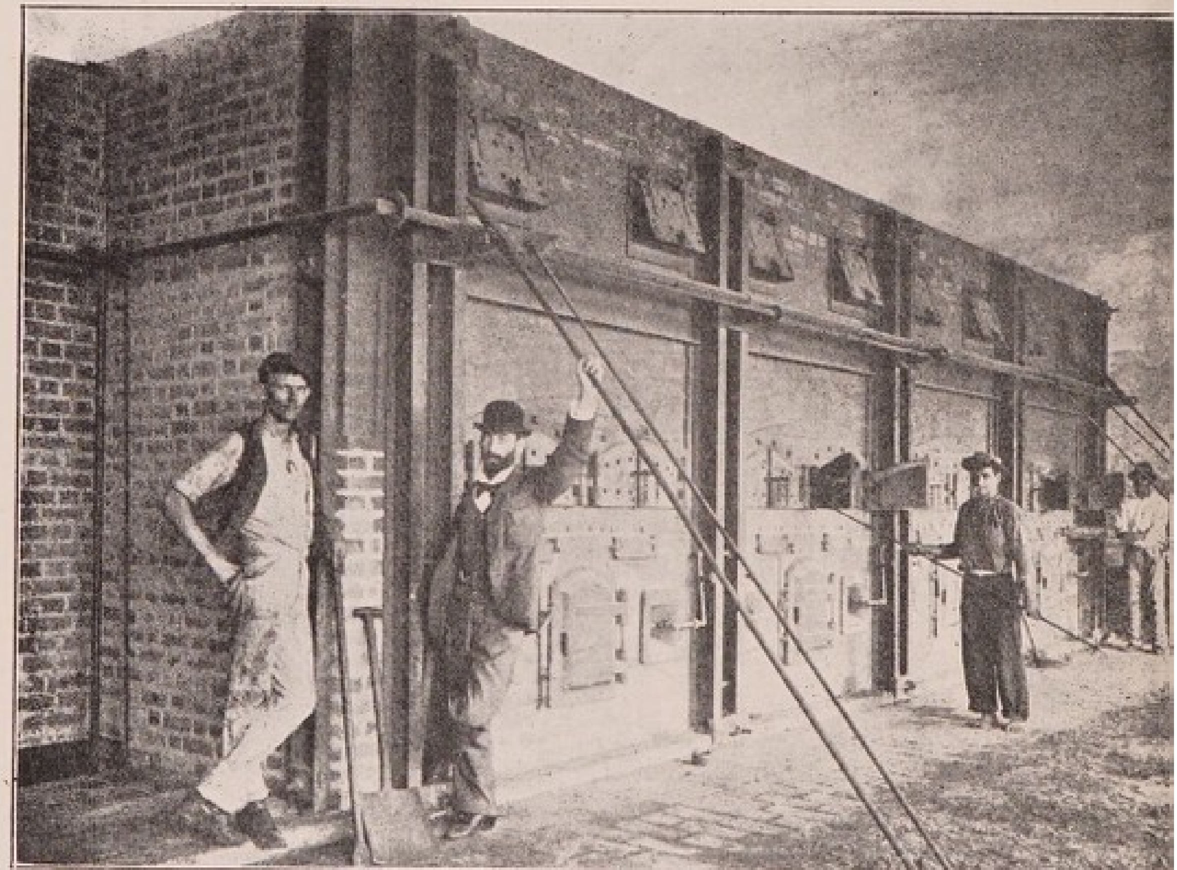


FIG. 95. PERNAMBUCO DESTRUCTOR. VIEW OF CELLS.

PERNAMBUCO (Brazil).

A four-cell Horsfall destructor of the back fed type was erected here in 1896. One multitubular boiler, 10 ft. by 6 ft., is provided, and this supplies steam for the steam jet blowers and also for driving a mortar mill. The chimney is 60 feet in height, and about 26 tons of refuse is destroyed per 24 hours. Fig. 95 is a front view of the cells.

Peru.

While a few cities on the eastern seaboard of South America have adopted modern destructors, the time-honoured system of tipping, perhaps in its most objectionable form, is still practised in many large cities on the west coast. According to a recent report from the capital city of Peru, one refuse tip known as "Tajamar" is still being added to day by day, although it has been in existence ever since Lima was founded.

As the city was founded in 1535, the "Tajamar" tip will probably rank as the oldest deposit of its kind, and it furnishes striking evidence of that apathy and disregard of sanitation which is a feature of most countries administered by Spaniards or those of Spanish descent.

One of two brief extracts from the report already alluded to will doubtless be of interest—

Parte 11.—*Destruccion de la Basura.*—Referring to the "Tajamar" tip, the writer remarks: "It is situated in the river bed, and now reaches a height in places of from 15 to 29 metres. . . .

Referring to another tip, known as the "Martinette," we are told—"I noticed several persons at this tip who were sorting the refuse, and I believe that people sleep there at night. The great objection to this practice is that these people mix with the rest of the inhabitants in the streets, and are liable to transmit any disease that they may have contracted at these dust heaps. . . . I consider that all refuse heaps should be surrounded by a fence, so as to prevent access to them by the public. . . . Alongside of the Hospital de Mayo there is a piece of waste ground on which loads of street sweepings and other refuse is deposited, also several dead animals; this is a most objectionable practice in such close proximity to an hospital."

Such is the report of a British engineer concerning the refuse disposal of a city now having a population of over 200,000, and one of the finest South American cities.

CONTINENTAL PRACTICE.

Continental practice is, perhaps, of greater interest to the student, emphasizing as it does the excellence of the British destructor, and clearly showing that our British practice can only be emulated by the adoption of British destructors.

Destructors of Continental design have been but few in number, and their record is not a satisfactory one. As in America so on the Continent, the problem has never been approached as a problem, and consequently it remains a problem. Such British installations as have been erected and which are here briefly recorded have on the whole been very satisfactory.

