The Collection and Disposal of Municipal Waste

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TO THE AMERICAN MUNICIPALITIES

PREFACE.

THE subject of waste collection and disposal in American and Canadian municipalities has from the first been a perplexing and difficult problem of municipal administration. It has not been given the attention bestowed upon other branches of municipal service, but most cities have followed the primitive methods in use from the settlement of the country and along lines that are now proven too unsatisfactory and too insanitary to be continued.

There is an increasing demand that more economical and sanitary results be obtained in this class of work, and to secure these it seems to be necessary that improved methods be employed, larger sums of money spent, and that the plants be designed and operated under more scientific and expert supervision.

In this work the author presents, in as compact a form as possible, data gathered by him during nearly twenty-one years of continuous work along these lines, together with information collected from scattered reports, papers, and a great variety of other sources.

The purpose of the author is to give a slight historical sketch of the work in the North American communities from the time when the subject first assumed general importance, about 1885, down to the present time. It is also his purpose to present an account of the various methods of waste collection and disposal that are in use in this country, together with a comparison of the older with the more modern systems of collection and waste treatment. There is also a short account of the progress of the work of refuse disposal in other countries of the world, for which the author is indebted to Mr. W. Francis Goodrich, of London.

The author begs to acknowledge the assistance of Mr. C.

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The thanks of the author are tendered for the assistance of other gentlemen—Mr. Rudolph Hering, Mr. J. T. Fetherston, Mr. X. H. Goodenough, Mr. J. H. Gregory, Mr. F. K. Rhines and Mr. W. J. Springborn for reports upon work in their several localities.

It is hoped that this book may be of assistance to those interested in the subject, and perhaps help to solve some of the many problems connected with the collection of waste and its disposal in American communities.

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PART I.

THE MUNICIPAL WASTE OF AMERICAN TOWNS.

CHAPTER I.

The Present Conditions of Waste Collection and Disposal in American Communities.

The production of waste and effete matter is the penalty of living. Everything that enters into the life of the person which by assimilation sustains Nature, or becomes a part of his environment, is subject to change and the gradual process of decay, and must be removed, since its accumulation will inevitably produce annoyance, discomfort and insanitary conditions tending to shorten life.

If this be true of individual cases, it applies still more closely when individuals are gathered into families and communities and the larger associations of towns and cities; hence, the need for cleanliness, as applied to the whole body politic, becomes imperative for the common protection.

Taking the family as the unit of communal life, there was at first no trouble in the disposal of waste matters; as the community increased in numbers, the primitive methods of dealing with effete matter, used by the individual and the family, were extended and enlarged to meet the increased production. The garbage was fed to swine or dumped on the nearest vacant ground, into adjacent swamps or ravines, or thrown into the nearest stream or ocean bay. No particular care or oversight was exercised; none was at first thought to be needed, the chief purpose being to get the material out of sight, if possible out of mind, at the least cost and trouble.

Feeding to Swine.

In the rural districts and smaller towns, each family kept a pig, raised on the family swill and slaughtered at the approach of cold weather. As population increased this became objectionable, and the swill was often given away for the cost of removal, and afterwards sold to farmers as food for stock. As the municipalities became alive to the need for public collection and removal, they arranged with contractors for its regular collection, or allowed these to make private terms with the individual citizen. This was almost the universal custom in New England towns and is still the method there most commonly used. Up to 1884, Boston sold the whole of its swill collection for delivery by wagon and train to farmers in Massachusetts, New Hampshire and Vermont. With the exception of four years, 1890-94, Providence has always sold its garbage, as do Pawtucket, Fall River, Taunton, Brockton, Newton, Cambridge, Brookline, Somerville, Malden, Lynn, Lawrence, Salem, Haverhill, Chelsea, Lowell, Springfield, Holyoke, New Haven, New Britain, and many smaller places. Several of the Western cities—St. Paul, Denver, Omaha, Saginaw, Bay City, Superior, Cedar Rapids—continue this custom. The city of Worcester, Mass., maintains a municipal hog-farm, from which it derives a very considerable revenue. In 1903 the return from the sale of pork, pigs, tallow, etc., was $11,941. The cost of collection of garbage was $18,140. The appropriation from the city was $6,000, which represents the net cost of collection and disposal for the year.

This custom of feeding is advocated by some health officials as being economical, not more objectionable than some methods of reduction or cremation and capable of being carried on with profit, and very little or no nuisance, if proper attention be given to transportation and feeding. The cost at Providence for collection and removal of garbage has averaged, for thirteen years, 15½ cents per capita per annum. In other towns the profit from the sale of garbage or from the sale of swine fed by the contractor, reduces the cost of collection one-third to one-half.

But there are some drawbacks to this admittedly economical system. Milk from badly nourished cows fed on swill is poor in quality, often offensive to taste and smell, and is condemned by nearly every health authority. Garbage-fed pork is liable to trichinosis, as shown by the reports of the Massachusetts State Board of Health (1889) when thirteen per cent. of hogs fed on the public garbage of Boston were subject to this disease, a far larger proportion than is found in Western swine. The dumping of municipal garbage in large amounts on open ground for feeding is attended with consequences objectionable in the highest degree. No one who has been at these feeding grounds in hot weather, and seen the process, can say it is sanitary. The clouds of flies and insects, the multiplied streams of the lowest forms of animal life radiating from heaps of fermenting swill, the nauseating odors arising from the polluted, trampled ground, all unite to create nuisance. It has sometimes happened that epidemics of hog cholera have swept away the whole herd, entailing expense for their disposal and renewal.

The chief claim for this means of disposal is on the score of economy, since it appears to be almost the only way as yet devised by which a town can recover some return for the outlay for collection and disposal. The foremost advocate of this method, after stating the arguments for and against the practice, says, "By this attempt to minimize the evil of the disposal of garbage by feeding to swine, the writer does not intend to maintain that it is a desirable method, and would simply venture the opinion that, under certain conditions, it is not a very bad method."

The smaller cities are not alone in this way of treatment. The large hotels and restaurants of New York City sell their garbage to private parties as food for stock. The collection is made, under permit from the Health Department, in barrels conveyed in large covered water-tight wagons, an empty barrel being left to take the place of each full one removed. All collections are made at night or in the early morning hours. The swill is emptied into large kettles, where it is cooked for twenty-four hours, or until the return of the wagons on the following day. The grease rising to the top is skimmed off, pressed, and run into barrels for sale, the remaining contents being fed to pigs or cattle, mixed for the latter with hay or bran. This cooking is essential to fit the swill for feeding. Formerly, the high price of grease yielded a profit from this source alone, but at 2½ cents per pound it is claimed that the grease product fails to pay the cost of the coal burned. The quantity of garbage thus treated is estimated at 30,000 tons per year.

THE INDIVIDUAL METHOD OF DISPOSAL.

Those who pay any attention to the subject are familiar with garbage dumps in all stages of beginning, growth and completion, since there is no release from the ever present evil. In the early days of any town, the vacant lots in the suburbs are garnished with all sorts of refuse matter, until some strong objection is made by the property owner. As the town grows, this refuse is consolidated at convenient points where low ground offers an excuse or roads need to be raised in grade. The dumps then include putrescible matter which under the hot sun of summer gives out noxious odors. A ravine or valley on the line of a small stream becomes a favorite place of deposit, or ground excavated for sand, clay, gravel or stone offers a favorable point because a large quantity can be disposed of in a small area. The cartmen, being under no restriction, select the nearest place to dump their loads, where there is least trouble or objection. Sometimes ashes or earth covers the surface, but as it is nobody's business to see that the dumps are kept covered, nobody cares much for the consequences.

THE LICENSE SYSTEM.

Under pressure of complaints and with an increasing knowledge of better sanitary conditions, the town authorities regulate the dumping of putrescible matters, place the service under inspection of the Health Department, and license certain cartmen to collect and remove the waste. It is usually made obligatory to employ these men, the cost of the work being paid by the individual householder according to the objectionable character of the waste, the quantity, and the distance it must be hauled for dumping. As the population increases, the expenses rise. If there are no sewers, the night-soil collection and removal adds to the burden. Those who are ready and willing to encourage civic cleanliness are, in a sense, compelled to pay for the whole, for many refuse to avail themselves of a service which should be employed by all. The dumps are often a serious interference with the rights of adjoining property holders, and further removal from the town entails more cost for service and inspection. The number of collectors increases, it is difficult to establish and maintain a satisfactory standard for equipment of carts and apparatus, and as the town continues to grow, this service becomes unwieldly and unsatisfactory.

THE CONTRACT SYSTEM.

Succeeding the system by licensed collectors comes the method of collection and disposal of city wastes by contract for a specific term. This may include the whole or a part of the waste; usually it includes the garbage only, leaving the ashes and rubbish to be dealt with by the licensed men or by private contract.

The service is performed daily, or every other day, for the thickly settled part of the town, and bi-weekly for the remainder. The contract provides for a standard equipment of carts, to be kept clean, the collection to be made without nuisance, the disposal to be at places designated, or by satisfactory apparatus.

The contract system is the most convenient way for the authorities, but less efficient than the municipal service. Under stress of competition, the contractor is often compelled to work for a small margin of profit, yielding poor service and giving rise to complaints. There is, in fact, but a limited responsibility, the contractor seeking to do the least possible work for the greatest payment. But this is often the only way the work can be done, and when performed under vigilant inspection and rigid enforcement of terms of contract, fairly good service can be secured.

THE MUNICIPAL SYSTEM.

In this case the town does all the work with its own equipment and employees. The preliminary expenses are large, but the force can often be used for other municipal work, dividing the cost. The responsibility for cleanly work is better defined, complaints are more promptly attended to, and with good executive officers the employees can be brought to take pride in their work and give the most efficient service. While most of the larger cities and towns have municipal service, and many smaller ones the contract or licensed methods, the greater number of places still use the primitive ways of treating waste. There is no rule of general application to methods of waste collection, but there is an evident preference for the municipal system if it can be had at not too great a cost. One eminent authority says: "There appears to be a well-nigh unanimous demand on the part of health officers, and oftentimes of the public generally, for the municipal collection of garbage." If municipal ownership be of advantage in other civic departments, it certainly should be in this, so intimately connected as it is with the health and comfort of the public.

TIPPING INTO WATER.

Towns on the seaboard, that could conveniently do so, formerly dumped everything overboard, regardless of consequences. New York City for many years sent outside the harbor thousands of tons of waste which ultimately floated to neighboring shores and gave rise to endless complaints. This was stopped, in part, by Col. G. E. Waring, and of late has wholly ceased, except when the work of disposal is interrupted by fires, or other accidents at the reduction plant. The garbage is now reduced at the Barren Island plant of the Sanitary Reduction Company, the ashes and street sweepings deposited behind bulkheads at Riker's Island and the rubbish partly sorted out and burned and partly dumped with the ashes. With few exceptions, all the northern seaboard towns now deal with their wastes on their own land. But Newport and Lynn send their garbage to sea, and Boston annually deposits outside its harbor 122,000 loads of ashes and street sweepings.

Many of the inland cities on the great rivers continue to use the primitive method of stream dumping. A report made by the Health Commissioner of a Western city, some years ago, gave figures of startling magnitude. According to this "eight cities dumped into the Mississippi River, 152,675 tons of garbage, manure and offal, 108,250 tons of night-soil and 3,765 animals. Four cities on the Missouri River discharged 36,110 tons of garbage, 22,400 tons of night-soil and 31,160 dead animals. Five cities on the Ohio River dumped 46,700 tons of garbage, 21,150 tons of night-soil and 5,100 dead animals."

The present situation on the great rivers is somewhat improved, but St. Louis still continues to dump annually 179,000 loads of rubbish and street dirt into the river; while many towns use the Mississippi and Missouri rivers as a common receptacle for all wastes. New Orleans discharges all its waste into the river, but there are no cities below it to receive the doubtful benefit of this proceeding.

The General Government has published a digest of the laws*

*Department of the Interior, U. S. Geological Survey; Water Supply No. 152, 1905.

forbidding the pollution of inland waters, which may be studied with advantage. The book is a comprehensive review of all State laws on the subject, with citation of cases and authorities. The principles laid down are briefly:

a. No riparian owner of a stream may appropriate all the water that comes to him, neither may he so corrupt or pollute it as to injure the other owners by diminishing the value of their property in the natural stream.

b. Whenever the pollution of a stream or other body of water injuriously affects the health, or materially interferes with the peace and comfort of a large and indefinite number of people in the neighborhood, such pollution becomes what is known as a public nuisance. . . . When there is a public nuisance caused by the pollution of water, it is the duty of public authorities to cause its abatement, and their right to do so has been sustained in numerous cases.

c. Where municipalities are expressly authorized by statute to construct a system of sewerage, and to cause the sewage matter to be discharged into any particular waters, the statutory authority is to be so exercised, subject to the implied condition that such discharge will not constitute a nuisance.

d. Speaking generally, jurisdiction over the pollution of waters in the United States is confined to the several States, except so far as such powers are restricted by the National Constitution or expressly delegated thereby to the General Government.

Statistics of Garbage Collection and Disposal.

Several attempts have been made to collect statistics on waste collection and disposal, but all have met with very indifferent success. The records of most American towns on this subject are incomplete and badly kept. No standard of measurement is taken for a basis, the vague report of so many cartloads being usually considered sufficient; there are few reports of cart capacity and no knowledge of the average weights at different seasons of the year; the weights and volume of different classes of waste are not separately tabulated. The percentage of moisture in garbage, of unburned coal in ashes, of salable paper and rags in refuse, and of the proportion of manure in street sweepings—all these points must be arrived at by comparison with the returns and reports from one or two large cities. Manifestly conditions and surroundings in different places vary widely, and each individual place should have its own system of records, with a basis for measurement common to all.

In 1902 an inquiry was made by Messrs. Winslow & Hansen, of the Massachusetts Institute of Technology, into the general facts of garbage collection and disposal in 161 representative cities of the United States. These range in population from 28,000 up to the largest, situate in all parts of the country, and include the most progressive and active as well as some of the least enterprising. The reports include the figures for collection service separated from other matters, as follows:

Methods of Garbage Collection	*Number of Cities.*
Municipal Collection System	54
Contract Collection System	48
Private Parties	41
No Systematic Collection	12
Not Reported	6
Total	161

It is understood that the term "private parties" includes the collection by the individual and license system, as opposed to contract and municipal methods. The statement in the paper of the authors is that out of 155 places twenty-nine have no systematic method; in 146 places reporting on collection method, sixty-one adopt the municipal plan, and in eighty-five the work is done by contractors. Almost universally, the ashes are dumped on low ground or used for filling, but in a few cases they are dumped, in whole or in part, into the nearest water. Rubbish is dumped with ashes in seventy-four places, burned on the ground in twenty-six, cremated in furnaces or utilized in nineteen, and thrown into water in six. The means of garbage disposal are thus stated:

Dumping on land	44
Burning in dumps	9
Dumping in water	14
Plowing into ground	18
Feeding to stock	41
Cremation in furnaces	27
Reduction or utilization	19
Irregular disposition	11

NOTE.—In several places different methods are used in different parts of the same city. Thus, in Boston 49,000 tons are delivered to a reduction company and 15,000 are taken away by contractors and presumably fed to swine or dumped with ashes and refuse on land.

It would appear, from this report, that the primitive methods are still the most popular; as out of 161 places only 102, or 63 per cent., have any systematic methods for collection, and out of 147 reporting on methods of disposal only forty-six, or less than one-third, have any improved methods of final disposition.

If this be true of 161 places of the best class, it is still more significant when towns smaller in population and of less enterprise in sanitary science are considered.

Mr. M. N. Baker, in the *Municipal Year Book* for 1902, says: "The stubbornness with which most American communities cling to primitive and unsanitary methods of garbage disposal is shown by the fact that only ninety-seven of the 1,524 cities and towns included in the Year Book have reported either garbage cremation or reduction plants."

That is to say, only 6.3 per cent. of the towns of the United States, having a population of 3,000 and upwards, have in fifteen years made any real progress on the lines of enlightened and scientific disposition of the communal wastes. This is not a very encouraging result for the expenditure of time, energy and money in this work, but still it represents progress which, though small in itself, will serve to indicate what will be the future of the work now fairly under way.

INSANITARY CONDITIONS PRODUCED BY DUMPING.

The deposit of organic matter in thin layers upon ground fully exposed to the salutary influences of light and air is far more sanitary than when the putrescible waste is buried in mass. Decomposition in the open air proceeds rapidly by the propagation of aërobic bacteria which, assisted by the absorbent action of the earth, resolve the compounds into simpler forms, while the disengaged gases are oxidized by the air.

But when deposited in masses and covered, the chemical changes are produced by anærobic organisms only, the released gases are greater in volume with intensely disagreeable odors, and these find exit through the adjacent soil. Even when mixed with ashes the putrescible matter is not rapidly changed, but continues in a putrefactive state for long periods. Many instances are reported of the presence of organic matter in offensive and dangerous forms, though years have passed since its deposit.

When ground made by such methods is covered by buildings, the health of the occupants is endangered. The statement made to the writer by the Health Commissioner of one of our large cities was that the continued presence of cases of diphtheria and scarlet fever in houses standing on ground filled with waste was undoubtedly due to the insanitary conditions of the foundations. These diseases followed the line of previous waste dumping, while adjoining dwellings on original ground were comparatively free.

Dr. Ezra Hunt, of the State Board of Health of New Jersey, says:

"Whole groups of zymotic diseases are traceable to ground conditions. When, as in some parts, soils are composed of an accumulation of decaying matters or of foul material removed from the streets, the building of houses over it may conceal but cannot destroy the contamination. More or less of the foul air must find its way out of the soil and endanger the health of the people living upon it."

It is stated by some eminent medical men that the continued tipping of refuse near South American cities largely accounts for the yellow fever scourge. That this standing menace to health is now becoming understood is evidenced by the fact that one of the largest South American cities is seeking for means to dispose of 400,000 cubic yards of refuse, the accumulation of centuries, deposited in the immediate vicinity of the city.

It may be said that there is a general consensus of opinion, all over the world, that this practice of tipping organic waste and putrescible matter of any sort upon land or into small bodies of water, objectionable and filthy in itself and productive of nuisance and obnoxious conditions, will, if continued, cause the inception of certain classes of disease which otherwise would be avoided.

There is an æsthetic side to the question that should be considered—the continued presence of these unsightly heaps of refuse matter on the outskirts of towns is not agreeable to the sight of residents or prospective citizens. Though care be taken to keep dumps covered, there are always floating paper, straw, litter and light particles scattered by the wind that cannot be controlled, and too often the bases of these heaps terminate in stagnant water, formed by the rains percolating through the mass.

One Health Commissioner says:

"Hauling of garbage to the dump pile is certainly not garbage disposal, but only the removal of filth from one locality to another. The germs of deadly diseases are deposited on the dump piles coming from the ash barrels of infected houses, and are in turn carried by flies, mosquitoes, cats, rats and dogs and by the wind into the homes of our people who are thus made ill, and not infrequently death ensues from such out-of-date, outrageous practice. Such methods are not in keeping with the teaching of the progressive spirit of to-day, or in harmony with claims our city would want to assume. The public dumps are made the receptacle of old mattresses, rags and filth of every description; they are unsightly, unsanitary and discreditable. The present dilemma can be met with more carts and more active service, but the final solution, according to present lights, must lie in the cremation of all garbage."

REFUSE SORTING AT THE DUMPS.

When municipal and private waste taken to dumps contains anything that can be recovered and sold, it is picked out and taken to market. As a rule, the trash collection will have paper of many kinds, books, cardboard, rags, carpets, bagging, clothes, shoes, bottles, iron, and a host of miscellaneous articles of no service to the original owner, but of some small value when brought together in quantities. When this mixed mass is tipped at the edge of the dump it is pulled apart and sorted by men, often by women and children, who make this their livelihood.

The recovered things, covered with dirt and dust, often saturated with filth, in the last stages of decay or usefulness, are thrown into heaps until enough accumulate for a cartload. The dry paper is roughly baled on the spot; the wet rags and paper are exposed to sun and air for drying; the clothing, bottles, iron, etc., are conveyed back to the town and again sorted and sold for junk. This is done in almost every place where there is a licensed or contract collection service, and many towns having municipal service permit it on condition that the dumps are kept leveled off without expense to the town.

The system has to recommend it only the fact that many poor people get a precarious living, and that contractors recover enough of value to enable them to do the collection work cheaper than they otherwise could. Some large cities sell the rights for picking, and some positively prohibit all sorting, but most pay no attention to the custom and allow its continuance unless complaints be made by adjoining property holders.

The recovery of these articles, as usually carried out, is objectionable for several reasons. It is not sanitary, as all persons connected with it are necessarily exposed to dust, dirt and possible infection from contaminated matters. The recovered portions again handled in sorting and baling, are in too filthy a condition to be returned to the town. The practice increases the nuisance of the dump, and is a frequent source of complaints. The refuse is not finally disposed of or rendered inoffensive, but becomes subject to further inspection and possible expense.

This recovery of the marketable constituents of refuse, if done at all, should be under municipal oversight and regulation, and the articles saved—the property of the town—should be credited to it as an asset against the expense of the collection service. The agency by which this work can be done in a sanitary and profitable way will be considered later.

The method of waste disposal at dumps has been the subject of many reports by the various health and sanitary associations, the State associations of the Health Officers, the civic improvement leagues and the clubs and societies for the betterment of municipal conditions and all, without exception, condemn the method as usually practiced, and in many instances cite particular cases where epidemics of diseases are traced directly to the presence of these piles of decaying matter.

When in some cases this means of disposal seems to be the only practicable one, a stricter oversight of the collections and more attention to the final processes at the dumps will do much to mitigate the evil consequences.

This question is now discussed with greater interest since the latest reports showing that the common house fly, which finds its best breeding places in these piles of waste, can carry the bacteria of some forms of zymotic diseases for long distances.

CHAPTER II.

The Classification of Municipal Waste.

Terminology: The Need of Definite Terms.—There is need of a better defined vocabulary of specific terms for use in discussing this subject, as the words and phrases now employed for the purpose frequently have different meanings in different places or when used by different writers.

The American Public Health Association defines the various classes of municipal waste as follows:

ORGANIC.

Garbage.........	The rejected food wastes.
Night-soil........	The contents of vaults and cesspools.
Sewage..........	Water-conveyed excreta.
Offal............	The refuse from slaughter houses, and animal substances only.

INORGANIC.

Ashes...........	Household, steam and factory
Refuse	Combustible articles from all sources; also glass, iron, crockery, house sweepings and generally everything from the house not included in garbage and ashes.
Street sweepings	Compounded of organic and inorganic substances.

This classification is accurate and comprehensive, but it is extended, and should be condensed for general use. Nearly every writer uses terms for defining particular items that are applicable to others quite dissimilar in nature. Some invent new words and phrases that befog the subject-matter. In describing apparatus and machinery there is frequently a conflict of technical terms which are not common to all, and in reckoning quantities there is the same uncertainty for lack of a definite standard of measurement. This confusion in nomenclature is largely due to the fact that waste disposal by modern methods is a comparatively new subject, with a very limited literature in this country, and with foreign terms and precedents not always applicable to our conditions. The terms employed by the author are those established by the American Public Health Association, with such modifications as are suggested by the conditions attending practical use.

In Great Britain the general term "towns' refuse"—sometimes called "dust"—is applied to the whole miscellaneous waste collection of the town. It includes animal and vegetable matter ("soft core"), ashes, breeze (cinders mixed with unburned coal), bones, rags, paper, glass, iron, metals, crockery ("hard core") dust and dirt. This is placed, at the house, in a general receptacle called the ashbin, and taken from there in a mixed condition for final disposal. Where there is no sewerage system, the excreta are received by the earth-closet, pail or pan method, and treated and disposed of apart from other refuse.

The American term "municipal waste" is held to include the whole miscellaneous city collection of rejected foods, rubbish, ashes and street sweepings. But there is here a further subdivision of wastes, and a separate collection of each which has brought specific terms into use.

"Garbage" means the animal and vegetable matters removed from houses, stores, and markets. It does not include dead animals, night-soil, slaughter-house offal, street sweepings, ashes or cinders, or anything but organic household waste subject to rapid decay.

This term is subject to modification in various places, as in New England, where "swill," meaning rejected foods only, is used instead of "garbage." In Philadelphia it is known as "slop." In some places it is called "offal," and in the South and some parts of the West "garbage" includes rubbish or refuse, but not ashes.

Definition of Garbage.—Where reduction methods are employed, garbage is more strictly defined. In New York City it means "refuse of an organic nature consisting of swill, every accumulation that attends the preparation, decay, dealing in, storage of, meats, fish, fowls, birds or vegetables, including all food wastes, and not including street sweepings—and not containing more than 5 per centum by weight of other refuse." Buffalo defines it as "all kitchen or table waste of an animal or vegetable nature, vegetables, fish, meat, bones, fat and all offal, carrion and general kitchen refuse, as clear of ashes and rubbish as it is possible to keep same." The Chicago definition is, "any and all rejected, abandoned or discarded waste of household, vegetable or animal food, offal and swill." In Washington it is "the refuse of animal or vegetable matter which has been used or intended for food."

The word "garbage" is used in places where a clear distinction is required as to the character of the organic waste, and as now commonly used, the word is limited to rejected food waste in all its forms, and will be so employed by the author in referring to waste.

In some sections of the country waste is not separated except by excluding ashes. Indianapolis provides that the word garbage shall be taken to mean all organic household waste, offal, animal or vegetable matter, such as has been prepared for or intended to serve as food, and in addition shall be construed to mean other industrial refuse, such as paper, cans, bottles, discarded tin ware, iron, and other similar material, excepting ashes, household sweepings and sweepings from stores, business houses and apartments. Though this wording is doubtful, it is assumed that sweepings and ashes are removed separately.

"Refuse" includes all combustible matters like wood, paper, straw, rags, mattresses, broken furniture, house sweepings, discarded clothing of all kinds; also glass, iron, tin cans, crockery, and the miscellaneous collection not comprised under garbage, ashes or street sweepings.

"Ashes" includes the household ashes from all varieties of coal and wood, but not steam or factory ashes from boilers or the large furnaces in hotels and trade and manufacturing establishments.

"Excreta." When there are no sewers, the night-soil contained in vaults and cesspools must for sanitary reasons be removed periodically. This is usually done by the license method, the contractor for the work providing a suitable excavating apparatus, and sealed tanks or barrels for transportation. The cost of removal is paid by the property owner under a sliding scale of charges fixed by the town, and disposal is usually made outside the city limits by dumping or burying, sometimes by composting.

The final disposition of this very dangerous matter should be under the strict superintendence and frequent inspection of town health officers, and should not be left to the convenience or caprice of the contractor.

Too often its insanitary disposal on ground draining into the water supply of the town has been accompanied by disastrous epidemics of typhoid fever, as witnessed by the outbreaks of this disease at Plymouth and Butler, Pa.; Ithaca, N. Y., and Columbus, Ohio.

Excreta are sometimes composted with earth or manures, and many attempts have been made to manufacture a commercial product called "Poudrette" by a process of drying the excreta and mixing with marl and other substances, but the offensive character of the material, together with its uncertain value in comparison with other fertilizers of standard composition, has made the method unprofitable.

In one or two places where the collection of night-soil is done under the direct charge of the town, the large returns received have paid for the cost and left a surplus to apply to the general expense of other waste collection.

Night-soil can be disposed of by fire in specially constructed furnaces, and many thousands of barrels of this waste have been and are now thus destroyed annually. The removal of excreta by a sewerage system is a separate department of municipal work, independent of the disposal of other wastes.

The statistics of collection and disposal of night-soil are reported from 36 cities by Prof. A. Prescott Folwell, secretary of the American Society of Municipal Improvements, in the *Municipal Journal and Engineer,* of New York, July 1, 1908. This information was obtained for the benefit of the members of the society and includes reports from eight cities of the first class, six of the second, seventeen of the third, and five of the fourth class, and is condensed in the table following:

The amount of night-soil removed depends entirely upon local conditions and the sewerage systems in each place. In this table the yearly quantities vary from 3,000 barrels in one place to 492,000 barrels from another city. The expense of removal is almost invariably a charge upon the property owner, the frequency of removal depending upon conditions, usually once a year and within certain months. The cost is usually fixed by ordinance, and varies from 33½ cents to 75 cents per barrel of from 36 to

TABLE I.—NIGHT SOIL COLLECTION AND DISPOSAL.

Cities	Collection					Disposition					Expense Borne By		If Considered Satisfactory				Control of Removal		
	Methods			Apparatus															
	By City Teams	By Licensed Men	By Sanitary Co.	By Pumping	By Barrels, Tanks and Wagons	Sewers	Tipping Into Water	Plowing into Ground	Earth Burial	Used for Fertilizers	Owners of Property	Householders	Yes	No	Fairly Good; Best That Can be Done	Doubtful	City Officers	Boards of Health	None
1st class.......... 8																			
2d " 6																			
3d " 17																			
4th " 5																			
................36	2	28	5	4	30	5	2	4	11	12	29	2	16	3	12	5	16	16	1
No reports..........	....	....	1	....	2	....	....	....	....	2	....	5	....	....	....	....	....	....	3

45 gallons. When no regulations are made as to cost, the contractor makes his own agreement. The control of the vault cleaning service is under inspection of the city officers or boards of health. The final disposition, if outside the city limits, receives but limited attention, unless complaints are made by adjoining townships.

"Dead Animals and Offal." In nearly every one of the larger towns the carcasses of larger animals, such as horses, cattle, swine and sheep, are taken by private parties who conduct rendering works which are not directly under the control of the town except as concerning the sanitary operation of the plant. A payment is usually made by the town, or by the owner of the dead animal, for its removal by the rendering company in a special wagon built for the purpose.

By various processes the carcasses are converted into many forms of commercial articles or substances which afford a revenue. Smaller animals, such as dogs, cats, rats, etc., are not usually thus treated. They go with the ashes to the dumps or with the night-soil for burial. Where crematory furnaces are installed, these carcasses are burned with the waste, and where there are no rendering plants the carcasses of the larger animals are also easily disposed of in this manner. Sometimes the collection and disposal of large dead animals is a part of the general contract for disposal of garbage, but it is usually a separate contract.

Condemned animal food, market and butcher shop offal, and all miscellaneous animal refuse are also disposed of by the private rendering companies without cost to the town. Generally every remnant of animal life can be utilized in one form or another by various economical means.

"Street Sweepings," while included under the general term of municipal waste, are not in usual practice collected or disposed of except by the town itself, separately from the other wastes, and they are not included in the contracts for collection and disposal of household wastes.

Trade and Industrial Wastes.—There are many kinds of trade and industrial wastes which are not generally included in municipal disposal work, but which are still under control of the town and are sometimes provided for by its agency.

When small in amount and organic in character, requiring frequent removal, the town sometimes comes to the aid of the factory, or the merchant, and makes disposal of the waste by its own means, for a fixed sum. When, however, the weight or volume of the waste is large, and the material is of inorganic character, means are often provided by the town for its transportation and final disposition by enlarging its own equipment, and it then receives payment *pro rata* for the quantity handled. In such cases the cost of the work is a matter of private agreement, the town performing its duty by publicly assisting a private enterprise for the common good of the community. But the point at which municipal control ceases and private responsibility begins is uncertain and indefinite and the fruitful source of much trouble.

In some localities the right to have waste removed by the town is determined by the number of persons or families in the building or buildings; or again, the volume of waste must not be over a stated amount; or only certain kinds of waste, strictly defined, may be removed. Manifestly, for a town to favor a private individual or corporation, by the removal and disposal of private refuse without a return of some sort, is an injustice to the rest of the community, and an exercise of arbitrary power which should not be permitted.

As a rule, all classes of private trade and industrial waste, and household waste of all kinds above a certain fixed quantity, must be removed and disposed of at the cost and risk of the parties concerned, and not through the agency of the town, unless payment be made of the cost of the work so performed. But the town is expected to furnish ground for dumping, or other satisfactory means for the disposal of all waste, when collection is made by private agency.

QUANTITIES AND PROPORTIONS OF WASTE.

It has been very difficult to give accurate data determining the quantities of waste materials from American towns. Until the last three years there has been little attention paid to the tabulation of amounts, and hardly any effort made to fix the relative proportions of each class or give the seasonal variations. But the investigations lately made by commissions and engineers in some of the larger cities have shown the value of accurate details in this direction, and by their assistance the towns are better able to say exactly with what amounts they are dealing, and to govern their costs of collection and disposal accordingly.

The study of this question, in respect to amounts and proportions, made in New York by the commission appointed by Mayor

TABLE II.—AREAS AND POPULATIONS OF THE FIVE BOROUGHS OF NEW YORK CITY.

Boroughs	Area in Square Miles	Population†		
		1904	1905	1906
Manhattan	22.00	2,060,041	2,112,528	2,165,015
The Bronx	40.50	301,161	326,324	351,487
Brooklyn	77.50	1,349,129	1,394,766	1,440,403
Queens	130.00	199,359	210,949	222,539
Richmond	57.25	74,969	76,956	78,943
Greater New York	327.25	3,984,659	4,121,523	4.258,387

†Calculated from United States Census of 1900, using same rate of increase as between 1890 and 1900.

TABLE III.—QUANTITIES BY CART LOAD, NEW YORK CITY.

	Total Refuse		
	1904	1905	1906
Manhattan: Number of cart loads	1,928,946	1,998,820	2,130,646
The Bronx: Number of cart loads	163,170	178,529	182,640
Brooklyn: Number of cart loads	714 995	740,755	738,058
Queens: Number of cart loads	....	89,756	125,122
Richmond: Number of cart loads	....	64,400	72,979
New York City	....	3,072,260	3,249 445

TABLE IV.—QUANTITIES BY VOLUME, NEW YORK CITY.

	Total Refuse		
	1904	1905	1906
Manhattan: Volume in cubic yards	5,009,179	5 010 607	5,422,643
The Bronx: Volume in cubic yards	405,424	435,453	452,439
Brooklyn: Volume in cubic yards	1,930,082	2,081,200	2,059,188
Queens: Volume in cubic yards	....	215,711	315,909
Richmond: Volume in cubic yards	....	96,600	109,469
New York City	....	7,839,571	8,359,648

George B. McClellan, consisting of Messrs. H. De B. Parsons, Rudolph Hering and Samuel Whinery, engineers of high standing and practical acquaintance with the subject, is undoubtedly the most comprehensive yet published.

The report made by these gentlemen deals with the quantities and proportions of waste in the five boroughs of Greater New York for a period of three years.

TABLE V.—QUANTITIES BY WEIGHT, NEW YORK CITY.

		Total Refuse		
		1904	1905	1906
Manhattan:	Weight in tons.........	1,933,982	2,021,500	2,146,453
The Bronx:	Weight in tons.	165,529	181,861	185,297
Brooklyn:	Weight in tons.........	629,144	648,169	645,925
Queens:	Weight in tons.........	....	83,823	115,964
Richmond:	Weight in tons.........	....	60,656	65,543
New York City................			2,996.009	3,159,182

TABLE VI.—AVERAGE WEIGHTS OF REFUSE, NEW YORK CITY.

Kinds of Refuse	*Manhattan and The Bronx	*Brooklyn	Queens	*Richmond
Average weight per cart load in lbs.:				
Garbage..................	2,037	†2,037	......	1,398
Ashes....................	2,172	1,950	......	1,800
Rubbish..................	1,050	1,126	......	300
Street sweepings...........	2,032	1,538	......	2,700
Average cubic yards per cart load:				
Garbage..................	1.85	†1.85	......	1.50
Ashes....................	2.00	2.00	......	1.50
Rubbish..................	7.31	7.31	......	1.50
Street sweepings...........	2 00	2.00	......	1.50
Average weight per cu. yd., lbs.:				
Garbage..................	1,110	†1,100	......	932
Ashes....................	1,086	975	......	1,200
Rubbish..................	143	154	......	200
Street sweepings...........	1,016	769	......	1,800
Average weight per cu. yd., tons:				
Garbage..................	0.550	†0.550	......	0.466
Ashes....................	0.543	0.488	......	0.600
Rubbish..................	0.072	0.077	......	0.100
Street sweepings...........	0.508	0.385	......	0.900

*From measurements.
†No figures given; taken the same as Manhattan and The Bronx.

TABLE VII.—WEIGHT OF REFUSE PER CAPITA IN POUNDS, BY BOROUGHS, NEW YORK CITY.

	Garbage	Ashes	'Rubbish	Street Sweepings	Total Refuse
Manhattan	217	1,327	108	330	1,982
The Bronx	119	708	51	176	1,054
Brooklyn	145	496	88	168	897
Queens	192	544	61	245	1,042
Richmond	256	561	40	804	1,661
New York City	184	940	93	267	1,484

TABLE VIII.—PER CAPITA AVERAGES OF YEARS 1904, 1905 AND 1906, NEW YORK CITY.

	Garbage	Ashes	Rubbish	Street Sweepings	Total Refuse
....	181	936	93	260	1,470

To carry these reports still further and determine the composition of the several parts of the waste, and the seasonal variations, the tables made by Mr. J. T. Fetherston, of the West New Brighton District, Borough of Richmond, are added:

TABLE IX.—COMPOSITION OF HOUSEHOLD REFUSE BY WEIGHT, DISTRICT OF WEST NEW BRIGHTON.

Month	From Mechanical Analysis									
							Garbage			
	Ashes and rubbish Percentage	Garbage Percentage	Fine ash Percentage	Clinker Percentage	Glass, Metal, etc. Percentage	Coal and Cinders Percentage	Vegetable Percentage	Animal Percentage	Free Water Percentage	Rubbish Percentage
1906										
January	83.5	16.5	40.5	1.4	3.1	34.7	14.3	0.6	0.7	4.7
February	87.6	12.4	40.3	1.3	3.4	38.3	10.9	0.4	0.3	5.1
March	86.0	14.0	42.6	1.2	3.1	35.5	12.2	0.5	0.6	4.3
April	79.3	20.7	40.8	1.0	3.2	31.5	17.9	0.8	0.8	4.0
May	78.7	21.3	37.7	0.6	5.7	31.8	18.7	0.7	0.7	4.1
June	71.9	28.1	30.7	11.1	8.4	16.2	24.4	1.0	1.4	6.8
July	58.3	41.7	23.8	0.8	9.0	12.6	36.3	1.6	1.7	14.2
August	54.3	45.7	20.0	0.5	10.9	9.0	39.7	1.7	2.0	16.2
September	50.5	49.1	21.7	0.6	8.5	7.7	42.5	1.9	2.2	14.9
1905										
October	60.1	39.9	29.0	3.5	6.6	15.2	30.9	3.1	1.5	10.2
November	71.4	28.6	31.8	0.7	5.2	30.8	22.6	1.8	1.0	6.1
December	76.6	23.4	34.4	0.9	3.1	34.6	19.6	1.1	0.8	5.5
Averages	73.3	26.7	34.7	1.8	4.8	26.7	22.6	1.2	1.1	7.1

TABLE X.—HOUSEHOLD REFUSE AS COLLECTED, WEST NEW BRIGHTON DISTRICT. POPULATION, 1907, 25,900.

Month	Ashes and Rubbish						Garbage						Total Collection			
	Volume			Weight			Volume			Weight			Volume		Weight	
	Cubic Yards	Percentage of 12 Months' Collection	Percentage of Total Monthly Collection	Tons	Percentage of 12 Months'	Percentage of Total Monthly Collection	Cubic Yards	Percentage of 12 Months' Collection	Percentage of Total Monthly Collection	Tons	Percentage of 12 Months' Collection	Percentage of Total Monthly Collection	Cubic Yards	Percentage of 12 Months' Collection	Tons	Percentage of 12 Montns' Collection
1906																
January	2,014	9.3	83.1	962.9	10.6	83.5	409	5.7	16.9	190.6	5.7	16.5	2,423	8.4	1,153.5	9.3
February	1,852	8.6	87.5	871.5	9.6	87.6	265	3.7	12.5	123.5	3.7	12.4	2,117	7.4	995.0	8.0
March	2,199	10.2	85.5	1,072.7	11.8	86.0	373	5.2	14.5	173.8	5.2	14.0	2,572	9.0	1,246.5	10.1
April	1,972	9.1	78.3	973.8	10.7	79.3	545	7.7	21.7	254.0	7.7	20.7	2,517	8.8	1,227.8	9.9
May	1,857	8.6	76.4	890.4	10.9	78.7	574	8.1	23.6	267.5	8.1	21.3	2,431	8.5	1,257.9	10.2
June	1,725	8.0	73.7	734.0	8.1	71.9	617	8.7	26.3	287.5	8.7	28.1	2,342	8.2	1,021.5	8.2
July	1,516	7.0	69.9	426.0	4.7	58.3	653	9.2	30.1	304.3	9.2	41.7	2,169	7.5	730.3	5.9
August	1,661	7.7	68.8	417.4	4.6	54.3	753	10.6	31.2	350.9	10.6	45.7	2,414	8.4	768.3	6.2
September	1,677	7.7	65.3	429.1	4.7	50.9	889	12.5	34.7	414.3	12.5	49.1	2,566	8.9	843.4	6.8
1905																
October	1,567	7.2	66.1	564.7	6.2	60.1	803	11.3	33.9	374.2	11.3	39.9	2,370	8.2	938.9	7.6
November	1,678	7.8	72.0	759.8	8.4	71.4	652	9.2	28.0	303.8	9.2	28.6	2,330	8.1	1,063.6	8.6
December	1,894	8.8	76.7	877.5	9.7	76.6	574	8.1	23.3	267.5	8.1	23.4	2,468	8.6	1,145.0	9.2
Totals	......	100.0	......	......	100.0	......	......	100.0	......	......	100.0	......	......	100.0	......	100.0
	21,612	......	......	9,079.8	......	......	7,107	......	......	3,311.9	......	......	28,719	......	12,391.7	......
Percentage of total collection	75.2			73.3			24.8			26.7			100		100	
Average amount per 1,000 inhabitants per day	2.77 cu. yd.			1.164 tons			0.91 cu. yd.			0.425 tons			3.68 cu.yd.		1.589 tons	

NOTE.—One ton=2,000 lb. { Daily collection of refuse, except Sundays and holidays.
Average weights per cubic yard: ashes and rubbish=0.42 ton; garbage=0.466 ton.

The following table of quantities of garbage only, collected in the city of Syracuse (population 115,000) for four years, is intended to give a basis for comparison from a city where this waste has been accurately recorded for disposal by reduction process:

TABLE XI.—GARBAGE COLLECTION, SYRACUSE, N. Y., FOR FOUR YEARS, 1904-1907.

MONTH	TONS			
	1904	1905	1906	1907
January	531.40	690.40	694.73	938.70
February	508.05	559.23	636.96	636.55
March	582.70	622.62	730.16	686.25
April	560.79	619.55	675.57	770.32
May	546.02	736.20	728.93	869.03
June	710.44	811.75	704.80	832.55
July	664.83	733.45	781.15	970.80
August	865.66	921.85	1,002.65	1,023.50
September	1,090.62	1,112.00	985.66	1,080.12
October	748.36	886.65	1,088.97	1,094.93
November	736.00	861.15	1,058.73	931.85
December	734.10	701.55	896.30	798.60
Totals	8,279.00	9,257.00	9,985.00	10,634.00
Average per week	159.2	178.0	192.0	204.5
" " day	26.5	29.7	32.0	34.0
Maximum per month	41.9	42.8	40.3	40.5

COLLECTION AND DISPOSAL OF MUNICIPAL WASTE, BOSTON.

In August, 1907, Mayor John F. Fitzgerald, of Boston, Mass., appointed a commission to report upon the current conditions of the waste collection and disposal service of the city, and to formulate recommendations for future action. The commission comprised Prof. Sedgwick, of the Massachusetts Institute of Technology; Mr. X. H. Goodnough, chief engineer of the State Board of Health, and Mr. W. Jackson, city engineer. The preliminary report upon the quantities and proportions and disposal means for the several city districts is contained in a paper entitled "The Collection and Disposal of Municipal Refuse," presented by Mr. Goodnough before the Sanitary Section of the Boston Society of Civil Engineers, January 1, 1908 (Journal of the Association of Engineering Societies, May, 1908, Vol. XL., No. 5).

This excellent report comes at an opportune moment, and is herewith condensed for purposes of examination and comparison.

The collection and disposal of municipal waste in Boston is carried on by a separate bureau called the Sanitary Department, which is unler the control of the Commissioner of Streets.

The city is divided into ten districts, the boundaries of which follow in part the natural topographic divisions and in part the original boundaries of former municipalities which have been annexed to the city at various times. These districts and the population of each are as follows:

		Population	
District No. 1	South Boston	71,000	
District No. 2	East Boston	51,000	
District No. 3	Charlestown	40,000	
District No. 4	Brighton	22,000	
District No. 5	West Roxbury	37,000	
District No. 6	Dorchester	89,000	
District No. 7	Roxbury	109,000	
District No. 8	South End	103,000	
District No. 9	Back Bay		
District No. 10	North and West Ends	73,000	
Total		595,000	
Population, census of 1905			595,380

CLASSIFICATION OF MUNICIPAL WASTE IN THE CITY OF BOSTON.

In the city of Boston the principal municipal wastes requiring disposal fall into six general classes:

1. Ashes, including house and store dirt.
2. House offal.
3. Combustible waste and rubbish.
4. Market refuse.
5. Street cleanings.
6. Cesspool and catch basin cleanings.

With the exception of No. 3, the above divisions apply to all parts of the city. The third item, combustible waste and refuse, is known as the third separation and represents an attempt to keep separate from the other wastes materials which if dumped into the harbor are likely to float ashore. It applies to that portion of the city lying north of Massachusetts Avenue, but does not include Charlestown and East Boston.

COLLECTION OF WASTES.

House Dirt and Ashes.—At the present time 213 single and 20 double carts are used for collecting house dirt and ashes in all parts of the city. All of the carts are of wood, are fitted with canvas covers and so constructed that their contents can be readily dumped. This class of material is collected by the employees of the Sanitary Department except in the districts of Dorchester and West Roxbury. In Dorchester all this work is done by contractors, while in West Roxbury less than one-third of the total quantity of ashes is collected by contractors.

House Offal.—About 138 carts are used for collecting house offal throughout the city. Fifty-seven are iron—40 of which have a capacity of about 50 cubic feet each, while 17 have a capacity of about 80 cubic feet each. Of the 81 wooden carts in use, 7 are large carts, having a capacity of about 80 cubic feet and the remainder are small ones, having a capacity of 40 cubic feet. All of the carts, with the exception of those last mentioned—the small wooden ones—are covered with wooden or canvas covers so arranged that the carts can be readily dumped. The small wooden carts are emptied by shoveling out the offal.

Waste and Rubbish.—The collection of this class of refuse is done entirely by employees of the Sanitary Department, most of the material collected being delivered at an incinerator plant on Hecht Wharf near Atlantic Avenue. There are 56 carts used in this work. Thirty-four of these have a capacity of 109 cubic feet each, while the remainder will hold double this amount. All the carts are of wood and are fitted with canvas covers. They are not so arranged that they can be dumped. The material has to be removed by hand through doors in the rear of the carts.

Street Cleanings.—Street cleanings are collected by the Street Department, which uses 104 carts in this work. They have a capacity of about 50 cubic feet each, are made of wood and are not covered. Sixty-eight of the carts are owned by the city and the remainder are hired. Part of the work, that in Brighton and West Roxbury, is in charge of the Street Paving Department.

Cesspool and Catch-basin Cleanings.—Cesspool and catch-basin cleanings are collected by the Sewer Department, and during the year 1906 42 carts, 22 single and 20 double were in use at one time or another on this work. Of the single teams, 16 belong to the city and 6 were hired from contractors, while of the double teams, 1 is owned by the city and 19 by contractors. The double wagons are all of wood, and are fitted with wooden covers, but part of the single wagons owned by the city are in the form of a half-cylinder fitted with covers so arranged that the material can be easily dumped. The half-cylinder carts have a capacity of about 30 cubic feet, while the larger wooden carts hold 35 cubic feet.

FREQUENCY OF COLLECTION.

House dirt and ashes are collected either once or twice a week during the winter time and only once a week in summer. Paper and rubbish are collected chiefly on Mondays and Thursdays, in the portion of the city north of Dover Street, and on Wednesdays and Saturdays in the remaining districts. In the districts of the city where there is no third separation, such material is mixed with the ashes.

House offal is removed from the dwelling houses, as a rule, once a week in the winter and twice a week in the summer, except in the Back Bay, where it is removed twice a week throughout the entire year, while in the business portion of the city—Districts 8, 9 and 10—the large hotels and restaurants are visited daily.

The following tables indicate that the quantity of ashes and house dirt per capita collected daily throughout the city was greatest in the North and West Ends and in the South End and Back Bay, the districts which include the business portions of the city and the larger hotels. Next to these districts, the quantity was greatest in the suburban residential districts of Brighton and West Roxbury. Practically all of the combustible waste and rubbish is collected in the downtown districts.

The quantity of garbage is greatest per person in the South End and Back Bay, Districts 8 and 9, and next largest in the North and West Ends, District 10, the districts of the great hotels. It will be noted that the quantity of garbage collected in East Boston is much greater per capita than that collected in South Boston or Charlestown. The explanation offered is that East Boston, being a very large shipping point, contains a large floating population in proportion to the population of the district, including sailors and employees of vessels, not recorded in the census.

TABLE XII.—BOSTON REFUSE DISPOSAL. TABLE SHOWING AVERAGE WEEKLY AND DAILY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM THE ENTIRE CITY DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (POPULATION, 1905, 595,380.)