The wretched practice of tipping refuse, so common in this country, is in vogue all over Europe. That it is not so severely condemned in many Continental countries by the medical profession as is the case here is quite true, but such indifference is no argument in favour of a filthy system. Such laxity but serves to show how assiduously our medical officers of health attend to their primary duty—the preservation of the health of a community.

Sorting and utilization is extensively practised in Continental cities. According to some reports, it possesses economic advantages under the peculiar existing conditions, but by no stretch of the imagination can such a system be called sanitary. In this country some of the strongest opponents of all systems of sorting and utilization are found among our medical officers of health, and such systems, which have never been popular here, are now almost entirely discarded, and it is quite certain that a revival is impossible.

When our Continental neighbours inspect destructors in this country, as frequently happens, their investigations are of the most searching and thorough character. The author has been impressed many times by the determination of the foreign visitor to see all that is to be seen, and to so see that he understands clearly.

Close investigation in a destructor building often involves much personal discomfort, but our foreign visitor is not daunted ; he appears quite willing, if necessary, to ruin a suit of clothes rather than gather a mere hazy notion concerning something which may not be quite clear to him.

The copious notes taken, the intense interest shown, and the discomfort endured, all stand out in sharp contrast when compared with the visit of the average British councillor, who too often likes to stand at a very considerable distance from that which he has come to see. Our British visitor coughs when there is no occasion to do so, and sometimes pinches his nose when looking into a cell at almost white heat. He does not like to come too near, it is unpleasant, whereas if it were possible to get closer to any object of interest by proceeding on all fours our foreign visitor would not hesitate to do so.

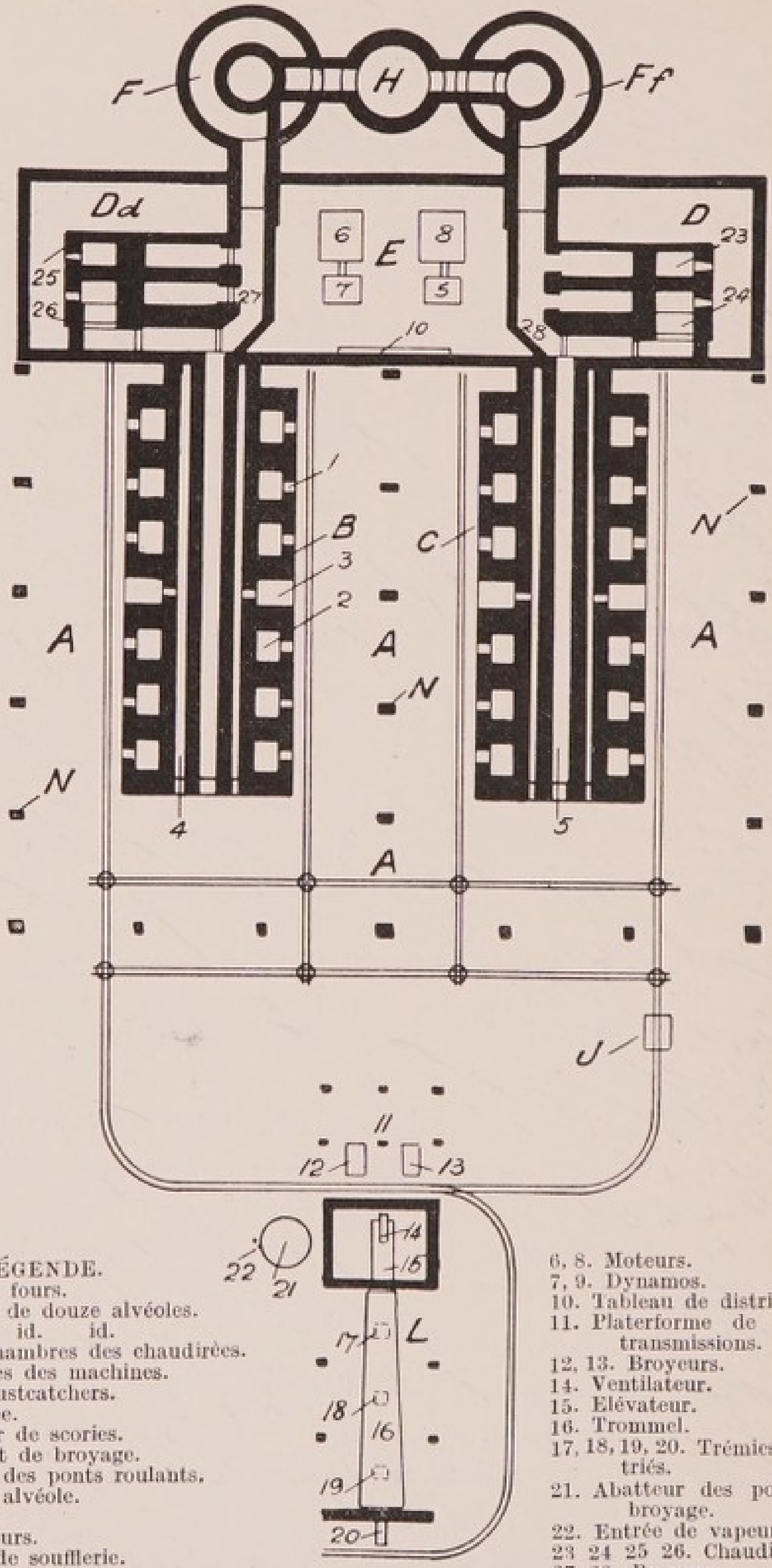
However well a destructor works may be designed and managed, close investigation of actual working conditions is impossible without some little personal discomfort to the lay visitor. It may perhaps be granted that the atmosphere does not inspire searching investigation, but the fact nevertheless remains that deputations are sent to *investigate*, and it gives the author no pleasure to remark that the example set by many Continental deputations might worthily be followed by British deputations.

It will be observed that although comparatively little has been done on the Continent in the way of final and sanitary disposal, yet some notable cities have shown the way, and while progress is slow, there is every indication that disposal by fire will ere long be recognized as the only solution.

Brussels (Belgium).

A destructor of the Horsfall type, comprising twenty-four cells, top fed and arranged back to back, has recently been erected at the "Quai-de-la-Voirie." Four water tube boilers are provided, and also two centrifugal dust catchers. Electrically driven fans supply forced draught to the cells. The chimney is 45 metres high, having an internal diameter of 250 centimetres. The destructor has a capacity of 150,000 kilos per twenty-four hours, and the power is used for works purposes, including the fans already mentioned, electrical cranes for lifting the refuse on to the top of the cells, also for the electric lighting of the works, and the operation of a clinker utilization plant, including screens and crushers.

Fig. 96 is a block plan which shows the general arrangement of the plant at Brussels.



LÉGENDE.

A. Hall des fours.
B. Batterie de douze alvéoles.
C. id. id. id.
D et Dd. Chambres des chaudirèes.
E. Chambres des machines.
F. et F. Dustcatchers.
H. Cheminée.
J. Mouilleur de scories.
L. Bâtiment de broyage.
N. Pylones des ponts roulants.
1. Portes d alvéole.
2. Alvéoles.
3. Ventilateurs.
4. Canaux de soufflerie.
5. Collecteurs de gaz.

6, 8. Moteurs.
7, 9. Dynamos.
10. Tableau de distribution.
11. Platerforme de broyage e transmissions.
12, 13. Broyeurs.
14. Ventilateur.
15. Elévateur.
16. Trommel.
17, 18, 19, 20. Trémies de produi triés.
21. Abatteur des poussières d broyage.
22. Entrée de vapeur.
23 24 25 26. Chaudières.
27 28. By pass.

FIG. 96. BRUSSELS DESTRUCTOR.
Plan.

Frederiksburg Municipality (Copenhagen), Denmark.

A large destructor of the Sterling type has recently been completed, boilers of the Babcock & Wilcox type being provided in connection therewith. The available steam power will be used for heating and lighting purposes at a large hospital in close proximity to the destructor works.

Gibraltar.

A two-cell Fryer destructor was erected here about ten years since. The height of the chimney is 90 feet. About fifteen tons of refuse is destroyed daily.

Berlin (Germany).

A number of experiments have been made in this city. In 1895 a three-cell Horsfall destructor was erected, followed by a two-cell Warner destructor, but after exhaustive experiments it was decided not to instal further cells of either make.

Owing to the unusual composition of Berlin refuse and the freedom from combustible material, considerable difficulty was experienced in securing a vigorous combustion, both with steam jet blower draught and fan draught. Latterly experiments have been made with a furnace of German design, and in so far as temperature and efficient combustion is concerned, very satisfactory results were obtained; it is, however, but fair to add that a considerable quantity of coal dust has been used to assist combustion.

Hamburg (Germany).

A thirty-six-cell Horsfall destructor was erected in 1895. The cells are of the top fed type, and arranged back to back. Four multitubular boilers are set in connection with the cells, supplying power for the electric lighting of the works, also for operating electric cranes, fans for forced draught, clinker crushing and screening plant, as well as for pumping purposes. The chimney is 48·6 metres in height, and 2·4 metres internal diameter. During the year 1900 an average of 270,288 kilos of refuse was destroyed per twenty-four hours.

Monaco.

A four-cell Horsfall destructor was erected here in 1898; the cells are of the top fed type and arranged back to back. One water tube boiler, having 75 square metres of heating surface, is set in connection with the cells, but the steam power is used for forced draught only. The chimney is 35 metres in height, and 1·30 metres internal diameter. About thirty tons of refuse is destroyed daily.

Paris (France).

In 1895 a small experimental destructor was erected at the Javal municipal workships at a cost of about 25,000 francs. The cells were of the modified Fryer type. Although fairly satisfactory results were obtained, the plant was not extended, and to-day Paris is still confronted with the refuse disposal problem.

Zurich (Switzerland).

A twelve-cell Horsfall destructor has recently been erected; the cells are of the top fed type and arranged back to back. Two water tube boilers are provided, and power is supplied for works purposes, forced draught, etc. This installation is very similar to that at Brussels, already described and illustrated.

SOUTH AFRICA.

Durban (Natal).

A four-cell Warner destructor was erected here in 1899; a further destructor is likely to be erected very shortly.

East London (Natal).

A four-cell Warner destructor was erected here in 1900.

Bloemfontein (Orange River Colony).

The municipality have recently decided to erect a small destructor of the Horsfall type.