		Cubic Feet		Tons			Cubic Feet		Tons	
		Average Weekly	Average Daily*	Average Weekly	Average Daily*		Average Weekly	Average Daily*	Average Weekly	Average Daily*
January	Ashes	431,800	78,150	10,797	1,963	July	252,400	45,892	6,311	1,148
	Rubbish	62,843	11,426	247	45		54,728	9,950	215	39
	Garbage	67,550	12,282	1,437	261		57,300	10,418	1,220	222
	Market refuse	6,030	1,096	128	23		2,410	438	52	9
	Total	568,223	103,314	12,609	2,292		366,838	66,698	7,798	1,418
February	Ashes	446,250	81,137	11,156	2,028	August	263,700	47,946	6,592	1,198
	Rubbish	58 838	10,698	231	42		57,247	10 408	225	41
	Garbage	65,300	11,873	1,391	253		62,850	11,428	1,340	244
	Market refuse	6,360	1,156	136	25		6,980	1,268	149	27
	Total	576,748	104,864	12,914	2,348		390,777	71,050	8,306	1,510
March	Ashes	439 300	79,872	10,983	1,997	September	258,900	47,072	6,474	1,177
	Rubbish	61,716	11,222	243	44		56,833	10,334	224	41
	Garbage	64,750	11,772	1,378	250		61,900	11,254	1,319	239
	Market refuse	7,050	1,282	150	28		7,920	1,440	169	30
	Total	572,816	104 148	12.754	2,319		385,553	70,100	8,186	1.487
April	Ashes	416 250	75,682	10,406	1,892	October	295,850	53,792	7,396	1,344
	Rubbish	62,784	11,415	247	45		62,130	11,296	244	44
	Garbage	61,250	11,136	1,305	237		66,400	12.072	1 414	257
	Market refuse	6,430	1,169	137	25		6,780	1,232	144	26
	Total	546,714	99,402	12,095	2,199		431,160	78,392	9,198	1,671
May	Ashes	366,500	66,636	9,162	1 666	November	325.150	59 118	8,130	1,478
	Rubbish	60,212	10 948	237	43		60,146	10,936	236	43
	Garbage	60.700	11,036	1,294	235		62,100	11,290	1,323	240
	Market refuse	7,250	1,318	154	28		6,160	1 120	132	24
	Total	494 662	89 938	10.847	1 972		453,556	82.464	9.821	1 785
June	Ashes	279 900	50,890	6,999	1,272	December	397,850	72 336	9 947	1,809
	Rubbish	59,873	10,886	236	43		61,422	11,168	241	44
	Garbage	61,400	11,164	1,309	238		66 650	12,118	1 421	258
	Market refuse	7,180	1,306	153	28		5,960	1,084	127	23
	Total	408,353	74,246	8,697	1,581		531,882	96,706	11,736	2,134
Average	Ashes						347 820	63,240	8,696	1.581
	Rubbish						59,899	10,891	235	43
	Garbage						63,179	11.487	1,346	244
	Market refuse						6,375	1,159	136	25
	Total						477 273	86 777	10 413	1.893

* 5½ days per week
1 cu. yd. ashes = 1,350 lbs.
1 " rubbish = 212 "
1 " garbage = 1.150 "
1 " market refuse = 1,150 "

The total quantity for any month can be obtained approximately by multiplying the average daily quantity, as given above, by 24

TABLE XIII.—BOSTON REFUSE DISPOSAL, SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM ENTIRE CITY DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (POPULATION, 1905, 595,380.)

		Cubic Feet		Tons				Cubic Feet		Tons		
		Average Weekly	Per Cent.	Average Weekly	Lb.* per Capita per Day	Per Cent.		Average Weekly	Per Cent.	Average Weekly	Lb.* per Capita per Day	Per Cent.
January	Ashes	431,800	75.9	10,797	6.60	85.6	July	252.400	68.8	6,311	3.86	81.0
	Rubbish	62,843	11.1	247	.45	2.0		54,728	14.9	215	.13	2.8
	Garbage	67,550	11.9	1,437	.88	11.4		57,300	15.6	1,220	.75	15.6
	Market refuse	6,030	1.1	128	.08	1.0		2,410	.7	52	.03	.6
	Total	568,223	100.0	12,609	7.71	100.0		366,838	100.0	7,798	4.77	100.0
February	Ashes	446,250	77.4	11,156	6.81	86.3	August	263,700	67.5	6,592	4.02	79.4
	Rubbish	58 838	10.2	231	.14	1.8		57,247	14.6	225	.14	2.7
	Garbage	65,300	11.3	1,391	.85	10.8		62,850	16.1	1,340	.82	16.1
	Market refuse	6,360	1.1	136	.08	1.1		6,980	1.8	149	.09	1.8
	Total	576,748	100.0	12,914	7.88	100.0		390,777	100.0	8,306	5.07	100.0
March	Ashes	439,300	76.7	10,983	6.71	86.1	September	258,900	67.2	6,474	3.95	79.0
	Rubbish	61 716	10.8	243	.15	1.9		56,833	14 7	224	.14	2.8
	Garbage	64,750	11.3	1,378	84	10.8		61,900	16.1	1,319	.81	16.2
	Market refuse	7,050	1.2	150	.09	1.2		7,920	2.0	169	.10	2.0
	Total	572,816	100.0	12,754	7.79	100.0		385,553	100.0	8 186	5.00	100.0
April	Ashes	416 250	76.1	10,406	6.36	86.1	October	295 850	68.6	7,396	4.51	80.3
	Rubbish	62,784	11.5	247	.15	2.0		62 130	14.4	244	.15	2.7
	Garbage	61,250	11.2	1,305	.80	10.8		66,400	15.4	1,414	.86	15.4
	Market refuse	6,430	1.2	137	.08	1.1		6,780	1.6	144	.09	1.6
	Total	546,714	100.0	12,095	7.39	100.0		431,160	100.0	9,198	5.61	100.0
May	Ashes	366,500	74.1	9,162	5.60	84.5	November	325,150	71.6	8 130	4.98	82.8
	Rubbish	60.212	12.2	237	.15	2.2		60,146	13.3	237	.15	2.4
	Garbage	60 700	12.3	1,294	.79	11.9		62 100	13.7	1,323	.81	13.5
	Market refuse	7,250	1.4	154	.09	1 4		6,160	1.4	132	.08	1.3
	Total	494,662	100.0	10,847	6.63	100.0		453,556	100.0	9,822	6.02	100.0
June	Ashes	279,900	68.6	6,999	4.28	80.4	December	397,850	74.8	9,947	6.07	84.7
	Rubbish	59,873	14.7	236	.15	2.7		61.422	11.5	241	.15	2.1
	Garbage	61,400	15.0	1,309	.80	15.1		66,650	12.5	1,421	.87	12.1
	Market refuse	7.180	1.7	153	.09	1.8		5,960	1.2	127	.08	1.1
	Total	408,353	100.0	8,697	5.32	100.0		531.882	100.0	11,736	7.17	100.0
Average	Ashes							347,821	72.3	8,696	5.31	83.0
	Rubbish							59,898	12.8	236	.15	2.3
	Garbage							63,179	13.5	1,346	.82	13.3
	Market refuse							6,376	1.4	136	.08	1.4
	Total							477,274	100.0	10.414	6.36	100.0

*5½ days per week. 1 cu. yd. ashes = 1,350 lbs. 1 cu. yd. garbage = 1,150 lbs. 1 cu. yd. rubbish = 212 lbs. 1 cu. yd. market refuse = 1,150 lbs.

COMPARISON OF QUANTITIES OF WASTE AND REFUSE COLLECTED IN THE CITIES OF BOSTON AND NEW YORK.

Before leaving the question of the quantity of wastes it will be of interest to compare the quantities collected per capita in the city of Boston with those collected in the boroughs of Manhattan and the Bronx, kindly furnished by Mr. Wm. Macdonough Craven, recently Street Commissioner of the City of New York. These figures are for ashes, rubbish and garbage. They show a very remarkable similarity in the total quantity of such wastes collected in the two cities.

METHODS OF DISPOSAL OF MUNICIPAL WASTE AND REFUSE IN THE CITY OF BOSTON.

Ashes and House Dirt.—Of the total amount of 466,000 tons of this material collected in the entire city in the year 1906, 132,000 tons, or 28 per cent., were delivered at Fort Hill wharf, on Atlantic Avenue, discharged into scows and dumped at sea off the mouth of the harbor. All of the remainder of this waste and refuse is disposed of by dumping it upon low grounds in various parts of the city.

Combustible Waste and Refuse.—Of the total quantity of waste and refuse, so called, collected in the city, amounting to 3,108,000 cubic feet in the year 1906, 2,829,000 were delivered to an incinerator plant on Hecht Wharf and the remainder deposited on dumps in various parts of the city, where a part of it was burned.

Garbage.—Of the 55,700 tons of house offal collected in the entire city in 1906, 41,960 were conveyed to scows at the Fort Hill and Albany Street Wharves—17,660 tons to the former and 24,300 tons to the latter—and towed to the garbage reduction plant at Spectacle Island. The remainder—13,740 tons— collected in East Boston, Brighton, West Roxbury and Dorchester, was sold for the feeding of swine.

During the past year the sale of offal from Dorchester for the feeding of swine has been discontinued, and this offal is now delivered at Fort Hill Wharf. Difficulty has been experienced on account of the disposal of offal from East Boston for the purpose of feeding swine, and it is likely that that method of dis-

TABLE XIV.—BOSTON REFUSE DISPOSAL. TABLE SHOWING AVERAGE DAILY* QUANTITIES OF STREET CLEANINGS AND CATCH-BASIN CLEANINGS COLLECTED IN THE CITY OF BOSTON DURING 1906.

SANITARY DISTRICT	South Boston	East Boston	Charles-town	Brighton	West Roxbury	Dor-chester	Rox-bury	South End and Back Bay	North and West Ends	Entire City
District Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8 and 9)	(10)	
Population (1905)	75,053	51,334	39,983	21,806	33,352	84,417	110,850	98,822	79,763	595,380
Street Cleanings—										
Loads	.60	24.2	33.4	25.7	17.5	30.0	33.4	119.2	65.1	408.5
Cubic feet	3,000	1,213	1,672	1,288	.875	1,500	1,673	5,975	3,255	20,451
Tons	55.5	22.5	30.9	23.8	16.2	27.8	31.0	110.5	60.2	378.3
Pounds†	1.48	.88	1.55	2.18	.97	.65	.56	2.24	1.51	1.27
Catch-Basin Cleanings—										
Loads	8.9	8.2	4.9	5.0	6.0	25.1	27.1	12.3	12.3	97.5
Cubic feet	266	245.5	146.3	151.0	181.0	756.0	814.0	371.0	371.0	2,930.8
Tons	6.65	6.12	3.65	3.78	4.52	18.90	20.35	9.28	9.28	73.27
Pounds†	.177	.239	.18	.346	.271	.448	.368	.188	1.88	.246
Total—										
Loads	68.9	32.4	38.3	30.7	23.5	55.1	60.5	196.6	196.6	506.0
Cubic feet	3,266	1,458.5	1,818.3	1,439.0	1,056.0	2,256.0	2,487.0	9,601.0	9,601.0	23,381.8
Tons	62.15	28.62	34.55	27.58	20.72	46.70	51.35	179.98	179.98	451.57
Pounds†	1.657	1.119	1.73	2.526	1.241	1.098	0.928	5.63	5.63	1.516

*5½ days per week. †Lb. per capita per day. NOTE.—1 cubic yard street cleanings = 1,000 lbs. 1 cubic yard catch-basin cleanings = 1,350 lbs.

TABLE XV.—BOSTON REFUSE DISPOSAL. COLLECTION OF REFUSE IN THE CITIES OF BOSTON* AND NEW YORK† (1906).

	Tons (2,000 Lbs.)				Per Cent. of Total by Weight		Lb. per Capita per Day‡	
	Total for Year		Average per Day‡					
	Boston	New York	Boston	New York	Boston	New York	Boston	New York
Ashes	466,100	1.903,500	1,628	6,654	87.29	82.04	5.470	5.582
Rubbish	12,198	192,496	42	673	2.28	8.30	.143	.565
Garbage	55,700	224,250	195	784	10.43	9.66	.653	.658
Total	533.998	2,320, 246	1,865	8,111	100.00	100.00	6.266	6.805

*Population (1905), 595,380

†BOROUGHS OF MANHATTAN AND THE BRONX—Population (1905)

Manhattan	2,112,380
Bronx	271,630
Total	2,384,010

‡5½ days per week

NOTE.—1 cubic yard ashes = 1,350 pounds
1 " " rubbish = 212 "
1 " " garbage = 1,150

posal will soon be discontinued and the offal from that district delivered to the reduction plant at Spectacle Island.

The works for the disposal of garbage in the city of Boston were *originally* constructed on the mainland, and, though located more than a mile from any dwellings, yet nuisance was severe, and the plant was subsequently removed to Spectacle Island. References to serious nuisance from this plant in its present location have been made in the newspapers during the past summer.

Street Cleaning.—Of the 5,850,000 cubic feet of street cleanings collected in the entire city, 1,965,000 cubic feet, or 34 per cent., are delivered to Fort Hill Wharf and dumped at sea. The remainder is dumped with the ashes and other refuse for the filling of low lands.

Catch-Basin Cleanings.—Cesspool and catch-basin cleanings amounted in 1906 to 837,000 cubic feet, of which 190,000 or 23 per cent., were shipped at Fort Hill Wharf and dumped at sea, while the remainder was dumped with the other refuse in the low grounds about the city.

Market Refuse.—The market refuse, amounting to about 8,600 tons, was dumped into scows at Fort Hill Wharf and disposed of at sea. A considerable quantity of market refuse is, however, disposed of on the land dumps in various parts of the city.

Dumping on Land.

The great bulk of the refuse material disposed of from the city is dumped upon the low grounds, and at the present time the number of such dumping places in use in the city of Boston is in the neighborhood of 60.

The total number of loads of waste and refuse dumped at these places was counted during certain weeks in the month of June, 1907, the results showing that at the largest of these dumps 477 loads of material were disposed of in a single week. At the next largest dump 282 and 283 loads, respectively, were disposed of in different weeks. At ten other dumps more than 200 loads per week were disposed of, and at eight others between 100 and 200 loads per week were disposed of.

These dumps are used in many places as a playground by children and are a source of constant annoyance to the Health Department from foul odors and especially from smoke caused by frequent fires. They are usually very unsightly and at times of high winds many acres of ground are sometimes covered by flying débris, chiefly paper, from a large dump.

OBSERVATIONS.

This paper by Mr. Goodnough is particularly valuable because of its division of the city into districts with the population of each carefully noted and the records of relative proportions of every class of waste in each district. It is also, as far as is known, the only published report that gives reliable data in regard to the quantities of catch-basin cleanings from a given area. While this class of refuse is not usually included in the waste disposal service, it is still well-known as one of the troublesome items with which every municipality has to deal. With the figures presented, which include the number of teams and the labor required, it should be a simple matter for the officials of any town to make calculations of costs according to the system desired.

Although this paper does not give details of the operation of the Refuse Utilization Station, it points out that the disposal of light refuse and rubbish by this method has relieved the city of a great volume of troublesome refuse which formerly caused a nuisance by flotation to adjoining shores when dumped into the bay.

The disposal of 2,829,000 cubic feet, equivalent to 104,407 cubic yards, or 11,067 tons, which was handled by the Refuse Disposal Station in 1906, shows the value of this method of treatment in strong contrast to the insanitary, untidy disposal at dumps.

This paper is an acceptable contribution to the literature of waste disposal in the New England States. (Note: House offal as here used means garbage. House dirt and ashes does not mean garbage and ashes, but other house refuse. Rubbish means paper and light refuse.)

GENERAL CONCLUSIONS.

In bringing together the reports of the various commissions and expert engineers it has been the author's intention to select the most practical information from all the available sources. Tables derived from reports in other localities might be added, but as quantities are contingent upon local conditions and vary for many reasons, a general recapitulation would be of little or no service.

With the aid of the figures given in the foregoing tables, the officials of any town, after making due allowances for local conditions, may obtain a close estimate of their quantities of separated waste, their special seasonal variations and some idea of the composition of each. This is the information needed when new methods for disposal are under consideration, and no uncertain and indefinite rough estimate of cart loads will afford a clear idea as to what the amounts are to be dealt with or of what special character they may be composed. Without a fairly close estimate, the town is at the mercy of the contractor, who proposes to collect or dispose of the waste by guessing at the quantities—and these are never on the smaller side—and then takes a chance as to the equipment he must provide, and the capacity of the incinerator he proposes for—and neither are ever too large. Between the two guesses there is frequently a wide variation from the facts, which makes trouble for both parties when the test comes for making good the contractor's guaranteed figures.

THE COLLECTION STATISTICS OF THE GENERAL GOVERNMENT.

The statistics published by the General Government (Department Commerce and Labor, Census Bureau, 1905) contain tabulated reports from 154 cities having a population of 30,000 upwards. These figures are not conclusive, nor do they accurately represent the conditions. They are usful as giving some general idea of the work of collection and disposal. From the tables the following condensation has been made:

TABLE XVI.—STATISTICS OF COLLECTION AND DISPOSAL OF REFUSE (FROM U. S. CENSUS, 1905).

CENSUS	GARBAGE					OTHER REFUSE					DISPOSITION	
According to Population	Not Reported	Collected	Burned	Reduced	Otherwise Disposed of	Animals	Ashes	Paper	Night Soil	Other Refuse	Disposed of by Householders	No Record
Group 1—15 cities, with 300,000 or over	2	13	4	7	5	9	10	4	3	4	2	2
Group 2—25 cities, with 100,000 to 300,000	3	20	6	5	11	19	9	4	1	5	11	3
Group 3—47 cities, 50,000 to 100,000	12	30	13	6	11	8	16	7	5	4	1	17
Group 4—67 cities, 30,000 to 50,000	21	43	11	2	28	27	18	6	9	5	21	5
154 cities	38	106	34	20	55	63	53	21	18	18	35	27

As compared with the government reports of 1900 on this subject there is a great improvement in conditions, as at that time 53 places failed to make any reports whatever, and the returns actually made were much less complete than those cited above.

SEPARATE GARBAGE COLLECTIONS.

There are several reasons for a separate garbage collection. The amount is approximately only ten to twelve per cent. of the whole bulk of waste, it is the most objectionable class, and it must be removed more frequently than any other. When in a cleanly condition it may be utilized in the reduction process or fed to swine. In most places the regulations for separation impose fines, or the refusal to remove the garbage when it is mixed with foreign matters.

In Southern towns it is the custom to collect garbage and rubbish together. Sometimes ashes and manure are included, and occasionally dead animals, and when thus mixed the only practicable disposal is by cremation, or by burying in the ground.

In only a few of the larger cities is the separation of ashes from garbage and rubbish completely accomplished. New York, Brooklyn, Boston, Washington and Buffalo have means for the recovery of the salable parts of the rubbish, and other large cities are considering the installation of rubbish stations. In the remaining towns and cities the ash collection includes the rubbish; the whole is discharged together, a small part of the refuse being recovered by dump picking.

Where there is a separate collection the burden of it comes upon the householder, as he is required to have three cans or vessels and to keep them in accessible places; he is also held responsible for their cleanly and serviceable condition. The room used for their storage and the care exercised in filling them are a considerable tax upon the patience and convenience of the house occupants.

THE COMPOSITION OF GARBAGE.

In dealing with separated garbage, its character and composition must be taken into account. Several analyses have been made, but there is need of a more extended and accurate quantitive anaylsis than any we now have.

TABLE XVII.—AVERAGE PERCENTAGE COMPOSITION OF GARBAGE.

	Waring; New York 1896		Craven; New York City, 1899	Fetherston; Atlantic City, 1901	Hering; Trenton, 1903
	Per Cent.	*Weight*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Moisture	71 =	1,420 lbs.	70	82	80
Solids, animal and vegetable	20 =	400 "	25 }	18 }	16
Grease recoverable	2 =	40 "	3 }		
Non-combustible	7 =	140 "	2 }	...	4
	100 =	2,000 lbs	100	100	100

Waring's report in 1896 was upon the average of 3,000 tons of summer garbage from different cities, treated by different methods of reduction. Craven's report, on one reduction plant, shows better methods. Fetherston's and Hering's figures were from cremation plants, where nothing of value was recovered.

The paper by Mr. B. F. Welton in the discussion before the American Society of Civil Engineers, December 18, 1907, gives the following analysis of dry samples of waste, including garbage representing collections for the years 1905-06 in New York City:

TABLE XVIII.—CHEMICAL ANALYSIS OF DRY COMPOSITE SAMPLES.

CONSTITUENTS	Coal and Cinders	Garbage	Rubbish
Percentage by weight of—			
Carbon	55.77	43.10	42.39
Hydrogen	0.75	6.24	5.96
Nitrogen	0.64	3.70	3.41
Oxygen	2.37	27.74	33.52
Silica	30.01	7.56	6.49
Iron oxide and alumina	8.98	0.41	2.03
Lime	1.21	4.26	2.26
Magnesia	Trace	0.28	0.57
Phosphoric acid	None	1.47	0.10
Carbonic acid	None	0.59	1.49
Lead	Trace	{ Sulphides }	0.52
Tin	Trace	{ 0.20 }	Trace
Alkalies and undetermined	0.27	4.45	1.21
	100.00	100.00	100.00

In an analysis of Milwaukee's garbage made by Prof. R. E. W. Sommer, he found in dry garbage 8.77 per cent. of grease, 1.61 per cent. of nitrogen, 12.50 per cent. of glucose, and 2.31 per cent. of phosphoric acid. Total combustion gave 61.88 per cent. of ashes and 38.12 per cent. of combustible matter. Wet garbage contained 78 per cent. of water. It was found that if placed to a height of 8 inches in a barrel, 0.67 per cent. of water drained off; at a height of 16 inches, 7.05 per cent. drained off; and at a height of 24 inches, 9.33 per cent. drained off.

The Weight of Garbage.

There is no absolute standard of weight for garbage that can be applied to all conditions. Heretofore it has been the practice to estimate the average weight for one cubic yard from 1,500 to 1,700 pounds. This includes the liquids which may be thus divided.

(1) The contained moisture in the organic composition of all vegetable substances, varying according to the nature of the vegetable. The summer garbage of American towns during the melon and fruit season carries a much larger quantity of liquid elements than the same amount of garbage does in the winter, when it is composed of the drier and more compact vegetable refuse.

(2) The free water, or liquids held in suspension in the interstices of the garbage by capillary attraction, coming from household cooking and washing, or from snow and rain falling into the uncovered garbage cans or carts. When this free water is allowed to drain off, the integral character of the garbage is unchanged, but the weight is reduced.

The latest examinations, as previously quoted, would indicate that the volume of contained water in average city garbage has been placed at too high a figure. It seems probable that the average weights of the liquid elements of garbage should be given as 70 per cent., 72½ per cent., or 1,400 to 1,450 pounds per ton.

The probabilities are that there is an average of 1,450 pounds to the cubic yard, 54 pounds per cubic foot, and 38 cubic feet to the ton, and this may be taken as representing the average collection of Northern towns where the garbage contains a normal precentage of moisture.

If the free water (estimated at twelve and one-half per cent. by weight) be omitted, then the figures would be 1,270 pounds per cubic yard, 47 pounds per cubic foot, and 42½ cubic feet per ton.

THE FERTILIZING ELEMENTS OF RAW GARBAGE.

There is some value in garbage as a fertilizer for poor soils, but the proportion of plant food is less than is popularly estimated. The fertilizing values are approximately, phosphoric acid, 0.65 per cent.; ammonia, 0.65 per cent.; potash, 0.15 per cent. These small proportions of plant food are present in the green garbage, and when the application of this to the soil is made by the crude method of plowing under it is attended with difficulties that are hard to overcome. It is strongly advocated by many, who argue that there must be a return to the ground of organic matter taken therefrom, to prevent a possible food famine in some far distant future, but it does not appear that efforts in this direction are successful. Many American towns have tried this method, and nearly all have abandoned it because of the nuisance produced, or for financial reasons. Large areas of suitable lands are seldom found in the vicinity of large towns; the presence of foreign substances in the garbage is embarrassing and detrimental, and the soil so treated must have time to oxydize and assimilate the garbage before another dose.

When garbage passes through the various stages of grease extraction by steam or naphtha, pressing and grinding, drying commonly known as the reduction or extraction process, the fats are separated and the solid portions, called "tankage," then contain the fertilizing elements in a concentrated form. This method of treatment will be considered later.

AGRICULTURAL UTILIZATION.

This method is used in all parts of Europe except Great Britain, and the reports made in Paris by the chief engineer in charge of this work are instructive:

In Paris house refuse is known as garbage (gadoues), and is composed of all kitchen refuse and any remnants produced by the sweeping of the inside of public properties or private buildings, not mixed with industrial waste, earth, gravel or rubbish. It is contained in pails having a maximum capacity of thirty gallons. The broken crockery, glass, etc., are deposited in separate receptacles. The garbage is collected by the city laborers, and removed by contractors in carts of six cubic metres (7.85 cubic yds.), and sent directly to the fields by wagon, rail and water, where it is delivered to the farmers. The quantity is six hundred thousand tons yearly. But the contractors have raised their bids, because the fields on which it is possible to utilize the garbage are growing fewer near Paris, and the suburban towns are refusing to allow it to be deposited on their grounds; and the farmers are able to buy chemical fertilizers at cheap rates, and will pay only a low price for the garbage-fertilizer, which requires careful sorting. Without such sorting their fields are strewn with tin cans, broken crockery and glass, etc., which are dangerous to their horses' hoofs.

To bring it into a better condition for use by the farmers, the garbage is sometimes ground into a homogenous mass, at grinding stations located as near as possible to the centers of collection. This process, as reported by M. Tur,* has some interesting and novel features:

The ground garbage looks like vegetable earth, mixed with bits of paper and straw. Its odor is hardly perceptible, can be endured for a long time, and may be removed by sprinkling with lime water.

The ground garbage can be used in the fields without giving the same trouble as the original garbage, all débris troublesome or dangerous to the farmers having been removed.

Hygienic considerations do not seem to enter into the question of the adoption of one or the other method (utilization or incineration) provided the agricultural utilization does not bring the garbage storehouses near the inhabited centers.

This method seems to have been invented to overcome the reluctance of the farmers to receive the garbage in its rough state, as "they will not take the least trouble to procure this fertilizer."

Experiments in incineration showed that the garbage was self-burning, *i. e.,* that it would burn without any addition of coal, and it was recommended that there be installed a destructor of the English type as near as possible to the center of the borough which it serves, to reduce to a minimum the charge for hauling.

The disposal of refuse in Paris is complicated by the existence of rag-pickers, numbering upwards of 25,000, who from long-continued custom have a vested right to first sort over the refuse. They are authorized by the janitors of houses to make the first collection from the pails before emptying, a second picking is being made while the carts are being filled, and the third in the stations at the trans-shipment of the garbage.

This method of grinding up the refuse to obtain a class of fertilizer more acceptable and better suited to the farmers' uses has been tried in three of the districts of Paris. The disposal by incineration in three other districts is now being done at three

*Proceedings Amer. Soc. Civil Engineers, 1904 International Engineering Congress.

destructor plants built by Meldrun Brothers, of Manchester, England, the united capacity of these being 700 tons per day.

These experiments in the city of Paris by opposing methods of utilization by preparing the waste for ground fertilizer, and its total destruction by fire, developing steam power for various purposes, will be watched with great interest by other cities of Europe where agricultural utilization has been employed for centuries. Another large city of France, St. Etienne, has adopted the destructor system of the Meldrum Company, and still others are investigating the subject.

DRY REFUSE OR RUBBISH COLLECTIONS.

The term "refuse," often used to designate the collective mass of municipal wastage, is also applied to any one particular item or part of the same mass. The author has preferred to follow the definition previously given, and to apply the word to the dry refuse and rubbish, as distinguished from other parts of city waste. Properly speaking, it should be used to designate only the very last stage, or the ultimate form of any kind of worthless matter, but this is a technical definition, and it is believed that it will be clearer and less confusing to employ it as defining that part of the genuine wastage known as dry refuse and not to use the word in connection with every form of waste as is generally done.

The separate treatment of refuse for the recovery of its salable parts has shown the need of a subdivision of the term "refuse." When the final disposition is by fire the refuse must be *combustible* in character, and after sorting out the valuable parts the remainder can be easily burned, leaving a small amount of ash that gives no trouble to dispose of. But the *non-combustible* part is more difficult to deal with, as it contains for recovery only metals and bottles that can be sold as junk, leaving the greater part absolutely worthless for any purpose. This is "rubbish," the last form of refuse, and the final residue of the whole collected mass of city waste.

This component (refuse) of city wastage represents many different things in different places. In the eastern part of the country it is called dry refuse or rubbish, and includes all the inorganic rejected substance from the house, except ashes. It also frequently comprises out-of-door waste, such as cut grass, the sweepings of lawns and walks, leaves, the branches of trees, etc. In the west it is also termed refuse and rubbish, and is called collectively "garbage." In the south it is "trash," and while generally including nearly every kind of waste except garbage, frequently contains this also.

There is no clear distinction possible except in cities where a separate collection service has been established; it then becomes necessary to define it accurately.

Regulations and ordinances have been adopted in practically all the municipalities of any size throughout the country, and these differ widely in various places. The question is receiving serious consideration by the authorities everywhere, and in time there will undoubtedly be more uniformity in the laws relating to the subject.

The Sanitary Code of New York City, probably the first to use definite terms, and which has guided most other places in this matter, defines the separation of wastes as follows:

CARD OF INSTRUCTION FOR HOUSEHOLDERS.

Put into Garbage Receptacles	*Put into Ash Receptacles*	*Put into Rubbish Bundles*†
Kitchen or Table Waste, Vegetables, Meats, Fish, Bones, Fat.	Ashes, Sawdust, Floor and Street Sweepings, Broken Glass, Broken Crockery, *Oyster and Clam Shells, Tin Cans.	Bottles, Paper, Pasteboard, etc. Rags, Mattresses, Old Clothes, Old Shoes, Leather and Leather Scrap, Carpets, Tobacco Stems, Straw and Excelsior (from households only).

*NOTE.—Where there is a quantity of shells, as at a restaurant, they must be hauled to the dump by the owner.

†All rubbish such as described in this third column must be securely bundled and tied, or it will *not* be removed.

REVERSE OF CARD.

It is forbidden by city ordinance to throw any discarded scrap or article into the street, or paper, newspapers, etc., ashes, dirt, garbage, banana skins, orange peel, and the like. The Sanitary Code requires householders and occupants to provide separate receptacles for ashes and garbage, and forbids mixing these in the same receptacle. This law will be strictly enforced.

Boston follows the same code and regulations, but requires that bottles and cans that have held food shall be put with the garbage, and all others with the ashes. Other large cities follow the same regulations, with local changes.

The item of tin cans gives trouble everywhere; no one wants them, as, except in large numbers, their value is nothing. When in bulk the solder and tin can be recovered by heating, and the iron will bring something for rough purposes. Tin cans properly belong with ashes, as any impurity is speedily deodorized by the fine ash.

There is a collection of refuse in some of the larger eastern towns, though little attention is paid to its disposal. About twenty New England towns have weekly or bi-weekly service, and some fifteen other places, west and south, collect refuse once a week.

THE PROPORTIONS OF REFUSE AND RUBBISH.

So few reports of the actual percentages of refuse are available that it is difficult to give any data except that obtainable from estimate and observation. The subjoined table, compiled by the writer some years ago, is believed to be fairly representative:

TABLE XIX.—APPROXIMATE PERCENTAGE OF DRY REFUSE IN WHOLE MUNICIPAL WASTE.

	Per Cent. by Weight	Per Cent. by Volume	Wt. per Cubic Yard	
New York...........	7 to 10	20 to 25	140 lbs.	Ready for sorting
Brooklyn............	8 to 12	20 to 25	155 "	" " "
Boston..............	4 to 6	15 to 20	202 "	Gross weight
Buffalo..............	8 to 10	25 to 35	215 "	" "
Philadelphia..........	6 to 8	15 to 20	175 "	Estimated

The lighter weights in New York or Brooklyn represent the amount collected by the city teams, but in reality the amounts produced are far greater. The best part of the dry refuse of New York City never comes to the city's carts. All large business houses sell their waste privately, or give it away on condition that their steam boiler ashes are removed free of cost. The janitors of apartment houses and the superintendents of office buildings control the waste paper for their own benefit. The city collects from private houses of the better class, and from the tenement districts and smaller shops, and all this is often picked over by junk dealers before the arrival of the city teams. Preliminary sorting for private sale is done in every large town to a greater or lesser extent; it is more noticeable in New York because of the relatively larger quantities.

The Boston collection is greater in weight and quantity, but of less value for market. The Buffalo refuse has a larger percentage of dust, dirt, iron and wood. That of Brooklyn is of the best average quality, as the paper and rubbish from the residential districts is cleaner and better than from the business sections. Chicago and some other places have a system of collection in stationary iron boxes at street corners, supposed to be for waste paper only, but which receive a large quantity of other matters. The franchise for the boxes is held by a company whose chief purpose is to use them for advertising purposes. The usefulness of this box service is very doubtful, considering the valuable room surrendered by the city at street intersections and the payment made of a small percentage upon the income received by the company.

THE VOLUME OF DRY REFUSE.

The amount of paper produced and consumed in this country is enormous in weight and bulk. Houses, shops, wholesale and department stores, office buildings, banks, factories and institutions, where the waste produced cannot be destroyed, send outside the building quantities of articles which have become worthless through use, or are not worth preservation owing to their cheapness and profusion.

Of this amount, paper in many forms is the largest proportion. The consumption of paper in the United States is stated on good authority to be 38 pounds per capita per annum. Asuming a population of eighty millions, this is 1,520,000 tons per year. To produce this paper whole countries and territories are laid under contribution, thousands of acres of forest trees are turned into pulp; the world is explored and ransacked for old or new forms of manufactured and vegetable products to be worked into paper stock, great factories and many firms and companies, with huge amounts of capital, are all busy trying to satisfy the insatiable demand of the public for more paper.

An instance of the use of paper in New York City may be cited. The combined weight of one number of each of six Sunday newspapers, on March 5, 1906, was 5¾ pounds, an average of 15 1-3 ounces for each paper. The whole number of sheets, if spread out flat, would cover 52 square feet of surface. The length of these sheets, if placed end to end, the long way, would be 393 feet, more than one city block. It is estimated that the newspapers of New York City daily consume 350 tons of paper, and that fully two-thirds of this remains in the city and is not sent out through the mails. This is upwards of 85,000 tons to be accounted for yearly, to which must be added the stream of other matter—circulars, posters, advertising and trade matter of all sorts, besides the great value of paper in the weekly and monthly journals and magazines.

By far the largest proportion of paper manufactured, after serving temporary and transient purposes, is thrown aside as worthless. It is so cheap as to be hardly worth saving; its abundance makes it a nuisance, and it is the custom to get rid of it as soon as possible,

CHAPTER III.

Municipal Refuse and Rubbish Collection and Disposition.

The history of the efforts made in this country to systematize the collection and saving of this kind of municipal waste dates from the beginning of the experiments made by the late Col. George E. Waring, when Street Cleaning Commissioner in New York, twelve years ago. He saw at Budapest a certain method of sorting the city waste by placing it in thin layers on an endless movable belt or platform, driven by power, and stationing on either side a file of women who, as it passed, picked out certain specific articles or substances which had a market value, or which could be put to some useful purpose. Not a cleanly, but a practical way of recovering things which would otherwise be wasted and lost. Col. Waring applied this idea at one of the New York Street Cleaning District Stations, and found that a large proportion of the rubbish could be saved, and that it repaid the effort and cost of recovery. He afterward built an experimental station to which was brought the refuse from three districts; erected a movable platform for sorting, and a furnace for burning the residue. The station built by the city, was run by contract, and the city received from it a revenue based upon a sliding scale, according to the quantities delivered, allowance being made for delay and stoppages. The collection of refuse was made by the city, and householders were asked to keep it separated from the garbage and ashes.

This experiment proved that there was a far greater value in city refuse than had been generally known; that the preliminary separation could readily be made at the house; that a separate force of men and carts could be profitably employed for collection; that the refuse could be sorted, baled and marketed, the worthless portions being destroyed without nuisance in the neighborhood of the works, and that there was revenue for the city in the process. Though the furnaces and machinery were not adequate for the work, yet the results were reasonably good, considering all the circumstances.

The returns from the Waring experimental station from January 1, 1898, to August 11, 1900—two years, seven months and eleven days—are shown by reports made by the Street Cleaning Bureau and by private observation. The amount of combustable refuse collected in three street cleaning districts, Numbers 12, 14 and 16, respectively included in the territory bounded by Sixth and Seventh streets, south, the Bowery and Fifth avenue, west, Twenty-second-street, north, containing 116,525 persons, and having a fair average of houses, shops, stores, department stores and factories is as follows:

TABLE XX.—RETURNS FROM EAST SIXTEENTH STREET REFUSE DISPOSAL STATION, NEW YORK CITY.

Year	Loads	Collections	Payments to City by Contractor	Value to City per Ton
1898	15,356	6,710	$4,141	61.7 cents
1899	12,946	5,660	3,109	54.9 "
1900	7,422	3,300	3,680	$1.10 (7 mos.)

THE QUANTITIES AND COMPONENT PARTS OF REFUSE RECEIVED IN 1899.

Paper, books, strawboard, etc.	3,058,616 lbs.
Rags, carpets, clothing, shoes, etc.	576,812 "
Iron, copper, brass, lead, rubber	132,438 "
Bottles, proprietary	29,000 No.
Bottles, common	350 bbls.

Nearly all this refuse came from houses and shops, the large department stores contributing about 1,500 loads of wrapping paper and strawboard. A smaller proportion of factory waste was received, useless except for fuel. These items may be still further classified.

Of the whole annual quantity by weight thus treated, 37 per cent. was sorted and sold, 60 per cent. was burned, and 3 per cent. to 5 per cent. was incombustible and was taken away with the ashes, which formed about 17 per cent. of the quantity burned. About 75 horsepower in steam was derived from combustion, of which less than 25 per cent. was utilized. This station was discontinued by a new city administration, and for two years all the

TABLE XXI.—PERCENTAGE OF SALABLE PORTIONS IN ONE HUNDRED PARTS OF REFUSE.

Paper, six different grades	74.5
Rags, clothing, bagging, twine	12.2
Carpets, four grades	3.3
Bottles, common and proprietary	2.5
Metals, iron, brass, lead and zinc	2.1
Tin, all sizes and kinds	1.4
Leather, shoes and scraps	1.9
Rubber, shoes, hose and mats	.2
Barrels, whole	1.4
Other salable material	.5
	100.0

city's refuse was gathered and marketed for the benefit of one contractor, who, after rough sorting it at the dumps, conveyed the remainder of the refuse in scows to fill land.

THE REFUSE UTILIZATION STATION IN BOSTON.

Up to 1898 the city of Boston collected the refuse and rubbish with the ashes, and towed the larger part to sea outside the harbor. Under the influence of tides and winds the lighter portions were carried to adjoining beaches, causing complaints and threats of litigation. The matter was taken up by the city Board of Health, under the leadership of Dr. Samuel H. Durgin, president, resulting in action by the Mayor and the City Council, who asked for plans and estimates for a disposal station for dry refuse.

The designs, estimates and superintendence of the author were accepted by Mayor Josiah Quincy, and a contract was made, in 1898, with a company organized for the purpose, for a term of ten years, with the privilege of purchase by the city at the end of five years, or an extension to the company for the same length of time.

The city furnishes the ground, collects and delivers all the refuse, and pays the company $5,500 annually. The plant, which cost $30,000, was erected and is maintained and operated by the company, which receives all revenue from the material sorted, and disposes of the residue.

The station is located at the Fort Hill dumping wharf, on Atlantic avenue, about one-half mile from City Hall, nearly in the geographical center of the city, and on the line of the elevated and surface car lines. It consists of a building 162 feet long, 80 feet wide, with brick walls and steel columns supporting a

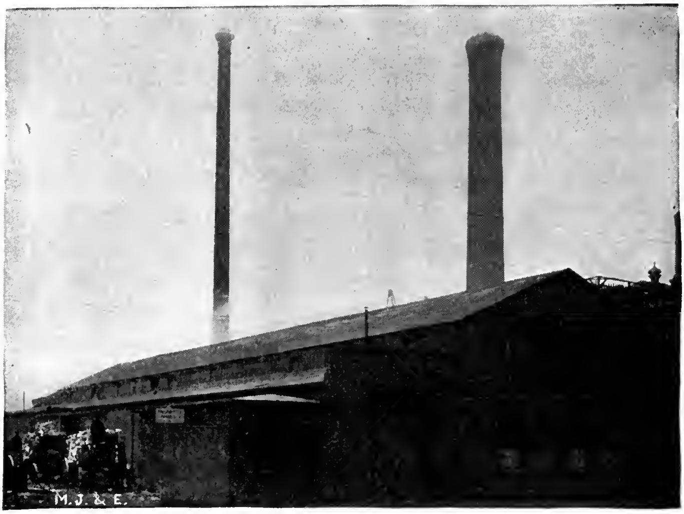

FIG. 1.—THE REFUSE UTILIZATION STATION, BOSTON.

wooden roof. (Fig. 1.) There is a sub-basement under one-half of the building containing the baling presses and destructor. A large

FIG. 2.—THE RECEIVING ROOM AND CONVEYOR, BOSTON.

storage space is provided for receiving the waste, the carts discharging with no delay, except for weighing each load. (Fig. 2.) From this receiving room the refuse, with a little preliminary sorting to remove heavier articles, is placed on an endless belt or movable iron platform 4 feet wide and 150 feet long, which carries it slowly toward the other end of the building. On each side of this moving conveyor stand files of men who pick out the several grades of paper, rags, cardboard, etc., and place in bins behind them.

The bottoms of these bins discharge into power-driven presses placed in the basement, which press the paper and rags into bales of 600 pounds. (Fig. 3.) The other articles, glass, iron, leather,

FIG. 3.—POWER AND HAND PRESSES, BOSTON.

twine, etc., are removed to separate bins. The portions of refuse not worth saving, which remain on the conveyor, are discharged in a continuous stream into the destructor placed across the rear end of the building, everything worthless being burned without delay, and without rehandling or sorting.

This destructor is of a special and peculiar type, built with interior walls of heavy fire-clay blocks, and exterior walls of red brick, solidly braced with buckstays and tie-rods; it is provided with fire-clay covers for the feeding holes, and doors for removing ashes and clinker. (Fig. 4.)

At the rear end, between the furnace and the chimney, is a

60-horsepower steam boiler with an independent fire-box, operated solely by heat from the destructor, and furnishing the power for moving all the machinery for sorting, baling, driving a dynamo for lighting the building (ten arc and thirty incandescent lamps), and for heating it in winter. No fuel has ever been used except the refuse, and but a portion of the heat developed is used.

A boiler of 200 horsepower can be maintained at its full capacity by the heat from the destructor. The draft is regulated by

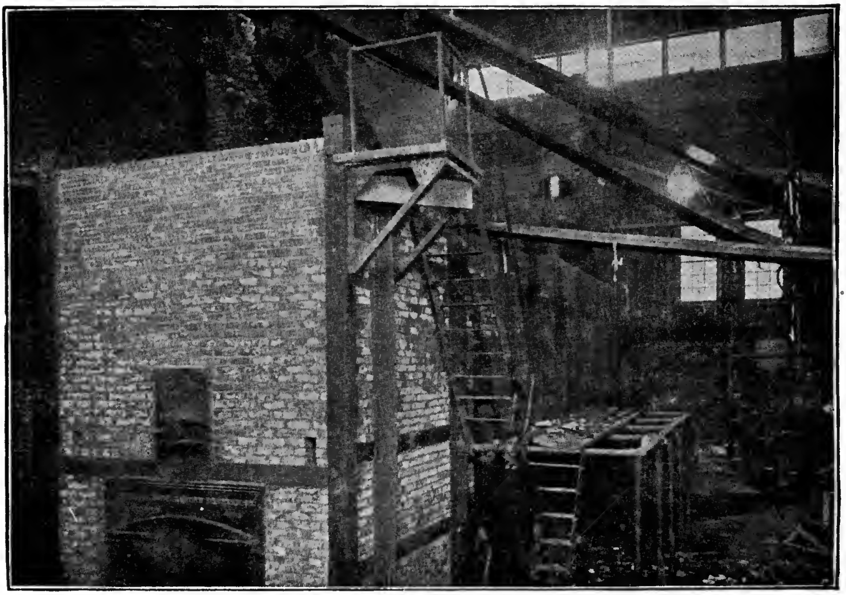

FIG. 4.—THE CONVEYOR, DESTRUCTOR AND BOILER, BOSTON.

heavy fire-clay dampers, the surplus heat going through a byepass to the chimney—a self-supporting steel shaft 140 feet high, lined with fire brick. The plant operates from 8 to 12 hours a day, dependent upon the supply of refuse, and has a capacity of 500 cubic yards in 24 hours.

The refuse is collected from city districts which include the business and a part of the manufacturing section, besides a large area of the residential part, the estimated population being 200,000, and covering 95 to 100 miles of streets. The collection is made daily by 17 large market wagons, and by 31 paper carts, the daily average being from 50 to 65 loads; a maximum of 100 loads has been dealt with.

The character and composition of this refuse is very nearly the same as in New York, but the separation of the various grades of paper and saving of minor articles is much more thoroughly done. The quantities sorted cannot be accurately stated, but in a general way it can be said that 50 per cent. by weight and 65 per cent. by volume is sorted available for market. The amount burned is

TABLE XXII.—APPROXIMATE QUANTITIES OF REFUSE RECEIVED AT BOSTON STATION.

Year	Loads	Estimated Lbs. per Load	Cubic Yds.	Tons
1899	16,926	796	......	6,736
1900	16,423	1,045	......	8,581
1901	17,585	1,045	......	9,188
1902	16,684	1,045	......	8,717
1903	15,875	1,045	......	8,294
1904	16,234	1,045	......	8,482
1905	16,008	1,405	......	8,364
1906	......	.....	104,407	11,067
	Total amounts (8 years)			69,429
	Yearly average			8,678
	Weekly "			167
	Daily "			28

about 25 per cent. by volume; 10 to 12 per cent. is worthless and is removed, with the 15 per cent. of ashes remaining from combustion, to the adjoining dumping scows and towed to sea.

The destructor was the first of its type erected, being a radical departure from the experimental furnace of Waring, and in many points unlike the existing types of American crematories. It is a down-draft furnace, taking all the material through a chute kept continuously supplied by the conveyor belt, the air for combustion entering through the same opening on the top of the furnace. This kind of bulky waste requires larger furnace capacity and more air than the usual garbage and rubbish, and the grates and flues must be arranged to allow the free and uninterrupted passage of a larger volume of gases, to avoid back fire when the furnace is full. There must also be ample provision for detaining small floating particles of ash or partly burned bits of paper, a point usually overlooked in American practice.

The boiler was intended only for the work of this plant, as no use could be made of the surplus heat, and the power now employed is less than 50 per cent. of the capacity that can be developed. If an opportunity offered, a boiler of 200 horsepower could be operated by the gases of combustion, and the earning capacity of the plant in steam power be increased nearly four times.

The automatic charging by the conveyor belt requires only two men to operate this furnace, an important saving as compared with incinerators where four to six men are constantly needed to fire by hand, stoke, and remove ashes. There was at first a secondary fire box provided for consuming gases by extra fuel, but as this was not needed, in repairing the furnace after six years of continuous use it was deleted. But few changes or alterations have been found necessary, these comprising power presses instead of hand, an ash lift for removing ashes and rubbish, and a hoist for loading the bales of paper. While there is no direct revenue from this plant to the city, it receives the greater benefit from this system of disposal, as the delivery of the refuse at this central station is less expensive than before, the cost of transportation outside the harbor is saved and the sanitary disposal is a vast advantage over the former methods with their attendant nuisances and constant complaints.

At the expiration of the contract of the Refuse Utilization Company the city proposes to erect a larger station on the same site and conduct the work by its own agents for its own benefit.

The work of this station for a continuous period of ten years is a striking illustration of the value of practical business methods applied to the recovery of waste materials heretofore lost.

It also points a moral in favor of successful municipal service by contract as contrasted with other works of the same general character, where the station has been operated by city employees, with apparatus theoretically designed to be perfect, but practically proved to be altogether inadequate.

THE FORTY-SEVENTH STREET REFUSE UTILIZATION STATION, NEW YORK CITY.

At the incoming of the reform city government of New York, in 1902, the Commissioner of Street Cleaning, Dr. J. McG. Woodbury, caused to be erected on a pier extending into the Hudson River at Forty-seventh street, a rubbish incinerator described by the designer, Mr. H. De B. Parsons, C. E., as follows:

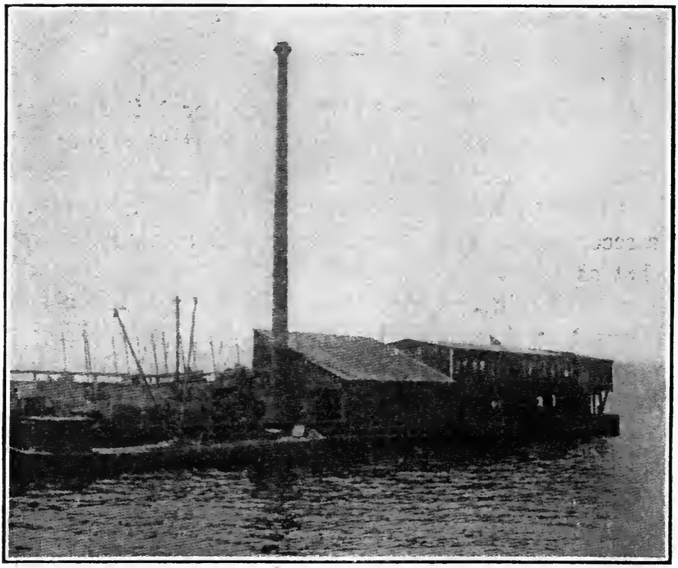

FIG. 5.—THE FORTY-SEVENTH STREET REFUSE STATION, N. Y. CITY.

The design of the incinerator, Fig. 5, consists of three cells, each having thirty square feet of grate area. The products of combustion pass over the cells into the smoke flue in such a manner that the product from cell No. 1 has to pass over cells Nos. 2 and 3; the product of combustion from cell No. 2 mixes with the products from cell No. 1, and together they pass over cell No. 3; and that from cell No. 3 mixes with the products from cells Nos. 1 and 2, and is intimately mixed again in passing along a tortuous flue to the base of the stack. The result of this arrangement has been highly satisfactory, as regards the non-production of smoke. Taking a stormy day, when the material was brought to the incinerator wet, the smoke was seldom visible for more than about seventy-five feet from the top of the stack, and then only during the period of stoking one of the grates.

This incinerating plant was constructed as an experiment. In order that it might be free from any hindrance from injunction or otherwise, lest it might create a nuisance to neighboring property, it was decided to locate the plant on one of the city piers, about 250 feet from the bulkhead line. The permanency of location, of course, was not considered, the idea being that if the plant could be constructed quickly, and show that combustion could be carried on without creating a nuisance, it would lead to the introduction in the future of other stations, more favorably situated, and at which better facilities could be provided for the reception of the material and for picking the same.

Shortly after the incinerator was built some changes were found necessary. The flues connecting with the chimney were simplified to allow a shorter passage of the gasses. A larger boiler was installed with more direct connection with the furnace; a picking belt, or conveyor (Fig. 6), with bins for sorting the

FIG. 6.—CONVEYOR AND SORTING BINS, NEW YORK STATION.

refuse, and an engine and dynamo for electric lighting were added.

An effort was made to change the method of charging by using an automatic conveyor direct to the charging openings, but it was found impracticable owing to the peculiar construction of the incinerator. After a period of about four years the cells were found to be greatly damaged by the heat, and specifications were prepared by Mr. Parsons calling for a new construction of a two-cell incinerator to be connected with the large boiler.

These two cells were to be built with interior walls of concrete 9 inches thick, and with exterior red brick walls 13 inches thick, the whole bound together with buckstays and angles in the usual manner. There were two top-charging holes for each furnace with heavy doors protected by fire-clay slabs.