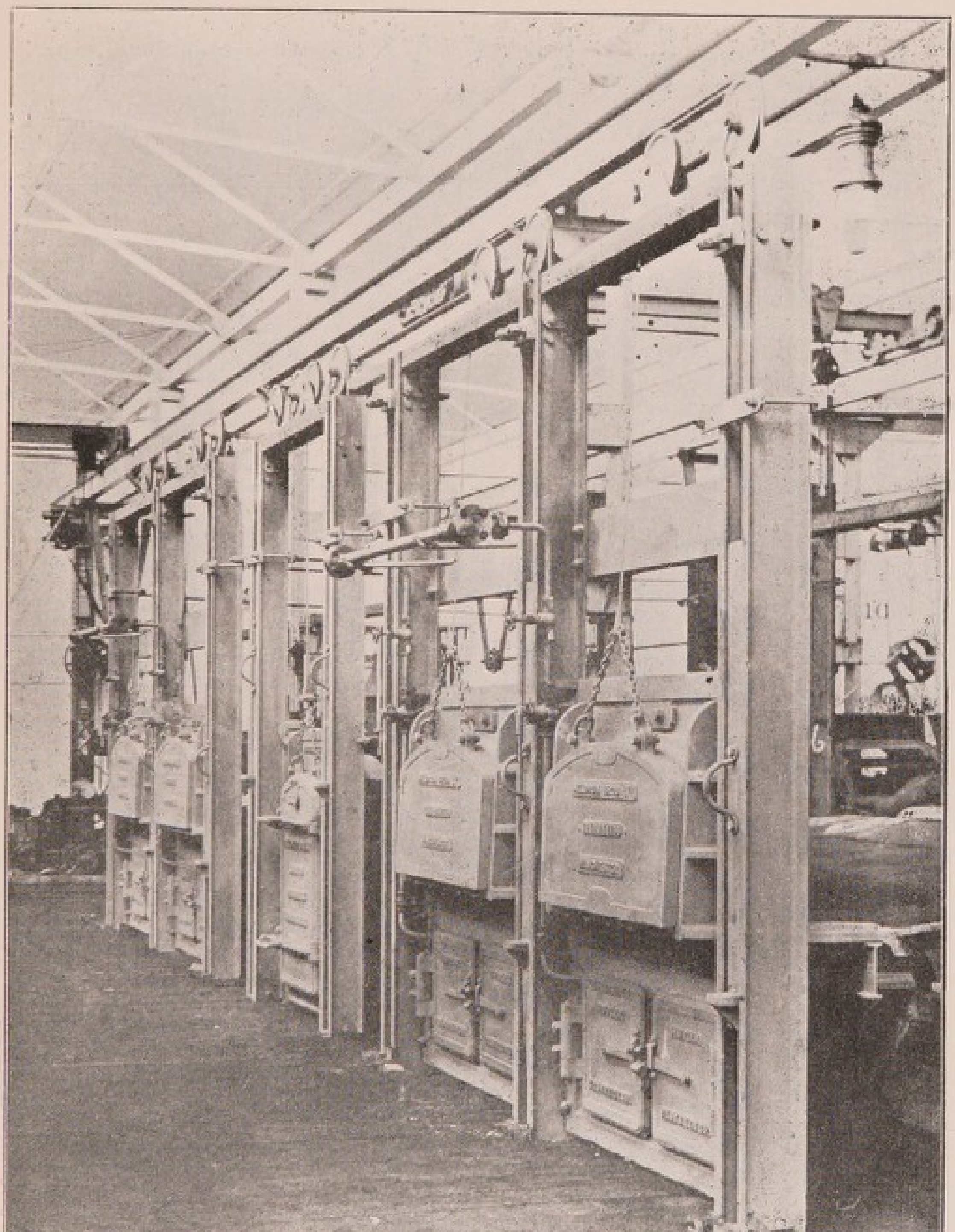


FIG. 97. JOHANNESBURG DESTRUCTOR. FURNACE IRONWORK FOR 4 CELLS, Erected in Messrs. Meldrum's Shops, Timperley.

JOHANNESBURG (Transvaal).

A destructor of the Meldrum improved top fed type is now being erected in this city. The plant comprises two four-grate unit destructors with regenerators for air heating, and two Babcock & Wilcox boilers, each having 1,966 square feet of heating surface. The capacity of this, the first modern destructor to be erected in South Africa, is 120 tons daily, and it is anticipated that a very useful amount of power will be produced therefrom for works purposes.

Fig. 97 is a view of the furnace fronts and ironwork in the maker's erecting shop prior to shipment.

The destructor plant will be contained within an iron building, and a sectional steel chimney, 100 feet in height and 6 feet internal diameter, lined with firebrick throughout, will be erected.

Under the Boer régime the question of refuse disposal was often discussed, but such obstacles were always presented that it was found impossible to acquire a suitable site. It is interesting to observe that at least one year before the conclusion of hostilities Major W. A. J. O'Meara, R.E., was deputed to proceed to this country on behalf of the municipal council to investigate and report to the council concerning the progress made in Great Britain in final and sanitary refuse disposal. The work now in progress is the direct outcome of Major O'Meara's investigations, and the startling and rapid change from the filthy methods previously in vogue augurs well for the future sanitary conditions of large South African municipalities.

AUSTRALASIA.

Melbourne (South).

A twelve-cell Fryer destructor was erected here about eleven years since; it is, however, reported that this is no longer used.

Melbourne (Victoria).

A two-cell Cracknell destructor was erected here some five years ago, mainly for experimentary purposes. Although favourably reported upon by the city surveyor, the installation was not extended. The Cracknell destructor was of Australian design, and, although capable of doing satisfactory work, the temperature obtained was not sufficiently high.

Toowoomba (Queensland).

Early in 1902 a two-cell destructor of Meldrum's improved Beaman & Deas type was erected, together with one Babcock and Wilcox boiler. This destructor was specially designed for destroying excreta, this material being destroyed with refuse, in the proportion of three parts of excreta to one of refuse.

The nature of the work being done by this destructor is probably without parallel anywhere; it is nevertheless being successfully operated without offence, although the chimney is but 40 feet in height.

Being specially designed for the work required, every possible provision was made for ensuring the constant exhaustion of all fumes through the fire. Further, careful provision is made for the easy cleansing of the containing hoppers, it being essential that notwithstanding the nature of the work the building must be free from offence.

Sydney (New South Wales).

A six-cell Warner destructor was erected here in 1902.

Annandale and Leichardt (Sydney, New South Wales).

A destructor of the Meldrum Simplex type was erected here in 1902, and being the first of this type to be erected in the Antipodes much interest was centred upon its performance. The installation is only a small one, comprising a two-grate unit destructor, together with a regenerator for heating the air, supply for combustion and a Cornish boiler. The guaranteed destroying capacity of the plant was one ton per hour.

The following report of the official test is of interest, this being conducted by Mr. W. M. Gordon, the city surveyor of Sydney.

ANNANDALE AND LEICHHARDT GARBAGE DESTRUCTOR.

Reports to the City Council on a 48 hours' Test.

City Surveyor's Report.

I have the honour to report that a test has been made of the destructor known as the Meldrum Simplex, of two cells, recently erected for the Annandale and Leichhardt Councils, for which purpose the City Council supplied garbage, and had an officer present throughout the trial. The work commenced at 4 p.m. on Tuesday, 28th, and was completed at 4 p.m. on Thursday, 30th ult.

The total amount of garbage consumed during the 48 hours was 60 tons 18 cwt. 0 qrs. 14 lbs., made up as follows—

	Tons.	Cwts.	Qrs.	Lbs.
City Council's Garbage	37	3	0	0
Annandale and Leichardt Council's Garbage	23	15	0	14

This is equal to 15 tons 4½ cwt. per cell per 24 hours.

The total residue was 24 tons 4 cwt. 1 qr. 24 lbs. (equalling about 40 per cent. of the whole), made up as follows—

	Tons.	Cwts.	Qrs.	Lbs.
Clinker	20	13	1	14
Ashes	3	11	0	10

The total cost of burning was £4 16*s.*, or 1*s.* 6¾*d.* per ton. Care was taken that as nearly as possible the same class of garbage was sent to this destructor as to the Perfectus at Moore Park, viz. first loads at night, early morning service, and trade refuse; and no complaints were received.

The garbage from Annandale and Leichhardt was not good (especially the latter), as it contained a large percentage of dust, burnt ashes, and yard sweepings. The loading on the 29th and 30th was very wet owing to the heavy rain, and more difficult to burn. More particularly does this apply to the garbage conveyed by the Annandale and Leichhardt carts, which are uncovered.

A feature of the destructor is that the garbage is all shovelled through the furnace doors, and although I was at first not favourably impressed with the idea, I am now convinced after demonstration that it is a marked improvement upon the dumping in of large quantities through hoppers over the furnaces.

Steam is used for the forced draught, and the temperature is very great, and, after experience with the Pinhoe and Perfectus, I am convinced that a much higher degree of heat is obtained in the Simplex.

There is no difficulty in keeping up steam, as, after the start, the steam never showed less than 65 lbs., and reached as high as 80 lbs.

The destructor is worked with two men in three shifts of 8 hours each, and only two men out of the six men employed had had any previous experience in the work.

The rate of wages paid is 8*s.* per diem, and consequently the cost is greater than it should be, as—

The cost per ton (wages at 8*s.* per diem) is	1*s.*	$6\frac{3}{4}$*d.*
While ,, ,, ,, ,, 7*s.* ,, would be . .	1*s.*	$4\frac{1}{2}$*d.*

The whole of the residue was kept separate, and, unfortunately,

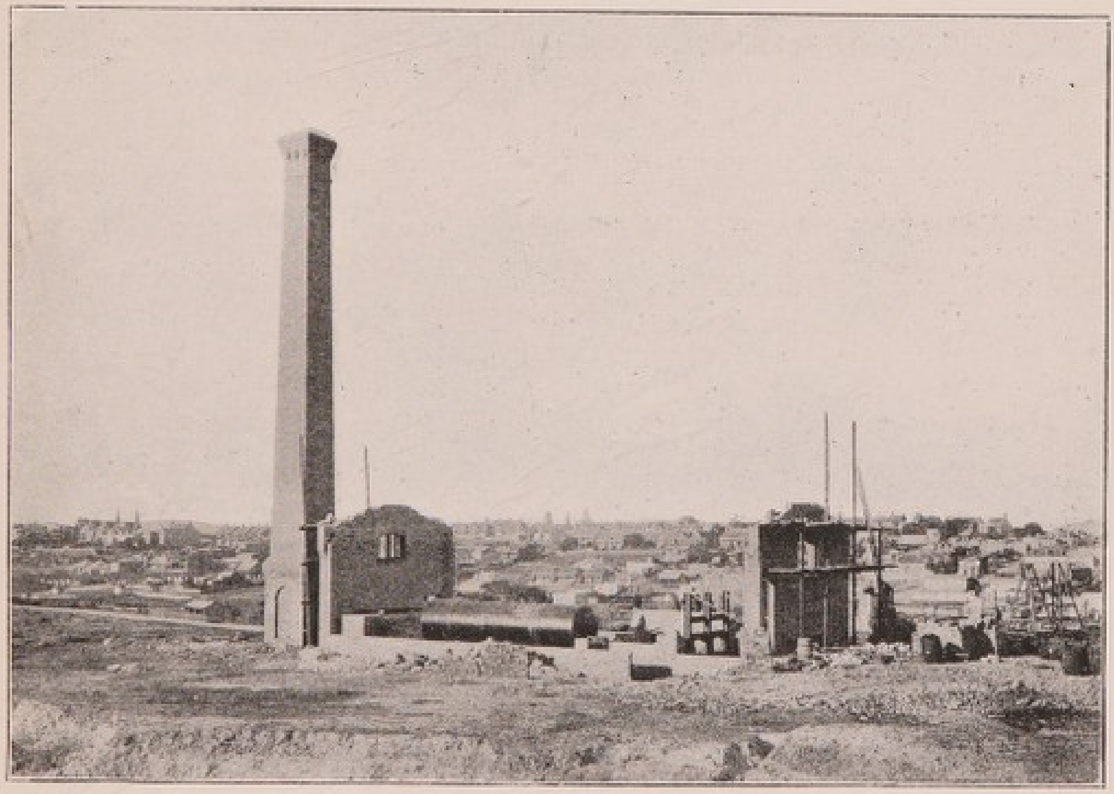


Fig. 98. Annandale (New South Wales) Destructor in Course of Erection.

was saturated with rain. Therefore, the trial may be said to be a severe one, inasmuch as the garbage was wet, and the weight of residue increased.

Upon examination of the residue, there can be little doubt about the completeness of the destruction, and although exception might be taken to the clinker, I am convinced that with the amount of dust and earthy matter it would be impossible to produce a much better clinker.

During the trial the destructor was inspected by Dr. Ashburton Thompson and the Medical Officer of Health for the Metropolis, the latter of whom is making a complete report to the Board of Health.

I am of opinion that the trial was in every way a most satisfactory one, and the results will no doubt be gratifying to the two suburban Councils, who are to be congratulated upon their combined efforts to cope with the destruction of garbage by fire.

I have to express my thanks to Mr. Hinsby, Council Clerk of Annandale, for his ready and willing assistance.

I have the honour to be, Sir,
Your obedient servant,
W. M. Gordon,
City Surveyor.

P.S.—The cost of weighing and wages of Council's officers will be charged to the combined Councils, an account of which will be forwarded.

Fig. 98 is an external view of the works, during course of erection.