The concrete walls for interior lining was to be made with one part Atlas cement, two parts powdered slate, and one part of clean steam ashes from not less than 1/8 inch in diameter. The grates were in sections five inches deep, tapering in thickness 3/4 down to 5/16 inch and spaced 3/4 inch.

No reinforcement of the interior walls was used. The contract was let, the incinerators built and work begun. Cracks and

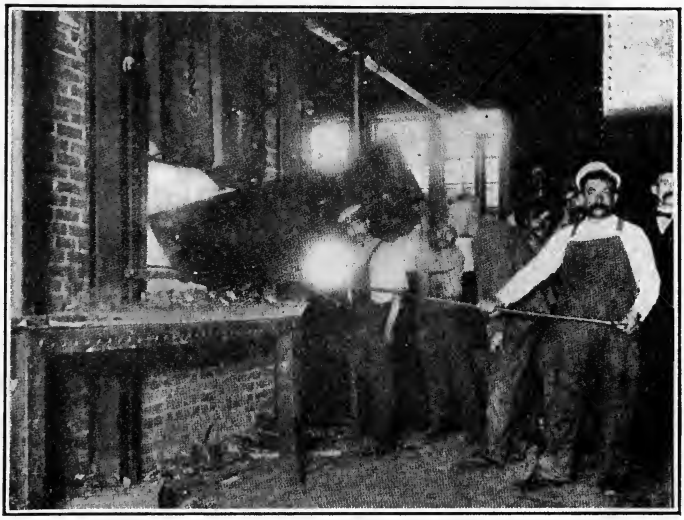

FIG. 7.—CHARGING THE INCINERATOR, NEW YORK STATION.

breaks presently appeared in the interior walls, rapid disintegration of the whole structure took place, and in a month it was practically destroyed. No incinerator has as yet taken its place and the refuse, after rough picking, is removed with the ashes to Riker's Island.

The tables following, condensed from the reports of Mr. F. L. Stearns, engineer of Street Cleaning Department, show the work done in two incomplete trials of the first incinerator. There are no reports from the second one:

REPORT OF FORTY-SEVENTH STREET INCINERATOR, NEW YORK, OCTOBER 7, 1904.

The measurements for weights, bulk, and fuel value of waste were made on the loads received for one-half day. The tests for power were made on the entire day.

TABLE XXIII.—QUANTITIES RECEIVED.

	No. of Loads	Cubic Yards	Cubic Yds. per Load	Weight Pounds	Weight per Cubic Yard
City carts.........	44	33¾	7.6	48,100 }	140 lbs.
Private carts......	10	39	3.9	4,530 }	

TABLE XXIV.—SORTED MATERIAL.

	Cubic Yds.	Wt., Lbs.		Cubic Yds.	Wt., Lbs.
Newspapers.......	98	5,184	Rags.............	6½	1,007
Manila paper......	54½	1,250	Bagging..........	1	184
Pasteboard........	105	4,909	Carpets...........	1½	274
Mixed paper.......	53	2,613	Shoes.............	½	180
Mixed paper and rags............	6	625	Hats..............	½	17
Books.............	½	259	Rope..............	½	111
Iron and tin.......	16	1,942	Barrels...........	21	2,826
Bottles...........	½	363	Boxes.............	11	1,400
Totals........	333½	17,145	Totals........	42½	5,999

Total picked out, 23,114 lbs.; 48.8 per cent. by weight, 63.5 per cent. by volume.

Total burned, 24,275 lbs.; 51.2 per cent. by weight, 36.5 per cent. by volume.

Total ashes from combustion, 3,529 lbs. = 6.8 cubic yards, at 519 lbs. per yard.

Percentage of ashes of amount burned, 10.7 by weight, 3.1 by volume.

TABLE XXV.—EXPERIMENTAL TRIAL FOR STEAM POWER OF 47TH STREET INCINERATOR.

Duration of test..................................	4½	hours
Quantity of rubbish burned.........................	23,011.0	lbs.
Average horse-power developed....................	232.7	
Quantity of rubbish to produce 1 horse-power per hour.	21.9	lbs.
Grate surface.....................................	154.0	sq. ft.
Horse-power per hour per square foot of grate area...	1.51	
Heating surface of boiler..........................	2,759.9	sq. ft.
Heating surface per square foot of grate area........	17.9	sq. ft.
Water evaporated per pound of rubbish..............	1.59	lbs.
Percentage of ash from rubbish.....................	14.5	
Weight of rubbish per cubic yard...................	111.0	lbs.

No use could be found for the power developed, though this was estimated at $8,000 per year in value. Owing to the peculiar construction of the furnace, it was fed by hand through front side doors by the continuous work of three men. The ashes were removed through the back side doors by two other men. The work required a foreman, an engineer and his assistant and two laborers for charging the boiler fire-box with large bulky articles that could not be burned in the incinerator. The force employed was nine to eleven men daily, varying with the quantities brought by the city teams. The city received payment for the sorted paper and rubbish at the rate of about $3.20 per ton of recovered paper. Applying this amount toward the expenses of the plant there was a deficiency of approximately $300 per week on the whole operation of the refuse station.

The following table of volume and weights per cubic yard is from the report of Mr. Stearns on the Forty-seventh Street Station*:

TABLE XXVI.—VOLUME AND WEIGHTS OF REFUSE N. Y. CITY.

Newspapers,	picked............	5,185 lbs.	98 cu. yds.
Manila paper,	"	1,250 "	54½ " "
Pasteboard,	"	4,909 "	105 " "
Mixed paper,	"	2,613 "	53 " "
Rags,	"	1,007 "	6½ " "
Mixed rags and paper,	"	625 "	6 " "
Iron and tins,	"	1,942 "	16 " "
Bagging,	"	184 "	1 " "
Carpets,	"	274 "	1½ " "
Barrels,	"	2,826 "	31 " "
Books,	"	259 "	½ " "
Bottles,	"	363 "	½ " "
Shoes,	"	186 "	½ " "
Hats,	"	17 "	½ " "
Rope,	"	111 "	½ " "
Boxes,	"	1,400 "	11 " "
Total........................		23,114 lbs.	372 cu. yds.
Waste........................		24,272 "	218½ " "
Total........................		47,389 lbs.	590½ cu. yds.

Percentage picked..................48.8% by weight, or 63% by bulk
" of waste................51.2% " " " 37% " "

*Transactions A. Soc. C. E., Vol LX., p. 345, 1908.

THE VALUE OF REFUSE.

The method of recovery and the value of marketable refuse in the whole of New York City is thus stated:

> The rubbish is picked over at the dumps [and utilization stations] by a trimming contractor, who pays the city for the privilege. The value of this marketable refuse to the city is about $3.20 per ton. The Commissioner of Street Cleaning has stated that this figure is too low; probably it should be increased 50 per cent. It is figured thus: The average rubbish collections are 300 tons per day, or 1,800 tons a week, of which the marketable proportion is 35 per cent., say 600 tons. For this the contractor pays the city approximately $1,920 weekly, or at the rate of $3.20 per ton. In this case the "City" comprises the boroughs of Manhattan and Bronx only, as Brooklyn, Queens and Richmond deal with their own refuse. The total yearly amount of marketable material is 93,600 tons, and the payment made for the privilege of sorting everything saleable is $110,000.

DELANCEY STREET REFUSE DISPOSAL STATION, NEW YORK CITY.

Following the construction of the Forty-seventh Street Station, the Department of Street Cleaning caused to be erected in November, 1905, a combined refuse incinerator and power plant in Delancey street beneath the Williamsburg Bridge. The building (Fig. 8) which contains the furnaces and boilers is a one-

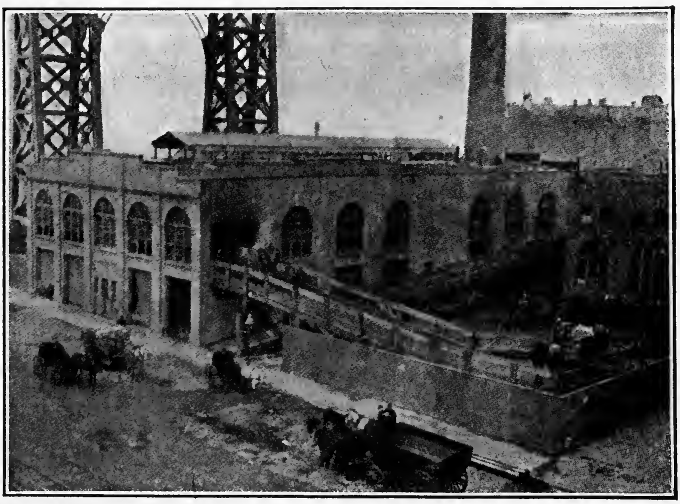

FIG. 8.—THE DELANCEY ST. REFUSE DISPOSAL STATION, N. Y. CITY.

story structure 70 x 150 feet in area, with brick walls and a steel trussed roof. It is divided into two rooms by a fire wall, in the front of which is the receiving, baling and sorting floor; at the rear end are the boilers used for steam generation.

From the sorting floor a short conveyor (Fig. 9) carries the

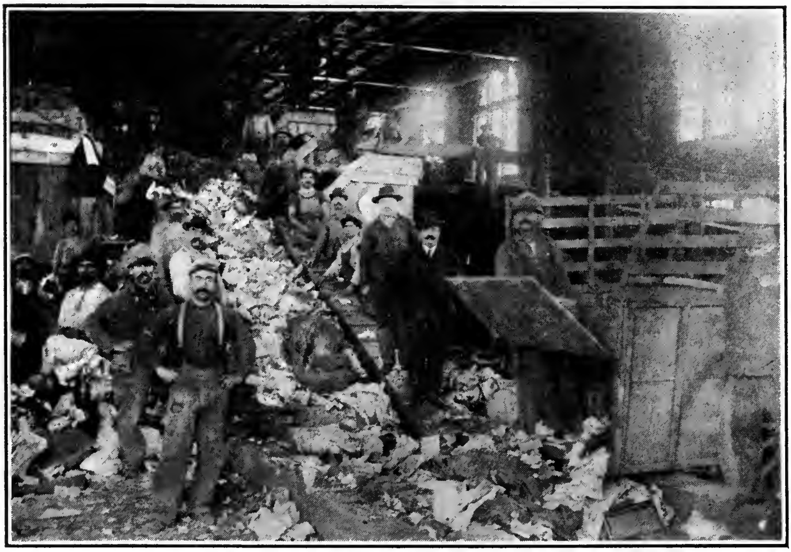

FIG. 9.—THE CONVEYOR AND SORTING BINS, DELANCEY STREET STATION, NEW YORK CITY.

refuse to the top of the furnaces, discharging between them, so that they may be fed by hand simultaneously. During the passage of the refuse over the conveyor the trimming contractor's men pick out a small proportion of the paper, which is baled by power presses and removed from the building. The remainder of the refuse furnishes fuel for the operation of the furnaces and the development of steam power.

There are two furnaces placed back to back, with a common smoke flue connection to the chimney. These furnaces are the same dimensions, but are unlike in interior construction. Furnace No. 1, designed by Mr. H. De B. Parsons, originally followed the same general construction as that of the Forty-seventh street incinerator, except that there were two separate cells instead of three, and two charging holes placed on the side and delivering the refuse over a short incline to the fire grates which form the floor of each of the two cells. The grates consist of wrought-iron bars riveted up in sections. Each cell is a complete furnace in itself, having a charging hole, and stoking and ash pit doors.

The gases of combustion pass upward to a cross flue which is connected with the boiler and the stack, and is controlled by large fire clay dampers. Each cell has a sliding door in the front end for the admission of large pieces of furniture, mattresses, etc.

The second furnace, designed by Mr. F. L. Stearns, of the Department of Street cleaning, is practically the same size, but has a different arrangement of feed holes and grates. There is but one side feed-hole, which is a straight passage from the charging floor to the fire grates, the other feed-hole being on the top near the outlet, and large enough to receive barrels and other bulky matter. There are two sets of iron fire grates, placed horizontally, one above the other, so that partially burned matter from the upper set of grates may fall to the lower and there be wholly consumed, the ashes being raked out of the ash pits below.

There are two 200-horsepower Sterling water tube steam boilers, each with 1,950 square feet of heating surface. These are provided with the regular fire grates for using coal, and can be run independently of the incinerators. The boilers are fed from a pump in the adjoining building, the feed line passing through an economizer coil in the base of the stack, which heats the feed water to a high temperature.

In the adjoining building are placed two 100-k.w. and one 50-k.w. direct connection engines, with generators of multipolar direct-current type, wound for 250 volts, operating a three-wire system. Their ratings permit an overload capacity of 25 per cent. The distribution, which is controlled by an eight-panel switchboard, provides for two circuits for local lighting and five for the bridge, which are arc lamps connected on the multiple system.

The chimney of these incinerators is of the radial brick type, and is 200 feet high; inside diameter 4½ feet at the top. The foundation is concrete, 14 feet thick, on 30 foot piles over an area 24 feet square.

The cost of the building, chimney, furnaces, conveyor and outside driveway was	$34,193.00
Boilers and Electrical Equipment	49,391.00
	$83,584.00

The saving effected by this method of disposal over the former one of dumping was expected to be $30,300 a year. This is 36.8 per cent. of the cost, and at this rate the whole expense of the plant, maintenance and repairs would have been paid in three years. The amount of refuse handled daily (approximately 1,050 cubic yards) is about one-fifth of the total daily output of the boroughs of Manhattan and Bronx.

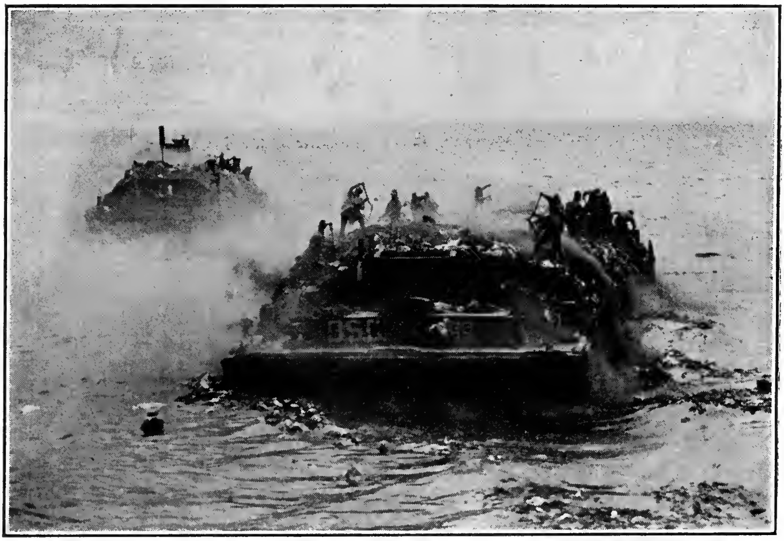

FIG. 10.—THE UNLOADING OF SCOWS AT SEA, NEW YORK CITY.

After the construction of this incinerator many changes were made. The charging holes were removed from the side and placed in the middle line of the furnace. The inner partitions between the cells were removed, and the incinerator thus became a rectangular open chamber floored with cast-iron fire bars and charged by two openings through the roof.

After its operation for six months the walls showed signs of weakness, and repairs were made. Subsequently, the strain put upon this furnace for developing high temperature for electric lighting proved its inability to withstand the pressure, and after an intermittent use of about two years the east incinerator was in too bad a condition to be operated.

At the present time the west furnace is used for destroying refuse rejected by the picking contractor, but no steam power is developed. The boilers have been removed, the machinery for electric lighting is dismantled and the whole plant is in poor condition for anything like satisfactory work.

TABLE XXVII.—DATA AND RESULTS OF EVAPORATIVE TESTS; RUBBISH INCINERATOR AND ELECTRIC LIGHTING STATION, DELANCEY SLIP, BOROUGH OF MANHATTAN, NEW YORK.

Trials made by H. De B. Parsons.

DATA	West Boiler		East Boiler	
Grate surface of furnace	.....	113 sq. ft.	.....	74 sq. ft.
Effective water-heating surface	.....	1,890 "	.....	1,890 "
Surface of feed-water heater coil in flue	.....	60 "	.....	60 "
TOTAL QUANTITIES				
Date of Trial	.....	Dec. 20, 1905	.....	Dec. 21, 1905
Duration of trial	.....	5.5 hours	.....	5.5 hours
Weather	.....	Fair	.....	Rainy
Condition of rubbish	.....	Dry	.....	Wet
Weight of rubbish delivered	.....	31,193 lbs.	.....	21,175 lbs.
Weight of rubbish picked out as: marketable	.....	8,926 "	.....	7,245 "
paper	6,876	.....	6,435	.....
rags	1,800	.....	610	.....
cans	250	.....	200	.....
Weight of rubbish burned	.....	22,267 lbs.	.....	13,930 lbs.
Weight of ash, estimated	.....	10%	.....	10%
Total weight of water fed to boiler	.....	29,925 lbs.	.....	24,675 lbs.
Equivalent water evaporated, from and at 212°	.....	36,568 "	.....	30,054 "
Number of furnace men: stokers	6	.....	2	.....
feeders	3	.....	2	.....
Boiler horse-power developed	.....	192.7	.....	158.4
ECONOMIC RESULTS				
Water evaporated, actual, per pound of rubbish	.....	1.34 lbs.	.....	1.77 lbs.
Equivalent evaporated per lb. of rubbish	.....	1.64 "	.....	2.16 "

From an article contributed by Mr. F. L. Stearns to the discussion before the American Society of Civil Engineers, the following explanation is included:

The plant began by furnishing 250 amperes at 250 volts and lighting only a part of the bridge. Later the load was increased until 800 amperes at the same voltage was generated, lighting the whole bridge. In creating this power, however, the plant was run beyond its reasonable capacity, resulting in the melting of the fire brick in the flue leading to the boilers, which it is now realized was too small. This portion of melted brick, together with ashes and other elements carried from the furnace in suspension, filled the flues with a slag like iron ore; while the melting brick gradually disappeared until the top of the flues caved in and the plant was obliged to discontinue lighting the bridge and was used simply to dispose of the rubbish.

The Edison Company about this time offered to light the bridge at the rate of 3½ cents per kw-h., which was cheaper than it could be done by a plant of this kind, however efficiently run, and this offer was therefore accepted and the use of the plant for lighting discontinued. Another furnace has been built close to the boiler, the connection between the two being, instead of a flue, an opening the full width of the boiler and furnace. This has as yet been run for only a year, producing steam to run the conveyor and presses without any repairs, melting of brick or production of slag. As there seems no use to put the power to other than lighting, and as this was being obtained more cheaply than the cost of furnishing it by the incinerating plant, this is used now simply for incinerating rubbish and the waste heat is permitted to go up the stack to the outside air.

The failure of the incinerating plant to light the Williamsburg Bridge does not prove that rubbish is not a good fuel, neither does it prove that it is impractical to generate steam power with rubbish as a fuel. Only twelve years ago this burning of rubbish alone was untried, and to-day we are not only trying to compete with coal-burning plants of the same capacity but with the large plants of the Edison Company. Experience with this plant seems to have demonstrated that, in competition with coal-fed plants of equal size, rubbish-incinerating power plants can furnish steam power economically. But no small plant can furnish power as cheaply as a large one; and a large incinerating plant is impracticable because of the undesirability and great cost of hauling the rubbish from such great distances as would be necessary to provide fuel for such a plant.

This statement by Mr. Stearns treats the question of the operation of the lighting plants very tenderly. The facts appear to be that the design of the furnaces was not based upon correct principles. It is true that the combustion of this class of waste had not been done in an extended way except at one point in the United States, but the calorific value of the fuel was fairly well understood, the quantities to be dealt with were known, the boiler power to be developed was a fixed quantity, and with these factors there should have been no great difficulty in constructing a furnace which should be equal to the work.

The actual results were most lamentable, one furnace having collapsed within six months after the first installation, necessitating many repairs, and even after changes were made in the design, there were still unfortunate results in the production of steam and in the maintenance of the furnaces themselves.

They were theoretical designs evolved from calculated formula, and, as a matter of fact, failed almost completely when it came to a practical trial under existing conditions. It is a demonstration of a truth that sometimes occurs in practical mechanics, that a theoretical design from carefully prepared data does not do the work nearly as well as even a rough construction by a practical man who understands the power of heat, and who can design and maintain his constructions from his own personal experience.

FIG. 11.—TIPPING ASHES AND RUBBISH INTO SCOWS, N. Y. CITY.

FINAL DISPOSITION OF ASHES AND REFUSE OF BROOKLYN.

In July, 1903, a five-year contract was made with the American Railway Traffic Company, organized to take over the contract from private parties for the final disposition of the ashes, street sweepings and refuse collected in the borough. There were established thirteen receiving stations, built and maintained at the expense of the company, at which the wastes (not including garbage) were delivered by the city carts. At two stations the carts (Fig. 12) discharged directly into cars run over the trolley lines of the Brooklyn Rapid Transit Company to a dumping ground near Coney Island. At eleven other stations the city carts discharge the ashes and sweepings into steel bins having a capacity of 9¼ cubic yards, weighing, when loaded, from five to eight tons. Four bins constitute a load, which is taken to the

FIG. 12.—THE CARTS FOR COLLECTION OF ASHES, NEW YORK AND BROOKLYN.

FIG. 13.—ASH BINS REMOVED BY TROLLEY, BROOKLYN.

dumping ground by trolley. All ashes and street sweepings are disposed of in this manner. (Fig. 13.)

The refuse, separated at the houses, is delivered by the city carts at the stations in separate buildings, wherein the marketable portions of the rubbish are recovered by sorting, the residuum being sent with the ashes to the dumps, or to the East New York Disposal Station, where it is destroyed and the steam power generated is utilized.

THE EAST NEW YORK DISPOSAL STATION.

The largest station operated by the American Railway Traffic Company, under their contract with Brooklyn, is at East New York, a suburb of Brooklyn proper.

The building of this station is 150 feet by 75 feet, wooden frame, corrugated iron covering, two stories high. One-half the area of the upper floor space is devoted to the ash collection teams which dump their loads into pockets, or bins, beneath which the cars of the trolley line are loaded.

The other half of the upper floor contains a short belt conveyor for sorting the refuse brought by city teams, the picking bins, and the office. The second half-floor below has another conveyor which receives the rubbish brought from the other stations, and which is burned without further sorting.

Conveyor No. 1, above, discharges into Conveyor No. 2 below, and the latter discharges directly into the furnaces.

The incinerator is a double furnace of the "bagasse burner" type, the fire boxes being divided by a bridge wall, so that either may be run independently of the other. There are two grates placed horizontally; the upper consists of iron pipes connected into headers outside the furnace, for water circulation, and spaced one foot apart. The lower grates are of the usual cast-iron firebar pattern. There are two doors at the front of each furnace for stoking and for removing ashes. Both furnaces connect with a common combustion chamber, and this with a Sterling water-tube boiler of 300 horsepower. The chimney is of radial brick type, 100 feet high.

The steam power employed is about one-half the capacity of the plant, and is utilized for operating an air compressor for drills and hammers in the neighboring repair shop of the Brooklyn Rapid Transit Railroad Company, and for heating the buildings and running the conveyors. The ash collection is from 50 to 70 loads, and the refuse 20 to 40 loads daily. All the baling is done by hand.

There are no available data in regard to the amounts sorted and destroyed at this station, since this is a private contract and is not under the control of the city. The American Railway Traffic Company is annually transporting one million yards of material, which represents the ashes, street sweepings and rubbish left after sorting. The company receives 35 cents per cubic yard for this work of final disposition, besides the revenue from all recovered material and the value of the steam power generated at the incinerator plant.

During the period that this system has been in operation, three and one-half years, about eighty-five acres of sunken marsh land have been raised to the grade of the surrounding country and made good taxable area.

THE DECARIE REFUSE INCINERATOR, BROOKLYN.

The American Railway Traffic Company has a small Decarie

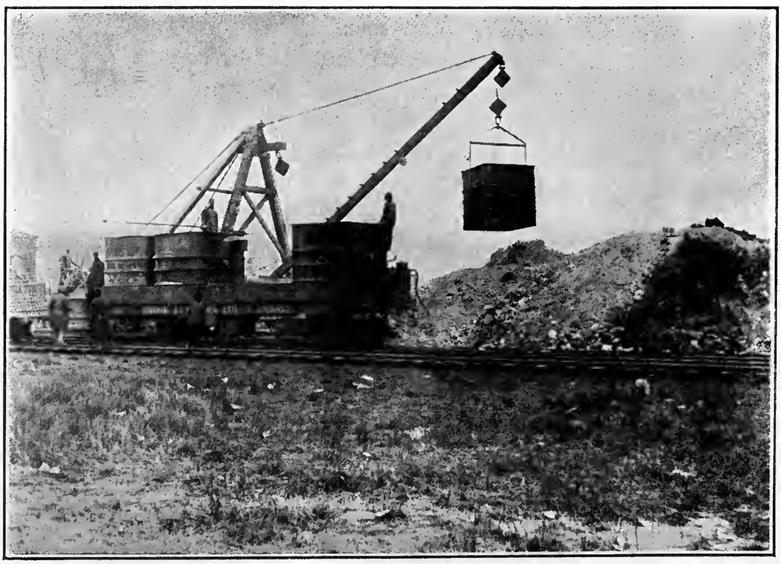

FIG. 14.—METHOD OF DISCHARGING ASH BINS, BROOKLYN.

incinerator in use in one of the Brooklyn districts. This is a square box of steel plate 10 x 10 feet and about 10 feet in height, with steel smoke stack 125 feet high. The usual water jacket construction is followed in this case, the double walls having space for water circulation, which is connected with the water-tube grates and the steam generator or square boiler box which forms the interior roof of the furnace. There is no steam power obtained from the plant, the conveyor for sorting being driven by electric motor supplied by currents from the street connections. The incinerator burns no garbage or other material than the dry combustible matters rejected in the process of picking. The capacity of the plant is stated at 30 to 40 cart loads daily, about 200 to 250 cubic yards. There are no reports of quantities received, sorted, or burned, and nothing is known as to the cost of operating and necessary repairs.

THE THIRTY-SEVENTH STREET RUBBISH INCINERATOR, SOUTH BROOKLYN.

For the disposal of the refuse of this district of South Brooklyn, the Street Cleaning Bureau has built a small incinerator of a simple design. This is a square box of steel plate (Fig. 15), lined

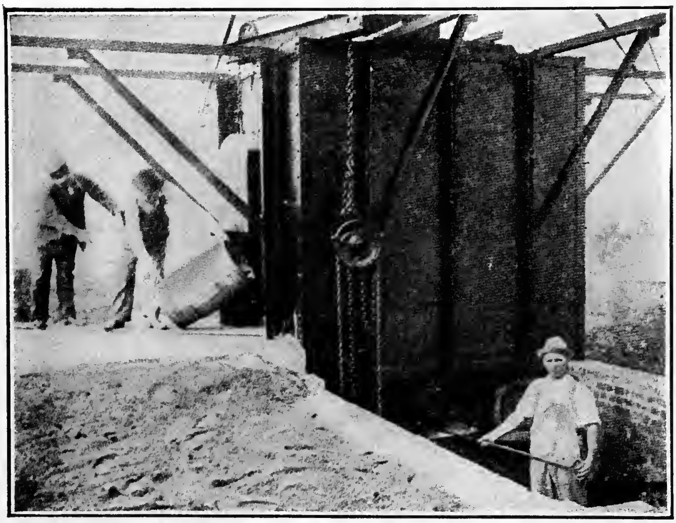

FIG. 15.—RUBBISH INCINERATOR, THIRTY-SEVENTH STREET, SOUTH BROOKLYN.

with fire brick, floored with cast-iron grates, with ash pit below, and flue connection with a short chimney at the rear above the fire bars. The furnace is charged through one large door at the level of the tipping platform. There is a corrugated iron covering house and inclined approach and platform for the collection carts.

The work is carried on by one man who recovers whatever of value he can pick out of the refuse as his payment for destroying the remainder.

The Refuse Disposal Station in Buffalo.

In 1903 the city of Buffalo had under consideration a plan for the reorganization of its service for the collection and disposal of waste; also for the disposal of sewage from a large district of the city that was below the level of the main sewerage system. An examination made by the Commissioner of Public Works, Col. Francis G. Ward, of several plans and methods, decided him

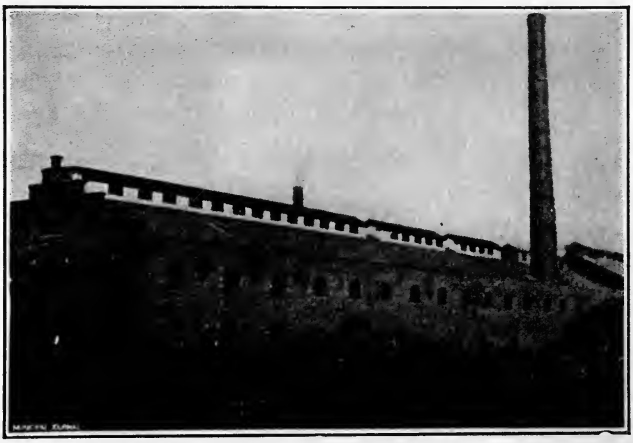

FIG. 16.—THE REFUSE UTILIZATION STATION, BUFFALO.

to accept the designs of Mr. C. M. Morse, deputy engineer commissioner, for the erection of a combined sewage pumping and refuse disposal plant on ground owned by the city at the Hamburg Canal.

The contract for the collection and disposal of the ashes, garbage and refuse for a term of five years, was awarded, after competition, to the Buffalo Sanitary Company, and provided for the erection of a refuse disposal station adjoining the sewage pumping station, which was completed in June, 1905.

The building is of brick, is 200 feet long, 50 feet wide and 25

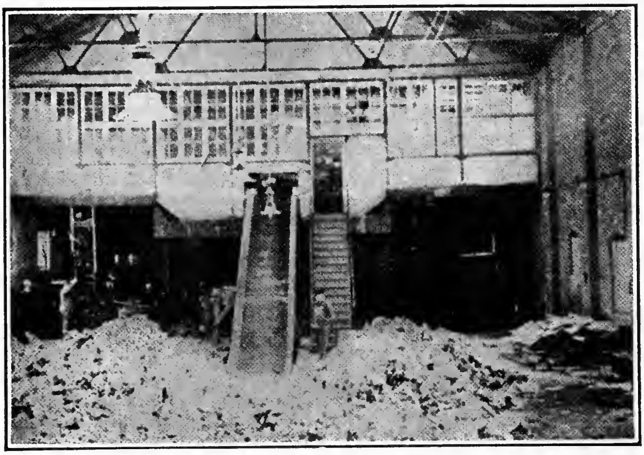

FIG. 17.—TIPPING FLOOR AND CONVEYOR, BUFFALO.

feet high at the eaves, with a steel trussed roof. (Fig. 16.) A division of the building into two parts is made by a fireproof wall; the main receiving room is 100 by 50 feet, and affords ample space for dumping the four or five hundred cubic yards of refuse

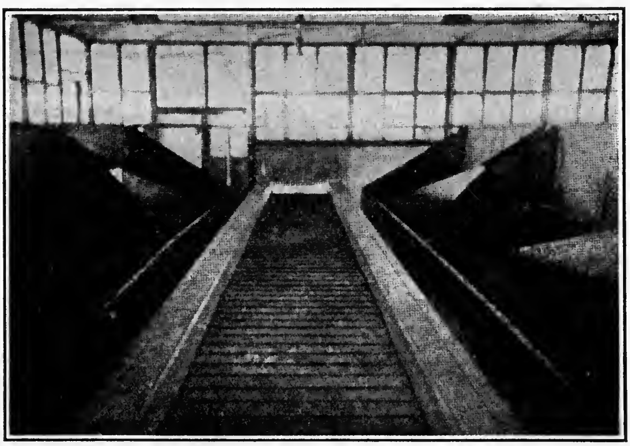

FIG. 18.—CONVEYOR AND SORTING BINS, BUFFALO.

received daily. Beyond the fireproof wall is the destructor, separated from the adjoining sewerage pumping station by another wall, through which the flues connect to the fire box of the steam boiler in the pumping station.

Between the receiving floor and the destructor is placed the conveyor, which carries the refuse up an incline to the floor of the sorting room, and thence 60 feet between the sorting bins. (Fig. 18.)

After passing the second floor the remaining worthless rubbish passes up the inclined conveyor (Fig. 18), and is discharged through a chute into one or another of the three charging holes,

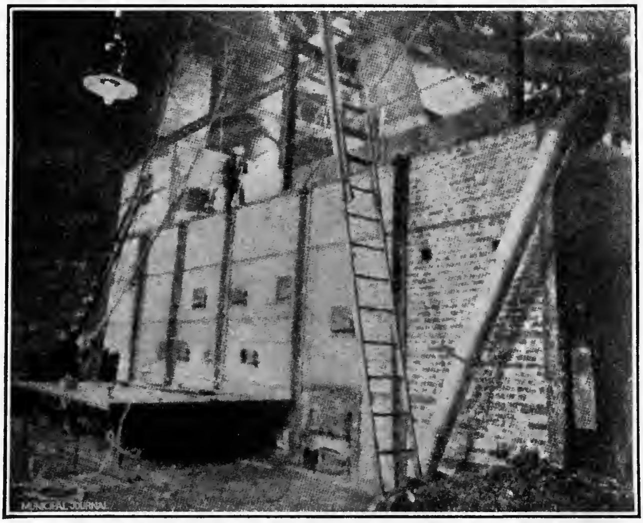

FIG. 19.—DESTRUCTOR AND STEAM BOILER, BUFFALO.

as may be desired. When the works are operating this stream of combustibles is constant, no hand-firing being required.

The destructor is 33 feet long, 12 feet wide and 13 feet high. The exterior is strongly braced by buckstays and tie-rods, and by longitudinal angle bars to which the frames of all doors are bolted. (Fig. 19.)

The interior construction really comprises a double furnace, with independent fire boxes and fire-brick grates for sustaining the refuse. The area of the fire boxes is 36 square feet, that of the refuse grates 160 square feet; a total of 196 square feet of grate surface. The fire boxes are separated by a bridge wall, so that they may be worked independently under forced draft. Behind the fire bars are two sets of fire-brick grates, one above the other, but divided from each other by a longitudinal bridge wall. Above the upper set of grates is the main receiving chamber of the destructor, approximately 20 feet long, 8 feet wide and 6 feet high, interior dimensions. At the rear end is a combustion chamber common to both furnaces to which all the gases are directed and from whence they are taken into the boiler of the sewage pumping station, or direct to the chimney by a bye-pass.

A small 75-horsepower boiler is set in connection with the destructor for the purpose of electric lighting, operating the conveyor and bailing presses, and for furnishing forced draft. By means of sliding dampers this boiler can be put out of commission when connection is made with the boilers of the sewerage plant.

The combustion of refuse is accelerated by forced draft from a 60-inch blower, introduced on each side of the destructor under the ash pits of the fire boxes. The chimney, which is connected with the boilers of the sewage pumping station and with the destructor, is 150 feet high, of radial brick, reinforced by a lining of fire brick to withstand the high temperature generated by the destructor.

The rooms which contain the dynamo and engine are separated from the main destructor room, and bathrooms and all other necessary conveniences have been provided for the comfort of the employees. The approximate cost of the refuse disposal station and all machinery, inclusive of the chimney, was $50,000.

The quantities of refuse received at the station for the first six months of its work, when under the control of the Buffalo Sanitary Company, was reported as follows:

TABLE XXVIII.—QUANTITIES AND DISPOSITION OF REFUSE, BUFFALO.

		Quantities	*Disposition*
June,	1905	12,736	Rubbish, dirt, ashes sent to dump from station, 2,116 cubic yards.
July,	1905	14,599	
September,	1905	15,176	
October,	1905	15,395	Tins marketed, 452 cubic yds.
December,	1905	10,887	Iron marketed, 2 tons.
January,	1906	10,924	Paper marketed not reported.
Delivered at Station		79,717 cubic yards.	

In May, 1907, the city purchased the buildings and equipment from the Sanitary Company for a payment of $50,000, and have since operated the station for its own benefit. The gross returns for recovered articles and steam supplied to the sewage pumping plant for 4 months 10 days, May 20 to September 30, 1907, was $11,957.83. After deducting the cost of operating and adding the allowances formerly made to the Sanitary Company for steam, the net returns from the station for the period named is about $5,000, or at the rate of $1,250 per month, or $15,000 per year.

The recovered articles included 2,362,417 pounds of paper, 83,703 pounds of rags, 53,626 bottles and four car-loads of tins.

The quantities received and sorted for one day, Oct. 14, 1907, were:

14	bales of newspapers	9,075 lbs.
34	" " mixed-paper	22,980 "
1	" Manila	535 "
1	" Rags	650 "
1	" Flour bags (paper)	635 "
51	bales	43,875 lbs.

FINAL DISPOSITION OF REFUSE AT LOWELL, MASS.

Since 1892 this city has destroyed its garbage by cremation in an Engle Cremator, except during times when it has been sold to the farmers for feeding swine. This cremator was not of sufficient capacity for the work required, and in 1904 the city erected a small incinerator for the disposal of the refuse.

The Decarie incinerator built at this place in 1904, at a cost of $10,000 for the furnace only, is a departure from the usual type of construction of this company. It is a circular, double-jacketed vertical boiler 8 feet in diameter and 10 feet high, having interior hollow pipe grates, arranged in a circle and at their upper ends tapped into the bottom sheet of the steam generator. On the front outside are two fuel grates arranged one above the other, the purpose being to make a down-draft from one grate through the other, the heat then passing into the incinerator. These grates and fire box are of no service and are not used. On the rear side exactly opposite to this is a square-jacketed brick chamber, having a grate at its upper and farther end, over which the gases from the incinerator are supposed to pass before reaching the chimney. The incinerator is charged through one large opening on the top 24 inches in diameter. There are nine doors for firing and removing ashes, one large charging hole above, and eight smaller circular 4-inch openings for stoking. The water-jacket and the hollow grates are part of the circulating water system. This steam boiler system generates a small amount of steam, not enough to utilize for power and which is allowed to go to waste.

The kinds of materials burned at this incinerator are rubbish, paper, small amounts of wood, sawdust, sweepings, barrels, and generally combustible refuse, with condemned food-stuffs from the market houses. An attempt has been made to burn garbage, but all the matter of this kind is found to pass through the grates into the ashpit below and is removed when partly burned, with the ashes. The furnace is not suited, nor is it used for the consumption of garbage in any considerable amount.

The official report of quantities for the week beginning April 1, 1907, is 47,125 pounds, or an amount of 3 1/3 tons per day. Time occupied, 8 in the morning until 5 o'clock at night. Fuel used daily, 150 pounds of coal and about 1 to 2 cubic feet of wood. The following report of quantities and cost of operating is condensed from the official report of the city for the years named—1904 to 1907 inclusive:

TABLE XXIX.—RUBBISH AND MARKET REFUSE, LOWELL, MASS.

Year	Paper and Rubbish		Market Refuse Number Tons Reported	Total Tons Collection	Total Costs	
	Number Loads Collected	Tons Taking 6 Yds. to Load, 200 lbs. to Yard			Per Year	Per Ton
1904....	536	321	303	624	$992.92	$1.59
1905....	606	363	664	1,027	1,101.20	1.06
1906 ...	723	433	1,046	1,479	1,762.45	1.19
1907....	708	424	1,195	1,619	1,489.80	.89
Totals.	2,573	1,541	3,208	4,749	$5,346.37	1.18

A report recently published has the following paragraph:

Garbage crematories have been installed in many cities in this country, but in a very large number of cases they have been reported as unsatisfactory or have later been superseded by other designs or by a different method. The crematories which are seen in American cities are furnaces operated under ordinary draft, usually with coal as a fuel. A recent examination of a furnace of this kind used, in this case, for the burning of market wastes, showed serious defects from a sanitary point of view. The heat was not great enough to destroy the odors at all times, and the heavy gases generated in the furnace, though discharged through a tall chimney, fell to the ground and were very offensive. The refuse was not completely burned, and the charred mass discharged from the furnace containing unburned material was offensive and much of it had to be reburned. Coal was being used, though not in large quantities, as the wastes contained much combustible material. The operation of this furnace in or near a populated district, in the manner in which it was being operated when examined, would be intolerable.

CHAPTER IV.

Municipal Ashes.—Collection and Disposal.

The largest item in waste disposal work is municipal ashes. The average quantity from towns using coal for domestic fuel is from 70 per cent. in winter to 50 per cent. in summer, an average of 65 per cent of the total waste collection for the year through.

The composition and character of municipal ashes varies not only with the kind of coal used but also with other local conditions. The character of the people has much to do with this. In wealthy residential towns the ashes are far greater in quantity and contain more unburned coal. The reverse of this is true in populous towns largely made up of working people. The geographical locality has perhaps the most noticeable effect. In the cold winter season of the north the consumption of fuel goes on at a much higher rate than in the temperate and warmer regions of the Middle and Southern States.

These various considerations make it impossible to assign any fixed percentage of ashes to any community unless the particular conditions are known.

The variation in American coals used for household fuels is roughly shown in the following table:

TABLE XXX.—APPROXIMATE ANALYSIS AND HEATING VALUES OF AMERICAN COAL.

Kinds of Coals and Localities	Fixed Carbon, Per Cent. Combustible	Volatile Matter, Per Cent. Combustible	Ash per Lb. Coal	Heat Units Per Lb. Coal
Anthracite, Penn. and Col.	100 to 92	0 to 8	10.0	13,700
Semi-Anthracite, Penn. and W. Va.	92 to 87	8 to 13	8.7	13,800
Semi-bituminous: Ill., Ind., Ia., Mo.	87 to 78	13 to 25	5.6	14,700
Bituminous: Pa., W. Va., Va., Ga., Ky., Tenn.	78 to 50	25 to 50	6.0	13,600
Lignite: Mon., Wy., Col., Wash., Id., Cal.	Below 50	Above 50	5.0	10,000

The refuse of a coal fire includes fine ash, clinker, slate, coal partly coked, and unburned coal. The proportion of each varies with the variety of coal, the kind of furnace, and the skilfulness of the fireman. The ashes of anthracite coal burned in the houses of the larger Eastern cities have been analyzed, and the results given by Waring,* tabulated and reported by Koyl and Craven, are accepted as the standard.

TABLE XXXI.—ANALYSIS OF ASHES FROM ANTHRACITE COAL, NEW YORK CITY. (CRAVEN.)

AVERAGE HOUSE COLLECTION	Apartment Houses	Large House Furnaces	Factory Egg and Nut	Steam Boilers, Pea Coal
Unburned coal recoverable...20%	35%	40%	25%	20%
Clinkers and partly-burned coal....................15%	20%	15%	30%	40%
Coarse ash and slate........15%	....	....	....	....
Fine ash..................50%	45%	45%	45%	40%

The proportions of unburned coal, clinker and fine ash by volume are very nearly the same as those by weight given above. This analysis was made shortly after the separation of wastes was instituted in New York City, and the quantities of unburned coal quoted in this table were then thought to be very large, but have since been found to be correct.

Any one who wants to see the coal that is carried from his own and other households has only to inspect an ash dump after a rainstorm has washed away the upper coat of fine ashes. He will see enough unburned coal in sight to convince him of the fact that an average of 20 per cent., or 400 pounds of coal per ton of ashes is a comparatively safe estimate.

The figures of the New York Commission are, for 1906, for Greater New York, two million tons of ashes taken from the households to Riker's Island and other dumping places. At an average of 20 per cent., or 400 pounds of coal per ton of ashes, this city is annually burying 400,000 tons of coal per year in preparing the foundations for the future municipal buildings to be built on this ground. By simply sifting out the coal and saving 50 per cent. of it, at the present market prices (and it will never be

*Disposition of the wastes of New York City, G. E. Waring, 1899.

lower) the city would provide in five years for enough money to erect the buildings to cover the site.

What is true of New York is true of all American cities in a greater or lesser degree. All are equally wasteful and indifferent, because, perhaps, it is nobody's particular business to look after trifling details of this sort.

The value of this fuel for heat production is an important factor in waste disposal work. Assuming that 20 per cent. of the coal and burnable clinker is recoverable it represents 400 pounds of fuel per ton of ashes, and the value in heat units and rate per ton is shown in the following table:

TABLE XXXII.—HEATING POWER AND VALUE OF WASTE COAL (KOYL).

	Average Heat Units	Per Ct. of Heat Units	Value per Ton Recovered Coal
New coal....................	11,000	100%	$5.50
Recovered coal and clinker...	8,000	73%	4.00 from ashes of new coal.

Later tests of these ashes from households has shown the coal and clinker that can be utilized as fuel under forced draft to be larger in quantity but less in volume of heat units, averaging coal and clinker 35 per cent. and 5,000 B.T.U. of heat. The question of fuel value is discussed at length under other heads.

The utilization of clinker from clean steam ashes for concrete manufacture of certain kinds is well-known, and is increasing in favor. In many places fine ash is screened, sifted and ground, and used as a constituent of mortar, with good results. Tests of this mortar demonstrate that it possesses the tensile strength of 65 pounds per square inch, as compared with that of ordinary lime and mortar of 15 pounds per square inch, and that it has a crushing strength of 1,000 pounds as against 150 pounds strength of ordinary mortar.

A large factory in New York uses fine coal ashes as a substitute for sand in certain kinds of brick-making, with entirely satisfactory results. It is also widely used for fireproofing in floor filling and similar construction work.

When dealing with disposal of wastes by incineration the ash resulting from combustion of the several kinds of refuse becomes an interesting factor. Not all waste produces the same returns in quantity or character when burned under different conditions.

ASHES FROM THE COMBUSTION OF ENGLISH TOWNS' REFUSE.

Under the English practice of burning all house refuse and ashes in furnaces operating at high temperature under forced draft, the residuum of ash and clinker is thoroughly calcined and freed from organic matters. There is a small amount of fine dust deposited in the combustion chamber and dust catchers of the furnaces, which is used as the basis of several kinds of disinfecting powders. The clinker, which is removed through the firing and stoking doors of the destructors is screened, ground, and mixed with hydraulic lime and cement, and is formed into paving blocks, flagging, tiles, bricks, and gravel for concrete filling instead of broken stone. At Liverpool some of the smaller municipal buildings are made altogether of this material, and the blocks and bricks used are suitable for many kinds of construction work, as they can be moulded in any form or made in any color. When properly seasoned these bricks are 50 per cent. stronger than the ordinary building brick, and are manufactured at far less cost.

The best selected clinker from English destructors is so perfectly vitrified that it is in demand for use on the filter beds of sewage works, and is found to perfectly supply the place of an equal volume of broken stone at much less than the cost of the latter.

TABLE XXXIII.—ANALYSIS OF DESTRUCTOR ASHES (GOODRICH); FROM REPORT OF MR. J. M. TAGGERT, BRADFORD, ENGLAND.

	Sample	
	Fine	Medium
Silicious matter	61.08	67.10
Iron and alluminia Oxide	21.50	19.30
Carbonate of Lime	7.80	6.00
Magnesia	Traces	Traces
Organic and Volatile Matter	4.12	1.80
Moisture	5.50	5.80
	100.00	100.00

The clinker from destructors burning mixed garbage, refuse and ashes, and operating at a temperature of 1,800° to 2,500°, is a very different product from the ashes of American crematories burning garbage and refuse only, at a temperature of from 600° to 1,500°.

No American form of crematory has yet succeeded in burning large quantities of mixed municipal waste (garbage refuse and ashes) with any reasonable success. It s not, indeed, attempted, nor is the form of furnace suitable to obtain and continue the higher temperatures reached in British practice. It is possible for American furnaces to attain high heat for brief periods, and under certain unusual conditions a clinker may be formed that is similar to the one described above, but this is the exception, not the rule. The American garbage crematories deal only with garbage and refuse under natural draft conditions, and do not attain the highest temperatures nor produce an ash that is completely vitreous and free from organic matter. On the other hand, there is a value to American crematory ash that should be taken into account when the values of all waste materials are considered.

ASHES FROM AMERICAN CREMATORS.

Fourteen years ago the writer caused an analysis to be made of the ashes from the Engle Crematory in Des Moines, Iowa. This analysis gave the following proportions of fertilizing elements:

Calcium carbonate	8.007
Magnesium Phosphate	3.010
Calcium phosphate	66.855

In transmitting the analysis Prof. Call, of Drake University, Iowa, after preliminary observations on the relative quantities of the constituents, says:

"Now as to the usefulness of this ash; I believe that the analysis shows this material to have value for fertilizing purposes. There is a relatively small amount of insoluable matter, and a large amount of matter which can be readily dissolved in water, and by the ordinary processes of nature made useful . . . I have no hesitancy in saying that this sample shows a high grade of value."

The opinion of Prof. Call has been confirmed and supplemented by the opinions of others, and the value of the ash is well estab-

TABLE XXXIV.—COMPARATIVE ANALYSIS OF THE ASHES OF GARBAGE AND WOOD ASHES.

EXPERIMENTAL STATIONS			TOTAL POTASH			TOTAL PHOSPHORIC ACID							
	Number of Analyses	Moisture	Maximum	Minimum	Average	Maximum	Minimum	Average	Sodium Oxide	Calcium Oxide (Lime)	Magnesium Oxide	Ferric and Aluminic Oxide	Insoluble Matters
Hatch Exp. Sta., Mass. Agr. Coll., Amherst; ashes from cremation of swill	15	4.86	8.83	1.25	3.97	32.36	7.47	14.16	.....	33.38	1.87	4.65	21.57
The same ashes from cremation of garbage	3	3.01	6.01	3.72	5.13	10.21	7.16	8.77	15.65	20.22	1.16	9.22	28.42
New York Agricultural Exp. Sta., Geneva; ashes from cremation of garbage	7	6.00	0.25	2.8	.....	15.4	1.7	8.7	.....	21.1	.....	.....	.....
Iowa Agr. Exp. Sta., Des Moines; ashes from cremation of garbage	2	0.77	6.01	5.68	5.84	10.21	7.16	8.68	15.65	16.7	1.16	9.32	28.41
Hatch Exp. Sta., Amherst; wood ashes	340	11.17	8.86	1.12	5.63	2.82	0.06	1.32	.....	34.54	3.31	7.43	18.28

AVERAGE PER CENT. OF INGREDIENTS CALCULATED IN POUNDS PER TON OF 2,000 LBS.

		Lbs.			*Lbs.*			*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Hatch Experimental Station; garbage ashes	.....	78	.....	.....	91	.....	.....	229	339	538	39	138	499
Hatch Experimental Station; wood ashes	.....	233	.....	.....	113	.....	.....	23	.....	691	66	149	366

ished. The preceeding table gives several anaylses of garbage ash, and for the purpose of comparison an analysis of wood-ash, a well-known commercial fertilizer, is added:

Although there are no nitrates found in garbage ash there is a large amount of calcium oxide (lime) present in its superior form. When animals are burned with the garbage, the ash is rich in phosphate and lime.

The value of ashes for land dressing does not depend altogether upon the amount of soluble phosphates and acids which by chemical analysis are shown to be present, but is due also to the fact that the ashes are an assistance or addition to the ground and act as filling for the interstices in loose and sandy soil, favoring the rise and retention of moisture, and on stiff clay soils rendering the texture pliable and easily worked. It also corrects acidity in some soils by the addition of alkaline properties. In the author's experience the use of garbage ashes as a fertilizer has been attended with uniformly successful results.