Christchurch (New Zealand).

A destructor was erected here in 1901, comprising four cells of Meldrum's improved Beaman & Deas type, and two Babcock & Wilcox boilers, this being the first modern high temperature destructor erected in the Antipodes. It was not anticipated that any serious amount of power would be obtained from New Zealand refuse, but in order to determine exactly what power was available, exhaustive tests were made over extended periods with very satisfactory results.

After thus demonstrating the possibilities of the destructor for power production, the Council decided to instal the following electrical plant for public and private lighting—

Two Davey Paxman high speed three-crank compound condensing engines and two Westinghouse 100 k.w. 250 volt compound wound D.C. engine type multipolar generators.

Steam is supplied to the engines at a pressure of 150 pounds to the square inch. The engines are mounted on extended base plates, and direct coupled to the generators. It was not anticipated by the destructor makers that sufficient power would be obtained from the refuse to warrant such a combination, and such a case as this but serves to show that the production of power from refuse is not likely to be confined to Britain.

Wellington (New Zealand).

A six-cell Fryer destructor was erected several years ago. The Council now have under consideration several schemes for a modern destructor and power plant, and it is likely that a large new plant will be erected in the near future.

INDIA.

Calcutta.

A four-cell Horsfall destructor was erected here in 1891. Ten years later the municipality issued a specification inviting schemes and tenders from British destructor makers, but the conditions embodied in the specification were such as to elicit but little response from destructor makers in this country. It was eventually arranged to make a trial of the Baker destructor, but as the installation has only recently been completed no information is yet available.

Bombay.

An experimentary destructor was erected some five years since by Messrs. Garlick & Christenson of this city, but the installation was not extended. The authorities decided to reclaim some low lying land at Coorla and Devnur, on the Great Indian Peninsular Railway, where the refuse or *kutchra* of Bombay is now taken by rail, at great expense to the municipality.

Karachi.

A six-cell Warner destructor has been erected in this city.

Madras.

A twelve-cell Warner destructor was erected here several years since, and more recently a small destructor of the Harrington type.

THE FAR EAST.

Singapore (Straits Settlements).

Two destructors have been erected here by Messrs. Garlick & Christenson of Bombay, a four-cell plant at Jalan Besar, and two cells at Tanjong Pagar.

Shanghai (China).

At present the whole of the refuse is removed by water, the bulk of the material being used for manurial purposes.

It is, however, anticipated that destructors will be installed within the next few years, and in view of this the following table, showing the component parts of Shanghai refuse for a whole year, will doubtless be of interest (see page 367).

TABLE FROM REPORT OF THE SHANGHAI MUNICIPAL COUNCIL FOR YEAR ENDING DECEMBER 31, 1899 (Mr. CHAS. MAYNE, ENGINEER AND SURVEYOR).

[1] Percentages by Weight of the Component parts of Shanghai Garbage for each month of the year, together with the Component Parts of Average London Garbage.

Component Parts.	Shanghai Garbage, 1899.												Average London Garbage.
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
Bricks and broken roof tiles	3·497	2·590	1·928	2·684	1·961	2·702	2·260	1·703	2·680	2·860	1·481	1·491	—
Cinders and ashes	27·338	31·257	30·530	27·544	17·167	21·697	12·841	12·224	11·303	10·213	9·972	8·330	69·69
Fine dust	45·285	40·791	42·409	40·798	37·204	43·789	47·630	35·588	31·790	34·511	35·050	32·785	19·51
Vegetable, animal, and various organic matter	13·776	14·750	14·304	17·551	34·121	18·092	23·785	37·745	45·925	44·006	45·552	50·098	4·61
Waste paper	·546	·564	·385	·419	·435	·569	·329	·220	·198	·242	·182	·212	4·28
Straw and fibrous material	8·102	8·694	9·251	9·667	8·094	11·822	11·973	9·380	7·283	7·100	6·749	5·916	3·22
Bottles, unbroken	—	—	—	—	—	—	—	—	—	—	—	—	·96
Coal and coke	—	—	—	—	—	—	—	—	—	—	—	—	·84
Tins	·538	·433	·292	·257	·259	·282	·227	·216	·122	·238	·179	·223	·79
Crockery	·386	·455	·494	·373	·277	·369	·282	·245	·181	·253	·215	·276	·55
Bones	·058	·056	·047	·069	·088	·088	·062	·063	·048	·055	·063	·065	·48
Broken glass	·078	·085	·079	·082	·074	·103	·122	·115	·075	·096	·088	·069	·47
Rags	·182	·141	·122	·172	·161	·222	·227	·182	·169	·178	·179	·196	·39
Iron	·062	·063	·051	·058	·052	·083	·076	·089	·052	·058	·076	·076	·21
Wood	·152	·121	·108	·146	·128	·182	·186	·230	·174	·190	·224	·263	—
	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·

Includes cabbage leaves, rinds of water-melon and pumpkin, khobar, feathers, dead cats and dogs, putrid meat, old shoes, fish and fowl entrails, fish heads and bones, refuse from the manufacture of beancakes and Chinese sauce (soy), etc.

[1] The above figures were arrived at by taking a sample cartload of garbage at random every day throughout the year, and the figures tabulated are a fair average.

Chapter XX

CONCLUDING REMARKS

The Destructor Chimney

WITH the introduction of forced draught and high temperature working it was at once evident that high chimneys would not be required. Firstly, because the use of artificial draught under the grates would permit of high rates of combustion being reached; and secondly, because the great increase in the combustion temperature ensured the discharge of inoffensive gases from the chimney.

Needless to add, the highest chimneys ever erected could not effect the same result as has been produced by means of the fan or steam jet blower, and it is no exaggeration to state that under modern conditions a high chimney is a waste of money. To erect a high chimney in connection with a good modern destructor is superfluous. Owing to the unnecessarily high velocity of the gases with such chimneys there is a constant danger of discharging dust, and so in many cases where the layman insists upon a high chimney being erected, he does his level best to produce that very nuisance which he is most anxious to avoid.