Household garbage burned under ordinary conditions leaves 10 per cent. of residuum. From this is screened out the broken crockery, tins, glass, and all other foreign matter, leaving about 5 per cent., or 100 pounds of ash per ton of garbage available for use. This is a conservative estimate, and is probably less than the average.

For fertilizing purposes, garbage ashes must be kept separate from coal and refuse ashes, should be housed under cover, foreign matter screened out, and samples frequently analyzed to show the proportions of fertilizers present. The ash should include all bones even though partly calcined.

ASHES OF REFUSE AND RUBBISH.

When municipal dry refuse (rubbish) is burned in incinerators, the residuums include large amounts of iron in many forms, tin, glass, and other incombustibles. If these be previously removed, leaving the combustible matters, the percentage of ashes, which is fairly constant in amount, can be ascertained. There is always present a large per cent. of silica in various combinations, the quantity depending upon the cleanliness of the collection and the locality from whence the refuse comes. The following table gives an approximation of the ashes of refuse from all available data:

TABLE XXXV.—ASHES FROM ONE TON OF MUNICIPAL REFUSE AND RUBBISH.

Places	Authority	Percentage	Weights, Lbs.
New York Utilization Station	Craven	17	360
Boston " "	Morse	15	300
New York " " 47th Street	Stearns	14.5	290
New York Utilization Station Delancey Street	Parsons	14.9	298
Buffalo Utilization Station	Morse	19.5	390
New Brighton. Average of test for 1 year	Fetherston.	13.8	376

The ashes from combustion of refuse in New York City were analyzed at the Lederle Laboratories as follows:

Sample of ashes from West Forty-seventh Street incinerator:

Moisture	2.12%
Potassium carbonate	2.65%
Calcium phosphate	1.98%
Alkaline earth carbonates, silicates, soda, oxides of iron and alumina, etc.	68.05%
Organic and volatile matter (loss on ignition)	25.20%
	100.00%

Sample of ashes from Delancey Street incinerator:

Moisture	0.75%
Nails and other metal	5.48%
Broken glass	4.05 "
Bone phosphate	2.71%
Potash	0.46 "
Alkaline earth carbonates, silicates, soda, oxides of iron and alumina, etc.	60.91%
Organic and volatile matter (loss on ignition)	25.64%
	100.00%

STREET SWEEPINGS—QUANTITIES AND VALUES.

Street sweepings is the last constituent of municipal waste to be considered, and although usually not a part of waste disposal work, still is an item of the whole mass of waste from which some returns may be expected.

In 1898 the General Government collected data in regard to sweepings, from which the following is quoted:*

*The fertilizing value of street sweepings, U. S. Agricultural Bulletin No. 55, H. W. Wiley and E. E. Ewell, Chemists.

Of 354 cities to which inquiries were sent, 150 made no report, and of the 204 reporting, 70 had no method of utilization; 74 used them (street sweepings) for filling land, and 60 cities, or about 17 per cent. of the whole number, with a population of 10,000 to 100,000, used them for fertilization. For the cities reporting, the average quantity collected was 168.9 tons for 1,000 population. Assuming this to be a true average, then, for all the cities of the United States the total amount would be three million tons.

The Fertilizing Value of Sweepings.

The value of sweepings for land dressing depends greatly upon the nature of the paving from which they are taken. It is practically nothing when it comes from macadamized roads, and only approaches good stable manure from the well-kept, hand-swept streets of crowded cities. Sweepings are often mixed with much foreign matter, which lowers their value. There are few reports of the value of sweepings available. These are presented in the table XXXVI following.

Street sweepings when dried average 50 per cent. of sand, powdered stone, abraided iron and other foreign matter, and 50 per cent. of combustible organic matter. During continued fine weather the sweepings become finely divided and pulverized, and when taken up by the wind are a nuisance to the public and a positive injury to property. It is claimed that disease germs are communicated in this manner, and it is reported by physicians in the larger cities that the increase in catarrhal and kindred diseases during periods of dry, windy weather are noticeably above the normal percentage.

In 1905 New York City separately collected the street sweepings and delivered them in bags at the dumps to the Long Island Railroad, which sent them to the farmers, charging only the cost of freight and handling. This experiment was not satisfactory, as the cost of the bags, which quickly rotted, and the freight charges, were more than the value of the material. There being no storage facilities, no disposal could be made in winter, and the attempt to utilize sweepings in this way was abandoned. They are now sent with ashes to fill land on Riker's Island. Though the approximate value of this waste is about $1 a ton, only under exceptional conditions of cheap transportation can it be made to return a revenue.

The government reports from farmers using sweepings are to the effect that their value is about two-thirds that of farmyard manure, giving best results when used as top dressing. The cost varies from 15 cents to $2 per ton, to $6 per carload. They contain a considerable amount of stones, cans, etc., that must be removed by the purchaser, and they should be well rotted before using.

STABLE REFUSE.

The waste from private stables is not generally considered as municipal waste. The view taken by most places is that this comes under the head of trade refuse or private waste with which the city has no concern. The waste from the city stables is commonly removed with ashes and dumped, and the householders make private agreement for the removal of stable refuse. Stable refuse in New York City is removed by a private company for the payment of a fixed sum averaging about $1 per load of 2,000 pounds. This is sent by rail to country depots for distribution to farmers.

The quantities, according to the data furnished by the great express companies, average about 30 to 32 pounds per horse for each 24 hours. The total quantities removed in New York cannot be stated, but the amounts are diminishing each year by reason of the adoption of self-propelled vehicles in place of horses.

Stable manure, when the liquids are drained off and the horse-bedding is of straw, peat, wood shavings or saw-dust, is combustible with forced draft without other fuel. Several large express companies burn their stable refuse under their steam boilers, and by adding a small quantity of slack coal, obtain power for electric lighting and workshop purposes.

Some of the larger cities class manure as a municipal waste and in calling for tenders for incineration include stable manure in the general waste to be destroyed. In one city, the average quantity to be destroyed is nearly 40 tons daily, the manure weighing about 970 pounds per cubic yard, and is nearly 13 per cent of the total city waste collection. Undoubtedly the disposal of stable manure will be done by city agency in an increasing number of places wherever incinerating plants are installed, as the value of manure for steam-producing uses is more than equivalent to an equal volume of mixed city waste. In the operation of the Westmount Destructor fresh stable manure is de-

TABLE XXXVI.—ANALYSIS OF STREET SWEEPINGS AND MANURE.

	Moist-ure	Ash	Organic Matter	Nitro-gen	Phos. Acid	Potash	Mag-nesia	Lime	Per Ton of 2,000 Lbs. Nitro-gen	Per Ton of 2,000 Lbs. Phos. Acid	Per Ton of 2,000 Lbs. Potash	Per Ton of 2,000 Lbs. Value per T
	%	%	%	%	%	%	%	%	*Lbs.*	*Lbs.*	*Lbs.*	$
Washington, D. C.:												
Average of 18 samples Street Sweep'gs	31.6	48.7	19.3	.44	.07	.19	.....	.....	8.8	1.14	3.8	1.06
Trenton, N. J.:												
New Jersey Exper. Sta'n St. Sweep'gs.	.....	.....	.....	.18	.30	.19	.....	.....	3	6	3	.90
New York City (Craven):												
Street Sweepings	37.28	32.	30.72	.25	.35	.....	.....	.....	5	7	7	1.00
Berlin (Vogel):												
Exper. Station Street Sweepings	39.89	37.67	22.44	.47	.45	.37	.34	1.8	9	9	7	1.50
Hatch Experimental Station, Mass:												
Horse Manure	11.24	.....	.....	.74	1.45	2.82	.....	.....	15	29	56	4.91
The same:												
Barn-yard Manure	67.01	.....	.....	.52	.39	.52	.30	.19	10	7	11	1.65

TABLE XXXVII.—APPROXIMATE VALUES OF RECOVERABLE COAL, REFUSE AND RUBBISH.

One Ton of Household Ashes									One Ton of Refuse				
Recovered Coal from New Coal at $5.50 a Ton			Clinkers and Coarse Ash			Fine Ash			Destroyed		Utilized		
Per Cent.	*Amount*	*Value*	*Per Cent.*	*Amount*	*Value*	*Per Cent.*	*Amount*	*Value*	*Per Cent.*	*Amount*	*Per Cent.*	*Amount*	*Value*
——	lbs.	$1.37	30.	600 lbs.	$0.12½	.45	900 lbs.	$0.12½	51.	1,020 lbs.	49	980 lbs.	$2.45

TABLE XXXVIII.—COMPARATIVE APPROXIMATE VALUES OF MUNICIPAL WASTE.

One Ton Each of—						
Garbage	Reduced to ashes	$0.55	As a raw fertilizer	$1.91	Treated by reduction process	$3.71
Refuse	Sorted parts only	2.45	.....	.....	.....	2.45
Ashes	Coal, clinker, fine ash	1.62	.....	.....	.....	1.62
Street sweepings	For fertilizer	......	.....	1.00	.....	1.00
Totals	.....	$4.62	.....	$2.91	.....	$8.78

stroyed with a greater rapidity than any kind of waste, with a proportional development of heat.

APPROXIMATE COMMERCIAL VALUES OF MUNICIPAL WASTE.

If garbage, refuse and rubbish, coal and clinker and other waste products of the city can be successfully dealt with by the contractors after being delivered to them in a separated condition, and if such work be remunerative to the contractors, why should not the town itself do its own work of waste disposal and recover at least a part of the profit it now allows others to make, applying this profit to the expense of the collection and disposal service?

There are several reasons for the present contracting methods. It has long been the custom to allow this work to be done by contract, and it is often difficult to break through traditions and precedents, and the personal influence, political pull and actual graft that too often govern matters of this kind. But modern, sanitary and economical methods can be established if the town authorities are willing to investigate and to act upon their convictions.

MARKET QUOTATIONS FOR REFUSE.

	Per 100 Lbs.	Per Ton	
Paper 7 grades....	$0.25 to $0.80	$5.00 to $16	These are wholesale prices for carload lots. The retail prices for smaller quantities are 15% to 25% lower.
Rags 6 "	.30 " .85	6.00 " 17	
Bagging 4 "	.65 " 1.00	13.00 " 20	
Carpets 3 "	.60 " .75	12.00 " 15	
Twines 2 "	.36 " .50	7.20 " 10	
Rubber..............	.30 " .50	6.00 " 10	

The value of a ton of ashes in an unsorted condition is practically nothing except for ground filling. A load (1,500 lbs.) of this brings from 10 cents to 25 cents, according to the demand and cost of hauling. Although the actual values in coal, clinker and fine ash are there, they must be established by the separation and utilization of the several parts. (See Table XXXVII.) This can be done economically on a large scale only, with large volumes of ash to deal with, and with a market for the several portions. The coal in ashes will always be salable; the clinker is coming more into use, and the fine ash is already being manufactured with lime and cement into building bricks of any desired color, possessing greater strength and density than ordinary brick, to which it is superior in every way. It is made in less than one-tenth the time of the ordinary brick, and is sold at no greater cost. This industry will undoubtedly be extended to include a wide variety of forms and shapes for building material in which ashes as a substitute for sand will be used in large quantities.

The value of the refuse in the above table is based upon the present market price of newspaper "commons," or the lowest class of printed matter sorted from city collections.

VALUE OF GARBAGE TREATED BY REDUCTION PROCESSES.

No statement of the value of American waste would be complete unless it included some estimates of the amounts returned by garbage when treated for the recovery of its commercially valuable constituents.

There are three reduction processes—by steam only, by naphtha, and by a combination of these two in one system. Although these three methods are fairly well known there are no complete and accurate data obtainable from the companies employing them, hence all estimates in regard to them must be made conservatively.

The following table, compiled from official sources, is an analysis of the identical product of different processes in different localities:

TABLE XXXIX.—ANALYSIS OF GARBAGE TANKAGE.

LOCALITIES—PROCESS	Nitrogen	Phosphoric Acid	Potash	Bone Phosphate	Lime
New York City, Pierce Process	3.4	3.1	.7	...	...
Providence, Simonin Process	3.5	3.5	1.	12.	...
Buffalo, Merz Process	3.7	3.9	....	...	...
Philadelphia, Arnold Process	3.	2.6	.66	...	...
Pittsburg, Flynn Process	3.	3.	1.15	...	5.6
Paterson, Merz Process	2.9	1.6	.6	...	...
Bridgeport, Holthaus Process	2.9	3.8	.6	...	...
Philadelphia (Terne) Maximum	3.7	6.	.5	...	...
" " Minimum	2.9	3.	.25	...	...
Baltimore, Arnold Process (Gascoyne)	2.5	2.7	.7	...	...
Penn. Experiment Station	2.1	3.	.27	...	...
American Reduction Co., *Brooklyn	1.64	8.08	1.20	...	...
Hatch Experiment Station, Mass.	2.50	6.92	.50	..	...
Average	2.90	3.93	.64	12.	5.6

*This analysis, made some ten years ago from samples submitted by a company not now operating, is included, although the sample probably contained a larger percentage of animal matter than is usually present.

The value of garbage for commercial products lies chiefly in the amount of grease extracted. This is assumed to be 3 per cent., which equals 60 pounds from an average ton of garbage—larger, perhaps, than is usually obtained. This grease is extracted from garbage by the process of boiling the garbage with steam in digestors, and afterwards pressing out the grease and water, which are then separated; or by using naphtha as a solvent, which is afterwards recovered from the grease. This grease is a dark brown, heavy oil containing many impurities and some moisture, and must be repeatedly refined before it is fit to be used. It is largest in amount in winter and least in summer. There is a constant market for the grease at prices which vary from 2½ cents to 3 cents per pound. Great quantities of it are sent abroad for use by soap manufacturers, and a considerable amount is bought here for the same purpose.

Tankage is the solid part of the garbage that comes from the dryers after the extraction of the grease. It is mostly the fibrous skeletons of vegetable matter, with a small percentage of animal substance. The proportions vary according to the amount of water present in the original mass of material, and averages about 400 pounds of tankage to each ton of garbage.

The value of tankage depends largely upon the nitrogen present, obtained from animal substances, and the amount of which is determined by an analysis of samples, the whole being sold upon the guaranteed percentage of fertilizing elements present. The market is not constant, as at certain seasons the supply exceeds the demand, and tankage is frequently disposed of by being burned under the boilers of the plant in place of coal. When the grease has been extracted by naphtha, tankage is often highly inflammable; sometimes there is an occurrence of spontaneous combustion. Four or five plants have been destroyed from this cause, and many cases of fires are constantly reported from reduction works.

The manufactured material does not readily lend itself to transportation to distant places because of its bulkiness in proportion to the weight. It quickly deteriorates in character, and must be marketed soon after production. As a fertilizer it is not applied in the tankage stage, but is used as a "filler" for superphosphates or other ingredients for making a complete manure.

ENGLISH METHOD OF UTILIZATION BY HAND SORTING.

The method of utilization by sorting out salable artices from a mixed mass of "town refuse" brought together at one point has been severely condemned by several English authorities. The conditions attending the work at one station in London are thus reported to the London County Council by the medical officer and the engineer:

"The process carried on in a London dust contractor's yard has not undergone much alteration since the following description by Dr. Ballard was written: 'On a load of dust being upset from the dust cart on the surface of the yard men and boys proceed to sort it. They are provided with a fork and an instrument called a drag, which has a short handle and three cast iron teeth set about three inches apart, and with these they fork and drag over the heap so as to separate from it obvious pieces of vegetable and animal refuse, bones, rags, paper, iron, crockery and glass. These are distributed, some into heaps, others into baskets; the bones are put into a bin or heap by themselves for sale to bone-boilers. The rags and paper are also usualy set aside for sale; the iron and old tins are always set aside for sale, and usually also the glass, while the broken crockery, brickbats, etc., etc., are laid in a heap to be used as material for making new roads.'"

These are practically the same conditions that apply to American dumps where we still allow the pawing over of ashes, refuse and rubbish, and where the situation is not unlike that described above. This practice is to be strongly condemned, and should be prohibited as unsanitary and in every way objectionable.

AMERICAN METHODS AT UTILIZATION STATIONS.

But these conditions do not apply to the refuse utilization stations that are established in large cities and operated under restrictions that compel cleanly work. True, there is dust, but it can be drawn off by proper ventilating apparatus, and there is dirt which is burned and not permitted to accumulate. All stages of disposal work are accompanied by these difficulties, which are unavoidable but which may be regulated and made less harmful and annoying by the employment of adequate means.

In this method of utilization by sorting at central stations the daily collection of refuse, the burden of the system comes upon the householder, who must do the first sorting. If there is no separation in the first stage than there can be none thereafter that is complete and satisfactory.

The householder, therefore, is the one that makes it possible for something to be saved, but he profits only in an indirect way. The separately collected garbage goes to a reduction company that agrees to accept paymeent from the city for its disposal upon condition that clean garbage is delivered to the company. The rubbish and dry refuse, in al cases cited except one (Buffalo), goes to a contracting company that benefits by the benevolent action of the housewife, who gives it clean paper to handle. The sole actual benefit that the householder receives is the removal of matter that has become embarrassing and with which he cannot deal alone. In places where there are no contractors and no municipal force to perform the service he must pay for its removal, out of his own pocket, from five to ten times the amount he would be assessed for the service on his property valuation if the town performed its work properly.

GENERAL SUMMARY OF WASTE UTILIZATION METHODS.

In this table (No. XXXVIII) are brought together the items of waste separately analyzed and classified in the previous tables, and it represents the theoretical commercial values which, although undoubtedly present in the waste, are in such combination with one another as to make it impossible to utilize them when collected in a mixed mass. But when separated into their classes at the houses there is no difficulty in providing treatment for the recovery of the commercially valuable of each class. This is done now by the separation of garbage for reduction, but the separation of refuse for market, and by the use of a part of the ashes for concrete work and brick making. It is necessary only to carry this one step further and in providing for waste disposal add the equipment required by each class of material and deal with all the waste, instead of dividing it up among several opposing methods or among several different contractors.

A return will always be available from the waste when it is properly treated by the best means. Coal will never be cheaper than it is now, and a partial supply from whatever source, even if of a poor quality, will always command a market. Clinkers and ashes have just been discovered to be of real worth, and we have only to note the many uses to which these unpromising materials are put abroad to see what may be done with the same things here. Paper stock is cash on demand, and nearly everything of a fibrous nature can be manufactured into one or another form of paper. The return to the earth of the waste of households in the form of fertilizers, of garbage concentrated into ash by fire or into tankage by mechanical processes, is an economical means of dealing with large volumes of matter which returns a revenue, or profit, over all expenses.

Bringing all the waste to one station and using each method best adopted to each material means economy in equipment and operation, as the residuum from one class of refuse will furnish power and heat for the treatment of the whole.

Now that the real value of certain parts of discarded matter are better known and have a recognized standing in the world's markets, there may be expected a movement, which is indeed already begun, that will give the benefit of the economical treatment of waste products to the people, who are the ones chiefly concerned, and who should chiefly benefit by the wisely administered, economical and sanitary methods at the service of municipal authorities.

Examples of the Utilization of Waste Materials.

Frequent reference has been made by many writers to the methods and appliances used abroad for the recovery of some useful by-product of the municipal waste, and many valuable hints are to be had from the records of towns that have had longer experience in this line than most of our American cities.

We have little to learn from the examples of Continental cities, except that some of their methods of careful collection and systematic service might well be adopted, but in Great Britian there are many ways of dealing with waste matter, born of the pressing necessity for economy and efficiency, that may well apply to our own needs. The quotation given in this chapter concerning the unsanitary method of sorting general refuse applies to the conditions of twenty years ago, when they were beginning the serious study of the question. Great advances have been made since those days by the use of mechanical devices for conveying, separating and utilizing the various parts of the town's refuse. All these are made possible by the use of steam power generated by the waste itself, and this steam power is the principal factor in the various methods and forms of utilization. But, aside from the value of the power developed in the larger English cities by the employment of powerful refuse destructors, and which is used for municipal lighting, traction, water and sewage pumping, etc., is the great field for the manufacture of certain forms of building material made from the clinker and ashes left after the destruction of the combustible part of the waste.

We have practically the same kind of waste to deal with, and one that contains a larger proportion of valuable matters than that of any foreign community. The American people enjoy a plentiful supply of food, clothing and fuel easily and cheaply obtained, and are more wasteful in their habits of life than any other nation. The absence of economy in the disposal of all residue excites the wonder and astonishment of foreign observers. This habit of wastefulness, probably caused by exceptional abundance, is a national trait that cannot and need not be changed, but there is every opportunity to profit by the example of others who have advanced the art of economic waste disposal by a quarter of a century.

DISPOSAL OF MIXED WASTE.

There is but one opinion as to the means of sanitary disposal of municipal waste when it is collected in an unseparated mixed condition by the city's cart—it should be destroyed by fire. The mass contains every class of waste intimately mingled by gathering from every source alternate layers of garbage, ashes, refuse, trade waste, street sweepings, leaves and park refuse, and sometimes manure also. The ashes of this mass furnish a temporary relief from the odors as the liquids are absorbed and the particles of animal and vegetable matter become coated with the fine ash, which arrests putrefaction for a short time.

When these loads of mixed wastes are discharged at the dumps, in order to save the expense of covering, and to avoid the nuisance of flying papers, frequently the refuse is set on fire and may burn for days, sending out clouds of nauseating smoke. The suburbs of most towns, where there are no means of disposal except by dumping, are nearly always subjected to this nuisance. In one New England city the dump fire, after burning for days, was so offensive that the Fire Department was called in for the relief of adjoining householders.

For the larger towns where separation is made there is less difficulty in disposal, for each class can be treated by itself, but for the smaller places where a mixed collection by private or contract service is made, the final disposition is the hardest problem that the town has to solve, and the most practical and sanitary solution is destruction by fire.

PART II.

THE DISPOSAL OF AMERICAN MUNICIPAL WASTE BY CREMATORIES AND INCINERATORS.

CHAPTER V.

Methods of Waste Disposal by Incineration in American Towns.

In attempting to collect and reduce to intelligible form the data existing on the subject of disposal of municipal waste in American towns in early stages, it has been very difficult to procure accurate and extended accounts that are of value as records.

At the beginning of the work, in the years 1885 to 1890, the control was almost exclusively in charge of the local health officers of the cities. They first recognized the importance of the question, and being responsible for the public sanitation, were the first to advocate better methods of removal and disposal of those parts of the waste which were most offensive and dangerous to the public health.

There was no system of concerted action. Each Health Officer treated the matter in his own way, always under the strong economical pressure of the City Council, which, as a rule, would only vote money to suppress an epidemic of disease, but could never be brought to recognize the wisdom of preventive measures.

The question was taken up in 1887 by the largest sanitary society in the country—The American Public Health Association (which afterwards included the Dominion of Canada and the Mexican and Cuban Republics), by the appointment of a Special Sanitary Committee for the collection of data and publication of reports on the subject. For nearly twenty years the committee continued its reports, which, with the papers contributed by the members of the Association upon the special and local conditions of their cities, formed the only definite and accurate accounts of the work.

In 1894 a special effort was made by Mr. Rudolph Hering, C.E., then Chairman of the Committee, to obtain data on the subject.

The replies to the circulars sent out contained much information, but it was so indefinite and irregular in arrangement, and so obscurely expressed that it was never reduced to tabulated form. The papers of the members in all parts of the country contained the best details and suggestions, and when made public were of great assistance to others. The Association continued its work through its committee up to 1904.

Meantime the business side of the matter was being developed by companies and persons who brought forward many furnaces for destruction of waste by fire, and means and apparatus for treatment for recovery of the valuable parts of the waste.

Still, the practical application of these means remained, as a rule, under the charge of the Health Officers. These gentlemen were not always fitted by experience in previous business and professional training to consider the detail of the best forms of construction and working of garbage crematories and reduction plants. Thus it happened that there were many failures both in methods and appliances, much time was lost and large sums of money wasted before the Boards of Health were willing to accept the conclusion that, in all the practical details of means, apparatus and application of inventions, this is an engineering question to be solved by men whose special training fits them for the work, and the responsibility that comes with it.

Meanwhile, the reliable literature of the subject did not keep pace with the growth of the work. The builders of crematories at widely separated points were intent upon pushing their individual ideas and their particular designs, each claiming his to be the best yet brought out, and paying little attention to what was happening elsewhere.

There are many accounts of the operation of crematories, written mostly by those directly interested on behalf of the builders or the town authorities. Probably the largest number of these were drawn up by newspaper writers, who designed to give a record of the current news items for home consumption, sometimes for personal, political or financial reasons, to exploit the efforts of their local authorities, or the particular device in use, and these reports were often inaccurate and not always true. In the absence of correct returns, these items were put forth as authoritative accounts of the work, were used as an indorsement of the particular furnace elsewhere, and, being accepted without investigation, perpetuated and multiplied the errors. While in many cases these accounts must be accepted as the only existing record, they must be taken with the utmost caution, until verified by other and more independent observers.

The sharp competition of opposing interests developed mutual misrepresentation and recrimination. Contracts were obtained by personal and political favor, by influential pull, by manipulation and graft, with little regard to the interests of the city or town. Each place having adopted a system, the local authorities felt constrained to endorse it to others. There was no standard for comparison except these indefinite newspaper reports. But more than all else, there was no accurate system of trials or tests to determine the initial efficiency of apparatus, and in most cases no subsequent official record of continuous operating results, tabulated for use.

In this connection the great engineering journals have exercised a wise discretion and admitted to their columns the detailed description and illustrations of plants installed, accepting no responsibility for their operation and refraining from comment upon the claims made for successful design or performance of any particular plant. This course has compelled accurate and better accounts, and it is to the columns of these journals that we must look for reliable details of construction and operation.

This state of affairs continued for nearly seventeen years, from 1885 to 1902, and this whole period is marked by the successive appearance of something like twenty-five or thirty different forms of apparatus and methods for the disposal of municipal garbage, for almost every one limited their constructions to the treatment of this item of waste.

It was in the year 1902 that the first examination and report upon the operation of an American crematory was made by a competant engineer qualified by training and acquaintance with other incineration systems to report upon the merits and deficiencies of the particular one noted.

The City Engineers of most places have not, as a rule, taken up the subject with intent to familiarize themselves with its details. Heretofore, they have not been anxious to offer suggestions, or perhaps they were not consulted by the Boards of Health or Committees of Council who had the matter in hand. But whatever be the reason the Engineers of the country have shown but little interest in the matter and allowed it to "drag its slow tortuous length along" with little help from them.

There are several notable exceptions to this where exhaustive studies were made and accurate reports submitted, and in some few cases the City Engineers have taken charge of and caused to be successfully operated crematory furnaces in their towns for continuous years. But within the last three years there has been a marked change in the engineering aspect of the subject. Six of the larger cities have appointed commissions or employed special engineering experts, and in one case the department controlling the collection and disposal of wastes has through its Chief Engineer, made a thorough study and formulated an admirable report. The reports already made by these gentlemen have been drawn upon in the previous tables, and will be still further cited.

FIRST GARBAGE CREMATORIES.

Up to 1884 there was little or nothing known in this country of the methods of destroying offensive waste by fire. In England, a Fryer furnace had been built at Manchester in 1876, and this destructor, with some changes and modern attachments, is still operating. This furnace was followed by the "Beehive" and several others. The *Sanitary Engineer and Weekly Journal* (now the *Engineering Record*), of New York, in its issue of September, 1884, gave a brief account of these, with such illustrations as were available, but little interest was shown in the matter, and no similar furnaces were built here until 1886.

FIRST U. S. GOVERNMENT GARBAGE FURNACE.

In December, 1884, Lieut. H. J. Reilly, U. S. A., at that time Post Quartermaster at Governor's Island, New York Harbor, addressed the Editor of the *Sanitary Engineer*, saying that he had a daily average of five cubic feet of garbage which he wished to cremate, and asked where he could find information as to the proper construction and size of a furnace for the purpose. In reply, the Editor referred to the previous issues of the *Sanitary Engineer* describing the "Fryer" destructor, the "carbonizer" at St. Pancras, London, the Leeds destructor, and the "Beehive" destructor at Burnley, England.

In the August 13, 1885, issue of the *Sanitary Engineer* appeared the letter of Lieut. Reilly reporting the construction of a garbage furnace at Governor's Island, New York Harbor, as follows:

Office Post Quartermaster, Governor's Island, N. Y.

July 29, 1885.

SIR:—I enclose herewith a sketch to scale of the garbage furnace which is in use here, as it may interest your readers.

The garbage, varying in daily quantity from ten to thirty cubic feet, used to be buried, but the small extent of good ground available for the purpose became so saturated that in the summer time especially the odor was distinctly perceptible, and not agreeable. For this reason it was finally decided to burn the garbage, and I made many unsuccessful attempts to get some information as to the proper construction of a furnace for the purpose.

I finally appealed to you, and it was on information derived entirely from your valuable paper that the furnace now in successful operation was built. An experimental one, which gave excellent results, was first tried by obtaining an old brick oven so as to get something similar to "Fryer's Destructor" which was described in your paper.

The one now in use consists essentially of a chamber 4 x 5 x 3 feet, lined with fire brick and divided into three spaces by two gratings, composed of ¾-inch round iron bars, with inch openings between them, and the necessary doors, grate bars (surface six square feet), and ashpit. The gratings are for the purpose of supporting the garbage, so the heat can get through and dry it and to prevent it from stopping the draft or putting out the fire.

The operation was commenced by making a coal fire and putting the garbage on the right side to dry; the next day's garbage was put in on the left side and the dry garbage was raked over the fire. By putting garbage in on the left and right sides alternately dry garbage is supplied and the fire kept constantly burning.

The chimney, owing to its location, had to be built fifty feet high, although it was intended originally to have it only thirty, which would have given ample draft. The total cost was about $350. There was a slight inoffensive odor from the chimney which is perceptible in certain conditions of the atmosphere; it is very similar to that given off by burning letter paper. No fuel of any kind other than the garbage is used or needed, unless the fire is allowed to burn out, when, of course, some fuel is necessary to start the new fire. One man has charge, and after putting in the day's garbage generally limits his attention to raking the dry garbage over the fire at noon and again at sunset.

Very respectfully,

H. J. REILLY.

This form of furnace was afterwards built by the U. S. Government at many of the Army posts and depots, and continued in use up to 1894, when the last example was built by the author at Fort Totten, Willets Point, New York Harbor. The capacity of all is very small, rarely exceeding one ton daily.

The same construction as that described by Lieut. Reilly was followed at Fort Totten, except that the grates for sustaining the garbage were made of steel railroad bars set in heavy cast-iron headers at the top and bottom. But the weakness of this form of grate bar exposed to the direct action of the fire made constant repairs necessary, and the absence of any device for consuming the gases that passed direct to the chimney was a fatal defect.

As the first example of the "garbage cremator" in this country it did the duty for which it was required quite as successfully as some of its later, more complicated successors. This furnace at Governor's Island was removed in 1904, after nineteen years of continuous service, and replaced by a furnace of a different form of construction.

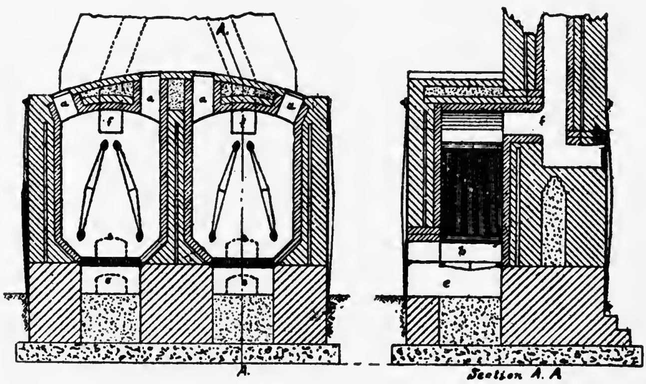

FIG. 20.—THE FIRST GARBAGE CREMATORY IN THE UNITED STATES, GOVERNOR'S ISLAND, 1885.

THE FIRST MUNICIPAL GARBAGE FURNACE.

Next following the Government garbage crematory built by Lieut. Reilly at Governor's Island, was that constructed by the Rider Company, at Allegheny City, Pa., in 1885. This appears to be the first one which engaged in the disposal of the garbage of a municipality. The cost of the plant was about $5,700, its capacity, 30 tons daily, it was operated by two men, and used the cheapest coal as fuel. The enclosing building was a cheap construction and the whole installation was largely in the nature of an experiment, although it continued in service some six or seven years.

It was a plain brick rectagonal box, with one horizontal set of grates, the main firing chamber being divided by a heavy bridge wall, over which the flames passed from the front to the rear. It was charged through ten small openings on top, the waste falling on the grates in small conical piles. The front section was fired with slack coal, and the heat generated was sufficient for combustion in the second compartment. The ashes were removed through doors on the grate level.

In the year following—1886—a Rider garbage cremator was built in Pittsburg, Pa., of the same general description as the one in Allegheny City. In this furnace, natural gas was the fuel employed, the work being carried on by four men. The arrangement of the plant was not convenient for receiving and charging the waste, and the expense of operating was very great.

During 1889 an attempt was made to record the quantities of waste destroyed, reported at 23,400 cubic yards, equivalent to 9,384 tons, an average of about 75 cubic yards per day. The cost was about 90 cents per ton.

This furnace was not adopted by other cities, as the operation was found to be very expensive, and there were many complaints of nuisance from the chimney.

The Pittsburg cremator was discontinued in 1901.

THE WHEELING NIGHT-SOIL CREMATORY.

In September, 1885, Dr. Baird, Health Officer of Wheeling, W. Va., appealed to the *Sanitary Engineer* for information on a night-soil furnace, and was responded to by a reference to the destructors used abroad, and to the Government cremator at Governor's Island. None of these suited the case, and the town authorities began a series of experiments in destroying night-soil by fire. At first the waste was mixed with coal slack and burned in gas retorts, which was too expensive; later an old steel-heating furnace was used with better success. Finally the city, in 1886, contracted with Mr. M. V. Smith, of Pittsburg, to build a furnace of the Siemens regenerative plan, employed for obtaining high temperature in iron and steel mills. The capacity was to be sixty tons daily of garbage, night-soil and dead animals. The location was on a top of a hill, chosen probably for fear of offensive fumes.

The furnace—afterwards known as the Smith-Siemens crematory —has been continuously in use for upwards of 21 years. Many repairs have been made, but the original design has been substantially followed. Natural gas is the fuel. No available reports of costs of construction, repairs or operation can be had, and so far as known there are no pictures or cuts of the plant in existence.

It is understood the city is about to advertise for bids for a modern disposal plant.

THE FIRST CANADIAN FURNACE.

The first furnace in Canada was in the year 1885, built by Mr. Wm. Mann, for the disposal of night-soil in Montreal.

This was a square brick chamber floored with grate bars, with ashpit below and at the back, a flue to the chimney in which was placed a secondary fire-box. Subsequently, in the following year a second furnace of the same general description was built in another part of the city. This one continued in use for about four year. Both these cremators were employed for night-soil in their first intention, though garbage in considerable quantities was burned in the later design. The large amount of fuel required for this work led to the discontinuance of these first cremators in 1891.

REPORTS UPON EARLY CREMATORIES.

The earliest furnace that came into general use was the Engle cremator, the first example being in Des Moines, Iowa, in 1887. During the following years up to 1893 there were twenty-five Engle cremators designed and built for destroying garbage and night-soil, using various fuels. These furnaces were described and reports of operation were given by many local authorities, but no official report was had until Mr. William S. MacHarg, civil engineer, in charge of water and sewage disposal of the World's Columbian Exposition, Chicago, 1893, made a test of the two Engle cremators designed and built by the author, and continuously used for the six months of the Exposition. From this report the following is condensed:

THE ENGLE CREMATORS AT WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

Number of Cremators, two, capacity each	50 Tons
Fuel, Crude Petroleum, fed by Air Compressor.	
Tons of garbage destroyed	5,009 "
" " sewer sludge destroyed, 1,854, equivalent to tons of garbage destroyed	4,000 "
Total destroyed during six months	9,009
Gallons of oil consumed	169,839 gals.
Labor, 3 shifts of 5 men and engineer eight hours each.	
Cost of disposal of garbage	$0.67½
" " " " sewage sludge	0.75½

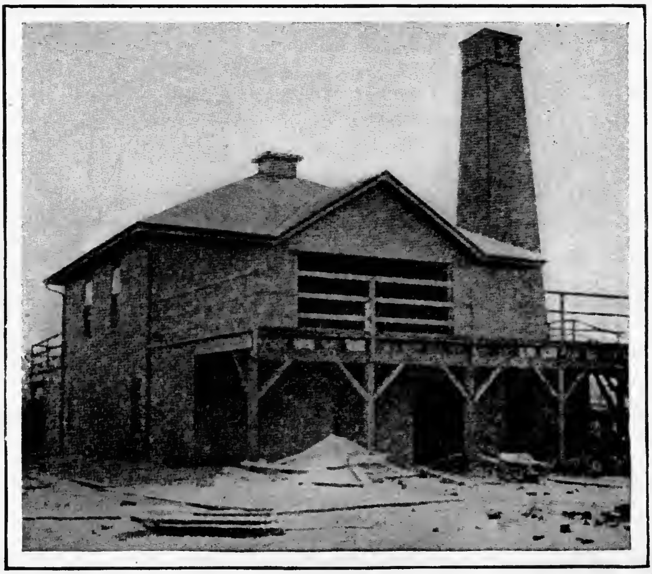

FIG. 21.—THE ENGLE CREMATORS, COLUMBIAN EXPOSITION, CHICAGO, 1893.

The operation of the cremators was entirely satisfactory. All the material was thoroughly burned without producing fumes or odor. The carcasses of many animals were also destroyed.

These cremators were removed from the grounds at the close of the Exposition. The Engle Company was awarded the grand prize for its work in connection with this exhibit, and another prize for the *Engle Fire Closet,* for the destruction of night-soil, also employed in exposition work.

THE ENGLE GARBAGE CREMATOR, RICHMOND, VA., 1893 TO 1908.

The official reports of this city show the continuous disposal of garbage, market refuse, rubbish and the smaller animals for a period of fifteen years by the Engle Cremator, built under the superintendence of the author in 1893. The quantities of waste destroyed are estimated from the detailed yearly reports of loads of garbage, market refuse and miscellaneous matter consumed. This approximates 6,182 tons per annum of mixed garbage, refuse and animals, but includes no night-soil, street sweepings or ashes. The cost for operating expenses and repairs (which includes the addition of ten feet to the cremator, raising the brick stack twenty feet and complete relining of furnace), was 68 to 70 cents per ton of waste destroyed. At this time all the garbage is destroyed without difficulty, and the cremator seems likely to fulfill its purpose for some years to come. It has been under the charge of one Superintendent, Mr. W. P. Belton, for the past fourteen years.

ENGLE GARBAGE CREMATOR, NORFOLK, VA.

The following data are taken from the report of W. T. Brooke, City Engineer, 1893 to 1902. The year 1896, when the cremator was operated by the contractor, is omitted:

Total loads mixed garbage and refuse, 58,793.

Expenses of operation and maintenance:

Labor	$16,735.64
Fuel (coal)	9,237.31
Repairs and sundries	3,263.39
Total expenses	$29,236.34

The collection is done by city teams, the carts holding forty-one cubic feet and averaging over one ton to a load. Assuming the quantity to be 60,000 tons for the period, this would give fifty cents per ton as the cost of operating, including also maintenance. During this time two steel chimneys have been supplied, and the furnace has been completely relined once, besides usual repairs to grates, etc.

For the past six years, 1902-1908 the quantity of waste has increased, because of nearly doubled population of the city; and the cremator is now too small for the work demanded. The cremator has been under the charge of one superintendent for twelve years.

These cremators of the improved Engle type (Warner patent) at Richmond and Norfolk, have, with the exception of the furnace at Wheeling, W. Va., probably been in continuous use longer than any of the American garbage furnaces. The first cost was small, about $7,500 each; the repairs and extensions have not changed the original designs, and there has been no serious complaint or stoppage on the score of nuisance, though both are located in close proximity to dwellings. In these two cities the growth of population and increase in quantities of garbage has made these furnaces too small for present demands.

SMITH-SIEMENS CREMATOR, ATLANTIC CITY, N. J.

In 1902 Mr. J. T. Fetherston, engineer in charge of Street Cleaning Service, Borough of Richmond, New York City, made a report upon the construction and operation of the Smith-Siemens garbage furnace at Atlantic City, N. J., built in 1894, which included some features of interest. The period reported was from September 1, 1901, to September 1, 1902.

ANALYSIS OF GARBAGE, AUGUST, 1902.

96	lbs.	vegetable and fine animal matter	64 per cent.
19	"	meat, fish and bones	12 "
12	"	oyster shells, crockery, tins, etc.	8 "
15	"	free water drawn off before analysis	10 "
9	"	water lost in making analysis	6 "
			100 per cent.

Tons of garbage burned yearly	9,663 tons
Cost of labor and repairs	$14,698
Cost per ton of garbage burned	$1.52
Total amount of coal used	1,728 tons
Garbage burned per ton steam coal	5.6 "
Tons of gas coal used	1,298 "
Garbage burned per ton of gas coal'	7.4

COST OF SERVICE FOR TWO YEARS, 1900-1902.

Average cost for two years of garbage burned	$1.48½ per ton
Garbage burned per ton of coal (total) 2 years	6.15 tons
Garbage burned per ton of gas coal (total) 2 years	7.70 "

1900—Total amount collected	10,477 tons;	cost, $11,594
1901— " " "	9,663 "	" 12,931
Totals	20,142 tons;	cost, $24,525

Average cost of collection, $1.22 per ton.
" haul, 2 miles; cost per ton mile, 61 cents.
Weight of garbage per cubic yard, 1,560 lbs.

This Smith-Siemens cremator was operated by producer-gas generated at the plant and employed only in this work.

This disposal plant was greatly damaged in the great storm of October, 1903, and the following year was replaced by a reduction system, operating under the Arnold process.

REPORT ON DAVIS CREMATORY, TRENTON, N. J. (1899.)

BY RUDOLPH HERING, C.E., AUGUST 4-9, 1902*

Garbage unmixed with ashes, in following proportions:

Moisture	81 per cent.	=	1,620 lbs
Garbage	15 "	=	300 "
Refuse	4 "	=	80 "
	100 per cent.	=	2,000 lbs.

Total garbage burned	188	tons
Total coal for main and auxiliary fires	13.7	"
Total garbage burned per ton of coal	13.8	"
Approximate average hours per day	14.0	hours
Equivalent number of days 24 hours	3.5	days
Garbage burned per square foot of grate surface per day of 24 hours	1,080	lbs.
Garbage burned per square foot of grate surface per hour	45	lbs.
Garbage burned per cell, 25 square feet, per day of 24 hours	13.5	tons
Percentage moisture in garbage	81.0%	
Corresponding water evaporated daily	25.5	tons
Coal required to evaporate this water on basis of 10 lbs. water per lb. coal	2.5	lbs.
Range of temperature of flue gases	600° to 1,000°	Fah.
Total daily capacity (24 hours)	53.7	tons

The report does not include the cost of labor and fuel, but this was unofficially reported at about 62 cents per ton.

This report of Mr. Rudolph Hering, an engineer, who had previously made investigations of this subject in Great Britain and Germany, was, as stated by *Engineering News*, "the first thoroughgoing engineering investigation of the operations of the American garbage crematories of which we have knowledge."

It was undertaken under instructions of a Committee of the City Council "appointed to investigate the workings of the city crematory, against which numerous complaints have been made," and a brief synopsis of the subject matter and the conclusions reached will be of value.

The garbage proper, or house refuse, is not of a combustible nature, containing much fruit and being almost saturated with water. The garbage from stores, markets, etc., is collected by

*Engineering News, New York, Sept. 11, 1902.

private parties, and much of it is very combustible, such as paper, rags, straw, wooden boxes, barrels, etc.

The sources of the trouble were:

(1) *The odors arising from the garbage* when collected by the city teams and delivered at the works. This may be abated by exercise of more care in loading and better regulations at the furnace.

(2) *Odors from ashes after burning.* These arise from piles of ashes containing unburned animal and vegetable refuse and occur because of the furnaces not being competent to thoroughly consume the waste, and also because of the unskillfulness of the attendants.

(3) *The dust escaping from the chimney.* This is due to the faulty design of plan or to improper manipulation of dampers, or both, and can be avoided by the construction of a dust chamber between the furnace and the stack, and by adding properly designed dampers.

(4) *Unburned particles escaping from the chimney.* This is annoying because of their charry or greasy nature, and dangerous because of the burning particles setting fire to roofs. Unburned particles were noticed at a distance of one-quarter, one-third and one-half miles, varying from one-quarter to three-quarters of an inch square. The cause was incomplete combustion and the remedy was a dust-collecting chamber, and dampers to be closed when charging.

(5) *Odors from the stack.* This is usually the most serious trouble from garbage cremation and due largely to the design of the furnace. A discussion of this question involves (a) the character of the material delivered for cremation and (b) the essential parts of the furnace to obtain complete combustion. The burning of garbage depends upon the amount of combustible it contains and the amount of dust, chiefly of an incombustible nature, which obstructs the free access of air, and also the amount of moisture present.

In European cities, where the garbage and rubbish is mixed with ashes, the combustible matters are sufficient in properly constructed furnaces to burn the whole without the addition of fuel. In our own country it has become the custom to separate the ashes and garbage, and the burning becomes a more difficult matter and can only be done by adding fuel.

FUEL VALUE OF GARBAGE.

The combustible value of garbage alone is thus stated:

Taking 31 tons per day, with 81 per cent. of moisture, there would be present 21 tons of water. Assuming that all this water must be evaporated in the furnace, and taking 10 pounds of water evaporated by one pound of coal, it would require 2.4 tons of coal to drive off this water. Again, assuming that 20 per cent. of solid material in the garbage will yield roughly six tons of dry combustible material of about equivalent value of one-third that of coal, this is equal to 20 tons of coal, thus leaving an average of 0.4 tons of fuel which must be added daily to consume the garbage with its present quantity of moisture.

The amount of coal actually used per day was 2.3 tons, and it is clear that the arrangement of the furnace or that the manner in which it is operated is not economical. The British cell destructor, with its sloping, drying hearth, the sloping fire grates with forced draft beneath, the combustion chamber for mixing the gases before passing to the steam boiler and the dampers for regulating the draft, is more efficient than the American crematory, with its large areas of horizontal grate, resulting in piling up the garbage in heaps, requiring laborious and careful stoking to distribute the material, and compels a slower combustion of a larger surface of exposed matter and the need of some secondary fire for destroying odors.

The brick chimney (120 feet high) of this crematory, collapsed on September 17, 1906, and in its fall damaged an adjoining house, injuring an inmate. A special committee of investigation, appointed by the City Council, reported October 2, 1906, that it "believed the wreck of the chimney was due to an explosion at the base of the stack." The chimney was replaced by one 150 feet high, of the radial brick construction, at a cost of $4,500.

THACKERAY INCINERATOR, MONTREAL, CANADA. 1894.

In 1894 Mr. Charles Thackeray built for Montreal, Canada, an incinerator of the English type, following closely the designs of the Fryer destructor at Manchester, England (1886), but with modifications and additions made by the inventor. The contract called for the disposal of 150 tons per day—24 hours—at a cost not to exceed 90 cents per hour, equivalent to 14.4 cents per ton. The chimney is 180 feet high and 7 feet internal diameter. Natural draft is used. The approximate cost of the plant was $50,000.

In 1902 Dr. E. Pelletier, Secretary, Superior Board of Health, Province of Quebec, made a report upon Refuse Disposal which includes some facts respecting the Thackeray Incinerator.*

His analysis of Household Refuse is:

	In summer	*In winter*
Kitchen wastes	65	25
Paper (combustibles)	15	10
Tins, bottles, rags, etc.	10	5
Ashes	10	60
	100%	100%

The collection is made in a mixed or unseparated state by the city's wagons. Only the refuse of the West District is burned; that of the two other districts (East and Central) is tipped. The incinerator had the same number of cells as when constructed, but

*Proceedings A. P. H. Assn., Vol. 28, 1901.

had been somewhat simplified by the removal or non-use of steam jets and mechanical fans for forced draft, the steam boiler removed from the main flue, the lower horizontal flue being discontinued, also the fourteen small supplementary cells, and the fume cremator at the base of the stack. There was added a screen or ash separator for removal of fine ash in winter season, as the large amount of fine particles interfered with the combustion of other matter.

From personal inspection Dr. Pelletier found that the household refuse of Montreal is auto-combustible during the summer, when the amount of ashes is 10 to 15 per cent. Mr. Doré, the Sanitary Engineer of the city, estimates the moisture of Montreal garbage and refuse to be 60 per cent.

The cost of incineration at Montreal, as stated by Dr. Pelletier, follows:

> From figures furnished by the Department in charge, the quantity of household refuse during 1901 was 17,445 loads, equivalent to 13,659 tons, destroyed at a cost of 93½ cents per ton. However, this does not give an exact idea of the cost of incineration, either on account of interruptions in the running of the incinerator (repairs or an insufficient amount of garbage), the wages of the men continuing to run just the same, or for other reasons. It is now well established that the net cost for the incineration of a ton of garbage is 39 cents per ton (note). I did not on any of my visits detect any bad smell resulting from incineration, and every one I have spoken to about the matter has always answered that they never heard any complaints.

NOTE.—It is understood this is operating cost only, not including interest charges on capital cost or depreciation. In addition to the ash separator, a picking belt for recovery of marketable refuse is also employed, but the power is not obtained from the incinerator to operate the screen and conveyor.—[ED.]

THACKERAY INCINERATOR, SAN FRANCISCO, CAL., 1897-8.

Following the installation at Montreal, four years later, a private company, The Sanitary Reduction Company, of San Francisco, Cal., bought the rights to build a Trackeray incinerator and acquired from the city a franchise for the disposal of its wastes for the term of fifty years.

This private company is the successor of two others organized for this work, and has encountered many difficulties in the prosecution of its work. The incinerating plant erected in 1897 continued up to April, 1906, when it was partly destroyed by earthquake.

From a report made to the *Engineering News,* May 17, 1900, the following facts are condensed:

Number of cells	32
Daily capacity, each 45 yards, or	20 tons
Total rated capacity of plant	1,500 yards
Equivalent in weight	600 tons
Square feet grate surface per cell	96 sq. ft.
Average quantity of charge per cell	15 yards
Time required for combustion of charge	4 to 8 hours
Average amount consumed per hour per square foot of grate	17.3 lbs.
Average daily amount at time of report	650 yards
Equivalent in weight	260 tons
Cost of labor (23 men) per day	$40.00
Average cost operating per ton	.15
Approximate cost of plant	$75,000.00
Amount charged for incineration per yard	.25

THE WASTE COLLECTION OF SAN FRANCISCO.

The collection of city's waste in San Francisco is made under the direction of a Scavengers' Association, which controls the entire service, making its own charge for collection from households and delivering the refuse at the works for disposal, paying 25 cents per cubic yard to the Reduction Company. The waste includes garbage, refuse and ashes mixed together, and is taken at the works just as it comes.

These disposal works are the largest in this country, covering three sides of a square of 265 feet; the buildings are of brick with steel corrugate roofing, and the tipping platforms and approaches wide and convenient. The chimney was the largest of its class on the Pacific coast, 262 feet high, 32 feet square at the base, with a central circular shaft of 210 feet and 14 feet in internal diameter.

At the time of the earthquake the upper third of the chimney was broken off and in falling destroyed the flues connecting with the eastern battery of cells and so wrecked this set of cells as to put them out of use.

These two Thackeray crematories are the only example of the English cell destructors yet built in this country. They followed in all main particulars the construction of the Fryer destructor, but neither made use of the "fume cremator" which was an essential feature of the English construction. In some respects the work of these furnaces was an advance over the methods of the American crematories. There was no separation of the wastes, the mixed collection of garbage, ashes and refuse being received; the high chimneys gave draught for combustion with small additional fuel, and the operating costs were low.

Owing to the slow rate of combustion (about 17 lbs. per sq. ft. of grate surface) the time required for disposal compelled the construction of a much larger plant than is now required for the same relative quantities.

Because of the low temperatures neither plant can develop steam power for its own uses, much less for any other purpose. It is probable both these installations will, as have the Fryer destructors abroad, be replaced by other more modern and efficient types. The city of San Francisco has passed an ordinance appropriating one million dollars for the waste collection equipment and establishment of a modern destructor system for disposal.

Montreal is proceeding on the same lines, and is about substituting a more efficient destructor to develop steam power to be employed in electric lighting work.

SUMMARY OF EARLY AMERICAN CONDITIONS.

In attempting to gather data respecting the earliest American crematories, from which reliable reports can be had, it has been found very difficult to record anything except the briefest outline of the work. In the first twenty years after 1885, some twenty-five different sompanies and firms came forward with incinerating furnaces, warranted by the owners to destroy everything with no trouble to the towns and with a profit for themselves and their backers. The most extravagant claims were made, based upon patents as yet untried, reinforced by promises to perform feats that were opposed to all accepted natural laws of combustion. Naturally, when put to the test they failed, and in failing they brought discredit upon the whole subject of waste disposal by fire.

The business of the few companies that had shown ability to do satisfactory work was hindered and obstructed by competitors, eager for contracts, but not at all anxious to make good, if it involved a loss to themselves, as it mostly did. The progress was slow, the returns small, the changes in companies many, and the general conditions both for towns and builders became unsatisfactory.

All of the earlier forms of furnace constructions, with one exception followed the type of furnace first made known by Andrew Engle in 1887. This was a long rectangular open interior furnace chamber, floored with transverse bars of iron or fire brick. The main fire box was placed at the front end, with a secondary fire box at some point within the furnace or immediately before the chimney flue. The flames and heat from the primary fires passed over and under the waste, and were intercepted at some point by the secondary fire which completed the combustion.

This was the type of what is known as the American crematory as distinguished from the English destructor form.

The general conditions attending this type may be thus stated:

All of the American garbage furnaces are designated as cremators, crematories or incinerators, following the descriptive titles used by the builders.

Those that survived preliminary stages and can show a record of four or five years of successful use follow the same general form of construction, with minor differences of exterior walls of brick or steel plate, but with the same charging and stoking methods, and the same employment of a secondary fire.

All without exception require fuel for primary combustion of the waste and secondary destruction of the gases.

They were built for the disposal of garbage and light refuse and sometimes included the larger animals and a small amount of night-soil.

They did not dispose of ashes or street sweepings, nor did they deal with the general miscellaneous collection of mixed waste.

They did not employ steam boilers in connection with the crematory, and could not guarantee steam power for any general service.

The exceptions to these general principles apply only to the form of grates, which in one case are hollow iron tubes filled with water, and in another case the burning chamber, instead of being open from end to end, is divided into short cells by transverse partition walls.

CHAPTER VI.

LIST OF MUNICIPAL GARBAGE FURNACES.—The Garbage Furnaces Installed by the United States Government. The Institutional and Private Garbage Crematories

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
1	1885	1	Gov. Island, N. Y.	Lt. H. J. Reilly, U. S. A.		$300			1904	First Garbage Furnace in U. S.
2	1885	1	Allegheny City, Pa.	L. P. Rider.	352,653	5,700		30	1893	First municipal furnace in U. S.
3	1885	1	Montreal, P. of Q.	Wm. Mann.	371,203				1886	First Can'an fur.; for n't s'l only.
4	1886	1	Wheeling, W. Va.	M. V. Smith.				60		Fuel, natural gas; still in use.
5	1886	1	Montreal, P. of Q.	Wm. Mann.	371,203				1891	Second Canadian furnace.
6	1887	1	Des Moines, Ia.	Andrew Engle.	372,304		50		1891	Replaced by Engle, No. 31.
7	1887	1	Milwaukee, Wis.	Forestal.					1888	Replaced by Engle, No. 9.
8	1887	1	Pittsburg, Pa.	Rider Furnace Co.		3,700	75	30	1901	Fuel, natural gas.
9	1887	1	Milwaukee, Wis.	Engle S. & Con. Co.					1889	Followed by Merz Red'n Proc's.
10	1887	1	Minneapolis, Minn.	Engle S. & Con. Co.		5,000			1888	Removed after one year.
11	1887	1	Fort Wayne, Ind.	Vivarttas.	390,922				1896	Followed by Dixon Crematory.
12	1887	1	E. 17th St., N. Y. C.	Vivarttas.					1889	Experimental.
13	1888	1	Chicago, Ill.	Wm. Mann.		11,000		150	1889	Experimental.
14	1888	1	Detroit, Mich.	A. L. Patrick.	413,832				1888	Experimental. Beehive pattern.
15	1888	1	Coney Island, N. Y.	Engle S. & Con. Co.		4,000	50		1891	Replaced by Engle, No. 33.
16	1889	?	Jacksonville, Fla.	Engle S. & Con. Co.		4,500	50		1890	Replaced by Engle, No. 23.
17	1889	2	Findlay, O.	Engle S. & Con. Co.					1896	Double fur.; one for nightsoil.
18	1889	2	Birmingham, Ala.	Engle S. & Con. Co.		4,000		20	1895	Double fur.; one for nightsoil.
19	1889	1	Brunswick, Ga.	Engle S. & Con. Co.		4,500	50		1890	Replaced by Engle, No. 24.
20	1889	1	N. Y. C. Disinfecting Sta.	Engle S. & Con. Co.		2,500		5		In continuous use since install'n.
21	1889	1	Newport, R. I.	Bliss Patent.					1890	Not accepted by city; removed.
22	1889	1	Savannah, Ga.	Hughes & Hoskins.	391,614				1889	Experimental; fuel, oil.
23	1890	1	Jacksonville, Fla.	Engle S. & Con. Co.		4,000	75		1897	To replace No. 16; fol'd by Dix'n.
24	1890	1	Brunswick, Ga.	Engle S. & Con. Co.					1897	To replace No. 19.
25	1890	1	St. Augustine, Fla.	Engle S. & Con. Co.		3,500	75		1894	Built for contractor.
26	1890	1	Tampa, Fla.	Engle S. & Con. Co.					1895	For nightsoil.
27	1890	1	Allegheny, Pa.	W. Swindell.	546,438				1906	In market house.
28	1890	1	Butte, Mont.	Engle S. & Con. Co.					1895	No reports.
29	1890	1	Panama.	Engle S. & Con. Co.			75			Still in use.
30	1891	2	Savannah, Ga.	Engle S. & Con. Co.		14,000	100		1903	Double furnace; one for nightsoil.
31	1891	1	Des Moines, Ia.	Engle S. & Con. Co.				25	1903	To replace No. 6.
32	1891	1	Chicago, Ill.	B. C. Heavey.	411,903			20	1902	Experimental; fuel, petroleum.
33	1891	1	Coney Island, N. Y.	Engle S. & Con. Co.		4,000	50		1896	To replace No. 15.
34	1891	2	Toronto, Canada.	Coatsworth.			100		1893	Built by day labor by city emp's.

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.—(Continued.)

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
35	1891	1	Buffalo, N. Y.	Jas. Bolan					1892	Experimental.
36	1892	1	Richmond, Va.	Engle S. & Con. Co.	468.851	7,500		20		Fur. enl'ged 1901; now in use.
37	1892	1	Norfolk, Va.	Engle S. & Con. Co.	468.852	7,500		20		Furnace relined once: op'g 1907.
38	1892	1	Munice, Ind.	Smith-Siemens	546,497	5,000			1905	Fuel, nat'l gas; fol'd by Decarie.
39	1892	1	Corsicana, Tex.	A. Brownlee	448.115			50	1902	
40	1892	1	Gainesville, Tex.	A. Brownlee					1903	
41	1892	1	Lowell, Mass.	Engle S. & Con. Co.		7,500		20	1905	
42	1893	2	World's Fair, Chicago.	Engle S. & Con. Co.				100	1893	Fuel, oil; awarded Grand Prize.
43	1893	1	Boston, Mass.	S. G. Brown	537.801				1894	Experimental; fuel, oil.
44	1893	1	Indianapolis, Ind.	Bulfinger					1894	Experimental.
45	1893	1	Philadelphia, Pa.	N. Dowling	533.448				1894	Experimental; fuel, oil.
46	1893	1	Philadelphia, Pa.	Vivarttas					1895	Followed by Smith-Siemens.
47	1893	1	Terre Haute, Ind.	A. Brownlee	537.339	9,000	75		1905	No reports.
48	1893	1	Elwood, Ind.	Dixon Crematory Co.	461.327				1901	Fuel, nat'l gas; dry rubbish only.
49	1893	2	Toronto, Canada.	Jones		15,000				Operating.
50	1893	1	Yonkers, N. Y.	J. McKay	530.623	5,000		25		Operating.
51	1893	1	Wilmington, Del.	S. G. Brown	501,181				1897	First water-jacketed furnace.
52	1893	1	Waco, Tex.	Garrettson & Taintor					1895	
53	1893	1	Chicago, Ill.	J. C. Anderson	520,283	60,000	500		1893	Experimental; fuel, oil.
54	1894	1	Salt Lake City, Utah	Engle S. & Con. Co.		12,000			1902	Destroyed by fire, fol'd by Dixon.
55	1894	1	Ogden, Utah	Engle S. & Con. Co.						No reports; believed to be op'ng.
56	1894	2	Atlanta, Ga.	Dixon Crematory Co.	517,816	12,190		50	1900	Followed by Lester furnace.
57	1894	2	Camden, N. J.	Dixon Crematory Co.	583,663	9,900				Double furnace; now operating.
58	1894	2	Atlantic City, N. J.	Smith-Siemens	546,497	65,000		150	1899	Fuel, producer gas.
59	1894	2	Philadelphia, Pa.	Smith-Siemens					1899	Fuel, producer gas.
60	1894	16	Montreal, Canada.	Chas. Thackeray	553.574	50,000		150		Operating.
61	1894	1	Troy, N. Y.	Brown Crematory Co					1905	Destroyed by fire 1906.
62	1895	2	McKeesport, Pa.	Dixon Crematory Co.				20	1904	Removed expirat'n lease of gr'nd.
63	1895	1	Helena, Mont.	Local Design		3,000				No reports; believed to be op'ng.
64	1895	1	Scranton, Pa.	Vivartas			125		1908	
65	1895	1	New York City	Colwell	583,566				1896	Experimental; dry refuse only.
66	1895	1	Flatbush, N. Y.	Burns					1896	Experimental.
67	1895	1	Charlotte, N. C.	Dixon Crematory Co.						Operating.
68	1895	1	Anderson, Ind.	Local Design						For dry refuse only; no reports.
69	1895	1	Trenton, N. J.	Dixon Crematory Co.					1901	Followed by Davis Co.
70	1895	1	San Antonio, Tex.	Brownlee					1906	

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.—(Continued.)

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
71	1895	1	New Br'ton, N. Y.	Brownlee		6,500			1898	Followed by Dixon Crematory.
72	1895	1	Evansville, Ind.	Engle S. & Con. Co.						Operating.
73	1895	1	San Salvador, S. S.	B. Boulger	537,181			25	1906	
74	1895	1	Lafayette, Ind.	A. Brownlee					1899	Followed by Dixon Crematory.
75	1896	1	Los Angeles, Cal.	Dixon Crematory Co.				50	1905	Followed by Decarie Incinerator.
76	1896	1	Syracuse, N. Y.	J. S. McGiehan	554,453				1897	Experimental.
77	1896	1	Richmond, Ind.	Engle San. & C. Co.		6,800		30		
78	1896	1	York, Pa.	Dixon Crematory Co.				25	1904	Not operating.
79	1896	1	Fort Wayne, Ind.	Dixon Crematory Co.				40		Operating. Add'l furnace in 1900.
80	1896	1	Washington, D. C.	S. G. Brown					1900	
81	1896	2	Dayton, O.	Dixon Crematory Co.		33,000			1898	Des'yed by fire; not rebuilt.
82	1897	4	Jacksonville, Fla.	Dixon Crematory Co.				80		Operating 1906.
83	1897	2	Wilmington, Del.	Dixon Crematory Co.		16,000				Operated by private co.
84	1897	32	San Francisco, Cal.	Thackeray Co.	644,980	75,000		600		Part'ly dest'y'd by ear'q'ke, Apr. '06
85	1897	1	Lancaster, Pa.	Davis Co.	462,035	15,350		50		
86	1898	1	New York City	Colwell					1900	Waring's Utilization Plant.
87	1898	..	Reading, Pa.	Davis Co.		9,850		80	1899	
88	1898	1	San Diego, Cal.	Dixon Crematory Co.				40	1905	Not operating.
89	1898	1	Wichita, Kan.	A. Engle & Co.	508,511				1906	Not operating.
90	1898	1	Topeka, Kan.	A. Engle & Co.					1906	
91	1898	2	Memphis, Tenn.	Dixon Crematory Co.		14,000		40		Two sep. 20-ton furnaces; op'ng.
92	1898	1	Youngstown, O.	Dixon Crematory Co.				40		Operating.
93	1898	1	Washington, D. C.	Smith-Siemens					1898	Never put into commission.
94	1898	1	New Orleans, La.	Dixon Crematory Co.					1902	Experimental.
95	1899	1	Dallas, Tex.	Engle San. & C. Co.	503,845				1902	Fol'ed by Dixon Co.
96	1899	1	Portland, Ore.	Engle & Thompson		16,000				Replaced by same builders 1901.
97	1899	1	Houston, Tex.	N. Risley	674,319	8,000			1906	
98	1899	1	Westmount, Can.	Decarie Co.	596,421			20	1900	First municipal Decarie plant.
99	1899	1	Trenton, N. J.	Davis Co.	462,035	24,000		53		Operating; additional cell & st'ck.
100	1899	1	Boston, Mass.	Morse-Boulger		30,000	500			For dry refuse only; operating.
101	1899	2	Havana, Cuba	Davis Co.	462,035			100	1903	
102	1899	1	Lafayette, Ind.	Dixon Crematory Co.		8,400		25		Operating.
103	1899	2	Memphis, Tenn.	Dixon Crematory Co.		5,400		25		Second installation; operating.
104	1899	1	Greenville, Miss.	Dixon Crematory Co.		1,900		20	1902	Furnace and stack only.
105	1899	1	Long Island City, N. Y.	Dixon Crematory Co.		9,940		15		Operating.
106	1899	1	New Brighton, N. Y.	Dixon Crematory Co.		9,940		15	1908	

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.—(Continued.)

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
107	1899	1	Flushing, N. Y.	Dixon Crematory Co.		9,940		15	1905	Followed by Pierce-La Chapelle.
108	1899	1	Far Rockaway, N. Y.	Dixon Crematory Co.		9,940		15	1905	Followed by Pierce-LaChapelle.
109	1899	1	Jamaica, N. Y.	Dixon Crematory Co.		9,940		15	1905	
110	1899	1	Bridgeport, Conn.	Dixon Crematory Co.		12,500		30	1904	Suspended.
111	1899	1	Plainfield, N. J.	Vivartas.					1900	Built for private company.
112	1900	1	Fort Wayne, Ind.	Dixon Crematory Co.		3,000		20		Second installation.
113	1900	1	Atlanta, Ga.	F. F. Lester.	658,658				1902	Followed by Decarie 1904.
114	1900	2	Grand Rapids, Mich.	Engle S. & Con. Co.	699,635	14,780		50		Operating 1908.
115	1900	2	Louisville, Ky.	Dixon Crematory Co.		23,960		100	1901	Not op'ng; contract not complete.
116	1900	1	Joliet, Ill.	Dixon Crematory Co.	667,445	8,000		30		Operating 1906.
117	1900	1	Ottawa, Ill.	LaChapelle & Pearce.	577,184				1902	
118	1900	1	Evanston, Ill.	LaChapelle & Pearce.					1903	
119	1900	1	Covington, Ky.	Dixon Crematory Co.		4,650		20		Operating.
120	1901	1	Waterbury, Conn.	H. B. Smith.	757,149			15		Operating; enl'ged or reb'lt 1906.
121	1901	4	Milwaukee, Wis.	Engle S. & Con. Co.	699,635			200		Operating
122	1901	1	Oil City, Pa.	Davis Co.		4,000				Operating 1906.
123	1901	1	Toledo, O.	J. Smead.	607,553				1902	Experimental.
124	1901	1	Chicago, Ill.	W. B. Wright.	575,088	14,000		30		Operating.
125	1901	2	Minneapolis, Minn.	Decarie Co.						Replaced by larger cons'ion 1906.
126	1901	1	Vancouver, B. C.	A. Engle.		16,000			1906	
127	1902	1	Mansfield, O.	Dixon Crematory Co.		3,500		15		Op'ing with sewage disposal plant.
128	1902	1	Allentown, Pa.	Dixon Crematory Co.		14,700		20		Operating.
129	1902	1	Wilmerding, Pa.	Dixon Crematory Co.				15	1902	Furnace and stack.
130	1902	1	Hamilton, O.	Dixon Crematory Co.		11,270		40		Operating.
131	1902	2	Newcastle, Pa.	Dixon Crematory Co.		8,500		30		Operating.
132	1902	1	Manila, P. I.	Morse-Boulger Co.		50,000		140		Operating.
133	1902	1	Newport News, Va.	H. B. Smith.		7,400			1902	Not accepted by city.
134	1902	1	Dallas, Tex.	Dixon Crematory Co.		8,500		25		Operating 1906.
135	1902	1	St. Catalina Islands, Cal.	Dixon Crematory Co.				15		Operating.
136	1902	1	Johnstown, Pa.	Decarie Co.				15		Built for private company.
137	1902	4	Winnipeg, Man.	Local Design.		14,000				To be followed by Decarie Co.
138	1902	1	Long Branch, N. J.	Municipal Eng. Co.	766,848				1907	
139	1902	1	Salt Lake City, Utah.	Dixon Crematory Co.		13,224		25		Operating.
140	1902	1	Clarksburg, W. Va.	Dixon Crematory Co.		4,000		10		Operating; furnace and stack.
141	1902	2	Canton, O.	Dixon Crematory Co.		19,985		40		Operating.
142	1902	1	W. 47th St., N. Y. C.	H. de B. Parsons.		15,300			1906	For dry refuse only; replaced by second incinerator.

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.—(Continued.)

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
143	1903	2	Homestead, Pa.	Dixon Crematory Co.		8,500		30		Operating.
144	1903	1	South Bend, Ind.	Dixon Crematory Co.	724,898	6,885		25		Operating.
145	1903	1	B. of Bronx, N. Y. C.	Decarie Co.					1903	Closed by City's order; removed.
146	1903	2	Oakland, Cal.	Dixon Crematory Co.				50	1906	Burned down.
147	1903	1	Coudersport, Pa.	Davis Co.						Operating.
148	1903	1	Spokane, Wash.	Decarie Co.		21,000		40		Operating.
149	1903	1	Meadville, Pa.	Dixon Crematory Co.		9,000		25		Operating.
150	1903	1	Tampa, Fla.	Decarie Co.		15,700		25	1905	Followed by Dixon.
151	1904	1	Charleroi, Pa.	Dixon Crematory Co.		4,295		15		Operating; furnace and stack.
152	1904	1	Charlestown, W. Va.	Pearson Incinerator		8,077		20		No reports; believed to be op'ng.
153	1904	2	World's Fair, St. L.	Dixon Crematory Co.				60	1904	Awarded Grand Prize.
154	1904	1	Buffalo, N. Y.	Morse-Boulger Co.		40,000	500			Utilization plant for dry refuse.
155	1904	2	Atlanta, Ga.	Decarie Co.		31,500		200		Operating.
156	1904	1	McKeesport, Pa.	G. H. Pearson.		12,077		50	1907	
157	1905	1	Muncie, Ind.	Decarie Co.	749,269	17,869		40		Operating.
158	1905	1	Boro Manhattan, N. Y.,	H. de B. Parsons		34,193	500		1908	For dry refuse only; removed.
			at Wm'gh Bridge, N. Y.	F. P. Stearns.	772,681		500			" " "
159	1905	1	Los Angeles, Cal.	Decarie Co.		70,864		200		Operating.
160	1905	2	Brooklyn, N. Y.	American R. T. Co.			800			For dry refuse only.
161	1905	1	Brooklyn, N. Y.	Decarie Co.			300			For dry refuse only.
162	1905	1	Marion, O.	G. H. Pearson.						Fuel, natural gas.
163	1905	1	Calgary, Mont.	Local Design					1907	
164	1905	1	Lowell, Mass.	Decarie Co.		10,000	50			For dry refuse only.
165	1905	1	Flushing, N. Y.	Pearce-LaChapelle		24,900		25		
166	1905	1	Butler, Pa.	Morse-Boulger Co.		5,700		25		
167	1905	1	Duluth, Minn.	Decarie Co.		29,000		80		
168	1905	1	Sacramento, Cal.	Dundon Incinerator		12,600			1906	Not accepted by city.
169	1905	1	Wabash, Ind.	Dixon Crematory Co.	789,329	5,638		10		
170	1905	2	Guayaquil, Ecd.	Dixon Crematory Co.		9,440		40		Material only.
171	1906	1	Shreveport, La	Dixon Crematory Co.		9,970		25		Fuel, nat'l gas; mixed waste.
172	1906	1	Elmira, N. Y.	Bennett Incinerator		16,277				Built for private company.
173	1906	1	Steubenville, O.	Lewis & Kitchen				25		Operating.
174	1906	1	Rockaway, N. Y.	Pearce-LaChapelle		24,975		20	1906	Not accepted by city.
175	1906	1	Westmount, Can.	Meldrum Co.		14,000		50		Power used for municipal electric lighting; cost not including building or stack.

TABLE XL.—CHRONOLOGICAL LIST OF AMERICAN MUNICIPAL GARBAGE FURNACES SINCE 1885.—(Continued.)

No.	Date of Con-s'tion	No. of Fur-n'ces	Location	Type of Furnace or Name of Builder	No. of Patent	Contract Price or Cost	Capacity in 24 Hours		Date of Dis-con-tin'ce	Remarks
							Yds.	T'ns		
176	1906	1	Greensburgh, Pa.	Dixon Crematory Co.				15		Operating.
177	1906	1	Ocean Park, Cal.	Decarie Co.		7,500		10	1907	No reports.
178	1906	1	Santa Monica, Cal.	Decarie Co.		7,500		10		No reports.
189	1906	1	Sacramento, Cal.	Decarie Co.		25,000		40		Operating.
180	1906	2	Lexington, Ky.	Dixon Crematory Co.		12,000		50		Operating.
181	1906	4	Tampa, Fla.	Dixon Crematory Co.		27,750		100		Operating.
182	1906	1	Sewickley, Pa.	Dixon Crematory Co.				15		Operating.
183	1906	1	Donora, Pa.	Dixon Crematory Co.				15		Operating.
184	1906	1	Jacksonville, Fla.	Wiselogel Furnace	803,650				1907	
185	1906	2	Winnipeg, Man.	Decarie Co.		126,420		140	1906	Not accepted by city.
186	1906	1	Vancouver, B. C.	Heenan & Froude		29,000		50		Operating.
187	1906	1	Edmonton, Alberta	Decarie Co.		40,500		50		Not completed.
188	1906	1	New York, 47th St.	H. de B. Parsons					1908	To replace No. 142; discontinued.
199	1907	1	Zanesville, O.	Decarie.						
190	1907	1	Jamestown, Va.	Dixon		6,000	15			World's Exposition.
191	1907	1	Ambridge, Pa.	Dixon			15			
192	1907	1	Oak Park, Ill.	Lewis & Kitchen			25			
193	1907	1	Sisterville, W. Va.	Dixon Co.			12			
194	1907	1	Waco, Tex.	Dixon			25			
195	1908	1	Norfolk, Va.	Decarie.		29,000	50			
196	1908	1	Seattle, Wash.	Meldrum			60			
197	1908	1	Stockton, Cal.	Decarie.		25,000	40			
198	1908	1	Hattiesburg, Miss.	Lewis & Kitchen			25			
209	1908	1	Duquesne, Pa.	Decarie.			15			
200	1908	1	New Brighton, N. Y. C.	Heenan & Fronde		25,000	60			Destructor and boiler.
201	1908	1	Regina, Alberta	Decarie.			40			Under construction.
202	1908	1	Cambridge, Mass.	Public Service		25,975	60			For ashes and refuse.
203	1908	1	Brooklyn, N. Y. C.	Local Design						For dry refuse only.
204	1908	1	Wilkes-Barre, Pa.	Bennett						For private company.
205	1908	1	Schenectady, N. Y.	Universal Des. Co. (Meld'm)			40			For Gen. Elec. Co., under const'n.
206	1908	1	Spokane, Wash.	Decarie Co.		40,000	60			Second Installation.
207	1908	1	Scranton, Pa.	Lewis & Kitchen		16,500	40			Under Construction.
208	1908	1	Guatemala, C. A.	Morse-Boulger Co.			25			Operating.

THE CHRONOLOGICAL TABLE.

In compiling this list (Table XL) it was the writer's purpose to place on record the complete series, in chronological order of construction, of the municipal garbage cremating furnaces built in the United States and Canada since 1885. The Dominion of Canada is included because of the almost simultaneous beginning of the work in the two countries in 1885, and also for the reason that two of the furnaces in use in the United States originated in Canada. There are also included the furnaces built by American constructors in five foreign countries—Panama (Columbia), San Salvador, Cuba, Equador and Guatemala—as a part of the American constructive work in regular order.

The list is restricted to municipal furnaces—those employed either directly by the towns, or by private contractors in municipal disposal work—and does not comprise the large number of installations for the United States Government, or the still larger number built for public institutions and private establishments. There are two exceptions to this—Nos. 1 and 20—both the first of their respective types.

The list also includes the crematories built at the three great world's expositions, Chicago, 1893; St. Louis, 1904, and Jamestown, 1907, but these were for temporary purposes, and not considered as permanent municipal plants either by the authorities or the builders.

Again, to preserve the chronological order of erection, those plants for the treatment and disposal of dry refuse are included, though all, with two exceptions—Buffalo, N. Y., and Lowell, Mass.—are owned and operated by private companies. In several cases where "no reports" can be secured, the furnaces are understood to be discontinued, and should be so accounted. In some others where the reports are not conclusive, they are believed to be operating and noted accordingly.

Number of Installations.—The whole number of plants reported upon is 208, counting each as a separate installation, whether containing one or more furnaces. This includes some five plants of the same type, replaced for reasons of their own by the same builders or designers, and also about six others now under construction or contracted for, which are yet to pass their final trials for acceptance, but are here classed as operating.

Those noted as experimental are also included. Several of these were large and very costly structures, and as all were intended for municipal service, they should, with justice, be comprised in this list.

Number of Furnaces or Cells.—This is governed by the plan of construction. In the so-called American plan with one large receiving chamber, they are frequently built in pairs, one on each side of a central stack. The cell construction allows an indefinite number, contiguous to each other, and connected with a common chimney. Hence the increase in the number of separate furnaces over the number of plants or installations.

Years of Installation and the Builders.—It has been stated that the first municipal furnace for waste disposal was that at Wheeling, W. Va., but this is probably not the case. It appears that the next after Lieut. Reilly's first construction for the United States Government at Governor's Island was that of L. P. Rider at Allegheny, Pa., and following this was the Walliam Mann furnace for night-soil at Montreal, Canada, both of which preceded Wheeling, W. Va. All were in the same year, and it is only a question of the month of construction of the first four installations. Andrew Engle's first experimental furnace for night-soil was in the same year, but his first garbage municipal furnace at Des Moines, Iowa, came two years later. In the years 1889 to 1894, many crematories were built by the Engle Sanitary and Cremation Company, but not until the plan of the furnace was changed and more durable material used in 1891 did it take the lead.

In 1892-93-94 many other builders came forward, and shortly after the World's Fair in 1893 several large plants were built; the Anderson and Heavey at Chicago, Ill.; the Vivarttas and Smith-Siemens at Philadelphia, Pa., the latter at Atlantic City, N. J., and Washington, D. C., and the Thackeray at Montreal. Of these, the Thackeray only has survived, the others being replaced by reduction processes.

The Dixon Crematory Company, after its change in plan of construction and personnel of its organization in 1894, acquired a firm foothold in the field which has never been relinquished, and has now the longest list of installations to its credit, the greatest number being in towns and cities of the third and fourth class in population.

From 1895 to 1899 six new types of furnaces were brought out, but none of these succeeded in their first attempt, one only surviving for future work after a radical change in its form of construction.

The years 1899 to 1903 were the period of greatest activity, nearly sixty installations being made of twelve different types, seven of which proved unsatisfactory and did not continue. Nearly all the plants erected were of small capacity, two only being of one hundred tons. In this period the first refuse disposal stations were built, as well as the greatest number of installations for the United States Government and for institutions.

During the last two years three new installations of new patents have been built. These are the Heenan & Froude at Vancouver, B. C., and New Brighton, N. Y.; the Meldrum destructors at Seattle, and Schenectady under contract, and the incinerator of the Public Service Co. at Cambridge, Mass. This last is, with some changes, the same as installed at East New York for dry refuse. The Bennett Crematory at Wilkes-Barre is the same as previously built at Elmira, N. Y.

The installations of the older companies are fewer in number than in previous years, and with less rated capacity, except in one notable Canadian instance, which is still unaccepted by the city after prolonged efforts on the part of the company to meet the requirements of the contract.

Locations Indicated in the Table cover the widest possible range of territory, from the northern limit of population to the tropical countries of the South, and the whole width of the continent frm the Atlantic to the Pacific oceans, and in five foreign countries.

Patents Issued by United States Government.

The patents for apparatus to burn wet fuels began with No. 383, reissued August 15, 1856, and this was followed by a long series of inventions to burn bagasse, mill waste, tan bark, stumps, and many forms of combustible refuse. The first patent recorded for cremating garbage was that of H. R. Foote, Stamford, Conn., January 21, 1879, No. 21,203. Mr. Foote's claims included nearly all of the ideas that were afterwards made the subject of separate inventions by others, but, as a whole, his scheme was in many ways quite impracticable. The rotary cylinder form of furnace was one of the earliest types, but, like most of the first devices, was too elaborate and complex to come into use. The first inventors tried to do too much, and did not clearly understand the character of the material to be destroyed.

The list of patents issued in this country from 1885 up to date includes over 160 for garbage cremating furnaces alone. Besides these are some 75 others for methods and processes for treating, converting, manipulating, and manufacturing municipal waste matter, and about 25 smaller devices for household use in connection with kitchen stoves, and for disposal of night-soil from isolated dwellings.

These inventors display great ingenuity and skill in their theoretical apparatus, but a lamentable lack of practical knowledge of the complex and conflicting character of the waste to be dealt with. The patents enumerated in the table are the ones that have undergone a practical trial under working conditions, and of these only a limited number have stood the test of continuously successful service.

Cost of Construction.—The prices given as the costs for installation are gathered from the published reports when bids are asked for or accepted by the towns. There is no way of determining whether they include a complete installation of building, chimney and furnace, with all driveways, etc., or are only confined to the furnace and chimney. As a rule the towns usually buy a complete plant, but sometimes have separate contracts for buildings, or, if in conjunction with other works, the furnace is only a part of a general contract.

There is no standard for comparison of costs of construction by the rated capacity of the plant that can be assumed to be accurate, nor is there any uniformity in the prices of the same construction by the same builders at different places, where the conditions are similar. It is true the expense is often influenced by difficulties in site, or local cost of freight, material, and labor, but this does not account for the wide variation in many cases which are substantially the same in all important features.

Operating Cost.—An attempt has been made to ascertain the operating cost for fuel and labor per ton of garbage destroyed at these plants, but this has been given up as impracticable. The reports obtained were conflicting and contradictory, tending only to mislead any seeking accurate detail. For lack of a common standard of measurement, there was no starting point to work from. Until there is some system brought into use for measuring and tabulating returns and reports from operating plants, with the items of quantities, time, fuel, labor, maintenance and capital charges, continued over at least one year's period, there cannot be any definite and serviceable details to record.

Capacity of Furnaces.—The crematories were at first rated by the cubic yard of material consumed in one day, a day being 12 hours and the cubic yard used because it could be easily computed by taking the measurement of collection carts. Later it was necessary to provide for continuous service, and the capacity is rated by the tons to be destroyed in 24 hours, and this is commonly taken as the standard, but unless there is an actual weighing of the waste in cases where accuracy is required, there is usually little reliance to be placed on reported figures of capacity.

Discontinued Installations.—This column indicates the years when the plants ceased to be active factors in waste disposal work, and were discontinued, abandoned, or replaced by others.

Taking the whole number reported, 208, and deducting those previously noted as not to be counted as municipal garbage destroying stations, 20 in all, there are remaining 188 installations built in American and Canadian towns in the past twenty-three years. Of this number more than one-half, about 108 in all, are permanently discontinued, leaving 80 still in use, including those built or under contract for the year 1908.

In some cases these have been replaced by other furnaces that are still operating; in several instances they were retired in favor of reduction processes, and in a very few waste disposal by cremation has been abandoned and the town has reverted to its former methods of tipping or else feeding to swine. The reasons for these repeated failures in this department of municipal work need not be discussed here, but will be reviewed later.

Explanatory Notes.—These must be very brief in so condensed a table as the following, and but little in this line has been recorded. The division and classification of the various types and constructions will also be attempted later.

This record, made up from statistics gathered in years past, is necessarily incomplete in some details, but it shows in a comprehensive way the work of the last twenty-three years in disposal of municipal waste by methods of destruction by fire in towns on the North American continent.

Thus the list represents the achievements of some ten builders whose furnaces to the number of two, or more, have continued in service and the entrance in the past two years of five others who are just beginning construction in this line. There remains some thirty other builders whose furnaces have been permanently discontinued.

GARBAGE FURNACES INSTALLED FOR THE UNITED STATES GOVERNMENT SINCE 1885.—TABLE XLI.

The first employment of Government furnaces devoted exclusively to the disposal of offensive matter seems to have been in the garrisons of the British Army. An American physician, Dr. Kilvington, while Health Commissioner of Minneapolis, in a paper read before the American Public Health Association at Milwaukee in 1888, described a garbage furnace seen by him at Gibraltar in 1865, devoted exclusively to the destruction of waste matters. This was the simplest form of a brick oven floored with fire-bars, having an ash pit beneath, and connected to a short brick chimney, the refuse being charged through the doors in front. This was perhaps the first instance of the "hand-shovel-fed" destructor of the British type, which has since followed this same method of charging.

The American Army posts found the same need of sanitary disposal of waste matters, and in 1885 the first American garbage furnace was built at Governor's Island, New York Harbor, by Lieutenant H. J. Reilly, as described and illustrated in the preceding chapter.

TABLE XLI.—LIST OF GARBAGE CREMATORIES INSTALLED FOR THE U. S. GOVERNMENT SINCE 1885.

No.	Year	No.	Builders	Location	Capacity, Tons	Cost	House or Building Incl'ded	Remarks
1	1885	1	Lt. H. J. Reilly, U. S. A.	Governor's Island, N. Y. Harbor.	.....	$300	No.	Discontinued 1904.
2	1891	1	Engle, San. & Crematory Co.	McPherson Barracks, Atlanta, Ga.	5	3,000	Yes.	Operating 1907.
3	1895	1	Engle, San. & Crematory Co.	U. S. Navy Yard, Brooklyn.	10	4,500	Yes.	Discont'd 1905.
4	1898	1	Dixon Crematory Co.	Santiago de Cuba	3	2,400	No.	Discontinued.
5	1899	1	Dixon Crematory Co.	U. S. Mil. Acad'y, W. Point, N. Y.	5	1,390	No.	Operating 1907.
6	1900	1	Dixon Crematory Co.	Ft. Warren, Boston Harbor.	5	1,200	No.	Operating 1907.
7	1901	1	Dixon Crematory Co.	Ft. Russell, Cheyenne, Wyo.	5	1,590	No.	Discontinued.
8	1901	1	Dixon Crematory Co.	U. S. Navy Yard, Portsmouth, Va.	8	4,344	Yes.	Operating 1907.
9	1902	1	Morse and Boulger Co.	U. S. Navy Yard, League Island, Philadelphia.	10	7,723	Yes.	Operating 1907.
10	1902	1	Dixon Crematory Co.	U. S. Hospital, Hot Springs, Ark.	5	1,869	No.	Operating 1907.
11	1902	1	Municipal Eng. Co.	Ft. Brady, Mich.	5	3,000	Yes.	Operating.
12	1902	1	Dixon Crematory Co.	U. S. Army Post, San Juan, Porto Rico.	5	3,985	No.	Operating 1907.
13	1902	1	Morse & Boulger Co.	U. S. Emigrant Station, N. Y.	10	5,280	Yes.	Operating 1907.
14	1902	1	Municipal Eng. Co.	Ft. Riley, Kansas.	5	....	Yes.	Operating 1907.
15	1902	1	Municipal Eng. Co.	Ft. Leavenworth, Kansas.	10	....	....	Operating 1907.
16	1902	1	Dixon Crematory Co.	Presidio, San Francisco, Cal.	5	....	No.	Operating 1907.
17	1903	1	Morse-Boulger Co.	U. S. Naval Station, San Juan, Porto Rico.	3	700	No.	Not including erection.
18	1903	1	Morse-Boulger Co.	Culebra, Panama Canal Zone.	5	1,050	No.	Not including erection.
19	1903	1	Municipal Eng. Co.	Fort Getty, S. C.	8	2,975	Yes.	Operating 1907.
20	1903	1	Municipal Eng. Co.	Fort Myer, Arlington, Va.	.....	....	....	Discontinued.
21	1903	1	Municipal Eng. Co.	Ft. Slocum, N. Y. Harbor.	.....	....	Yes.	Operating 1907.
22	1904	1	Municipal Eng. Co.	Governor's Island, N. Y. Harbor.	.....	....	Yes.	Operating 1907.
23	1904	1	Morse-Boulger Co.	Fort Banks, Boston Harbor.	5	2,740	Yes.	Operating 1907.
24	1904	1	Morse-Boulger Co.	Ft. Russell, Cheyenne, Wyo.	12	8,200	Yes.	Discontinued.
25	1904	1	Lewis & Kitchen	Ft. Sam Houston, S. Antonio, Texas	10	4,925	Yes.	Operating 1907.
26	1904	1	Sanitary Eng. Co.	Ft. McKinley, Portland, Me.	5	4,000	Yes.	Operating 1907.
27	1905	1	Lewis & Kitchen	Obispo, Panama Canal Zone.	5	1,791	No.	Operating 1907.
28	1905	1	Morse-Boulger Co.	U. S. Navy Yard, Brooklyn.	10	3,000	Yes.	Operating 1907.
29	1905	1	Sanitary Eng. Co.	Ft. Barrancas, Pensacola, Fla.	8	4,220	Yes.	Operating 1907.
30	1905	1	Morse-Boulger Co.	Ft. Logan, Colorado.	5	....	Yes.	Operating 1907.
31	1906	1	Lewis & Kitchen	Ft. Ontario, Oswego, N. Y.	6	3,586	Yes.	Operating.
32	1906	1	Dixon Crematory Co.	Ft. Des Moines, Ia.	30	4,500	No.	Operating.
33	1906	1	Lewis & Kitchen	Ft. Dupont, Delaware City	6	3,300	Yes.	Operating.
34	1907	1	Lewis & Kitchen	Pensacola, Fla.	6	....	Yes.	Operating.
35	1907	1	Morse-Boulger Co.	Fort Myer, Va.	25	....	Yes.	Operating.
36	1907	1	Lewis & Kitchen	Ft. Russell, Col.	25	....	Yes.	Operating.
37	1908	1	Lewis & Kitchen	Naval Training School, Newport, R. I.	8	....	Yes.	Operating.
38	1908	1	Lewis & Kitchen	Ft. Hancock, N. Y.	6	4,400	Yes.	Operating.
39	1908	1	Universal Destructor Co.	Ft. Lyon, Col.	5	....	Yes.	Operating.
40	1908	1	Morse-Boulger Co.	Ft. Andrews, Boston Harbor	16	3,950	Yes.	Under construction.

This furnace, known as the "Government Garbage Crematory," was installed at many stations of the Army, but has now been abandoned at nearly all, the surviving examples being at Ft. Sheridan, near Chicago, Forts Wadsworth and Totten, New York Harbor, and at one or two of the smaller Army Depots.

The first departure from the Government type was made by Col. W. Jacobs, then A. A. Q. M., U. S. A., at McPherson Barracks, Atlanta, Ga., who caused to be built in 1892 an Engle garbage cremator of a special design, under the superintendence of the author. In this cremator (which was the distinctive term given to all the early Engle constructions), a radical change in form of construction from the original Engle patents was made, which was afterwards secured by new patents and became the regular type of Engle furnace. This first Government cremator at Atlanta is still in use, and in the sixteen years of its service has required less than $50 for repairs.

First Furnace for Navy Yards.—The first cremator for our naval service was also an Engle, built at the Brooklyn Yard in 1895 from the designs of the author. It was removed in 1904, as the site was included in the new dry dock location, and was replaced in 1905 by a Morse-Boulger destructor.

These furnaces were followed by others at the various army posts and naval stations, and are becoming a recognized part of the equipment for the disposal of waste at all the Government reservations, including the military camps and the equipment depots of the Panama Canal Zone.

Construction and Capacity of the Furnaces.—Up to 1902 the design of the house and furnace and the capacity was left to the judgment of the builders who submitted proposals, but at League Island (Phila., 1902), the Government specifications first defined the required combustion per square foot of grate, and the specified quantity of fuel to be burned per ton of garbage destroyed. The present specifications are usually for the destruction of eight to twelve tons of garbage, containing the average quantity of moisture (65 to 72 per cent.) in a period of from six to ten hours, with the consumption of a guaranteed amount of coal per ton of waste consumed. This is practically one-half the actual capacity of the furnace, the maximum being reached only when the stations are crowded with the ships of a great squadron, at the army posts contain a large number of troops for a limited period.

Since the contracts usually go to the lowest bidders, the house construction at many of the army posts is of the cheapest character, not in harmony with the other permanent buildings of the post. The disposal stations at the Navy Yards of brick construction are more sightly and better suited to the purpose required.

The contract prices vary widely, being controlled by the difficulties of foundation, the local cost of material, the accessibility of the station, and consequent cost of freight and labor. As a rule the contract includes the covering houses and approaches, with furnace and chimney and all apparatus for operating.

After erection there have been thorough tests or trials of the furnaces, and when accepted they have been operated under oversight of engineers in charge of government work, or of those in control of the machine equipment of the institutions.

Government furnaces cover a limited period, only from 1900 to date. Once established, however, their use has been almost without failure, removals being for reasons other than those of furnace construction or performance. But it must be held in mind that these government disposal plants are not called upon to do their work for long daily periods under exacting conditions; and also that they have a reserve capacity of one-half of their maximum rating, all of which tends to preserve the construction. As government officers do not report quantities destroyed or the cost of fuel, labor, or repairs, there is no basis for comparison between the several types of furnaces at any point except the cost of the installation.

THE FURNACES FOR INSTITUTIONS AND BUSINESS ESTABLISHMENTS.—TABLE XLII.

The need for a sanitary and convenient way for disposal of waste matters has always been recognized by those in charge of institutions devoted to the prevention and mitigation of human suffering, the care of the feeble and infirm, and the control of those mentally or criminally unable to care for themselves. These hospitals, asylums, sanitaria, and prisons have always presented

TABLE XLII.—LIST OF GARBAGE FURNACES AT PUBLIC AND PRIVATE INSTITUTIONS, ETC., SINCE 1885.

Year	Builders	Hospitals and Sanatoria	Public Institutions, Colleges, Medical Schools, Laboratories, etc.	Hotels and Business Establishments
1886	Dr. J. S. Billings		Johns Hopkins University, Baltimore	
1889	Engle San. & Crematory Co.		N. Y. City Disinfecting Station	
1891	" " " "	N. Y. Hospital, N. Y.		
1891	" " " "	St. Luke's Hospital, N. Y.		
1891	" " " "	City Hospital, Wilkes-Barre, Pa.		
1891	" " " "	City Hospital, Newport, R. I.		
1892	" " " "	City Hospital, Boston		
1892	" " " "	Woman's Hospital, Philadelphia		
1894	" " " "	Kingston Ave. Hospital, Brooklyn		Apartment House, Chicago.
1894	" " " "	Consumptives' Home, Brooklyn	Hudson Co. Institution, N. J.	Canning Factory, Chicago.
1900	Morse and Boulger	Bellevue Hospital, N. Y. City	Cornell Medical College, N. Y.	Apartment House, N. Y.
1900	Dixon Crematory Co.		Blackwells Island Institution, N. Y.	
1901	Morse and Boulger	Lying-In Hospital, N. Y.	Bellevue Medical College, N. Y.	
1901	" " "		Kings Co. Institution, N. Y.	
1901	" " "	City Hospital, Boston (2)	Pathological Laboratory, Boston	
1901	" " "		Sailors' Snug Harbor, N. Y.	
1901	" " "	Pennsylvania Hospital, Phila.	Private Laboratory, N. Y.	
1901	" " "	Burb'k Hospital, Fitchburg, Mass.	Lab. U. S. Marine Hospital, Wash.	
1901	Dixon Crematory Co.			Reading R. R. Station, Phila.
1901	Morse and Boulger	Montefiore Sanatorium, N. Y.		
1902	" " "	Homeopathic Hospital, Brooklyn		
1902	" " "	City Hospital, Brookline, Mass.		
1902	" " "	Mt. Sinai Hospital, N. Y.		Macy's Dep't Store, N. Y.
1902	" " "		University of Michigan, Ann Arbor	
1903	Morse-Boulger Co.		University of Iowa, Iowa City	Hotel Astor, N. Y.
1903	" "			Penna. R. R. Station, Phila.
1903	" "			Snelenb'g Dept. St., Phila.
1903	" "	Milford Hospital, Milford, Mass.		Litt Bros. Dept. St., Phila.
1903	" "	U. S. Sanatorium, New Mexico		Hotel Bellevue-Stratford, Phila.

TABLE XLII.—LIST OF GARBAGE FURNACES AT PUBLIC AND PRIVATE INSTITUTIONS, ETC., SINCE 1885.—(Continued.)

Year	Builders	Hospitals and Sanatoria	Public Institutions, Colleges, Medical Schools, Laboratories, etc.	Hotels and Business Establishments
1903	Morse-Boulger Co.	....	....	Hotel Martinique, N. Y.
1903	" "	....	....	14th St. Dept. Store, N. Y.
1903	" "	....	....	Hotel Belmont, N. Y.
1903	" "	....	....	Hotel Sturtevant, N. Y.
1904	" "	Samaritan Hospital, Philadelphia	....	Zoological Garden, Philadelphia.
1904	" "	Episcopal Hospital, Philadelphia	....	Storage Warehouse, N. Y.
1904	" "	City Hospital, Butler, Pa.	....	Western Elec. W'h'se, N. Y.
1905	" "	Hospital City of Mexico	Lab. Rockefeller Institute, N. Y.	Siegel Dept. Store, Boston.
1905	" "	St. Francis Hospital, N. Y.	Randalls Island Institute, N. Y.	....
1905	Dixon Crematory Co.	....	....	Private Est., Canandagua, N.Y.
1906	Morse-Boulger Co.	German Hospital, N. Y.	Carnegie Library, Pittsburg	....
1906	" "	Eye and Ear Hospital, N. Y.	....	....
1906	" "	....	Jefferson Medical College, Philadelphia	Hotel Plaza, N. Y.
1906	" "	Hospital St. Johns, N. B.	....	....
1907	" "	Hospitals at Five Points in Canal Zone	Charities Dept., Randalls Island, N. Y.	Homestead Hotel, Hot Sp'gs, Va.
1907	" "	Municipal Crematorium, Wash., D.C.	....	....
1907	" "	Olongopo Hospital, Philippines	....	....
1907	" "	St. Johns Hospital, Long Island	....	....
1907	" "	Manhattan Hosp., Wards Is'd, N. Y.	....	....
1907	" "	Bellevue Training School, N. Y.	....	....
1907	" "	Seton Hospital, New York	....	....
1908	" "	St. Vincent's Hospital, Staten Island	....	....
1908	" "	Jersey City Hospital, Jersey City	....	....
1908	" "	Newport Hospital, Newport, R. I	....	....
1908	" "	St. Mary's Hospital, Hoboken	....	....
1908	" "	St. Luke's Hospital, Chicago	....	....
1908	Dixon Co.	....	State Camp, Perry, O.	....
1908	"	....	State Sanitarium, Montalto, Pa.	....
1908	Universal Des. Co.	....	....	Loeser Dept. Store, B'k'n, N. Y.

the problem of dealing with waste in a larger volume than would be produced by the same number of persons under ordinary conditions of life, and are often at a serious disadvantage as compared with the means of disposal offered by the usual municipal agencies, the use of which they are in most cases debarred from enjoying. Commonly this institutional waste is burned under the boilers and heaters, always to the detriment of the boilers and the cause of complaints from engineers and firemen, whose regular work is interfered with. Certain kinds of hospital, medical school and laboratory refuse cannot be disposed of in this way, but must be removed, often at great expense.

Again, the accumulation of a large volume of refuse, inevitable in large business establishments, becomes troublesome, and the same difficulty arises in hotels and other places where people are brought together for special reasons for short lengths of time. As a rule the towns do not provide for the removal of institutional or trade waste, and the burden is on those in charge of the buildings.

Hence the development of destruction methods for institutions and business houses by incineration in properly constructed furnaces has been far more rapid, more satisfactory and more sanitary than the development of disposal by municipal agencies.

Institutional Crematories—In Table XLII, are brought together the American installation of garbage and refuse cremating furnaces other than those for municipal and government use. They comprise a large variety of forms and methods for disposal by incineration that are not familiarly known.