Fifteen years ago when the use of high chimneys was strongly advocated, nuisance was frequent, and fully as much annoyance was caused then by the discharge of dust as by the emission of offensive gases. A high chimney was at that time necessary for purposes of draught production; now ample draught is secured independently of the chimney. Offensive gases were then rightly discharged at a high altitude; now under high temperature conditions offensive gases are not liberated into the atmosphere.

The high velocity necessary under the old conditions is now no longer required; actual experience has dictated the necessity for ensuring a low velocity, both in the flues and the chimney, and it has been demonstrated again and again that under modern conditions low chimneys can be used, being absolutely void of offence either from escaping fumes or dust.

In modern practice it is found that a chimney of reasonable height having ample area fulfils all requirements, and many such chimneys have been erected amid such surroundings as permit of no nuisance whatever.

The reader will have noted in the tabulated information that in the case of some few towns high chimneys have been erected within recent years. In most cases the explanation will be found in the fact that coal-fired boilers are also in use. For instance, at a combined destructor and electricity works this is so, and it should not be forgotten that at a works of this kind the chimney has to be built of sufficient capacity to admit of additional coal fired boilers being installed as required over a number of years.

In other cases sentimental reasons explain why a high chimney was erected, and, as already observed, many of those who have clamoured for the high chimney will yet be disillusioned when they notice the presence of dust.

It is unnecessary to further discuss the chimney question here; the low chimney has been severely tested and has not been found wanting. It has come to stay, and in itself it furnishes most conclusive evidence as to the excellence of the modern destructor.

The Retention of Dust.

As the result of a month's test at Nelson, Mr. J. A. Priestley was able to show that the weight of the dust produced amounts to no less than 5 per cent. by weight of the actual quantity of refuse charged into the destructor cell, and it may be assumed that this is a fair average.

Being desirous of ascertaining exactly where the dust had been deposited and what proportions of the total quantity had been deposited at certain points, the destructor was cooled down at the end of a month's continuous run, the dust then being carefully removed and weighed. The result is seen in the following statement—

	Tons	cwt.	qr.
Fused dust from combustion chamber	17	11	0
Fused dust from bridge, and roof of furnace	3	13	2
Dust from centre flues of boiler	0	7	1
Dust from under boiler, i.e. flame bed	1	12	3
Dust from side flues of boiler	0	16	3
Dust from pit under regenerator	1	1	3
Dust from main flue	5	13	0
Total	30	16	0

These figures are of more than passing interest to the student, clearly showing as they do exactly where the dust was deposited. At Nelson the combustion chamber is placed at right angles to the cell as seen in fig. 24, and it should be observed that the proportion of dust removed from the cells and combustion chamber amounted to rather more than two-thirds of the total quantity. It should also be noted that this proportion was *fused*. This is an important point; dust will only thus fuse by exposure to constant high temperature, and fused dust is immovable, i.e. all dust deposited in such a position that it fuses cannot then travel further.

Ordinary dry dust accumulating at any point is constantly disturbed by the current of the gases, but once fuse the accumulation and it becomes stationary. The large proportion of dust deposited in the combustion chamber further serves to conclusively prove the efficiency of the combustion chamber as a dust catcher.

Assuming that no combustion chamber were provided, it must be obvious that a very large proportion of the dust would be deposited in the centre flues, side flues and flame bed of the boiler; the inevitable effect must be that the heating surface of the boiler would be covered, and in the result the steam raising efficiency of the plant would be seriously reduced.

It must be admitted that it is of great importance to secure the deposit of the bulk of the dust between the cells and the boiler, and not only for ensuring the efficient working of the boiler. There is another and a powerful reason why the deposit of dust should be definitely secured at an early stage in its travel: to do so is to limit the risk. A certain amount of dust must be produced; if two-thirds of the total quantity can be trapped immediately upon leaving the cell, the balance to be deposited is not a serious quantity, and it has a long way to travel before it can possibly escape.

In the foregoing statement it will be observed that only a very small proportion of the dust was deposited in the internal and external flues of the boiler, and further that over one ton of dust was deposited in the pit under the regenerator; this is so far satisfactory because only a comparatively small quantity remains for deposition in the main flue beyond.

Every system with which a combustion chamber is provided next to the cell offers a primary location for dust, and it is impossible to over-estimate the importance of this. It should, however, be borne in mind that the position of the combustion chamber in relation to the cell or cells is a factor of importance, in so far as the efficiency of the combustion chamber is concerned.

It is scarcely necessary to add that every destructor scheme should include definite means for securing the deposit of dust, and, as already observed, the *earlier* the dust is deposited the better. Under no circumstances may dust be permitted to escape from the chimney. However satisfactory a destructor may be in other respects, any discharge of dust is sufficiently serious to warrant the destructor being classed as a failure.

It has already been pointed out that a low velocity of travel of the gases in the chimney is a desideratum; this low velocity of travel is also of importance in the flues, and to ensure the same the flues must be of ample area. So much can be done in this simple way towards ensuring the deposit of dust that the method has been termed "the common sense method."

Dust traps in the flues have been frequently tried, but they are not often used in modern practice. We may define modern methods as follows: Firstly, the combustion chamber, which ensures the earliest possible deposit of dust; and secondly, dust catchers or special dust collection chambers arranged at the chimney end of the main flue.

That the dust catchers and collection chambers secure the deposit of dust will not be questioned; they are effective, and they answer the purpose for which they are erected. It must, however, be remembered that a large proportion of dust must be deposited on the destructor side of the dust catcher—that is, in the boiler flues and main flue. This, as already observed, is avoided with the early dust catcher—the combustion chamber—and therefore this system of dust trapping must be the more efficient of the two.

The position of Horsfall's centrifugal dust catcher is illustrated in fig. 87. It has been highly successful in arresting dust, and has been extensively adopted, but owing to its position it must be defined as a *late* dust catcher, being usually placed near to the chimney.