First Laboratory Furnace.—In 1886 Dr. John S. Billings, the well-known sanitarian, then connected with Johns Hopkins University, of Baltimore, designed a furnace for the destruction of small dead animals, for use in connection with the work of the Pathological Laboratory at the University. This was a small fire-box built alongside the main chimney of the building in the laboratory room, having an inclined hearth or small chamber at the left side, with a door for receiving the bodies, and above, a second inclined hearth, with door, which leads to a second fire-box below the fire-bars.

The principal fire below consumes the bodies placed on the two inclined hearths, the fumes and products of combustion passing through the upper fire-box are consumed or deodorized before being discharged into the chimney.

This is believed to be the first laboratory furnace brought into use, and is still in service, but limited to the disposal of very small animals, and the debris of bacteriological investigations that must be burned.

First Municipal Institutional Furnaces.—Beginning with the Engle cremator, built by the author in 1889, at the disinfecting station, East Sixteenth street, New York City, there followed a long series of installations for the great hospitals in New York, Brooklyn, Boston, and Philadelphia, and many smaller places, built mostly by one concern.

This first furnace in New York (see table XL) is a striking instance of the value of such an apparatus in times of great emergency, as when the health of the city is menaced. During the typhus fever epidemic of some ten years ago for weeks together there were burned in this furnace many thousands of infected articles, mattresses, bedding, clothing, furniture, etc., and in the eighteen continuous years of its service several millions of infected pieces have been destroyed with rapidity and perfect sanitary protection from contagion.

Taken in connection with the steam and formaldehyde disinfection apparatus installed by the author in the adjoining building it is one of the chief agencies in the city for sanitary protection, and the largest of its kind in the world.

New York City and Brooklyn have four installations at the various groups of institutions, and three others in the largest hospitals under municipal control. Boston has four furnaces in different departments of the great City Hospital. Chicago has a large equipment at the Cook County institutions, and Jersey City a large crematory at the Hudson County institutions. Many of the larger cities and towns are still without this most necessary appliance for the efficient disposition of dangerous forms of waste. It would seem that if there is any place where such a device is useful it is certainly at the stations and hospitals where the worst forms of infectious and contagious diseases are received and treated. Instances are on record where the employees of the street cleaning service have contracted disease resulting in death from exposure to infected matter during its removal by the city carts from the public institutions.

The First Hospital Installation was that of the New York Hospital in West 17th Street, in 1891. This is a special design by the author after the Engle pattern and the first steel case garbage furnace construction built in this country.

This was followed by others at St. Luke's, Bellevue, Lying-in, Mt. Sinai, German, St. Francis hospitals, and several smaller ones. Philadelphia has furnaces at the Pennsylvania, Samaritan, Episcopal, Jefferson and several of the smaller hospitals, and other towns have followed these examples.

The need of this help to efficient sanitation is universally recognized by the officers in charge, but there is sometimes difficulty in finding convenient room in the older institutions, and often a lack of funds for construction. The latest modern hospitals usually provide space for destructor furnaces, though not all build them. There are few reports from these installations, but their usefulness is so great that once they are built they are rarely allowed to go out of commission, and there are but one or two cases of discontinuance.

Medical Schools and Laboratories.—Following the example of Johns Hopkins University, the medical colleges have found it greatly to their advantage to install small powerful furnaces for the disposal of a very refractory and objectionable form of refuse. These special constructions in one or two cases employ oil as fuel; in others, gas, natural or artificial, is used with equally good results.

All laboratories use fire for the destruction of certain substances, but for pathogenic and bacteriological work a different and larger form of destructor is found to be indispensable. These constructions are of special form, placed often on the upper floor of buildings, using any available fuel, and are compact, very powerful and serviceable.

Installations for Hotels.—The addition of a garbage furnace to the machinery equipment of a great modern hotel involves but comparatively small cost, and provides a rapid and satisfactory way to get rid of objectionable waste—the removal of which entails cost and often causes nuisance. When the usual agencies of removal are interrupted by storms or unforeseen accidents, there is always trouble, and the accumulation of two or three days becomes a serious question to deal with. The architects and engineers of the latest great hotels now provide for the installation of furnaces, and arrange for their flue connection with the smoke flue or direct with the chimneys. The great height of these chimney-stacks and strongly induced draft does away with the necessity of a forced draft at the destructor. The capacity of these furnaces, burning every form of waste matter produced, excepting only the ashes from the boiler fires, is sometimes five to eight tons daily, as large as would be built in a town of 5,000 to 8,000 people.

The heat developed is sometimes utilized in separately attached steam boilers employed in the minor service of the hotel, or may be used for heating the feed water of the main battery of steam boilers.

For apartment houses a smaller form of furnace is constructed, and this may be fitted with coils of piping for the hot water supply of the building. All these furnaces must be provided with approved apparatus for destroying the noxious gases thrown off, or there may be complaints of nuisance.

BUSINESS INSTALLATIONS.

Business men of the present day as a general rule recognize the value of by-products, and do not destroy refuse of any kind until the last salable item that can be extracted is taken out. There are many examples where the by-product to be had from apparently worthless matter when intelligently treated, brings large returns.

But, whatever may be the process, there still remains a last and ultimate form of refuse that is best disposed of by incineration, and there is probably no better illustration of the usefulness of special furnaces for destruction by fire than instances shown in table XLII.

Under the head of trade refuse is included every class of waste produced or remaining unsalable in trading or business establishments or manufacturing industries. As a rule the removal of this is not done by the town, though the town furnishes a place for its deposit, and the oversight of the means for handling it.

Within the past few years it has become evident that incineration on the premises is more convenient and economical, as the cost of a properly constructed furnace can be saved in a year or two.

First Installation.—The Macy Department Store, New York City, in 1902, was the first of this class of business establishments to destroy its waste within the building. A special form of furnace was designed by the author and placed in connection with one of the steam boilers of the building.

The waste from each floor is discharged through a chute to the receiving room, the salable parts sorted out, and the remainder, with the refuse from the restaurants and all worthless matters, is destroyed. This same design was afterward adopted at several large department stores, and at various warehouses and factories with equally good results in every case.

The waste from great railroad stations is destroyed quickly and without offense, but demands a special form of furnace suited to the mixed character of refuse.

This method can be employed with great advantage in a great variety of cases when the disposal of waste is difficult to deal with in the usual way.

In General.—Beginning in 1900 the author designed and built many furnaces for hospitals, colleges, hotels and business establishments. In most instances these were of special form of contruction intended for particular purposes, and included a wide variety of designs in their application to the disposal of every class of waste produced by these buildings. Since then a great number of furnaces of this character have been built, and they have increased so rapidly that it is impossible to furnish data in regard to them.

In addition to the styles of furnace enumerated there are a considerable number of smaller incinerators used in the Regular Army camps and in the cantonments of State Militia, when these troops are assembled for annual practice manoeuvers, and in many such places the grounds are provided with stationary crematories of differing types, suited to temporary use, and installed by the Government at moderate cost.

There are also several builders of still smaller incinerators which are used in camps and the dwellings of summer residents. These, and several other forms of small furnaces, do not properly come under the classification of institutional furnaces, and, therefore, are not included in the foregoing lists.

SUCCESSFUL PRIVATE INSTALLATIONS.

Under this title are included all forms of construction that are not limited to municipal and governmental service. Here there is a wide range covered, a remarkably successful use of every opportunity, and a gratifying absence of failure as compared with the larger and more ambitious forms.

These installations have not only been able to meet all the conditions imposed, but they have maintained and extended their usefulness and have established a reliable means for the destruction of every class of worthless matter.

This country has long been under the imputation of signal failure in methods and apparatus for the treatment of public wastes, perhaps a deserved reproach when we consider what has been done elsewhere on similar lines of public work. But this cannot be said to apply to cases of individual waste disposal in institutions, in manufacturing establishments and in private businesses.

We may be behind in the branch of municipal work, owing chiefly to causes and conditions peculiar to our country and which do not exist abroad, but we not only lead in the variety of small furnace designs and their adaptation to the special work required —we have a far larger number of them in use and they are fully as efficient and economical as any of their class built elsewhere.

It should be noted that this type of furnace construction does not follow any foreign pattern, but that it is the logical development along certain lines of the crude beginnings of twenty years ago, marking each difficult progressive step by improved apparatus and better results. Within a well-defined and limited field of work the furnaces have been uniformly successful.

REASONS FOR MUNICIPAL FAILURES.

The large percentage of failures of installations for municipal work has previously been briefly noted.

Of two hundred and eight the whole number built and here reported, one hundred and eight, or 50 per cent., have been discontinued and abandoned. On the other hand, only 4 per cent. of the total number of furnaces built for government or private use have failed of continuance. The reasons for this striking difference may be thus stated:

1. A lack of professional knowledge necessary for the accurate analysis of the character of the various kinds of waste, and in lieu of this information the estimate of quantities and qualities by guesswork, without a definite standard for reference and comparison.

2. The want of sound engineering knowledge of the principles of combustion, heat and resulting gases; mistakes in estimating the proper dimensions and proportions of the working parts of the installation, and from lack of scientific training the inability to remedy defects or correct errors.

3. Faults in design and construction arising from an apparent disinclination to profit by the experience of others, leading to a repetition of futile experiments and forms of construction tried elsewhere and abandoned.

4. An overconfident opinion that a machine or process that deals successfully with certain kinds of waste material will produce equally good results from municipal waste.

5. The unskillful management of garbage crematories by men appointed for reasons other than their fitness for the work. This is forcibly stated by an authority as follows:

"The expert garbage fireman who is considered essential to success in England is generally supplanted here by a man whose only qualification for this position may be that he can shovel coal or pull out clinker, but generally has not the remotest knowledge or even conception of the difficulties of burning on a large scale the most heterogeneous mass of all forms of solid mater to be gathered from a modern community." (Transactions of Am. Soc. Civil Engineers, Vol XXIX, p. 82.)

6. There are too few official reports that give quantities, costs and other details to show what is being done from year to year, thereby enabling the authorities to correct errors and improve the service. These reports, if truthful and complete, would soon fix the responsibility for bad apparatus and poor management, and would, moreover, be of great assistance to other communities seeking information. But the truth should be told without fear or favor, or there will be a misrepresentation of conditions and a perpetuation of errors.

THE SHARE OF MUNICIPAL RESPONSIBILITY.

The responsibility for failures is not all on the side of the designer or builder. The municipal authorities are themselves a large factor of uncertainty in the general result.

When the nuisance of incompetent waste disposal—or the want of any—becomes plainly evident, and the protests of the people are loudly insistent, the matter is referred to a committee with instructions to obtain information, examine and report. Details are asked for, and straightway a great bulk of pamphlets, plans, reports, schemes and suggestions from all sorts of interested parties are submitted. To deal with this mass of conflicting detail, and to reduce it to any sort of intelligent order and formulate a report, demands more technical knowledge and time than the average official can give. The town officers and employees who are competent to give assistance have their own departments of duty and are not always available, for practical help in this preliminary stage. They are, moreover, not anxious to offer advice or suggestions upon a subject with which they have had little or no experience, and certainly no technical training.

The inspection of plants operating under conditions like their own, in towns of similar size, seems to be considered a necessary part of the preliminary work as it is conducted at present. Junketing excursions to distant places must be made at some one's expense. For town officials it is part of the "perquisites of office"; to a prospective builder who pays traveling expenses, it is an investment for a purpose and sometimes returns to him with compound interest.

When the specifications are to be issued for bids the uncertainty as to just what is really needed makes it impossible to state definite terms and conditions. Usually it is left for open proposals from all interested parties, frequently ending with the rejection of all, and the process is repeated until a choice is at last made.

The methods that sometimes determine this final selection do not always procure the best results for the town. One writer has expressed himself clearly on these questions: *

It should in justice to the builders of municipal plants be added that the fault of most failures lies at the door of the municipal authorities, on one or another of the following scores: Acceptance of an untried installation designed by some local party without substantial experience or attainment in this line of work. Contracting in good faith for an unsuitable installation, because of ignorance by the purchaser of what the conditions to be met really are. Determination by the municipal authorities to award work to contractors who will pay the largest sum to those who have the power to determine who shall secure the contract.

Unfortunately, in spite of the recent outcry against graft, the affairs of

* "Garbage Crematories in America." W. M. Venable, N. Y., 1906. Jno. Wiley & Sons.

most American cities and towns are controlled by persons who either demand contributions from public contractors for themselves or permit their subordinates to demand them in order to retain the services of those subordinates. So many and so various and subtle are the methods by which political prostitutes may cheat the people of money that few contractors and few engineers are able to withstand the pressure brought to bear upon them, if they seek to serve a public where the grafters are in control, or even in the minority, on the city council or other public body in control of the municipal administration.

This is a plain statement of facts which, though often difficult to prove, can still be well substantiated in many cases. There is probably no department of municipal service in which greater opportunities are afforded for doubtful and crooked work, and certainly none where it is so persistently and openly practised. It is not an attractive nor always an agreeable branch of work, but yet it is one that deserves more rigid attention and more honest treatment than is commonly given it.

SHARE OF RESPONSIBILITY OF THE ADVISORY BOARDS.

Not all the blame for mismanagement and incompetency in disposal work should attach to the financial and executive departments. The advisory boards of health, whose province should be strictly limited to investigation, report and advice on matters that concern public hygiene, are frequently placed in positions that require them to select and install apparatus with which they are either unacquainted or in the purchase of which they may be personally interested.

While the physician is recognized as the authority upon questions that concern the prevention, discovery and treatment of disease, whether of the individual or of the community, there is a distinction to be made between that which relates to the professional and medical side of the subject and that which applies to the mechanical and physical side.

Undoubtedly the whole general question can be dealt with by the medical fraternity, but in a municipal administration there should be separation of the advisory and executive branches of the Health Department, as each phase of the subject requires technical education and special training in order to achieve the best results.

WHAT IS HYGIENE AND WHAT SANITATION.

Hygiene in its widest sense is "the science that treats of the preservation of health," and this term includes sanitation as the means of specific, well-defined method of health preservation.

The difference has been well defined by an eminent authority, whose services in both branches are well known: *

> The sphere of hygiene is naturally separable into two distinct hemispheres, one dealing directly and chiefly with individuals or masses of individuals, the other directly and chiefly with their environments. . . . In spite of its admitted importance, hygiene occupies only a very small place in our medical schools, partly, I believe, because *sanitation* has become so large a part of hygiene, and sanitation belongs in schools of engineering. . . . It is to-day absurd for the average well-trained medical student to think of becoming an expert in such branches of hygiene as water supply, sewerage, heating and ventilation, street building, cleaning and watering, garbage collection and disposal, gas and other forms of light, ice supply, milk supply, the abatement of nuisances, etc. Those belong rather to the sanitary engineer, sanitary chemist and sanitary biologist; to sanitation rather than hygiene. . . . As for research, it is idle to expect the ordinary medical man to spend much time upon or to be greatly interested in the detailed problems of water or sewerage purification, even if he has—as he generally has not—the requisite training.

AN ENGINEERING PROBLEM.

Briefly, then, sanitation as concerned with waste disposal is an engineering problem, and the difficulties encountered can best be overcome when competent engineers are employed for the special purpose.

As compared with the usual way of conducting this work, the engineer has many advantages that can be hardly overestimated. An examination made by a competent man, trained in this special line of municipal work, would proceed on this line:

The review of the municipal records—if there were any—of the past, to know what has been done, and the preparation of a clear and concise tabulation of this as a basis for future work, is only the beginning. Then comes a careful study of reports, papers and writings on this subject that may bear upon this particular case. It must be remembered there is but little reliable literature on this subject, foreign experience does not always agree with our local conditions, and a good deal of ground must be covered with relatively poor returns.

*Prof. W. T. Sedgwick, "Contributions from Sanitary Research Laboratory," Vol. III. Mass. Institute of Technology.

Later the investigation of the various methods available is taken up, and here the technical training in fundamental principles that underlie the many schemes, plans, processes and sytems is absolutely essential. He must be able to distinguish between the true and the false, and to be proof against the plausible arguments, misrepresentations and appeals brought to bear through personal, political and financial pressure. When all this is finally threshed out, and a well-defined plan or policy fixed upon, the report is drawn up and the specifications prepared, which eliminate the weak, crude, impracticable and vicious elements and state clearly what the town desires to obtain and what conditions the tenders must conform to; and this final report, with the diagrams and plans, is submitted for action.

The responsibility is thereafter upon the town authorities. They have before them a clear and accurate report, that covers every phase of the question they must decide upon, and which is unbiased and unpartisan, and presumed to be unconnected with any local clique or party, and not in the interest of any particular builder, machine, apparatus or process. The actual expense connected with this work is usually less than would be incurred by the present method of united or separate personal investigation by the members of a committee of the Council or Board of Health.

THE INTEREST OF BOARDS OF TRADE.

This means of arriving at the facts is often undertaken by the Boards of Trade, the Citizens' Business League, or other local associations that act independent of the local authorities, and submit the results of their efforts in the form of recommendations or resolutions for consideration of the City Council.

The Woman's Societies and Improvement Leagues often take a prominent part in these movements for better conditions of cleanliness, health and civic improvements, and especially in the control and abatement of nuisances, too often overlooked and ignored by the town officers.

The effect of this concerted action of these representative bodies of leading citizens, whose purpose is the good of the town generally and not the up-building of a political machine, or the promotion of private interests, is always for the betterment of the civic welfare. When their remonstrances, protests and petitions are presented in a clear, forcible and intelligent manner, they sometimes carry greater weight and are productive of greater benefit than the half-hearted, hesitating and spineless official measures of the town authorities.

Public sentiment is the power behind the throne, and when this is fairly interested in behalf of a movement there are apt to be surprising results.

Reasons for Slow Progress.

Since the preparation of data for this book was begun the author has received many letters relating to the points touched upon. One of these points is that of the reason for the lack of progress in disposal work in this country during the past twenty years. Among those who have expressed themselves most forcibly is Mr. F. K. Rhines, until recently Secretary and Engineer of the Dixon Engineering and Construction Co., who has for many years studied the matter from a practical standpoint, and who has had wide experience in dealing with the various phases that are presented. His statement may be read with the respect due an honest expression of experience and a desire to contribute to the solution of the problem. His statement is as follows:

Without considering at present those municipal governments (by no means as uncommon as they should be) which are controlled by political bosses, individual or corporate, and ignoring for the moment that element of public life, let us be thankful for the case of the honest, intelligent public official who earnestly desires to serve the people who elected him. His case is of interest, for in it only is found any present promise of fulfillment of the real function of the officeholder—the service of the people.

Honest and intelligent the man may be, but how often are these admirable, but insufficient, attributes combined with the complementary qualification of competency? The practice has so established itself through long custom that, although we usually put a C. E. in the City Engineer's chair, and demand a Health Officer who can show a doctor's degree, men are set up as law-makers for their city without question as to their qualifications, provided only that they can show the required number of votes.

But honesty and intelligence are quoted too high in public life to be lightly discarded. Let us be thankful for these, and content—for a beginning. That we are still only at the beginning of many things municipal which will be considered as elementary necessities half a century hence, is no great wonder when it is remembered that so comparatively short a time has elapsed since the beginning of everything in this country that we have been obliged to face our manifold problems of civic life in the order of their insistence.

There are scores of cities whose Mayors went swimming as boys where the City Hall or Post Office now stands, which have had their whole civic growth compressed into a quarter of a century, and surely they may plead the excuse of a "busy day" if they have neglected some of the more modern arts and principles of municipal well-being. But there are plenty of others that were well-groomed cities before their present Mayors were born, which still have made no pretence of establishing even a system of public refuse collection, to say nothing of disposal, and which, apparently, have not even commenced to awaken to a sense of civic responsibility in the matter.

So, when many of our cities and towns have not yet recognized the fact that there is any "garbage disposal problem," and the rank and file of the city fathers are still far from being specialists in such familiar matters as street paving, lighting, water works and sewerage, is it not more cause for regret than wonderment if they are all at sea when it comes to handling those newer departments of municipal endeavor which are still unknown, unheard of, to so many?

But ignorance is merely an explanation—not an excuse! And it is becoming more inexcusable every day. If by mistakes we learn and by failures we advance, then the past twenty years of American experience in garbage disposal cannot be without value; yet it would almost seem to be so, as far as concerns the usual way of getting at the facts.

It is a distinctly American trait to yearn for first-hand experience. As cities we are not willing to take anybody's word for anything. But in the case in question, is it not generally true that the desire to be "shown" arises from ignorance of the fact that there is any one whose opinion is of value,—for whose expert advice money spent is not merely spent, but well invested?

The most superficial survey of the experience of almost any dozen cities in this country cannot but convince one of the haphazard nature of the efforts put forth in this direction. When bids are invited for the construction of a garbage disposal plant, not one city in a hundred can give prospective bidders any intelligent idea of the amount, character or composition of the waste matter to be dealt with. Frequently it has not been even decided whether the reduction or incineration method will be employed, where the plant will be located, what classes of waste will be handled, whether it is desirable to attempt power production, or what disposition is to be made of the residue. Yet these are all data to which the bidder is entitled,—which he must have in order to design and build a plant suited to the city's individual needs, and in order to be at all certain of accomplishing the results sought after. Without this information, which the city receiving proposals is rarely able to give, and which the bidder is still more rarely able to secure for himself, the installation of any system must be made more or less at random, and results are bound to be in the same degree problematical.

Yet instead of securing the services of some competent consulting engineer who has made a special study of refuse disposal, the average city, when it finally does step out and determine to do something toward cleaning up and becoming a pleasanter, decenter place to live in, goes about the matter as if it were exploring unknown wilds. Little heed is given to the mistakes and failures, or even the successes, of other cities—too little, at any rate, to learn why failure or success resulted. Some energetic Health Officer conceives the idea of inaugurating better methods of garbage disposal, and brings the matter to the attention of the City Council. At best an inevstigation and report are asked of the City Engineer; or perhaps it is referred back to the Health Officer, whose hands are already more than full, if all his duties are properly attended to. even if he were competent to furnish the expert knowledge needed—but more often the whole question is turned over to a committee of Council-men who are still less qualified to solve the technical difficulties of the problem.

Incompetent builders certainly share with incompetent officials the blame for much that is wrong and unsatisfactory in existing conditions,—but the former are the direct result of the latter. When competent engineers make the necessary preliminary investigations, draw the plans, compile the specifications and supervise the construction, none but competent builders can do the work.

On the fingers of one hand can be counted the American cities which have confronted this question in a really intelligent way. In many others tolerably satisfactory results have been attained, but chance has always had a hand in the game and it merely happened that good luck, not bad luck, held the trumps.

It is interesting to note that at the present time some of our most important cities are commissioning Consulting Engineers to make reports and recommendations in reference to refuse disposal, but this is an innovation, whereas it ought to be the ordinary, everyday, matter-of-course procedure.

CHAPTER VII.

THE AMERICAN GARBAGE CREMATORIES.

Need for a Better Classification of Garbage Furnaces.

There is evident need of a better classification of the terms at present used for the description of the several classes of American garbage furnaces. Since there is no distinction made in the words cremator, crematory, garbage furnace, incinerator, or destructor, when used in connection with phrases defining cremation of waste or refuse, there is a confusion and uncertainty as to what kind or class of furnace is intended to be meant, when these terms are used.

The titles *garbage furnace* and *night soil furnace* were used by Rider and Mann in the two first installations. The word *cremator* was adopted by the Engle Sanitary and Cremation Company and described all their municipal furnaces. They applied the term *fire-closet* to the small installations for domestic and schoolhouse purposes.

Crematory was the term employed by the Dixon Sanitary Crematory Company and until lately it was a part of their official title.

When the Montreal installation was made by Mr. Charles Thackeray, he used the "Thackeray patent incineration and cremation systems" and called his refuse furnace an *incinerator.* This was a misnomer, as the furnace, copied from the "Fryer," was properly a destructor.

The Davis Company called their furnace a *garbage furnace,* and their apparatus for burning bodies a *cremation furnace.*

Mr. I. Smead, of Toledo, in building closets for the disposal of night soil in school buildings, called them *dry closets,* but his large furnace for municipal work was a *garbage crematory.*

Col. Waring, when building his furnace for dry refuse at East Sixteenth street, New York, called it an *incinerator,* and this title has been followed by Mr. H. De B. Parsons, who calls his two New York installations for dry refuse *rubbish incinerators.*

The author, when installing the Boston plant for dry refuse, chose the term *destructor,* mainly for the purpose of a distinctive name not previously used in this country. This was continued in the title of the Morse-Boulger Destructor Company. This is a furnace that burns garbage and refuse, not ashes, and the word destructor has not the broad application as employed in British practice.

One American author* writing on this subject has made a classification which does not appear to give much help. He divides the crematories into five groups:

Those where the garbage is burned by direct heat without previous drying.
Where it is partially dried before burning.
Where it is burned on a hearth or grate by fires from other grates.
Where it is extensively dried, then stoked to another grate to be burned.
Where gases from one grate or cell are passed through others to dry the garbage thereon.

He further proposes a sub-division of these groups with respect to the garbage grates:

Solid grates of iron.
Grates of fire clay.
Grates of hollow iron cooled by water.
Grates of hollow cast iron cooled by air.

This classification is not exact in terms, altogether too confusing and unwieldly for reference, and conveys but little idea of the constructions of our crematories. His list of patents cited illustrates the difficulties of these divisions, as many furnaces are built under two or more of these groups, and some are altogether outside this list.

The classification of this apparatus by the U. S. Patent Office was at first made under the title "furnace for cremating garbage." Afterwards "garbage crematory" was used, and infrequently "furnace for incineration of garbage or night soil." The present custom is to include everything under the title "furnace," with a sub-division, "garbage furnaces" or "crematories," and "incinerators" for the destruction of other substances.

The popular use of all the foregoing terms is combined in the

*Garbage Crematories in America. Capt. W. M. Venable. Jno. Wiley & Son, N. Y.

term "garbage crematory," but this does not appear to be sufficiently distinctive for the three separate types or forms now employed, since it is applied to furnaces quite unlike in construction and for different uses.

Since the purposes, the construction, and the limitations of the various apparatus are now much better defined than formerly, and since there is a need for a better distinctive classification, it seems only wise to separate them by using such terms as will distinctively indicate the particular uses for which they are built.

PROPOSED CLASSFICATION.

Thus, a *crematory* would mean a furnace for burning garbage and refuse mixed or not separated, but not ashes; an *incinerator* would mean a furnace for refuse or rubbish only, and a *destructor* would imply the destruction of all classes of waste together in an unsorted condition, following the British term and practice. If this nomenclature were adopted, it would simplify and make the whole subject clearer to those whose knowledge is, as yet, somewhat limited.

There would undoubtedly be opposition from some builders who now use and claim one or another of these terms as their own title and property, but no valid objection can be made on this score, as each builder now constructs furnaces of different plans, for quite different uses, under the same patents, and may, with advantage to themselves as well as to the public, adopt a distinctive title for each, prefixing their own or the company's name to the furnace.

OPERATING CREMATORIES.

In attempting to describe the cremating furnaces now mostly in use the writer has found it difficult to get accurate descriptions, except from the patent drawings, and as each builder departs somewhat from his original plans according to local conditions, these drawings do not precisely represent the furnaces.

The intention is to give such descriptions—not in technical terms—and illustrations as will enable the reader who may be interested in the subject, to understand something of the construction and operation of the various forms.

As far as possible the builder's own terms and description are followed, and there is added some slight sketches of those who have longest been identified with this work.

INVENTIONS OF MR. ANDREW ENGLE.

This inventor was one of the first whose devices for sanitary work came prominently before the public. As early as 1884 he took out a patent for an apparatus that "conveyed solid and fluid matter through tubes to a retort in a furnace, subjected this to heat, and conveyed the volatile matter into a superheater, converting it into inflammable gas, at the same time converting the solids remaining in the retort into charcoal."

This and another invention were purchased by a company formed for the purpose, and were extensively exploited. Subsequently, Messrs. Engle and Thompson secured a new patent (508,511, 1893) and under the title of the Engle Crematory Company, built furnaces at Vancouver, Portland, O., and Topeka, and Mr. Thompson built one at Wichita, Kan. None of these are now operating. Mr. Engle's latest invention is "Engle's Fuel and Fertilizer," "a combination of garbage, night soil and manure with a material that renders it valuable for the purposes of fuel or fertilizer. The product may be made in bricks with a press and stored for use, or it may be used while green for making fires in kilns, steam plants, or crematories. The fertilizer is equal to bone meal."

The inventor further says: "I seek to devise means by which the wastes may be kept from the streams at a financial compensation to the town so doing. While I recognize I cannot hope to do it all, I feel ambitious to give to the world results that will save life and aid the world in better health and consequently greater happiness."

Mr. Engle has for more than twenty-five years been identified with sanitary work in many lines, and is a student and analyst of very considerable attainments. The Engle fire closet and Engle cremator have made his name known all over this country.

Engle Sanitary and Cremation Company was formed at Des Moines, Ia., early in 1886 to take over the patents of Mr. Andrew Engle.

The officers were: J. C. Savery, president; Jas. Callanan, treasurer; G. H. Warner, secretary. The Western business manager was W. C. Smith. The Eastern business was done from a New York office of which W. F. Morse was manager and Benjamin Boulger constructor. This was the first company to systematically push its business, and during the sixteen years of its work built many cremators in this country. The most successful installation was as the World's Fair, Chicago, in 1893. It was the first company to build abroad; its Panama furnace (1892) is still in active use. During the panic of 1893 the officers of the company suffered financial reverses and few constructions were made thereafter. The two last ones at Grand Rapids and Milwaukee were not under the Engle patents, though under their name.

The success of this company and the development of this idea

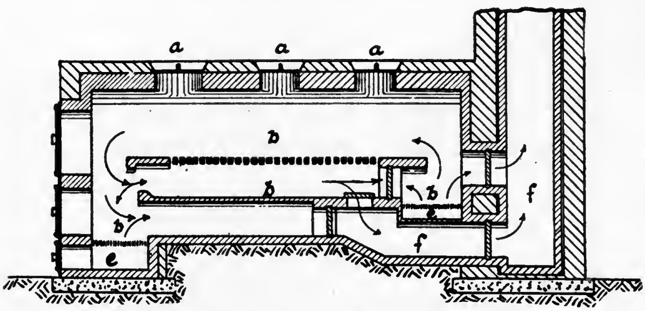

FIG. 22.—THE ORIGINAL ENGLE CREMATOR.

of destroying worthless matter by fire in this country was largely due to the unfailing financial support of Mr. James C. Savery, the president of the Engle company. He took the keenest interest in the work and was a firm believer in the benefits to be had from improved sanitary conditions brought about largely by these cremators.

Mr. Savery died in 1905 and his place in the business of the company and in the progressive spirit of this line of sanitary work has never been filled.

ENGLE CREMATOR.

The early form of the Engle cremator (Fig. 22) was a rectangular brick construction whose exterior dimensions in height and width were each about one-third of its length. There was usually a steel chimney of 75 feet and a wooden covering house with inclined wooden approaches and wide platform for wagons.

The interior was lined with fire brick and divided by a horizontal set of grates, made at first of hollow iron pipes, and below these a platform of fire-clay tiling.

The garbage was discharged direct from the carts through three circular openings to the upper or first set of grate bars, the liquid not held in suspension in the garbage passing through to the platform where it was evaporated. At the rear end of the cremator was the first or primary fire-box, separated from the chimney by a damper. The secondary fire was at the front end and below the level of the drying platform. Dampers controlled the volume of gases in such a manner that the heat from the primary fire passed over the garbage piled on the upper grates, and under these over the platform, or under the platform, as desired, or direct to the chimney as determined by the damper between them.

The theory of this furnace—which is indeed the theory of its successors and imitators—was that the gases and vapors of the combustion of the waste piled up on the grates should be compelled to pass over the secondary fire before being released to the stack. By arrangement of the dampers the second fire may become the primary fire, and the first one in turn consume the gases.

One of the openings for charging in the top was large enough to admit the carcass of a horse. The evaporating hearth received all moisture and also the ashes from the grates above; but with this exception, no attempt was made to dry out the moisture before burning. The operation was without nuisance when properly conducted, and the cremator used any available fuel, gas, coal, wood or coke. Very large quantities of night soil and saturated garbage were destroyed when required, with reasonable expense for fuel and labor.

The points of weakness in this form were the grates of iron piping, the damper of cast iron, and the tiling of the evaporating hearth, which gave way under high temperatures when saturated with moisture. A new form of stronger construction was finally adopted and became the standard.

In this furnace (Fig. 23) the same general exterior dimensions and appearance are kept, but the interior is greatly modified. There are two fires placed on horizontal lines at opposite ends of the grate, which is made of a series of railroad bars, spaced and inverted and held in this position by clips. The lower hearth is omitted, the liquids passing into the bottom compartment, being helped in evaporation by the hot ashes from the grates above. The dampers are fire-clay slabs and the interior walls of heavy blocks of fire clay. Subsequently the iron rails of the garbage grates were replaced by a specially fire-clay grate, and this by a series of flat fire-brick transverse arches which are still used.

In all furnaces of this type the garbage grates are difficult to maintain. Those of hollow pipe, even when brought through the

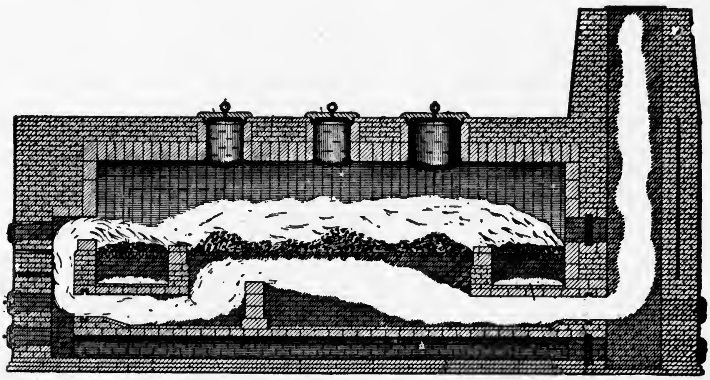

FIG 23.—THE LATER ENGLE CREMATOR.

furnace walls to the outside to obtain a circulation of cold air, speedily gave way. Afterwards these grates were connected to headers and a circulation of water kept up, but the loss of heat and incomplete combustion of garbage in contact made it necessary to discard this system. The steel railroad bars are probably the best for iron grates and give better service than any form of triangular hollow cast-iron bars, or of water grates where the heat taken up by the water is a very large item of loss.

There are still some ten or twelve of the Engle cremators operating. The largest in continuous service and the oldest installations in this line in this country are at New York, Panama, Richmond and Norfolk, Va.

The Engle Cremator was the first in garbage disposal work and the general features of its construction were followed by those who same after, with such modifications as were patentable.

THE DIXON SANITARY CREMATORY COMPANY.

This organization was formed at Findlay, O., in 1893, to take up the patents of S. W. Dixon (October, 1891, and April, 1894). After remodeling the Engle cremator at Findlay the first crematory was built at Elwood, Ind., followed by others at McKeesport, Pa., and Atlanta, Ga. In 1898 the patents and business passed into the hands of a new company at Toledo, O., with D. C. Shaw, president; G. H. Breyman, vice-president, and E. J. Little, secretary and treasurer. In the succeeding years this company secured new patents and built many crematories all over this country, including nine installations for the United States Government and several institutional plants. This was the first company to unite with local corporations for the collection and disposal of all municipal waste, as at Trenton, N. J., and Oakland, Cal.

A large share of their success was due to the energy and enterprise of Mr. E. J. Little, who was the active manager. His improvements in furnace construction and methods of collection service were of great value to his company, as also to the general work of waste disposal for municipalities. By reason of the long railroad journeys and the tremendous labor of oversight of contract and construction at widely separated points, Mr. Little died in 1905. He was succeeded by Mr. F. K. Rhines, who for some time had been his chief assistant. Mr. Rhines was the Secretary and Chief Engineer up to January, 1908, when he retired from the association. The corporation changed its title in 1907, and is now *The Dixon Engineering and Construction Company*.

THE DIXON CREMATORY.

The Dixon crematory of the earlier form (Fig. 24) is an elongated rectangular brick structure, enclosing a fire brick chamber divided by horizontal transverse garbage grates into two nearly equal compartments. There is a double fire box at the front end, from which the heat passes over and under the garbage grates, the gases uniting to pass through a flue at the rear end to a combustion chamber fitted with a fire box, and over this a series of staggered fire brick "stench bars," for deodorizing and destroying the products of combustion.

The earlier forms used cast-iron bars for garbage grates, since discarded for a more durable arch of fire-clay tile in two sections. This furnace is charged through the openings directly from the carts to the garbage grates with no attempt at preliminary drying. The passage of the flames to the chimney is uninterrupted, except by the stench bars, and this constitutes the "direct draft."

In the later forms the rectangular top is arched and rounded to form a segment of a circle, and the exterior casing is of

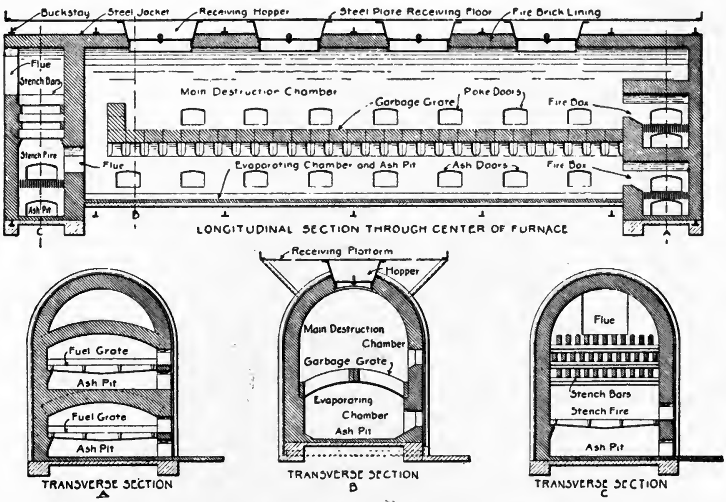

FIG. 24.—DIRECT DRAFT DIXON CREMATORY.

steel plate, braced and strengthened by angle bars. The top charging platform is of steel plate supported on standards bolted to the iron jacket of the furnace. The chimneys are usually of steel, placed on the end of the crematory above the combustion chamber.

The other form of the Dixon crematory has three important changes of the interior construction differing from the direct draft type as shown in Fig. 25.

The purpose of the inventors was "to provide means for drying the garbage, so that itself will serve as fuel for its own combustion, and for the rapid evaporation of water and other fluids, and for feeding to the furnace at such points and in such quanti-

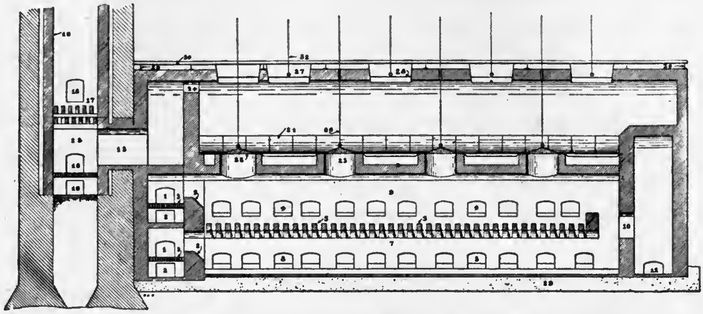

FIG. 25.—RETURN DRAFT DIXON CREMATORY.

ties as may be desired, the dried or partly-dried substances to be consumed."

The crematory is divided into three compartments, the upper

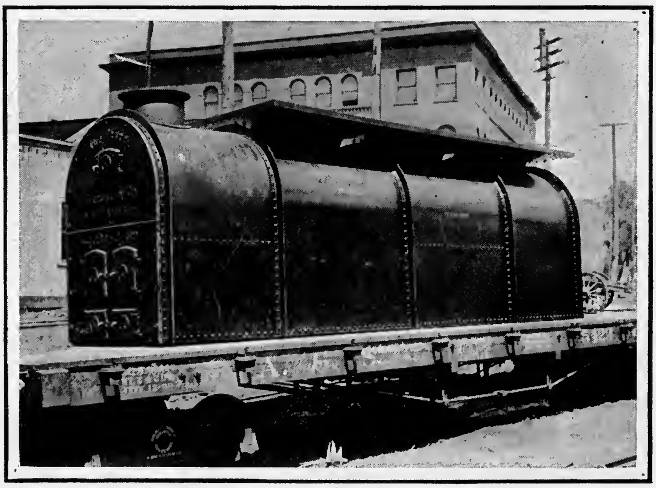

FIG. 26.—EXTERIOR OF DIXON CREMATORY, READY FOR TRANSPORTATION.

one called a drying chamber receives the charge of green garbage from above, and has a series of trap doors with covers operated by chains, through which it is passed to the destruction chamber below. When partially or completely burned, it passes to the third or lower evaporating chamber, from which the ashes are withdrawn The liquids pass to the lower compartmenr.

The fuel boxes are at the chimney or rear end, the heat passing under the floor of the destruction chamber, and through this, or above through the drying chamber, as may be desired.

The same arrangement of secondary fire and stench bars in the combustion chamber of the stack is continued, or this may be replaced by a series of horizontal fire-clay tubes, heated from below by the primary fire box, in which the gases of combustion are finally destroyed.

FIG. 27.—DIXON CREMATORY, FORT WAYNE, IND.

This combination of three chambers, for different purposes, with the necessary doors and dampers, is somewhat complicated, and needs attention to secure good results. This "return draft" furnace is used mostly for the smaller installations, and employed but three times in municipal work.

As stated by the manager of the Dixon company: "In all forms of crematories built under the 'Dixon' name, there is manifest a desire to adhere to the simplicity of principles which was the key to the success of the original invention."

The work of this company has extended all over this country, and the largest number of operating disposal plants stands to its credit. There are two Dixon crematories in South America, and a small furnace was built in Cuba during the Spanish-American war.

The company was awarded the Grand Prize for its work at

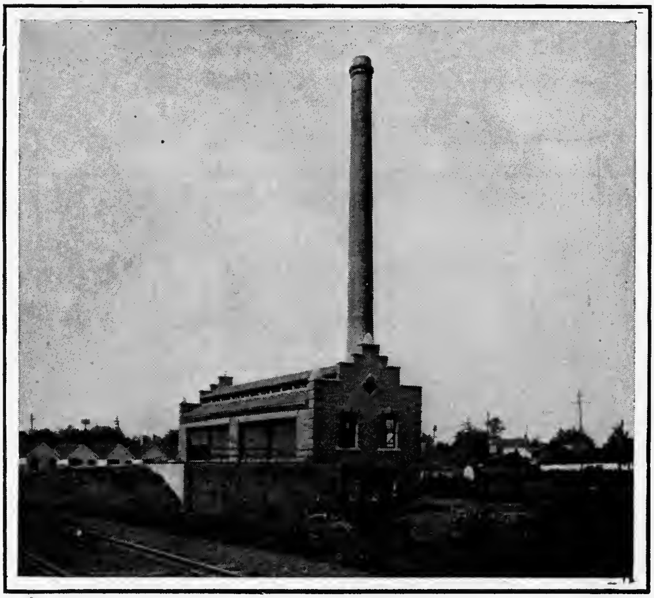

FIG. 28.—DIXON CREMATORY, LEXINGTON, KY.

the World's Fair, St. Louis, in 1904, and the Dixon crematory was installed at the Jamestown Exposition at Norfolk, in 1907.

THE DAVIS GARBAGE FURNACE COMPANY.

The Davis Garbage Furnace was the invention of Dr. M. L. Davis, Lancaster, Pa., October, 1891. The first installation was at Lancaster, 1891, followed by furnaces at Reading, Pa., and Trenton, N. J., 1899. The Reading furnace was discontinued in 1899. Others were built at Oil City and Coudersport, Pa., and for the United States Government at Havana, now discontinued. The Trenton furnace is the best known one of this company, and was reported upon by Mr. Rudolph Hering (previously noted).

The Davis furnace as described by Mr. John H. Hook, secretary of the company, is composed of three separate compartments or chambers.

The Primary fire chamber for fuel to begin the work, afterwards for the garbage dried upon the grates of the drying chamber.

The Garbage drying chamber, which is charged from above through a circular opening in the roof, and which is floored by a movable iron grate which may be raised, or inclined toward the primary fire box for dumping the dried charge when desired.

Beneath this inclined grate is an iron evaporating pan, which receives the liquids from the garbage above. The evaporated vapors pass through the grate, and, with the products of combustion of the garbage, pass through a short flue into the third division.

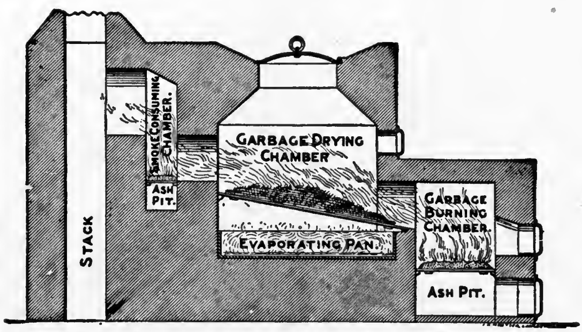

FIG. 29.—DAVIS GARBAGE FURNACE.

The Smoke consuming chamber is at a higher level, and so arranged with a fuel box and ash pit below that the smoke and gases of combustion must pass completely over this fire to reach the flue connecting with the stack.

The furnace is a large cell with a capacity of about eight tons per day, and two or more may be built in battery connected with a chimney in common.

The patentee, Dr. M. L. Davis, has made several useful inventions in the line of sanitary work, the Davis cremation furnace and the Davis Hospital for Contagious Diseases being among those best known.

THACKERAY INCINERATOR COMPANY.

The garbage and refuse furnace built at Montreal by Mr. Charles Thackeray in 1894 was the first departure from the popular form of American crematory. He took the "Fryer" destructor as his model in all the essential points, except that each cell or furnace was made independent of the others, and placed back to back to form a battery or series of cells having a common charging platform on top. (Fig. 30.)

Each cell is charged from the top, the garbage falling on a short, sharply-inclined hearth of fire-brick (f) just above the fire bars. These inclined fire grates are two sections, the upper ones stationary (a), the lower ones are rocking grates, by the motion

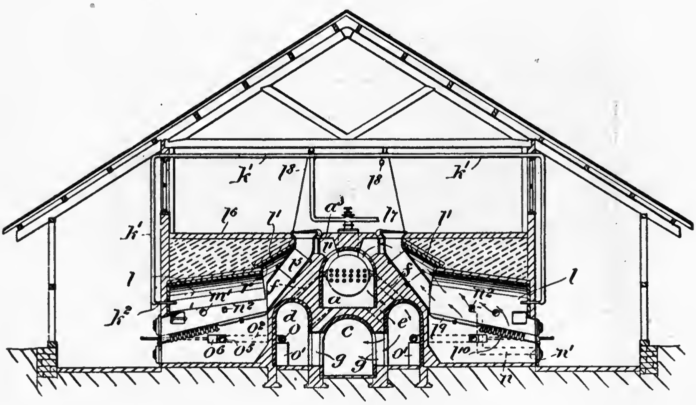

FIG. 30.—THACKERAY GARBAGE INCINERATOR.

of which the refuse is gradually moved forward and the clinkers deposited on the dead plate are removed through the doors.

The gases and products of combustion pass through side flies into passages between the cells and back and downward to the smaller longitudinal flue (e), which at the end discharge into the main central flue (c) to the chimney. There was at first a steam boiler set in this central flue, as shown in the figure, but as this obstructed the draft, and did not develop steam sufficient to furnish a forced draft or move the rocking grates, it was removed.

The furnaces are operated by natural draft, the chimney being

180 feet heigh. Additional details of cost of construction and operating expenses are reported in preceding chapters.

GARBAGE FURNACES OF W. F. MORSE AND BENJAMIN BOULGER.

Some time after the Engle Company had suspended business, W. F. Morse and Benjamin Boulger, who had been connected with this company, obtained a contract for a crematory at San Salvador, Central America. All the material needed was sent from New York, and Mr. Boulger installed the furnace in 1895-6 under the patent obtained by him in 1893.

Externally this furnace (Fig. 31) was of the usual form of American crematories, but provided with an extra number of charging holes. It was divided by a vertical bridge wall into three compartments, one long upper chamber, with garbage grates

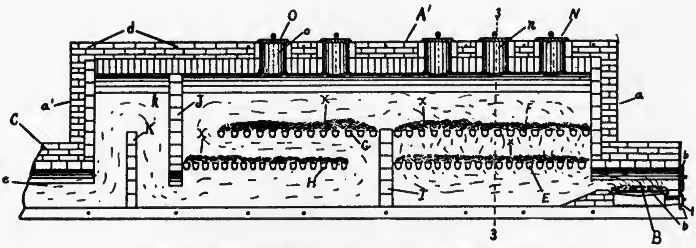

FIG. 31.—FIRST BOULGER CREMATOR, 1895.

continuous from end to end, and below this two smaller divisions with grates parallel to the upper tier, but with openings for the passage of the gases. At the chimney end the combustion chamber was divided by a vertical wall for the lower half of its height. The fire-box was at the front end, but placed outside the furnace.

The theory of this furnace was that the heat from the exterior fuel-box should pass up through the two sets of grates of the first compartment, then over the garbage on the grates of the second division, and beneath these to the combustion chamber and the chimney. A secondary fire-box was placed on the lower flue of the second division at some point before the combustion chamber.

But one installation of this form was made—at San Salvador, Central America—and this is not now in operation.

In November, 1906, Mr. Boulger took out a patent (No. 835,-

699) for new and useful improvements in garbage furnaces, the construction and operation of which are thus described by the patentee:

In feeding this destructor the drier matter is dumped preferably into the charging hole nearest the main fire-box. The wet swill is received on two tiers of fire-brick arches laid in rings spaced several inches apart, the whole forming drying and burning hearths, through which the waste and fire can readily make their way.

The iron sloping grates in the fire-box may be given an oscillating downward movement. This slowly carries the waste and garbage thereon to the lower end, where the resulting ashes and clinker may be dumped. These sloping grates have an independent ash-pit, into which hot air is forced by steam jet blowers, situated under the back end of the furnace. The air passes along through the ducts under the furnace and absorbs some of the waste heat from the bottom of same before reaching the ash-pits. Passing up through the grates and garbage of the main fire-box, this heated air assists in the drying and combustion process.

The heat and flames from the primary fire and sloping grates pass the

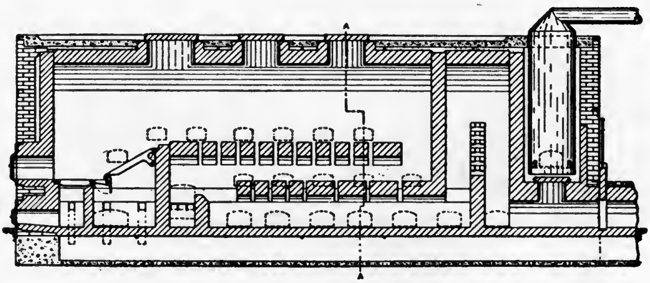

FIG. 32.—BOULGER GARBAGE CREMATORY.

length of the furnace over the garbage deposited upon the first fire-brick hearth and return underneath them and over the second tier, igniting and destroying all the material thereon, and finally turning down under the second tier. At this point the secondary fire contributes its heat to the flaming gases, which pass into the combustion chamber and expand, and in their incandescent state are drawn against and through the fire-brick checker work. The resulting carbondioxide is discharged into the chimney or carried up the by-pass to the boiler.

All ashes are removed through the lower clean-out doors. The main fire doors can be placed on the side with the other door openings to economize floor space.

When the destructor is started and attains the necessary temperature, little, if any, additional fuel is needed, as long as the garbage is supplied for consumption.

This form of furnace is employed in the smaller installations, for institutional and business purposes. For the larger sizes a small vertical steam boiler is connected with the combustion chamber and operated by the furnace heat. The power from this is employed for a forced draft, and for rotating the oscillating iron sloping grates. There is a small surplus of power available when the furnace is burning at its greatest capacity.

The only municipal installation of this furnace is at Butler, Pa.

THE MORSE-BOULGER DESTRUCTOR.

In 1898-9 Mr. Morse designed and constructed the Refuse Utilization Station at Boston, Mass., and here for the first time was built that form of furnace that afterwards came to be known as the Morse-Boulger Destructor.

In this Boston furnace the original horizontal garbage grates of the early Engle pattern were used, but the front end of the

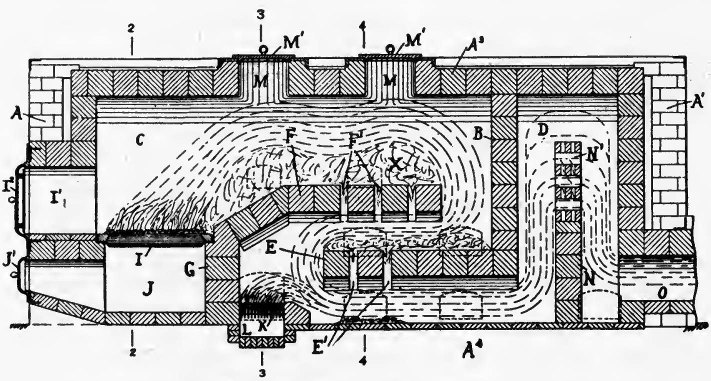

FIG. 33.—MORSE-BOULGER DESTRUCTOR.

upper tier was inclined sharply down to the fire-box. These grates were parallel arches of fire-clay brick with spaces for passage of ashes.

The secondary fire was in the lower flue, over which all products of primary combustion passed, the light particles and fine dust being detained by perforated vertical walls. There is also a 60-h.p. vertical boiler on the top of the rear end, operated by the furnace heat, but having its own fire-box. The plant has been in continuous work for ten years, and is fully described and illustrated in Chapter II.

Though this Boston furnace was for dry refuse, the forms of grates and position of fires made it well adapted for the disposal of garbage. It was improved upon, and many installations for institutions and other private purposes were made by Morse & Boulger up to 1904.

The Boston plant was duplicated with many improvements, at Buffalo, and a large destructor was built at Manila, P. I., with a steam boiler for obtaining forced draft. This was the first instance of the application of blast under ash pits in American disposal work.

In 1902 the business of Morse & Boulger was capitalized under the title of the Morse-Boulger Destructor Company, and a new patent taken out in 1904. This company held the American rights

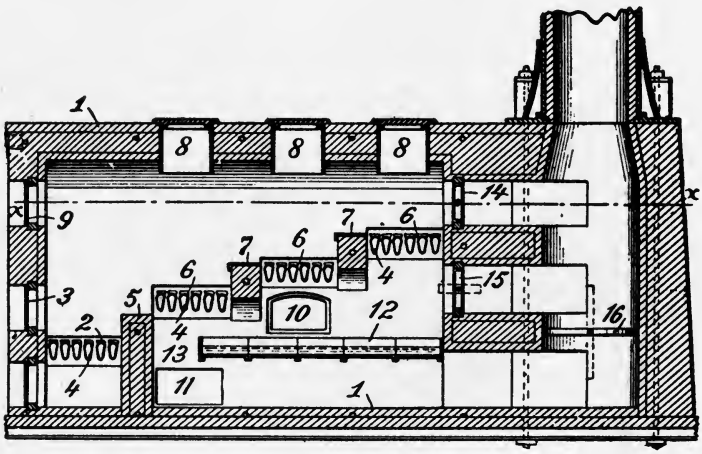

FIG. 34.—CREMATORY OF THE MUNICIPAL ENGINEERING COMPANY.

for the Meldrum Brothers' Destructors, of Manchester, England, but did no work under these patents. Mr. Morse retired in 1904, and the business has since been continued by Mr. Boulger as President, Treasurer and Manager, with a nominal Board of Directors. The control of the Meldrum Destructors was assumed by Mr. Morse.

THE MUNICIPAL ENGINEERING COMPANY.

The Municipal Engineering Company, of New York, was organized in 1901 by Messrs. F. Brown, Lyon, C. McFarland and Fred P. Smith. Shortly afterward, Col. Willard Young became a stockholder and president. The crematories erected by this company under the patents of F. P. Smith were at Long Branch, N. J. (the only municipal plant), and at Forts Leavenworth, Moultrie, Brady, Slocum, and at Governor's Island, New York Harbor. All these furnaces were of small size.

Fig. 34 is a longitudinal section of the crematory of this company. The exterior walls, as a rule, are of steel plates lined with fire-brick, the general design and dimensions corresponding to the plan of the American crematories. The primary fire-box (2) at the front is a series of hollow cast-iron bars (4), arranged to discharge the air heated by passing through these above and behind the grate. The garbage grates are also of this same construction of hollow bars. They are placed in a series of steps, ascending from the primary fire, and separated by narrow, arched bridge walls of fire-brick (7).

Below these grates is a shallow iron evaporating pan (12), which catches the drippings from the wet material on the grates above. There are dampers (14-15) behind each set of grates, which lead to the chimney, and below the evaporating pan is a passage (13) open to the chimney, but controlled by a damper (16).

There are doors for fuel boxes and for stoking the garbage from the highest grate downward to the fire-box, where it furnishes fuel for drying and burning the successive charges. By the intelligent operation of the dampers at proper intervals, the air and heat are drawn through the garbage on the grates, carrying off the fumes and gases direct to the chimney; or by closing the dampers the gases are directed downward beneath the evaporating pan through the lower passage.

All of this interior construction, except the bridge walls and lining, is of cast-iron, the special features being the hollow grate bars, through which a current of air is induced by the stack draft, preserving the bars from giving way and providing heated air for combustion. This company was the assignee of six patents of Mr. F. P. Smith for various forms of furnaces for waste materials, but no others than the one described were built.

STANDARD CONSTRUCTION CO. AND MR. W. B. WRIGHT OF CHICAGO.

In 1899 Mr. W. B. Wright erected under patent No. 575,088. 1897, an incinerator for the garbage and refuse of the group of institutions of Chicago at the "Bridewell."

This invention (Fig. 35) is known as the Wright Garbage Incinerating Furnace, and follows in its general plans the cell type of the English dectructors. It is practically two cells placed back to back, having a charging port (2) in common. The garbage falls upon a sharply inclined fire-brick hearth, having its surface serrated or notched to form shallow gutters or steps (7); the purpose being to separate the liquids, draining these off at the sides, and to break up the masses of packed garbage in their descent to the fire-box.

The grates of the fuel-box (13) are inclined from back to front and have over them an arch of fire-brick (9) deflecting the

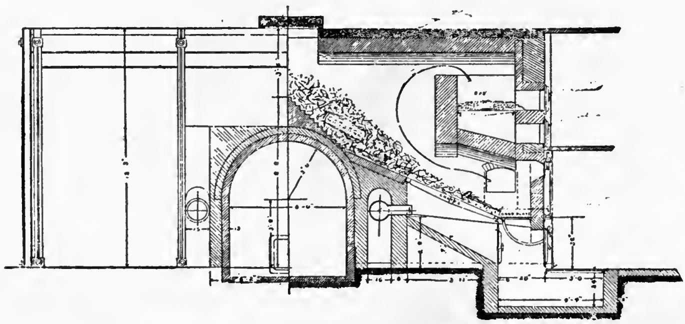

FIG. 35.—THE WRIGHT GARBAGE INCINERATORY FURNACE.

flames from the fuel-box downward to the garbage below, and also by the radiated heat above the arch assist in the combustion of the gases passing through the flue (10) downward between the walls of the furnaces and backward to the main central flue (11) leading to the chimney. There is provided a hinged iron platform or plate (17) between the fire-bars and the foot of the inclined drying hearth, for removal of ashes, and a similar arrangement at the front end of the grates, where coal is employed for fuel. This furnace may be fired by any oil or gas, through burners above the fuel box.

There is also provided a forced draft of steam or air under the fire-bars, and a special set of dumping grates for the clinkers and ashes. The construction of this incinerator is always upon the double-cell principle. Though both cells are recorded as one furnace, each may be separately operated. In the experimental furnace erected for a trial of this system a steam boiler was placed in connection with the main flue, and about seventy-five horsepower was developed and maintained. This experimental furnace was not continued. The special features of this incinerator are the serrated surface of the drying hearth, which retains the liquids and decomposes the garbage; the high temperature and consequently complete destruction of the waste, and the cell form of construction, which permits of the use of a greater or lesser number of furnaces, according to the seasonal collection of waste.

The only example of this incinerator now operating is at the "Bridewell," Chicago, in use since 1899, having a rated capacity of thirty tons per day.

The construction of the Wright garbage incinerating furnaces is in the control of the Standard Construction Company, Chicago, Ill.

NATIONAL EQUIPMENT COMPANY AND THE BRANCH INCINERATOR.

Mr. Joseph G. Branch, M.E., St. Louis, Mo., has brought out many valuable inventions in various lines of mechanical equipments and apparatus for industrial uses. He is also the patentee of the Branch garbage incinerator (patented November 21, 1905), a furnace for the disposal of garbage and refuse. This may be built in several sizes and combinations, but all follow the same type of construction.

The incinerator is of a single unit or furnace, in exterior dimensions and appearance similar to the general form of the American crematories. The furnaces are inclosed in a steel exterior casing strengthened by stays and tie rods in the usual manner. There are three charging ports on the top for garbage and one large circular opening for carcasses. The chimney is at the rear end, connected by flues with the furnaces, or placed beyond the battery of boilers if these are employed. There are two fire-boxes, one above the other, with the usual fire bars and ash pit.

The garbage charged through the ports in the top is received in a V-shaped basket formed of hollow water grates connected on the upper ends to headers, on the sides of the incinerating chamber, and tapped by threaded screw joints at the lower ends into a single large header placed in the middle line of the chamber. The headers and the water grates form a circulating water system, intended for heating feed water for the boilers when

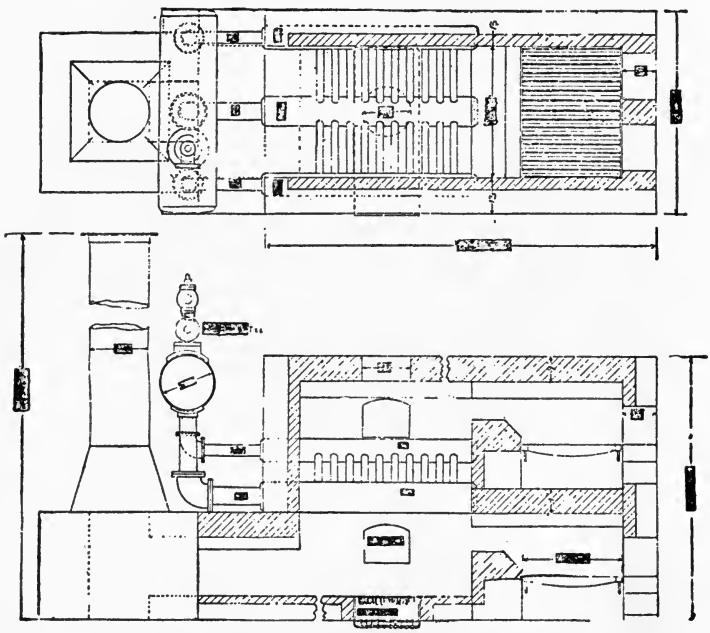

FIG. 36.—BRANCH GARBAGE INCINERATOR.

used. Below this garbage grate is an iron evaporating pan to receive the liquids. At the sides of the incinerator are two chutes of steel which receive very wet portions of waste and are connected at their lower ends with the evaporating pan, forming a part of the lower hearth. Doors are provided for firing the two fuel boxes, stoking the garbage in the central chamber and for removing ashes.

The secondary fire for destroying gases is omitted. There is an offset or break in the rear of the furnace, by means of which the unconsumed gases from the upper and cooler compartment are brought down into the hotter and larger furnace compartment below, where they are mingled and consumed before being discharged into the chimney or under the boilers, when these are used.

The advantages claimed for this incinerator are: no odors or dust, no sorting or handling of waste, no auxiliary furnace or checkerwork needed, no firebrick for garbage grates, no uneven distribution of heat in the furnace, the fewest number of threaded joints of piping exposed to the fire, no water jackets or stay bolts, a complete and positive circulation through water grates and ease of access at all times. When the units are arranged in pairs the increased length of travel given to the heated gases insure better combustion and higher temperature under the boilers.

Since the invention of this incinerator only one experimental plant has been put into operation, and no municipal plants are yet built. There are as yet no records of experimental trials, and but little is known as to the powers of the incinerator in the actual municipal disposal work.

CHAPTER VIII.

AMERICAN GARBAGE CREMATORIES—*Continued.*

American Garbage Cremator Co. and Mr. Samuel G. Brown, Boston.

Early in 1893 the City Council of Boston, Mass., appointed a committee to examine into the subject of garbage disposal with instructions to report upon the methods in use elsewhere and their adaptability for that city. This committee held meetings at which several of the representatives of reduction and cremation companies were present, and described their systems and apparatus. Afterwards the committee made an extensive tour for the inspection of these methods as employed in other cities.

For the purpose of demonstrating the efficiency of the furnace of the American Garbage Cremator Company, of Boston, Mr. S. G. Brown designed and erected an experimental plant upon the city's ground at Albany street, which was operated for some time in March and April, 1893.

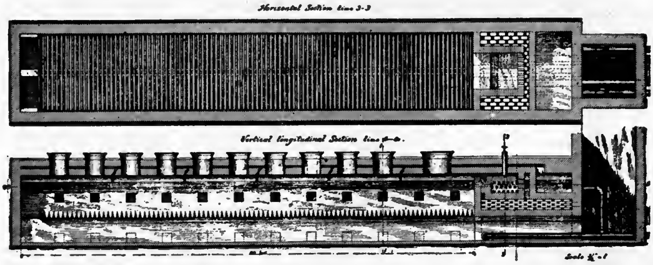

FIG. 37.—THE BROWN GARBAGE CREMATOR.

The Brown Cremator, Fig. 37, was 28½ feet long, 9 feet wide and 6½ feet high. The exterior casing, of steel plates, was bound together with buckstays and tie rods. The interior was lined with fire brick with a flat arched roof of two parallel arches of fire brick with air space. The furnace was divided by a longitudinal horizontal iron grate, the bars of which were A-shaped, hollow, triangular sections 10 inches high. The hollow spaces of these bars were filled with a refractory metallic composition, the secret of the inventor. Below this grate a longitudinal bridge wall divided the lower compartment into two equal chambers, or long flues, which connected with the chimney.

At the rear end, on the same plane with the grates, was a brick chamber that contained the oil burner for generating heat. This burner consisted of three concentric pipes, the innermost, of small dimensions, carrying steam; the second conveying the oil, and the third larger outer one containing hot gases drawn from the lower heated flues of the chimney.

The simultaneous discharge from these pipes converted the oil to gas, and, mixing this with the hot gases from the flues, formed a new combustible gas, which was assisted by transverse currents of heated air from the air spaces of the roof and sides of the furnace.

By the force of the blast, this was driven over a transverse bridge wall onto the garbage piled upon the grates, and, passing the length of the furnace, was returned through the lower flues to the chimney. The blast was maintained by a blower driven by a separate small steam boiler fired with coal.

The operation of this furnace—the first to attempt the destruction of garbage by liquid fuel—attracted attention, and was tested by the City Engineers, and temperatures were recorded by Professors Holman and Wendell of the Massachusetts Institute of Technology.

At the final trial, April 25, 1893, the following reports were tabulated by the city authorities:

TEST OF BROWN'S CREMATOR, BOSTON, APRIL 25, 1893.

Time occupied	10 hours
Garbage consumed	19½ tons
Garbage consumed per hour	1.95 tons
Area of garbage grates	60 square feet
Quantity consumed per square feet grate per hour	65 pounds
Oil consumed, 10 hours	323 gallons
Oil consumed per hour	32.3 gallons
Coal used in steam boiler	400 pounds
Labor (1 engineer, 1 stoker, 2 laborers), per hour	$1.00
Total cost per hour, labor and fuel	$2.39
Cost per ton garbage consumed	$1.22
Weight of ash residuum	1085 pounds
Weight of ash per ton garbage	55 pounds
Temperature near bridge wall, first trial	2580° Fah.
Temperature near bridge wall, second trial	2460° Fah.
Temperature outer end of furnace	1850° Fah.
Temperature opening in top of furnace	1760° Fah.
Temperature flue gases	1680° Fah.

So far as known this was the only official report of garbage disposal by liquid fuels where the temperatures were accurately recorded. The operation of the furnace was at a higher cost than similar work at the Chicago Exposition by an Engle Cremator, where the expense for labor and fuel was 63 cents per ton.

The Brown Cremator was built at Wilmington, Del. (1894), with the double exterior water-jacket casing, the first recorded instance of this form in American practice.

Because of the expense of operation, using oil as fuel, this crematory was dicontinued in 1897. The Brown cremator was built at Troy, N. Y., and Washington, D. C., but all are now discontinued. Petroleum is an ideal fuel for garbage disposal work, but too expensive for use unless at the points where the oil is procured direct from the ground.

In 1900, Mr. Brown took out patents for a cremator of nearly similar construction, using coal as fuel, but there are no records of installations in this form. The American Garbage Cremator Company did not continue the Brown furnaces after the Washington, D. C., installation.

BROWNLEE GARBAGE FURNACE.

In 1891, Mr. Alex. Brownlee, of Dallas, Tex., formerly a representative of the Engle Company, procured a patent, No. 448,115, for a garbage furnace, under which he built several furnaces in Texas. Subsequently, in 1895, he took out another patent for an improved form of this crematory, the chief installation being at West New Brighton, Saten Island, N. Y.

This furnace, Fig. 38, follows closely the form and construction of the Engle cremator, being almost exactly identical in exterior dimensions and differing slightly in interior arrangement. There is the large upper combustion chamber (B), charged through circular opening in the roof (D), the transverse longitudinal garbage grates (C), and the fireboxes (H) at each end of the grates. Below the grates is an enclosed pit (G), filled for half its depth with sand to catch and retain the liquids dripping through the garbage grate, and provided with drainage pipes.

Below this sand box is a lower flue (I), at the end of which is the passage to the chimney (I^1). The third fire for consuming the gases is at some point in this flue or outside at the chimney connection.

The grate bars (C) are hollow iron pipes, supported in their middle line by a larger pipe, the whole system of piping being connected with an exterior tank or boiler (F), which provides for a continuous water circulation through all the grates exposed to the fire.

The flames and heat from the main firebox (H^1) pass over the garbage, are reinforced at the second firebox (H^2), and pass under the grates and over the sand pit, thence through the opening (I) to the flues (I^1), and over the third firebox to the chimney. The usual doors for stoking and ash removal are provided.

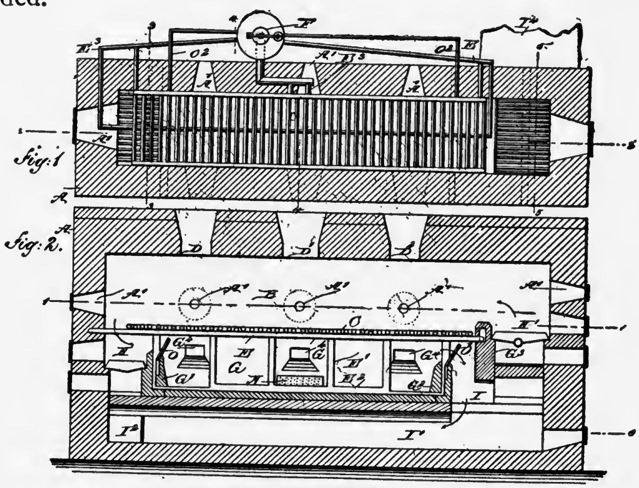

FIG. 38.—THE BROWNLEE GARBAGE FURNACE.

In practical operation of this crematory it was found hard to secure the passage of the smoke through the tortuous flues to the chimney, and still more difficult to obtain the temperature for perfect combustion because of the loss of heat taken up by the water grates. In one instance the furnace was discontinued by legal proceedings because of nuisance from the stack caused by incomplete combustion. There is now but one example of the Brownlee crematory operating, and this has been radically changed in construction from the plans and inventions of the original builders.

BRIDGEPORT BOILER WORKS, AND MR. H. B. SMITH OF BRIDGEPORT, CONN.

This invention is another example of a garbage furnace with water grates for receiving the garbage and of alternate action in passing the heat from one to the other of the chambers. The crematory was first built at Waterbury, Conn., in 1901, and has been intermittently used since then. The largest installation made by the Bridgeport Boiler Works, who were the builders under the patents of Mr. H. B. Smith, was at Newport News, Va., in 1902.

The crematory (Fig. 39) comprises two seperate chambers, connected by a flue or opening for the passage of the gases, from

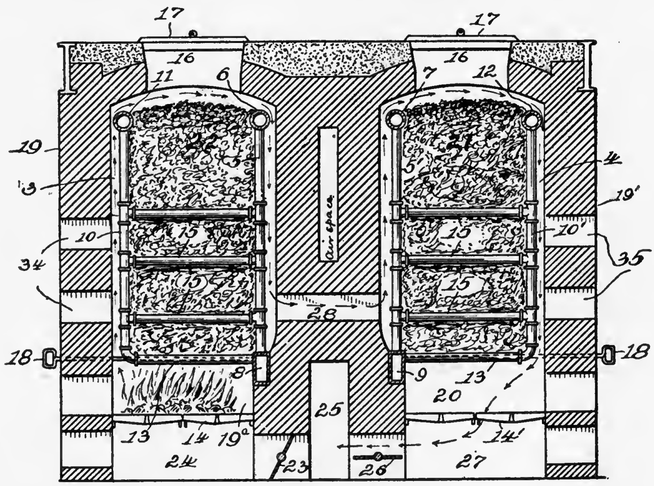

FIG. 39.—CREMATORY OF H. B. SMITH, BRIDGEPORT, CONN.

one to the other alternately. In each chamber is suspended a cage or basket made of hollow iron piping, with larger pipes at the top and bottom. This basket receives the garbage through circular opening in the roof. The cages are set away from the walls to form a passage to permit the passage of the flames around and over the cages and their charges of garbage, and their final exit through the opening (26) into the second chamber, where, after passing around and over the baskets, the gases descend through the second fire-box (20) to the lower flue (26) to the chimney. The pipes of each set of baskets are connected with headers and these with a water tank or exterior boiler, which maintains a circulation of water through the system of piping. There are provided doors (35) for stoking or stirring the garbage, and a series of iron rods (18) between the lower tier of garbage pipes, which may be drawn, permitting the dried charge of garbage to fall into the fire-box (13) and be consumed.

The theory of this furnace is the alternate firing of the chambers, the heating and drying of the charge of garbage by the iron pipes of the basket, and the combustion of the waste without the need of a secondary stench-cremating fire.

The installation at Newport News did not fulfill the conditions of the contract and was not accepted by the city. No other examples of the H. B. Smith furnace, except at Waterbury and Newport News, have been built.

Water Grates.

In addition to the furnaces already described (Decarie, Branch, Brown, Brownlee and Smith), there are some seven or eight others which include water bars as an important part of the construction. These are mostly examples of patents, only one or two having reached the stage of experimental construction.

Besides those, six or seven other inventions have been brought out for small water heaters and refuse consumers, using this prinicple of water grates. For the disposal of small amounts of dry combustible refuse this form of small furnace is used in many installations, but they are not so successful when wet masses of garbage are to be burned, since the maintenance of the temperature to destroy the garbage requires large amounts of fuel, and there is no provision for consuming the smoke and gases of combustion, threatening a discharge of noxious fumes from the chimney.

The Cragin, Dube, Long, and other refuse burners and water heaters are used in apartment houses and dwellings, and in a limited way are quite successful, but this method is distinctly confined to individual small installations for private work, and in no sense can be considered as a plant for municipal service. Several of these water heaters have the double water jacket connected with the hollow pipe grate, forming a circulatory system for the protection of the parts, but owing to the loss of heat taken up by the water their power as garbage burners is very limited.

SMITH-SIEMENS GARBAGE FURNACE AND MR. M. V. SMITH OF PITTSBURG.

One of the earliest furnaces for garbage and night-soil disposal was that invented by Mr. M. V. Smith in 1885, at Wheeling, W. Va. The history of the first furnace of this type has been briefly alluded to.

The subsequent installations of Mr. Smith were in many particulars different from the early forms, and as built at Philadelphia and Atlantic City it was one of the most interesting and, in a way, successful attempts to cremate larger amounts of garbage than had been heretofore deal with.

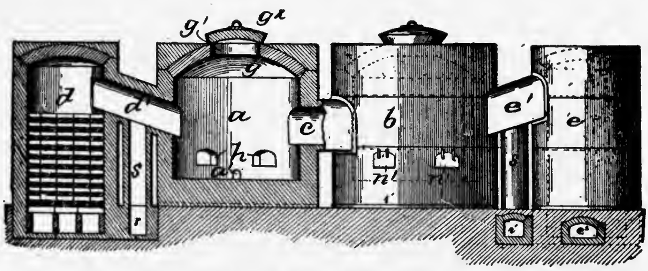

FIG. 40.—SECTION.

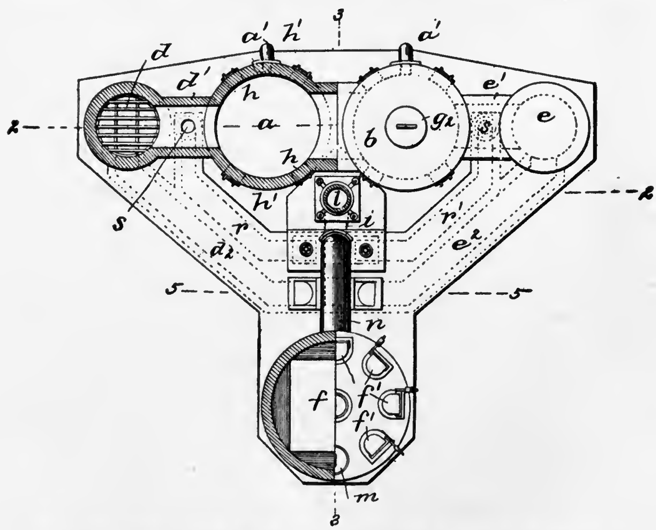

FIG. 40.—SMITH-SIEMENS GARBAGE FURNACE, PLAN.

The Smith-Siemens garbage furnace (Fig. 40) was an imitation or modification of the Siemens process for attaining high temperatures in the work of iron manufacture. There are three distinct constructions, which together formed the complete apparatus.

These were (Fig. 40, plan) (a-b) the two garbage furnaces, the two regenerators (d-e), and the gas producer (f). Each of these separate constructions consisted of a steel exterior circular wall, which was lined with fire brick, and all were connected by a system of flues, controlled by dampers. The garbage chamber is charged through the roof, the waste falling on the bottom, and forms a conical pile. There are doors, through which the mass may be stirred, and at the bottom is a discharge spout (a^1), which is opened for drawing of the liquids and afterward the slag, or residual products, from the chamber.

The regenerator chambers (d-e) are filled with checkerwork of fire brick and provided with flues (d^1-e^1) leading downward, so as to throw the flames directly upon the mass of garbage in the chamber (a). From the base of each regenerator is an air flue (d^2-e^2), connecting into a common chamber, which is provided with a reversible valve. These flues are also connected with the escape flue (i), which leads to the stack or chimney (L).

The producer (f) is provided with charging ports, through which the coal is passed for conversion into gas, and also has a garbage port which may receive waste for conversion into gas. There are valves and dampers to regulate and cut off the flow of gas and air, the purpose being to produce the gas for combustion from the garbage itself when the proper temperatures are reached.

The operation is begun by starting a fire in the gas producer, and as soon as gas is generated it is fed through the main gas flue (n) to the distributing chamber and by the flues (T^1) is carried to one of the garbage chambers (a^1). On its passage it receives the air from the regenerator and combustion takes place within the garbage chamber. From the chamber (a^1) the heat passes into the adjoining chamber (a) to the second regenerator (d) and from this through the air flue to the stack.

When the garbage in the first chamber is consumed the action is reversed, the gas then flowing through the ducts from the producer to the furnace (a), thence to the second furnace, which has meanwhile received a fresh charge, and through the first regenerator (e) to the chimney. It is claimed that when the highest temperatures are reached the garbage alone will produce the gas for its own combustion, with little or no assistance from the producer, but this seems to occur only when the garbage is comparatively dry and contains little mosture. During the operation of this furnace in Philadelphia and Atlantic City the repairs necessary for maintaining the complicated apparatus, exposed to very high temperatures, were made at a very considerable cost.

SEABOARD GARBAGE CREMATOR CO. AND MR. A. VIVARTTAS, NEW YORK CITY.

One of the early furnaces for disposal of waste was invented by Mr. Aloha Vivarttas, of New York, who in 1887 built a large plant at East Seventeenth street, New York, under the style and title of the Seaboard Garbage Furnace Company, Patent No. 390,922, October, 1888.

This was the first furnace of its kind in New York City and was intended for the disposal of all classes of waste then collected together—ashes, garbage and refuse—which was then dumped at sea.

The furnace of Mr. Vivarttas, Fig. 41, was very high in proportion to the length and width, the exterior walls of the usual construction, the interior of fire clay, brick, and tiles. The top charging ports (a^1) discharge into small chambers inclined from the middle line to the furnace walls, and terminating in a chute (a^3) controlled by a sliding fire clay dumper (H^2). This upper chamber is then discharged upon a lower drying hearth (D^1), inclined at a sharp angle in the opposite direction from the one above. Thus there was formed an interior drying and burning chamber (B) of large capacity, into which all the smaller chambers above discharge, and in which the final combustion was made. The sides of this middle chamber (B), inclined to the center, led the ashes and residuals of combustion down to a throat (D^1) or narrow flue, floored with water grates, below which the ashes are removed.

The two fire-boxes (F F^1) are supplied with coal, the heat passing under the inclined hearth of the burning chamber and through narrow passages behind the smaller charging chambers, and then downward through the four downtakes (B^1) to the chimney, by underground passages. In this New York installation there was also a conveyor for receiving the mixed refuse and ashes and passing this through a water bath to separate the heavy and lighter portions before charging into the furnace.

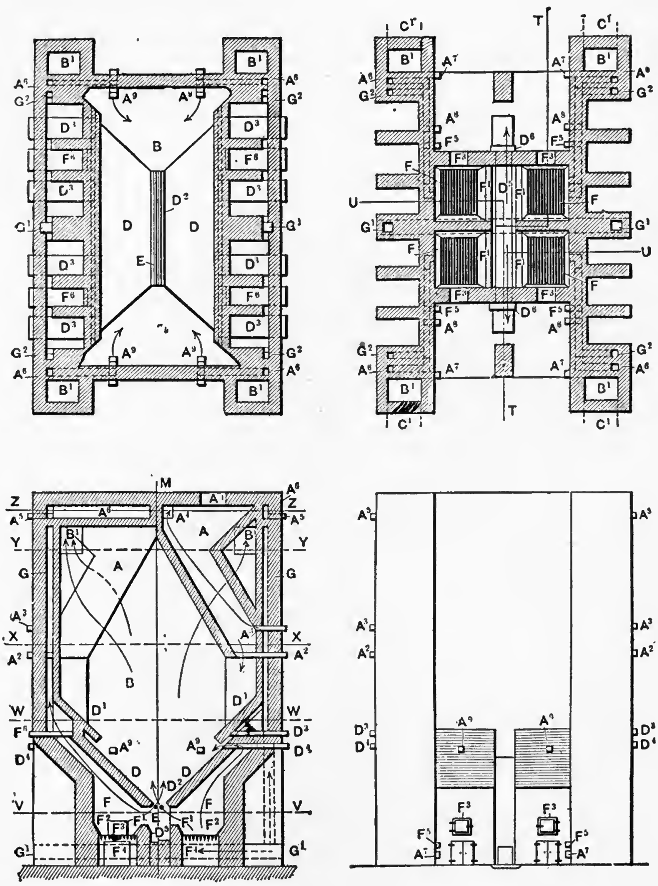

FIG. 41.—VIVARTTAS GARBAGE FURNACE.

But the conditions attending this disposal of mixed waste by fire were not then well understood. It was found impossible to produce and maintain combustion in the central burning chamber, there was poor provision for the removal of residuals, the furnace construction was too weak to stand the strain, and after many vain efforts to continue operation the attempt was abandoned in 1888.

Subsequently Mr. S. R. Smith, of Plainfield, N. J., became manager for this company and installed plants in Philadelphia, Plainfield, Scranton, and Fort Wayne, Ind. Three of these were in service for two to three years, but at this time none are operating.

DECARIE MANUFACTURING COMPANY.

The Decarie Incinerator was the invention of Mr. F. L. Decarie, of Montreal, Canada, in 1897. The original invention, described in U. S. Patent No. 596,421, was probably the most complicated apparatus yet devised for the destruction of municipal waste. There is no record of this ever having been used in the original form. About June, 1901, Mr. Decarie applied for another patent which was issued January 12, 1904, No. 749,269. This is the basis of the present form of this incinerator, though many changes are made in the latest constructions.

Two forms of furnaces were included in this plant, alike in exterior dimensions but differing in interior details. The first is an incinerating chamber, with interior length about twice its width and height. These exterior walls are of brick built and stayed in the usual manner. The floor of this chamber is a series of heavy firegrates, supported on bearing bars, with an ash-pit beneath, the bottom of which is a shallow double-jacketed iron pan, holding water.

The walls of the incinerating chamber support a shallow rectangular iron box or "steam generator," covering all the roof of the chamber. Above this box is another of a larger capacity, also of iron, and provided on the top with four charging ports, with covers. One large charging hole extends through the drying chamber and the steam generator to the incinerating chamber below; the others do not connect with the incinerating chamber, but discharge into the drying chamber only. This generator is made after the usual boiler construction, with a multiplicity of stay-bolts and provided with pipes for steam and water supply. The garbage grates are a series of hollow pipes connected at their upper ends by screw-threaded joints tapped into the bottom plate of the generator. The grates describe a curve or incline to the middle of the lower part of the incinerating chamber, where they are connected with one large header, just above the fire bars. These grates form a basket to hold the garbage charged through the generator, but are placed on the sides. The circulating system includes the steam generator, the water grates, the headers, and the double steel outer water-jacket, which is sometimes used instead of the brick walls, the purpose of this

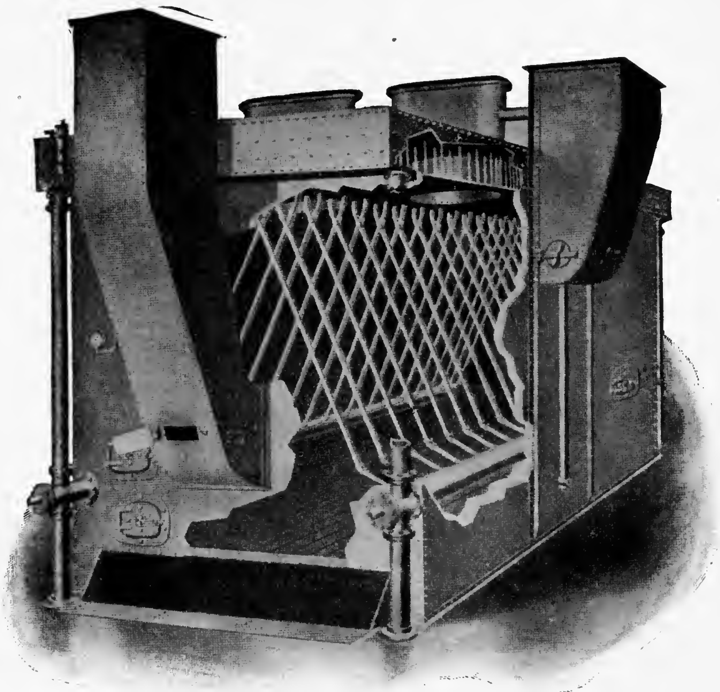

FIG. 42.—THE DECARIE GARBAGE INCINERATOR.

water system being to preserve the iron parts from destruction by the heat from the fires below. In some constructions the roof of the furnace is of fire-brick, and the generator is replaced by two large headers at the upper corners of the chamber.

In the other form described in the patent, the brick construction for the exterior walls is replaced by a double steel casing, secured by many hundreds of stay-bolts and connected with the water circulating system.

A later form of construction is shown by Fig. 42, and is similar in exterior dimensions to those previously noted, with some interior changes. Here the steam generator is made deeper and occupies all the space above the incinerating chamber, leaving out the drying chamber altogether. The charging holes on top extend completely through the generator, but are placed on the sides. On the outside of the sides and ends are smaller charging chutes, for very wet material, the liquids from which are conducted to the evaporating pan under the ash-pit.

The garbage grates are inclined from the middle line of the steam generator, where their upper ends are tapped into the bottom sheet, to the headers along the sides of the chamber.

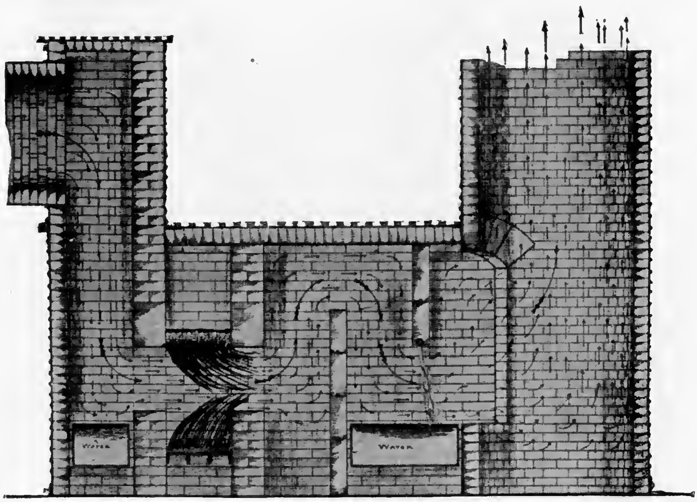

FIG. 43.—THE DECARIE FUME CREMATOR.

There is a union or connection in these pipes and a short level section of piping just before the connection with the headers.

These grates, inclined from the middle of the generator to the furnace walls, from a basket of iron pipes, enclosing a triangular space, which receives the garbage charged through the holes above. All the parts that will admit of it are of hollow iron spaces with water circulation, somewhat resembling a magnified locomotive steam boiler. The partially dried garbage which is confined within the suspending basket, may be mechanically stoked down into the fires below by bars thrust through the stoke-holes in the walls of the furnace at various points. To reach the inner surfaces of the basket the rakes must be thrust through doors on the opposite sides of the furnace, or through the larger doors at the front and rear ends. There are upwards of forty doors and openings of various sizes in each incinerator and fume cremator of 50 tons capacity.

To consume the gases and products of combustion there is, in the latest forms, a "fume cremator" (Fig. 43), placed between the incinerator and the chimney. This is a separate brick chamber enclosed in steel plate with many doors for removal of ashes,

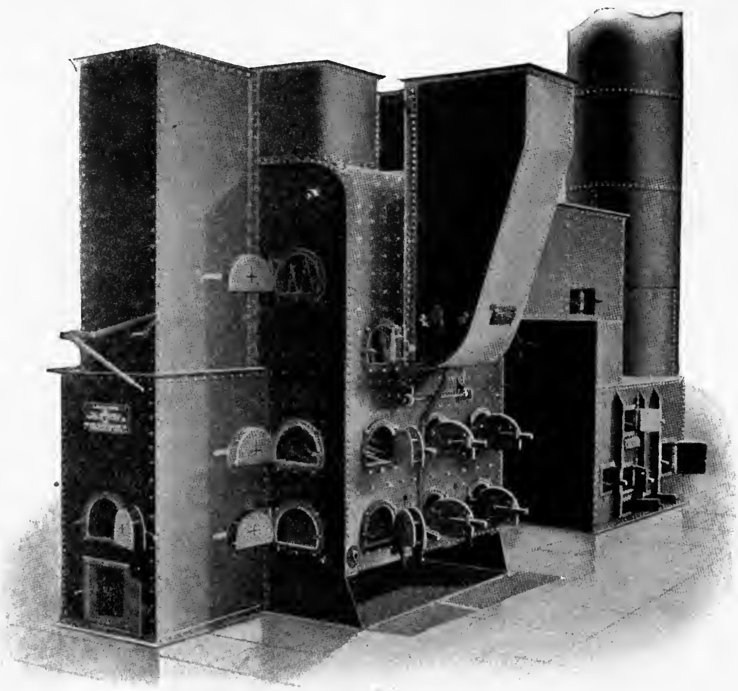

FIG. 44.—THE LATEST DECARIE INCINERATOR.

supply of fuel and water. The gases from the incinerator first pass through a perforated brick partition, then into a descending flue floored with a water tank, then between two fuel boxes, are then deflected upwards by the bridge well and downward by the hanging wall, passing over the surface of the two water tanks and through the curtain, or scrubber, of water or steam from the perforated pipes to the chimney. This complicated arrangement of walls and water tanks is necessary to arrest the flying particles of paper and dust, and to reheat and reburn the carbon in the smoke and gasses of the combustion products from the incinerator.

The latest form of the Decarie incinerator is wholly of an all-steel water-jacketed design, with double shell throughout, and water-jacketed crown and steam space. The arrangement of the charging hoppers permits dry rubbish to be charged in front, the heavy ordinary garbage to be charged through the top hoppers, and the storage of very wet material in the side hoppers, which are provided with facilities for draining off the liquids before discharging on to the upper grates. The evaporating pan below the fire bars is for the disposal of these liquids by steam jets turned into the evaporating steel pan, the vapors passing up through the fire bars. There is also what is termed an extension fuel grate placed at the front, provided with two grates constituting an up-and-down draft fire-box, which may, on occasion, assist in the more rapid evaporation of the liquids. The gas consuming chamber is connected with the main garbage chamber by heavy continuous steel construction, and forms a part of the complete incinerator, instead of being a separate construction, as previously used.

DUNDON IRON WORKS, OF SAN FRANCISCO, AND THE DUNDON GARBAGE INCINERATOR, AT SACRAMENTO, CAL.

In 1905 a plant was erected at Sacramento, Cal., by the Dundon Iron Works, of San Francisco. The original designs were furnished by the Mildrum Bros., of England, but these were changed in many essential features, and it was built quite different from the plans of the patentees. It was claimed that this furnace failed to meet the conditions of the contract, and it was not accepted by the city. No other installation of the Dundon Excelsior Garbage Incinerator has as yet been made.

BENNETT GARBAGE CREMATORY, ELMIRA, N. Y., AND WILKES-BARRE, PENN.

The Bennett Garbage Disposal Company is capitalized under the laws of the State of Pennsylvania, and collects and disposes of street sweepings, garbage, ashes and refuse, junk, dead animals and other waste matters. Its capital is $35,000. This company has been given franchises at Elmira and Wilkes-Barre for terms of ten years. At Wilkes-Barre the collections are to be made from the household in garbage cans of a uniform size to be furnished by the company, transported upon special platform wagons. The company has certain protective rights against competitors for collection, and gets its remuneration from the householder at a rate fixed by ordinance. The householder pays 15 cents per can, and the disposal of larger amounts is subject to special prices and discounts.

The disposal stations as described by Mr. Bennett will consist of modern fireproof buildings designed to meet the most discriminating laws of sanitation in the handling and disposal of the various kinds of garbage, with entire freedom from objectionable odors of any kind."

SANITARY ENGINEERING COMPANY.

This corporation in 1904 acquired the property and patents of the Municipal Engineering Company, the principal stockholders being Col. Young, Mr. F. Nevins and Capt. Wm. M. Venable. They secured a patent (830,027, September 4, 1906) for an "improvement in crematories, in which garbage or refuse is burned on grates with an updraft, either with or without previous drying."

In exterior dimensions and construction this furnace (Fig. 45) was nearly the same as the other, though the exterior walls may be of brick construction if desired. The garbage is charged through the ports (4) and is received on the iron drying floor formed of a series of hollow triangular cast-iron grates (11-12-13). Beneath these are a number of fire-boxes (5), separated by bridge walls of fire brick extending below to the bottom of the furnace to form ash pits.

A flue or passage (10) connects with a secondary chamber for combustion of the gases (9), above which is a space (19) for receiving the heated air generated in the hollow grates of the drying floor and the air spaces at the sides of the lining. The chimney is connected with the secondary consuming chamber, which in the larger construction is supplied with a fuel grate.

Doors are provided for the fires and ash pits and for stoking the garbage on the drying floor. The grates may be rotated from the outside of the casing to assist in the stoking and drying process.

The operation of this crematory is somewhat complicated, depending upon the passage of the currents of air heated by

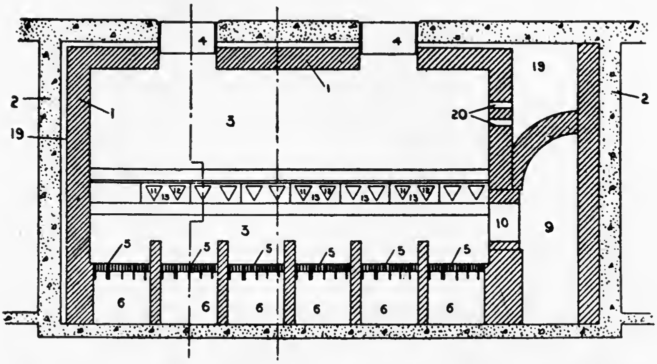

FIG. 45.—THE CREMATORY OF THE SANITARY ENGINEERING CO.

passing through the hollow grates, and their introduction into the space (19) above the secondary combustion chamber, from which they are passed through the openings (20) to the upper consuming chamber. The special features are the hollow prismatic air-cooled grates, forming the drying floor, and below, the independent fire-boxes, for the partially dried garbage and for fuel to complete combustion. The only construction of this furnace is at Fort Barancas, Fla. No municipal plant has yet been built under this patent.

GARBAGE CREMATORY OF MESSRS. LEWIS & KITCHEN AND FRED P. SMITH, OF CHICAGO.

The inventions of Mr. F. P. Smith for the disposal of municipal waste are marked by versatility and bold designs. There are several forms of fire closets, incinerators and furnaces under his patents, some of which have been built by the United States Government and by private contractors. In 1904, as engineer for Messrs. Lewis & Kitchen, he designed and built at Fort Sam Houston, Texas, a new form of crematory, which was also installed at Fort Dupont, Del., 1906, and which is described in the *Engineering World*, Chicago, as follows (Fig. 46):

Garbage and refuse is dumped from sanitary carts upon a steel platform, whence it is thrown upon the garbage grates above the incinerating fires. When the garbage is dried and is partially burned upon the upper grates of clay, it is stoked to the lower grates for final combustion and to become the fuel for the drying of the succeeding charges of wet garbage. Fumes are destroyed and dust is arrested in the chamber at the base of the chimney. Air for combustion is heated before admission to the furnace by heavily flanged castings, which form the sides of the fire-boxes and the evaporating floors.

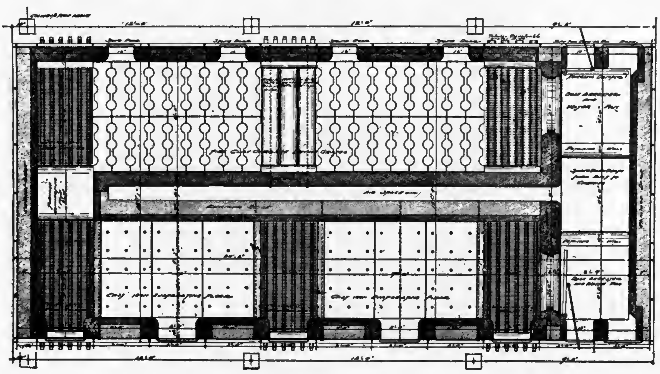

FIG. 46.—PLAN OF SMITH CREMATORY OF LEWIS & KITCHEN.

The exterior is constructed of cast-iron sections with heavily reinforced flanges. The lining is of fire clay bricks with molded refractory clay blocks for the openings of doors and garbage hoppers. The garbage grates are of refractory fire brick.

This description does not clearly explain the construction or work of this furnace.

Fig. 47, of a crematory of larger capacity, shows more clearly the plan. The outer wall is of sectional cast iron flanged divisions, held by bolts and presumed to be rigid and strong enough to hold the thrust of the fire pressure. The interior lining is of sections of fire-clay tile, corresponding in size to the exterior casing, and having an air space next to this. The grates are heavy blocks of fire-clay, spaced to permit passage of garbage, and carried by projection of the interior lining. These bars are 10 x 10 inches in cross section and 6 feet in length, weighing upwards of 500 pounds each. The arrangement in two horizontal planes at different heights, with intervals between, is a novel departure from the usual methods.

The lower division of the furnace is a series of cast-iron evaporating platforms, alternating with transverse fuel-boxes, and so placed below the garbage grates to receive the partly dried waste, the liquid falling upon the evaporating surfaces.

The secondary fire is placed in the combustion chamber at the base of the stack. The exterior casing is pierced at intervals for air inlets, and the doors are arranged for stoking and firing

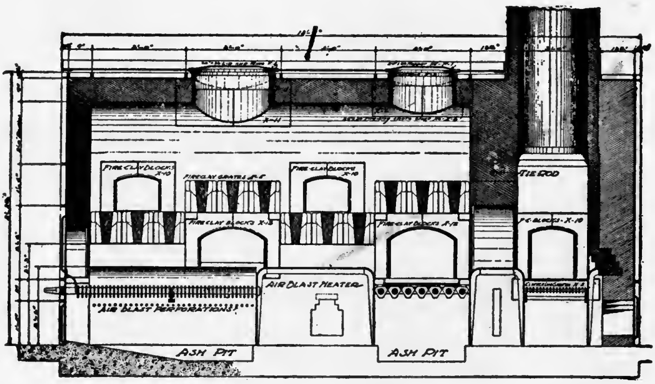

FIG. 47.—LONGITUDINAL SECTION, F. P. SMITH CREMATORY.

in the usual way. The larger sizes have four charging ports, one being large enough for a large carcass.