This dust catcher consists of an outer annular chamber and an inner well. The gases enter the outer chamber and swirl rapidly round it, thereby throwing off the suspended dust against the outer wall. The exit from the annular chamber is in the upper part, leading into the inner chamber or well. Here the gases have to pass downwards, and an outlet is provided near the bottom leading to the chimney. Cleaning doors are provided for removing the dust which accumulates in the pockets formed at the bottom of each chamber.

As remarked already, the escape of dust from the chimney must be fatal to the record of any destructor, no matter how satisfactory the plant may be in other respects. But it will be observed that in the case of a well-designed installation the discharge of dust can be absolutely prevented.

Automatic Checking Accessories.

In the case of a combined works it is advisable that every possible check should be introduced with a view to maintaining the efficiency of the destructor. Constant tests should be undertaken for the purpose of ascertaining how the temperature is maintained under normal working conditions; the data thus obtained will be found useful for determining the range of fluctuation, and having reduced this to the minimum it should not be allowed to seriously vary.

Seeing that so much depends upon the temperature, this is a matter of much importance; nevertheless, but little has yet been done in this direction.

The temperature diagrams herein reproduced were obtained with a Callendar's electrical recording pyrometer, and although the hot dust carried in suspension in the gases has proved to be troublesome by settling on the thermometer tube, yet very satisfactory results have been obtained with this instrument.

Another valuable accessory which has been more extensively adopted is the constant steam pressure recorder, a most useful appliance and one which is sure to be even more largely adopted in the future.

Every check of this kind upon the operations of the staff must be productive of good results. It is true that the working man possesses no great love for any mechanical contrivance which "tells tales," and no doubt the relentless pen leaving its impress on the chart is apt to be exasperating at times; but it affords a very necessary check upon the operation of the plant, and this is no more than those in authority are entitled to have.

A further important check is the periodical testing or analysis of the gases. The importance of this has already been fully discussed; it has also been remarked that with but few installations has conclusive proof been thus furnished that the combustion is perfect, or at any rate as near perfect as possible.

During the past few years, both in this country and on the Continent, the problem of combustion has been tackled in a more scientific manner than ever before, and it is now generally recognized that the efficiency of combustion must be determined by the percentage of CO_2 (carbon-dioxide) in the gases.

In connection with the combustion of coal, this test is becoming increasingly popular because it pays to secure the highest attainable efficiency. As it pays with coal so will it pay in the combustion of refuse, and it should not be forgotten that there are other reasons apart altogether from considerations of fuel efficiency why the combustion process with the destructor should be above suspicion.

My closing remarks shall be addressed to those who have to make the choice of a destructor. To such the Author would make a few suggestions.

It should be remembered that when destructor makers are tendering for the supply and erection of a destructor, each maker is offering his own specialty. It is not a case for comparison with the aid of the quantity surveyor as to the relative cubic capacity of the cells, the number of rods of brickwork, or tons of ironwork. The relative value of two entirely different destructors cannot be ascertained in this way.

Schemes and tenders can only be reasonably compared after careful scrutiny by one competent to analyse each scheme, and, needless to add, such work should be undertaken by the permanent official—the engineer and surveyor.

Obvious as this must be, yet the energetic councillor would often take upon himself the task of choosing between various schemes, and, frequently being devoid of technical knowledge, he is to a serious extent influenced by the price—a factor which, while being of some importance, very often offers the loophole for the selection of an experimentary plant.

Municipalities have no right to spend public money on experimentary installations. It is clearly the duty of a municipality to make close investigation and to ensure the best possible investment for the ratepayers. In the case of destructors it will have been observed by the reader that not only are there many types, greatly differing in design, but the difference in efficiency is often as marked as the difference in design. Again, there is a very wide difference in the labour cost, the area of ground necessary for erection, and the height of the chimney suggested.

In a paper[1] read at the Exeter Congress of the Royal Institute

[1] *Recent Practice in Refuse Disposal and Utilization Plants.* By Mr. Frank Watson, Royal Institute of Public Health, Exeter Congress, August, 1902.

of Public Health, last year, Mr. Frank Watson clearly stated the case for the destructor maker, and his remarks, which are here quoted *in extenso*, are worthy of careful perusal.

It must be borne in mind that when tenders are invited for refuse disposal plant each patentee is offering his own specialty; the conditions are, therefore, totally different from those which obtain when an engineer or architect issues a set of drawings and quantities for a building, or a sewer, or a new road. It may easily happen that the firm which asks the highest price is giving much greater proportionate value than the firm which asks the lowest, and that, if the lowest tender be accepted, the contractor will make a greater profit than would the contractor who sends in the highest tender, provided always that the contractor succeeds in fulfilling his guarantees and getting paid for his plant. It is a not uncommon error to suppose that the firm which offers the highest pecuniary penalty in case of failure is the most reliable. The inventor, however, is proverbially sanguine, and in attempting to introduce a new and untried scheme will usually agree to any conditions which may be proposed in order to get the scheme adopted, his faith in his own inventions being in inverse ratio to his experience of their results. Complicated mechanisms, designed to save labour, are frequently brought forward in connection with these plants. It should always be remembered that the conditions under which a destructor works are all against the success of mechanical arrangements situated within the furnace. Every appliance, whether for opening or closing doors, producing the necessary forced draught, or charging or clinkering the furnace, should be of the simplest and most direct character. An apparent economy is often entirely discounted by the cost of maintenance, and, what is still more serious, by the stoppage of the works during repairs.

So many destructors are now in operation in this country, under such a variety of conditions, that it is possible for most intending purchasers to inspect quite a number of installations working under conditions practically the same as will obtain in their own case. Such are the installations to inspect and critically compare. It is useless to attempt to get an adequate idea of what a two-cell plant would be by inspecting a ten-cell plant, nor is it reasonable to compare a plant erected fifteen years ago with one of a modern character.

It may be fairly submitted that the best modern destructors are highly satisfactory, that they may be erected in the most central positions without fear of nuisance, that they fulfil their primary object perfectly, and lastly, that a very useful amount of power can be produced. To utilize such power for the best interests of the community should be the aim of those in authority. Wherever the available power will yield the best return for the ratepayers there should it be utilized.

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