The operation of this crematory is somewhat complicated. By reason of the longitudinal division wall the crematory is divided into two furnaces, alike in construction, and so arranged with connecting flues and dampers that the heat from fuel-boxes may be directed over either upper compartment and return above or below the adjoining compartment, passing finally through the common combustion chamber to the chimney. This action is assisted by the currents of heated air from the hollow fire-grates, and from a special heating device placed under the evaporating platforms.

The constructions described in Figs. 46 and 47 were those employed by Mr. Smith up to 1906. During this time no municipal plant was built by Messrs. Lewis & Kitchen under the Smith patents, but four or five small crematories for government use were installed at several army posts.

The next installations showed a radical change in the use of material for the inner linings and grates. The cast-iron evaporating surfaces were abandoned, the double form of furnace changed for a single unit which was made longer and wider than before, and in which the garbage grates were made of heavy blocks of fire clay and the iron evaporating surfaces replaced by the hollow cast-iron revolving bars. The name *incinerator* was used to describe the furnace as distinguished from the term *garbage crematory* previously employed.

Fig. 48—the longitudinal section of one of the latest incinerators—shows the present construction. The furnace is charged

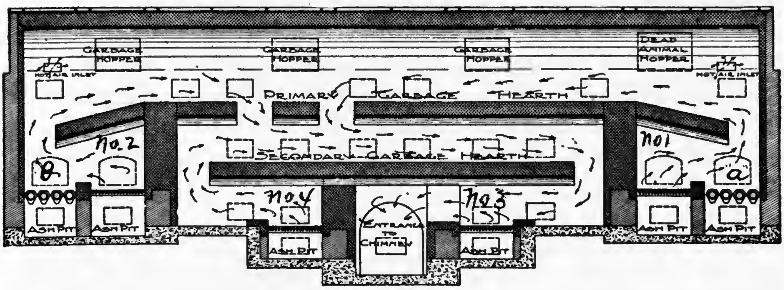

FIG. 48.—LONGITUDINAL SECTION OF LATEST SMITH INCINERATOR.

through side ports on the top, the carts dumping the loads through large openings directly to the upper tier of garbage grates, which is called "the primary garbage grate." When the charge is dried out it is stoked through open passages and around the ends of this upper grate to the "secondary garbage grate," where final combustion is made. There are four principal fire-boxes for fuel, and two secondary boxes floored with revolving hollow cast-iron bars, called the clinkering grates.

The theory of the combustion is that the heat generated from fuel in the two fire-boxes at either end of the furnace (Nos. 1 and 2) must first pass over the clinkering grates, then upwards around the ends of the upper grates, meeting in the two openings or passages through this upper grate and passing downward along the upper side of the secondary grate and turning again downward, pass over the fire-box No. 3 on its way to the chimney flue placed below the level of the floor. The heat from the second left hand fire-box (No. 4) is added to the other two boxes when required.

The division of the upper grate into two unequal parts is for the purpose of burning a small amount of waste on the left hand division, when the whole area of the furnace is not needed for so small a quantity. The arrows show the direction of the gases from the primary fires. To distinguish the fire grates, these are numbered 1, 2, 3, and 4; the clinkering grates lettered A and B.

The stoking or moving of the charge is done through five doors on the upper grate, six doors on the lower tier and two doors on the floor line. Stoking may also be done through the charging ports from the top of the furnace.

The Interior Walls of this incinerator are formed of heavy sections of fire clay, the dimensions of each corresponding to the sections of cast-iron which form the exterior shell of the furnace. These sections of fire clay and iron must be of the same dimensions to permit the unbolting and removal of the cast-iron section, and then the removal of the interior fire-clay section to take out any one of the garbage grates which may have been broken.

These garbage grates are blocks of fire clay 6 to 8 feet long and 8 by 10 inches in cross section. They are not arched, but depend for their strength upon their size and thickness. Because of their dimensions and weight (each grate bar weighing 400 to 500 lbs.) they cannot be replaced when broken except by removing the top of the furnace or a cast-iron section of the sides and the corresponding interior fire-clay section of the wall, which will give an opening through which the broken grate bars of the lower tier may be withdrawn and new ones substituted.

The Fig. 48 shows the construction of the garbage grates to have eight exposed edges over which the heat must pass, turning a right angle in each case, and also over which the charge of garbage when dried on the primary or upper grate must be stoked down to the secondary grate or to the clinker boxes. There are then eight hanging fire-brick bars unsupported on one side, over which liquids, metals and incombustible matters must pass, besides being exposed to action of slice bars and rakes used to move the dried charge.

This construction provides for a series of blocks of fire clay of heavy cross section. placed side by side horizintally from one wall to the other across the furnace, forming a platform 16

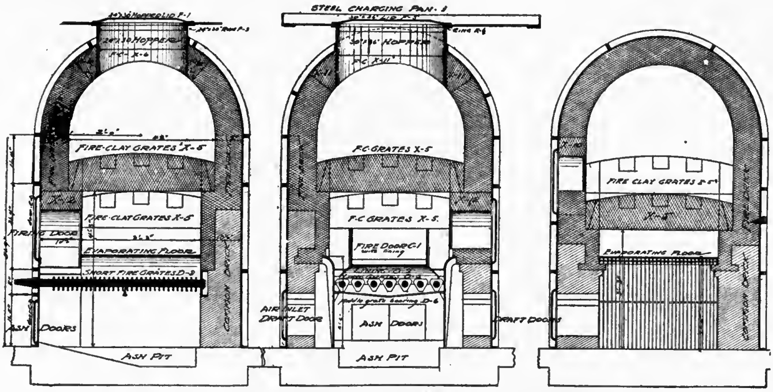

FIG. 49.—CROSS-SECTION SMITH INCINERATOR.

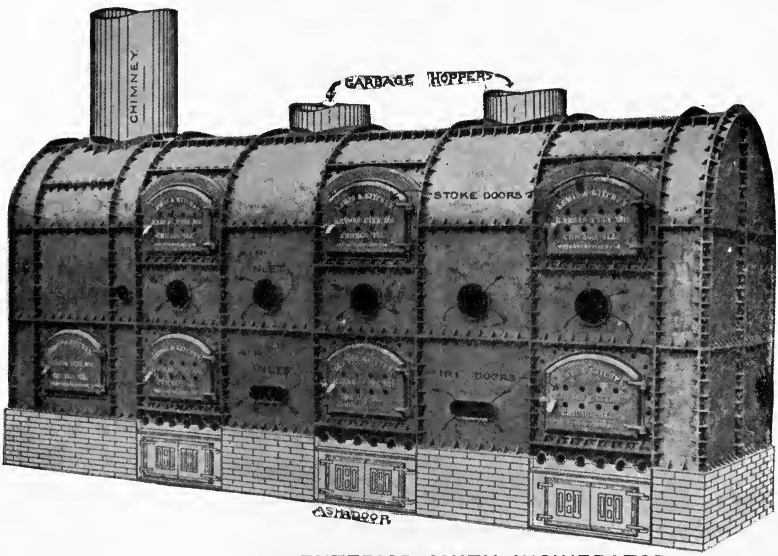

FIG. 49.—EXTERIOR SMITH INCINERATOR.

feet long and 6 feet wide, which is to carry a weight of five tons of garbage with the lower surface exposed to a temperature of 1,500 degrees or upwards. This same construction is repeated in the secondary garbage grate with greater risk, as these grates are directly over the two fire-boxes, 3 and 4. Fig. 49.

The upper surface of the grates which receive the charge of garbage direct from the collection carts must, at times, be covered with saturated garbage containing 60 to 70 per cent. of water. If night-soil be charged into the furnace the liquid contained may be as high as 80 to 90 per cent. At the same time there must be a high temperature on the secondary grate, which radiates its heat to the under side of the grate above. If this be the case, there will be a condition of liquid saturation and consequent contraction of the upper surface, and an expansion of the lower surface of the same bar or block caused by the high heats of the secondary grate. Heretofore it has been found very difficult to maintain garbage grate of double fire-clay blocks of short length dovetailed together in the middle and arched to support the weight of the garbage charged from above.

If fire-clay bars can be maintained in such a case as this and be found durable and efficient, it will be an advance in the art of using fire clay garbage grates such as has not been attained by any previous builders. The stability of this form of construction depends upon the garbage grates being able to maintain their place under all conditions of unequal and varying temperature, and also be able to support the weight of five to eight tons of garbage received for one charge.

The latest incinerators of this type are at Hattiesburg, Miss., Oak Park, Ill., and at the U. S. Naval Training Station, Newport, R. I.

The construction of the F. P. Smith crematories is carried on by the engineering firm of Lewis & Kitchen, Chicago, Ill.

PUBLIC SERVICE COMPANY, OF NEW YORK.

In October, 1907, the city of Cambridge, Mass., advertised for bids for a refuse disposal plant to burn sixty tons of house ashes and refuse per day, no garbage being included. Upon a second advertisement the contract for the construction of the plant was awarded to a New York corporation under the title of the Public Service Company, at the price of $25,975. The plant included a brick building 60 x 65 feet, a radial brick stack 125 feet high, and a cremating furnace following the same lines of construction as that adopted at the refuse incinerator of the Railway Traffic Company, of Brooklyn. The special features of this construction include a long fire-box which is charged through four openings on the top of the furnace. About two feet above the fire-bars is a series of horizontal water-tube grates which receive the refuse thrown from above. There is a longitudinal fire brick bridge wall dividing the furnace into two equal cells, both of which are connected with the common combustion chamber. The rear end of the fire grates are inclined sharply upward, and behind them is placed a dust-receiving chamber to allow the settlement of light particles of unburned matter. From the combustion chamber the gases pass into a Sterling water-tube boiler of 200 h.p. There is provided a fan driven by the steam power from the boiler, which conveys a current of air into the ash-pit under the fire bars. The provisions of the contract call for the disposal of 60 tons of mixed ashes and refuse per day. At the first trial of the incinerator it was found impossible to consume this quantity within the require time. Subsequently, the collection service was changed, and a smaller amount of ashes brought for disposal. At the present time the city is reported to have accepted the plant. The power development from the amount of refuse burned at present is only sufficient for the operation of the plant itself.

MORSE DESTRUCTOR FURNACE AND THE UNIVERSAL DESTRUCTOR COMPANY.

In 1906 Mr. W. F. Morse obtained patents for certain new and useful improvements in garbage furnaces. In exterior proportions this invention follows closely those of the American type of furnace, as previously described. The Morse Destructor Furnace (Fig. 50) is charged from the top through circular holes with sliding fire clay covers. When desired it may also be fed through the large front doors.

The interior arrangement provides for a primary fire-box (6) of greater or lesser dimensions, according to the material to be burned, with fire-bars inclined from rear to front. Behind the fire-bars are two drying and burning platforms of fire brick arches, arranged in an inclined position, the upper tier (1) beginning at the fire-bars (6) and gradually rising nearly to the arch of the furnace roof.

Below this is a second platform, or closed curtain arch (11), that forms a flue (12) for the passage of the smoke and gases, and as this becomes incandescent it radiates the heat to the under side of the grates above, greatly aiding to dry out the moisture and increasing the combustion.

Underneath this platform is an expanding chamber (9) triangular in shape, extending from the partition or bridge wall of the fuel box (13) to the curtain wall (21), which encloses the

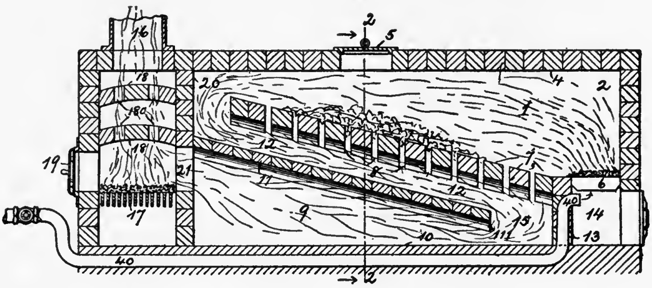

FIG. 50.—THE MORSE DESTRUCTOR FURNACE.

combustion chamber (18) and the secondary fire-box (17). Above the secondary fire-box in the combustion chamber is a series of transverse arched partitions perforated to admit free passage of the gasses.

Below the floor of the expanding chamber (10) is a hot-air conduit. Through the cold-air inlets at the rear end of the furnace air is drawn by the action of the stack draft, or by a system of steam jet blowers into the space beneath the floor of the furnace. This air in its slow passage is raised in temperature by the radiated heat through the bottom of the furnace, and when brought under the bars of the primary fire-box the temperature is increased to upwards of 150° F. The blowers are connected with a steam jet from the boiler, which gives increased combustion in the material on the fire-bars above.

The addition of this regenerating system of heating the air brought under the fire-bars of the primary fire is a means of increasing combustion not before recognized in American practice. This heated air may be increased to any desired pressure by means of the fan or steam jet, upon the well-known principle of the English destructors, and any proportions of mixed waste, garbage, ashes and refuse may be destroyed without change in the apparatus except by increasing the blast.

The sloping platform, which gradually diminishes the area of the combustion grates, causes a more intimate contact with the heat, and greatly aids in the downward movement of the garbage to the fire-grate to form additional fuel. The delay of the gases in the expanding chamber permits the deposit of fine dust, which is withdrawn through doors on the bottom.

At the top of this furnace above the combustion chamber, or at the side or back of this, may be placed a steam boiler of the vertical or water-tube type having its own independent fire-box, and so connected with the furnace by a system of flues and dampers that it may be operated altogether by the crematory, or partly or entirely by the heat from its own fuel box. By enlarging or diminishing the area of either the primary fire or of the sloping garbage grilles the destructor may consume a larger proportion of either refuse or garbage as conditions may require.

There is no iron surface exposed to the direct attack of the heat except the upper surface of the fire-bars of the primary and secondary fires. It is believed that the simplicity of construction, and the few essential elements, make it almost impossible to get out of order or to be destroyed by high temperatures unless by gross carelessness.

This destructor may be built in many forms and dimensions suited to the different kinds of waste and differing conditions of service.

The present installations of the Morse Destructor are at the Government post, new Fort Lyon, Col., the Hudson Terminal Building, New York, with special installations at Loeser's Department Store, Brooklyn, in conjunction with two 150-h.p. B. & W. steam boilers, and are so arranged that the power from one or both boilers may be utilized as desired.

The Universal Destructor Company is the American representative and agent of Meldrum Brothers, Ltd., of Manchester, England, and controls the installation of the Morse Destructors and Meldrum Simplex Destructors and the Beaman and Deas Destructors in the United States, Canada, Mexico, the Central American States and Cuba. The Meldrum Destructors now operating in this territory are described and illustrated in the chapter on British destructors in America.

CHAPTER IX.

AMERICAN GARBAGE CREMATORIES—*Continued.*

Calorific Values of Municipal Waste.

Portable or Traveling Garbage Crematories.

The idea of a garbage cremator that should come to the premises, and not only take away, but destroy at once all useless matter, has been the dream of inventors. If such an apparatus could be made to work quickly, efficiently and without objectionable noise, odors, smoke or dust, there would be many advantages in its favor as against the prevailing methods of removal by collection carts. Some of the American cities have experimented with this form of garbage and refuse destroyer, but so far as known none are now employing a portable traveling furnace as a part of their disposal work.

The first American Portable Garbage Incinerator appears to have been invented in 1895 by H. C. Fellenbaum, of Philadelphia. Patent 546,396, September, 1895. "The purpose of the inventor was threefold, to provide a compact, efficient incinerator which shall do its work without noise or noxious fumes, to so construct that it may be drawn or propelled to permit of the destruction as it is collected or while the apparatus is in motion, and to arrange the various parts of the apparatus so they shall be protected from injury by burning, bending or warping." There is a fire box of large capacity lined with firebrick. Above this are horizontal tubes forming a steam boiler, and above this, on the outside of the boiler casing, an engine connected with the steam pipes of the boiler. At the front end of the boiler tubes is a sloping platform of water pipes arranged to pass liquid to a chamber below. Above this platform is a set of circular revolving cutters or knives, rotated by the engine, and above these knives is the hopper or bin for receiving the garbage. There is a hollow tube of large size extending through the length of the machine, which contains a screw to move the finely divided particles of garbage after passing the knives, drying the garbage in its passage and dropping it into the fire box to serve as fuel.

The smokestack is at the front end, and may be telescopic, to permit its being raised above windows of adjoining houses. The incinerator is presumed to generate steam for operating the cutting knives, for driving the conveyor, and for power for its own locomotion. Oil burners are placed in the fire box to begin the work or raising the initial steam; thereafter the dried garbage continues the operation. The front chamber below the boiler is a smoke box, in which all gaseous products are consumed or deodorized before passing to the stack.

This incinerator is a remarkably ingenious theoretical attempt to combine in a small compass all the various machinery and methods for chopping, drying and burning the garbage, for producing steam power for its own uses, and for destroying the products of combustion in such a way as not to produce nuisance. In practical use there are still some points to be dealt with, and it is possible that the claims for its continuous successful operation might not be realized. There is no record of trials or actual work performed.

The Apparatus for Treating and Cremating Garbage of Mr. Oscar D. McClellan, Philadelphia, patents Nos. 558,974-5-6-7, April, 1896, include several novel and ingenious arrangements for the treatment of garbage by a tapering screw to press out the moisture, its drying for fuel, and the operation of a powerful vertical tubular boiler. The later patents describe another method of drying the garbage, the vaporizing of the moisture and the development of steam power for the work. These methods are described at great length, and seem to cover several theoretically successful ways of dealing with the waste, but there is, so far as known, no reports or records of the apparatus being in experimental or actual service.

The Traveling Garbage Crematory of Mr. Chas. J. de Berard, of Chicago, patent 581,686, May, 1897, was brought into actual use in Chicago in 1897-8. The purpose of the inventor was to provide means for the disposal of garbage, both dry and wet, of suitable construction and size, to be mounted upon wheels, and to be drawn through streets and alleys. The crematory, Fig. 51, is a circular iron shell, 8 ft. long, 5 ft. in diameter. The lower part of this shell is divided transversely by the bridge wall (7) into two compartments (8-9), and above the first compartment (8) are placed grate bars (10) forming the primary fire box (11). Above this primary fire box is a horizontal diaphragm (12), strengthened by bars and flanges (13) to prevent warping. Below the primary fire box is an ash pit with door (15). Above the second compartment (9) is a second set of grate bars (17), inclined from front to rear, with a door (18) for moving the dried material from the floor (12). There is an ash pit below these grates with a door (19) for removal of ashes. The smoke

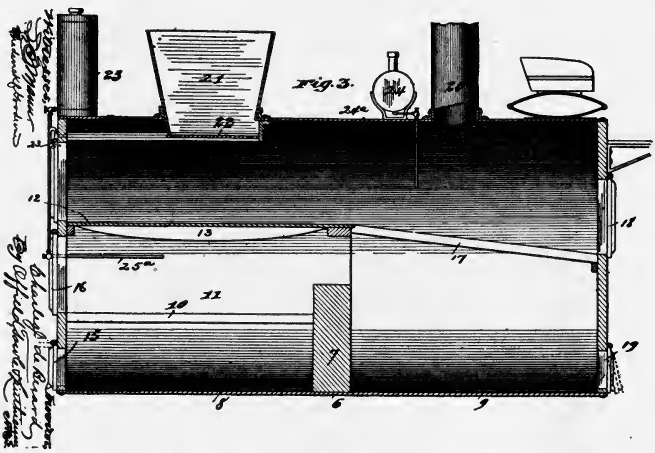

FIG. 51.—THE DE BERARD PORTABLE CREMATORY.

pipe is directly above the last burning chamber of the bars (17). There are oil tanks (23-24) with openings into the spaces above the fire bars for assisting combustion. The garbage is charged through the hopper (21), which is controlled by a slide valve (22).

In operating this crematory the refuse and combustible matter is charged into the primary fire box, and furnishes fuel for drying the charge of wet garbage placed upon the drying hearth (12) above. When this charge is sufficiently dry to ignite it is pushed or pulled forward to the secondary chamber (17), and the combustion assisted by oil until it is reduced to ashes. All offensive odors are driven off while the garbage remains on the floor (12), and these mingle with the flames from the burning material on the bars (17) and are intercepted and consumed on their passage to the stack. This Berard crematory was used in Chicago for several months, and from the reports and criticisms of the daily press was successful in its work. It was discontinued early in 1898 and has not been employed since. Since there was no lining of fire brick the iron shell must have been injured or destroyed after a short time. It is also doubtful if the methods for destroying the gases were altogether successful in this most important point of a portable furnace.

The Inventions of Mr. Isaac D. Smead and Smead's Traveling Crematory.—The inventions of Mr. Isaac D. Smead, of Toledo, now of Cincinnati, are among the most numerous in the line of sanitary appliances which deal with excrement and similar wastes. *The Smead Dry Closet* (patented 1891-2) was formerly in use at a great number of isolated buildings—mostly school houses—and is still employed in places where no sewerage facilities are accessible. The *Smead Combined Crematory and Heating System* (patent 691,328, May, 1902), is an apparatus for consuming garbage and refuse matter and applying the heat for the circulation of water for heating buildings. It is intended for uses of large buildings, is operated by using coal, and is ingenious and elaborately complicated in the arrangement of the working parts.

The *Smead Garbage Crematory* (1902) was an amplification and extension of the ideas contained in the heater, and was experimentally tried on a large scale at Toledo. There is no record of the continuance of this crematory.

The Smead Traveling Crematory, Fig. 52, is Mr. Smead's latest contribution to the long list of patents standing in his name. This first portable crematory was built for experimental purposes at Springfield, Ohio, in September, 1905, where several trials were made dealing with the usual garbage and refuse collection. At a public exhibition, at which the city officials were present, a severe test was made with very wet garbage, which, according to the published reports, was quite successful. Subsequently the machine was brought back to the makers to be "tractionized" or made self-propelling. A second trial was made in February, 1906, but the city did not then purchase the crematory. Since then this crematory has been improved in several ways, and is

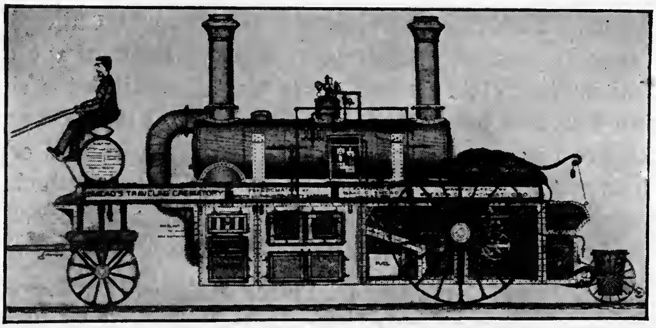

FIG. 52.—THE SMEAD TRAVELING CREMATORY.

now offered for the disposal of all classes of garbage, refuse and rubbish in competition with the other forms of stationary furnaces.

Portable Rubbish Incinerator of the Street Cleaning Dfpartment of New York City.

The people of New York City pay but little attention to the ordinances forbidding the throwing of litter and refuse into the streets. What becomes of the newspaper, the parcel wrapper, the paper fruit bag, and the banana, orange and fruit rinds, nobody knows or cares, once they are thrown aside into the gutter. The cans for deposit of refuse are infrequent, being mostly placed at the park entrances and walks, and at the wider street intersections are not always available. The quantity of this refuse scattered about the streets is enormous in bulk and is one of the chief sources of trouble to the Department, as it must be swept up and held until the daily collection of the street cart.

The idea of burning this on the spot has long been entertained, but no serious attempt was made until February of last year, when there was brought into service a small portable furnace, described as follows by the inventor:

The portable refuse destructors are formed from two wornout street cans, making a furnace by superimposing one on another. The lower one has a grate introduced above the bottom just far enough to leave a space for an ash-pit. The sides of the can are perforated to allow of the admission of air necessary for the combustion. The upper can is inverted and fits to the lower, forming a dome, which prevents the escape of the fire in the lower one. This furnace is placed on the ordinary can carrier now in use by the street cleaners and is fed by them as they patrol their beat, and the operation of disposal is continuous and effective. The resultant ash is placed in the ordinary street cans. When not in use these furnaces are stored at the sections, and the carrier is used for its original function. The cans used measure 18 inches across the top and are from 16 to 21 inches high. The grate is placed 10 inches above the bottom. The perforations are in three rows around the can and above the grate, the top hole being 10 inches above the grate. The feed door is 8 x 10 inches. The capacity of the furnace is about two cartloads of rubbish per day, and the resultant ash about one pailful. As the material is on hand, the cost is only for labor, being the wages of two men at $4.00 per day, or $8.00—that is, $1.00 per furnace. The advantages of these portable destructors are obvious, as they clean up the rubbish that would otherwise be mixed in with the street sweepings and ashes. They also handle the litter on the street surface, and when the man has reached the end of his route there remains to be handled but a small quantity of ash. The first one of these furnaces was put in operation on Saturday, February 16. At this writing there are about twenty-five at work. The reports from the district superintendents, the section foremen and also from the men who handle them are favorable, and it appears that this is a reasonable proposition and one that will save considerable trouble and add very largely to the sanitary state of the work of this Department.

In the practical use of this portable incinerator some points of difficulty developed, which will probably cause its discontinuance in the present form. The furnace will keep up combustion without serious emission of smoke if it be fed continuously with small pieces of light paper, but will not burn fruit rinds or wood. When there is a large quantity of paper charged at once then there is smoke followed by flames and sparks from the top of the upper can. The expense of collection and slow feeding is greater than that of the old method of sweeping and removal by carts. The slight thickness of iron soon warps and gives way under the heat and is not worth the trouble and cost of repairs. Since nothing but light paper and cardboard can be burned there is left a large amount of other refuse, which must be swept up and cared for in the usual way, making double work for the sweepers. During the strike of the cart drivers of the Department in 1907 these incinerators were of very considerable service, but could deal with only a small fraction of the total street refuse. Of the twenty-five built there are but few left at work, the number is not increased, and at this writing the Department had decided not to continue their manufacture or use in this form.

THE PORTABLE FURNACES OF THE ENGLISH DESTRUCTOR BUILDERS.

The construction of portable furnaces has been carried on by the English builders, following in their main details one general form, but each builder adding such special features as are common to their own standard destructors.

The Meldrum Simplex Portable Destructor (Fig. 53) is perhaps one of the best examples, being specially designed for military camps and for sparsely settled communities, where the cost of refuse collection and haulage to a central station would be excessive.

The destructor is a steel cylinder mounted on wheels and provided with large doors at the rear end for light refuse with a

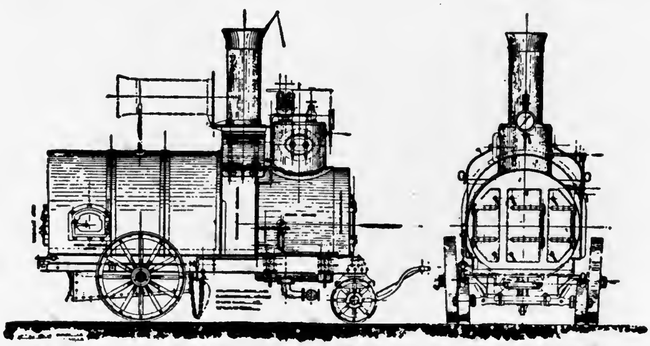

FIG. 53.—THE MELDRUM PORTABLE DESTRUCTOR.

smaller door on the side for wet offal. The grate surface of the fire box is as large as possible and there is provision for obtaining forced draft from the steam boiler. High temperatures are maintained, and there is a special apparatus for destroying the fumes of all combustion, as in the standard Meldrum furnaces.

The Horsfall Destructor Company also manufactures a portable destructor for use in districts too thinly populated to justify the use of a destructor of the usual type, also for military camps and similar purposes. This portable destructor consists of three pieces, destructor proper, the boiler and the smoke box containing a dust-catching arrangement. It is built on the well-known principle of the Horsfall Destructor, and may be relied upon to consume miscellaneous rubbish economically and without nuisance. The boiler is of the locomotive type, and supplies steam for the blowers, and is provided with a junction to which can be coupled the steam pipe of an engine for doing any useful work, such as

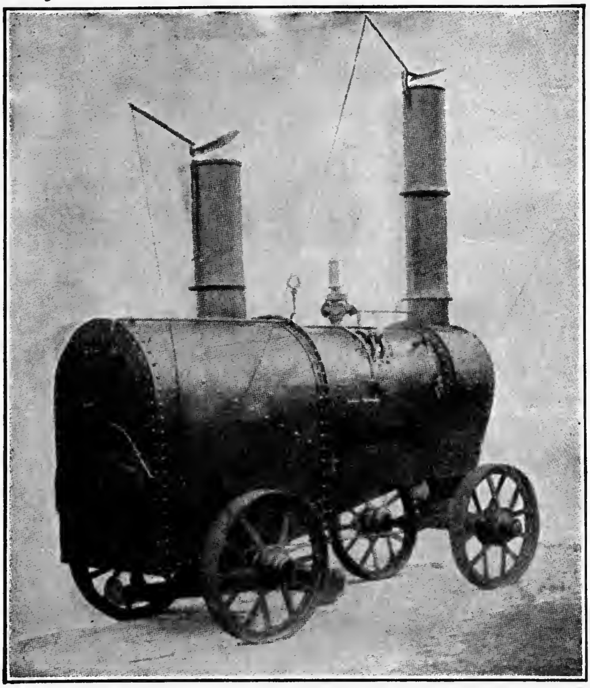

FIG. 54.—THE HORSFALL PORTABLE DESTRUCTOR.

driving a mortar mill or a small lighting plant, or a steam disinfector may be connected. This destructor may be easily removed from place to place by horses or by traction engine, and will readily burn six tons or more of refuse every 24 hours.

There are two sizes manufactured, with capacity of 500 and 1000 lb. per hour, respectively, being the usual mixed, unsorted waste collections.

There is no record of the use of these portable furnaces continuously in municipal disposal work. Their chief purpose is the destruction of large amounts of light refuse produced by the temporary presence of a considerable number of persons, where the cost of the regular service would be too great. In times of epidemic, when the occasion might arise for the prompt and effectual destruction of dangerous matters, a powerful portable furnace would be of great help to the sanitary authorities. Since there is a boiler, raised to any desired pressure, there would always be a current of steam at high temperature to assist in the disinfection work, so necessary in times of emergency.

PORTABLE FURNACE STILL EXPERIMENTAL.

There is undoubtedly a place for a portable furnace, and within its powers it will be a useful adjunct to the other methods of municipal waste disposal. But it does not seem to have passed the first experimental stages of construction. Those that have been tried here have developed inefficiency in some essntial point, or prhaps too much has been expected of thm and too great claims made for their work. To burn large quantities of wet garbage in a traveling furnace with a chimney necessarily low, and to discharge the smoke and gases incompletely destroyed into the air on a crowded street would manifestly be an unwise proceeding. Even the best and most powerful forms of furnaces are not always at their highest efficiency, and with the varying, uncertain amount and character of usual city waste, the results of portable furnace work would be exceedingly doubtful.

THE CALORIFIC VALUE OF MUNICIPAL WASTE.

In determining the most suitable forms of cremating furnaces for the disposal of waste by fire it becomes desirable to ascertain the calorific value of the waste in mixed and separated collections of the usual and average composition in American towns.

It is only within the past two years that reports upon this point have been available, and in only one town have they been prepared with the aid of scientific laboratory tests. The theoretical values obtained through the medium of a calorimeter have been checked by practical trials made with various classes of municipal waste, extended over the period of a year. The average of each experiment may be accepted as representing approximately the calorific value of waste in American towns where conditions are similar, making, of course, whatever allowance is necessary for exceptional proportions of any waste constituent.

The following table has been made by the author from the reports of Mr. J. T. Fetherston upon the municipal wastes of West New Brighton, Staten Island, N. Y.:

TABLE XLIII.—CONSOLIDATED TABLE OF CALORIFIC VALUES OF MUNICIPAL WASTE.

Materials as Collected—See Table	One Ton Ashes, Rubbish Garbage and Refuse			One Ton Rubbish, Refuse and Garbage						One Ton Ashes, Rubbish and Refuse				Equival † coal value in one ton each separated waste, ashes, garbage, refuse, lbs.
	Component Parts as Coll't'd	Per Cent. Proportion in One Ton Pounds	Coal Equiv. at Calorific Values Lbs.	Component Parts as Coll't'd	Per Cent. in One Ton %	W'ght in Lbs.	Garbage — Composition Per Cent.	W'ght in Lbs.	Coal Equiv. at Calorific Value Lbs.	Component Parts as Coll't'd	Per Cent. of W'ght %	W'ght in Lbs.	Coal Equiv. at Calorific Value Lbs.	
Ashes: Fine Ash	34.7	694	103	......	......	......	....	......	......	34.7	46.2	924	138	164
Ashes: Coal and Cinder	26.7	534	201	......	......	......	....	......	......	26.7	35.6	712	268	318
Ashes: Clinker	1.8	36	3	......	......	......	....	......	......	1.8	2.3	46	4	5
	63.2	1,264	307							63.2	84.1	1 682	410	487
Rubbish: Glass, Metals, etc.	4.8	96	......	4.8	13.0	260	....	260	......	4.8	6.4	128	......	......
Garbage: Free Water	.....	498 { Moist., 71.4% =355	......				....	.....	......	......	......	......	......	......
Garbage: Moisture	24.9	Solids, 28.6% =143 }	90				71.4 Moist.	967	......	......	......	......	......	......
Garbage: Solids	.....			24.9	67.7	1,354	28.6 Solids.	387	252	......	......	......	......	363
Refuse	7.1	142	92	7.1	193	386	....	386	250	7.1	9.05	190	122	1,298
Totals	100 Pts.	2,000	480	36.8	100%	2,000	100%	2,000	502	75.1	100%	2,000	532	2,148

Assuming these figures as correctly representing the accurate and theoretical values, in the table following they are extended to cover the various collections of mixed waste, and expressed in equivalent coal values.

In all these tables the author has used the word "refuse" to mean the dry combustible light waste, and employed the word "rubbish" to mean the residuum left of incombustibles, after sorting out the marketable and combustible portions. Rubbish properly includes the glass, metals, tins, crockery, and generally all unburnable matter.

TABLE XLIV.—THEORETICAL CALORIFIC VALUES OF AMERICAN CITY WASTE, IN EQUIVALENT COAL.

Combined waste:	1 ton ashes, garbage, refuse and rubbish	480 lbs. coal
	1 " garbage, refuse and rubbish......	502 " "
	1 " ashes, refuse and rubbish........	532 " "
Separated waste:	1 " ashes..........................	487 " "
	1 " garbage........................	363 " "
	1 " refuse.........................	1,298 " "
	1 " rubbish........................	....

It must be noted that these equivalent coal values are theoretical results only—since the determinations are based upon laboratory tests, and the ratios calculated from these.

These theoretical results are to be considered as indicating the amount of heat units, but do not show the actual product of power developed by the burning waste.

TABLE XLV.—CALORIFIC VALUE PER POUND OF WASTE FOR DIFFERENT PERIODS.

PERIOD	Calorific Power of Combustible, B. T. U.	Moisture Per Cent.	Ash, Per Cent.	Combustible Per Cent.	Remarks
Spring.....	4,747	14.03	50.06	35.91	Computed results based on average figures for corresponding periods, except that average calorific values for summer components were used in arriving at September results.
Summer...	3,477	28.86	39.74	31.40	
Autumn...	3,833	27.74	39.74	32.52	
Winter....	4,358	13.11	52.72	34.17	
Year......	4,274	19.74	46.03	34.23	
September.	3,265	35.83	33.69	30.48	

The actual measurements of heat values of unseparated city waste, according to the observations and deductions of several experts, are shown in the table XLV:

Mr. Hering gives the following estimate of calorific values of the waste of Milwaukee as collected:

Garbage (as collected)	1,500 B. T. U. per pound
Rubbish and ashes mixed	5,000 " " " " "
Manure	2,000 " " " " "

These computations vary according to the different constituents of waste, and its physical conditions as containing more or less water. They agree in one point only, that the actual heat units per pound of waste is sufficient to continue combustion, and if taken together in mixed collections require no additional fuel for combustion. But the conditions of combustion are those of forced draft or of a chimney draft of equivalent power.

THE CALORIFIC VALUE OF ASHES.

In examining these calculations there are some unexpected and surprising results. For instance, the fuel value contained in ashes seems to be far greater than has been supposed. Household ashes are known to have from 25 to 35 per cent. of unburned coal mixed with cinder and slate, and also contains nearly 40 per cent. of finely burned ash. This ash has not been held to possess any heat value, and under the usual furnace conditions with natural draft does not develop power. But when treated by itself it contains a considerable proportion of combustibles. This is illustrated by laboratory tests made in July last, with samples of steam-boiler ashes from the plant of one of the largest manufacturing works in this country, where the daily output of ash is from twenty-five to thirty tons. All of the boilers are fired by mechanical stokers of various patterns. All use the same semi-bituminous coal.

TABLE XLVI.—LABORATORY ANALYSIS OF STEAM ASHES.

Moisture	0.54 per cent.
Ash	51.42 " "
Total combustible	48.04 " "
Calorific power	7,737 B. T. U.

Following the same line of calculations as in previous tables, it would appear that one ton of these ashes has a theoretical equivalent coal value of 1,100 pounds. Assuming the combusti-

TABLE XLVII.—RANGE OF CALORIFIC VALUES, SHOWN BY TESTS, AND THE PROPORTION SUCH RANGE BEARS TO THE AVERAGE VALUES.

Basis	Anthracite Coal		Bituminous Coal				Municipal Refuse (1906)					
	DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY NEW YORK CITY		U. S. GEOLOGICAL SURVEY				LABORATORY, COMMISSIONERS OF ACCOUNTS					
	From Pennsylvania (56 Samples)		From West Virginia only (12 Samples)		From West Virginia, Pennsylvania, Illinois and Iowa (23 Samples)		Coal and Cinders, From Borough of Richmond (24 Samples)		Garbage, From Borough of Richmond (23 Samples)		Refuse, From Borough of Richmond	
	Range, in British Thermal Units	Percent. of Av'ge Value	Range, in British Thermal Units	Percent. of Av'ge Value	Range, in British Thermal Units	Percent. of Av'ge Value	Range, in British Thermal Units	Percent. of Av'ge Value	Range, in British Thermal Units	Percent. of Av'ge Value	Range, in British Thermal Units	Percent. of Av'ge Value
On the basis of the calorific value per pound of combustible.	1,080	7.5%	879	5.7%	3,458	23.8%	1,960	13.7%	2,220	21.5%	1,640	19.0%
On the basis of the calorific value per pound of dry sample.	6,379	50.0%	1,464	10.0%	5,342	42.0%	5,155	60.0%	4,265	51.0%	3,053	42.0%

bles according to another determination at 5,000 B. T. U., the coal equivalent would be 768 pounds. These results seem to be unexplainable except upon the supposition that a large proportion of the fine coaldust falls through the grates and is removed with the ash, clinker, and cinders.

The table (XLVII) by Mr. Welton gives the range of the theoretical values of the three classes of waste; at New Brighton, as actually collected, and on the basis of a dry sample. The camparison made with the kinds of coal shows the approximate calorific value of the waste.

With respect to the foregoing table Mr. Welton says:

To those who are not familiar with the calorific values of the staple fuels, such as anthracite and bituminous coals, it may appear that no great confidence should be placed in the results of these tests on material which would naturally be expected to vary widely in character. As a matter of fact, the experiments have shown a uniformity of character in the material which is all the more remarkable in that it was not anticipated. Indeed, now, when all the data are at hand, the conclusion might easily be drawn that in the instances where the largest variations in calorific values per pound of combustible occur, this variation is more likely to be due to the difficulty of obtaining representative samples from the collections than from actual differences in character.

Moreover, few who have had no occasion to study the mater of analyses and calorific tests of coal are aware of the variation in fuel value of its combustible portion or what is known as "pure coal."

THE CALORIFIC VALUES OF OTHER WASTE.

The subject of the disposal of many forms of waste matter other than municipal refuse is attracting attention all over the world. Abroad, the large industrial corporations which have trade waste or a large output of steam-boiler ashes are taking up the question of their economical disposal. At several places in England, where the colliery waste will frequently spontaneously ignite, causing much trouble, it has been demonstrated that these fuels of low calorific value and a high percentage of incombustibles can be profitably consumed. Similarly in shipyards, railway shops, and large manufacturing concerns where there are large quantities of wood chips, shavings, sawdust, paper, cinders, and ordinary works refuse, the saving in fuel when burned in a specially designed plant has warranted the outlay for equipment and overcome the difficulty of disposing of these waste materials. The following table gives the approximate calometric values of some waste matters that can be advantageously consumed:

TABLE XLVIII.—CALORIFIC VALUES OF WASTE MATERIALS.

Class of Material	Lbs. Water per Lb. Fuel From and at 212° Fah.	Colliery Refuse	Lbs. Water per Lb. Fuel From and at 212° Fah.
Cotton waste	4.1	Fine washings	10.20 to 5.01
Sugar refuse	2.35	Pond settlings	10.3 to 12.04
Newspaper	6.85	Shale pickings	4.45 to 9.62
Tissue paper	6.2	Fine coke dust	9.4
Brown paper	5.6	Screen pickings	8.05 to 13.
Wood chips, wet	3.5	Tank settlings	5.75
" " dry	8.2	Coke and coal dust	10.2
Brick kiln cinders	4.8		
Shoddy refuse	5.2	Peat, dry	10.62
Cider refuse, wet	1.9	" wet	7.65
" " dry	8.4	Straw, dry	6.5
Spent tan bark, dry	5.46	" wet	5.6
" " " wet	3.84	Sawdust	5.1

The value of some forms of industrial waste is shown in the following report of a test made in January, 1908:

XLIX.—RESULTS OF TESTS CARRIED OUT BY MESSRS. HARLAND & WOLFF, BELFAST, IRELAND, ON A 3-GRATE (75 SQ. FT.) MELDRUM SIMPLEX DESTRUCTOR INSTALLED FOR BURNING THE REFUSE COLLECTED IN THEIR SHIPBUILDING YARDS AND SHOPS, JANUARY 21, 1908.

	Hrs.	*Mins.*				
(1) Total Duration of Test	10	20				
Less for meals	1	40		*Hrs.*	*Mins.*	
Net duration of test				8	40	
(2) Fuel Consumed:	*Tons*	*Cwt.*	*Qrs.*			
General rubbish	14	18	0			
Sawdust, shavings and lighter stuff	9	12	0			
Gross	24	10	0			
Less iron, wood, etc., sorted out	1	0	0	*Tons*	*Cwt.*	*Qrs.*
Net rubbish burnt				23	10	0
	Tons	*Cwt.*		*Tons*		
(3) Fuel Burnt per Hour	23	10		=2.71		
	Hrs.	*Mins.*				
	8	40				

(4) Total Water Evaporated During Test (weighed) ..... 102,933 lbs.

(5) Water Evaporated per Hour.. 102,933 lbs. / *Hrs.* 8 *Mins.* 40 =11,890 lbs.

(6) WATER EVAPORATED PER LB. OF FUEL (actual)........ 1.955 lbs.

(7) TEMPERATURES:

Gases leaving boiler	540° F.
Temperature of steam leaving superheater	650° F
Temperatuıe of steam at laıge separatoı	410° F.
Temperature of steam at No. 2 Engine	400° F.

NOTE.—Temperature of saturated steam at our working boiler pressure of 200 lbs. per square inch=388° F.

(1) The normal evaporation of the Scotch Marine boilers in our Generating Station is 10,300 lbs. of saturated steam per hour.

(Signed) HARLAND & WOLFF, Limited.
E. W.

As illustrating the power to be had from refuse coal waste, there is appended the details of a trial made at the North Navigation Collieries, South Wales, on two Meldrum Simplex Colliery Destructor Furnaces, coupled to two Lancashire boilers, 30 feet long by 8 feet 6 inches diameter, consuming coke oven breeze and pond settlings, with evaporation from cold feed water.

	DURATION OF TEST	
	8 a.m. to 9 a.m.	12 noon to 4:30 p.m.
Fuel used	C. breeze and P. settlings.	C. breeze and P. settlings.
Water evaporated per hour	1,872 gals	1,620 gals.
Total water evaporated	1,872 gals	7,400 gals.
Temperature feed water	40° Fahr.	40° Fahr.
" atmosphere	45° Fahr.	45° Fahr.
Steam pressure	125 lbs.	125 lbs.
Fire	Clean at start	Two furnaces cleaned during test.

The utilization of trade waste in developing steam power in private business establishments is rapidly coming to the front in this country. Not only does the incineration produce power, but it also provides a practical way of getting rid of forms of worthless matter which are frequently troublesome to deal with and costly to convey away from the works. Every manufacturing company has to deal with this problem in a greater or lesser degree, and the examples of this method of disposal reported from foreign factories are being followed by American manufacturers. The installation of a Meldrum destructor at the great works of the General Electric Company, at Schenectady, N. Y., will turn all the waste matter of the plant into steam to be utilized in the premises. The same means is to be employed in a large department store in New York City, and a hotel in New York is about to install two separate destructors, each with steam boilers for obtaining power from the combustion of the refuse of the building.

In each one of these instances a special form of powerful destructor furnace, with forced draft and air regenerating apparatus, is employed. The usual form of American crematory cannot deal with such problems, since up to the present time only one or two constructions have been able to produce boiler power more than barely sufficient for the needs of the furnace itself.

SURVEY OF AMERICAN CREMATING METHODS.

With this chapter the history of American crematory furnaces down to October, 1908, is brought to a conclusion. Those that have been built in the United States and Canada in 1907-8, with few exceptions, are either of an improved American type under American patents, or of the British type, which has now acquired a foothold in this country in four or five installations. These are separated and taken up later as a distinct advance from the cremators and incinerators of the preceding descriptions.

Did space permit, there might be added an account of many attempts made in the past to construct and operate garbage cremating disposal works, some of which were costly and ingenious experiments that barely failed of success. Others that simply implied stupidity and ignorance in the fundamental principles of the art, and still others that were built for the sole purpose of making a show to secure a contract.

Undoubtedly there will be still brought forward many forms of furnaces for this work that are destined to fail, and some that may achieve a success that will be permanent. The field is a wide one, the opportunities many, the necessity undeniable and the rewards great in promise.

But it must be remembered that with the experience of past years behind them, with the assistance of expert engineers who are now turning attention to this neglected branch of municipal service, and with a better knowledge of what the several communities really need, the municipalities are not disposed to accept offers of furnace builders unless there be positive and reliable evidence of the capacity, durability, efficiency and sanitary operation of the forms of furnaces offered.

This evidence should not consist of the profuse and glittering statements of prospective builders, even though they be supported by flowery newspaper accounts of a trial made at the instance of and in the interests of the builder, nor the telegrams of a far distant city official whose knowledge comes solely from an employee whose place depends upon putting the most favorable aspect upon what is really a lamentable failure, or at best only a partial success.

Nothing but an official record of costs and results over a period of at least one year should be accepted, and this should be verified by the personal inspection and unbiased report of a competent engineer of their own city, or from one whose knowledge of this branch of work includes experience and study of all the various forms universally used.

Only by a thorough, exhaustive examination of all the points involved can the town authorities be certain that they are securing the best and the most suitable apparatus for the particular work they want done.

DIFFERENCES IN FORMS OF FURNACE CONSTRUCTION.

When considering and comparing the various forms of American garbage cremating furnaces, it will be seen that they may be divided broadly into two general classes or groups, the members of each group having many points in common, similar methods in operation, and all arrive at practically the same results in their general work. In each class there are some minor subdivisions, but none that depart widely from the distinguishing type.

The first class or group have the following distinctive points:

1. They are the crematories and incinerators that burn only garbage and refuse upon long horizontal garbage grate bars, either in single or double arrangement, and charge the waste through circular or rectangular openings in the roof.

2. They deposit the garbage upon the largest area of surface that the plan of the furnace will permit, piling up the largest quantity possible to charge without stopping the passage of the flames. In one form of fur-

nace these bars are of hollow iron inclined from the middle line to the sides instead of being horizontal.

3. The heat is not utilized for operating a steam boiler, nor does the construction permit the use of a boiler with any certainty of obtaining power.

4. They consume the waste by heat applied from fuel boxes at one end, one side, or below the grates, and pass the heat over and under the masses of garbage, since it is practically impossible to force the passage of flame or heat through thick masses of wet household garbage by chimney draft.

5. For the purpose of stoking or stirring the garbage there must be a series of doors on the line of the grates, and below a second series for removing ashes. These doors admit large volumes of cold air, which must be heated to the temperature of the furnace interior before combustion can continue.

6. This operation of stoking causes moisture and unburned garbage to pass through the grates into the lower compartment, where it is slowly dried out until in a condition to burn. The evaporation from this moisture is not completed or destroyed until the secondary fire is brought to bear, and then only when this fire is at a temperature of 1,500° or above.

7. There is an average low temperature in all parts of the furnace except immediately adjoining or above the fuel box. The presence of moisture in masses of household waste over which the flames and heat pass to the chimney, the continual admission of volumes of cold air reduce the temperatures until the smoke and gases are not destroyed. In one experiment where an electrical pyrometer recorded the temperature the heat immediately behind the fuel box was 1,500 degrees, but decreased for each four feet of the garbage grate 300 degrees, finally leaving the burning chamber at 600 degrees in the shape of smoke and watery vapors taken up but not consumed. In one instance the sides and top of the furnace are double jacketed steel plates, with which are connected all the water grate bars for sustaining the garbage. This to some extent maintains the construction, but lowers the temperature, as the heat is absorbed by the surrounding water surfaces.

8. There is always an imperative need for a secondary or smoke-consuming fire in the furnace itself or in immediate conjunction to reheat and reburn the incomplete combustion.

9. And it follows that fuel must be used in greater or lesser amounts to keep up the initial heat of the furnace fire and maintain the smoke and gas-consuming temperatures of the secondary fire.

Conditions Necessary to Success.—When crematories are required to burn garbage and refuse (excluding ashes) in the usual proportions as collected in American towns, and when these wastes are separately collected and brought to the crematory to be destroyed by natural draft, the work of combustion is not performed in the most efficient way.

The conditions of success of burning wet fuels, as stated by Prof. R. H. Thurston, are "the surrounding of the mass so completely with heated surfaces and with burning fuel that it may be rapidly dried, and then so arranging the apparatus that the rapidity of combustion be precisely equal to and never exceed the rapidity of desiccation." How far these conditions are met in the construction and arrangement of cremators and incinerators can be easily seen by inspection of the previous plans and descriptions.

When garbage and refuse, separately collected, are brought to an incinerator, or crematory, and charged separately into the furnace, what then takes place is further described by Prof. Thurston: "When this rapidity of combustion is exceeded the dry portion is consumed completely, leaving the uncovered mass of wet fuel, which refuses to burn." This is precisely what happens when large volumes of dry rubbish are burned with an excessive amount of cold air, and the heat is rapidly carried to the chimney, leaving the wet mass of garbage on the grates. Coal or other fuel must then be added to continue the combustion.

These imperfect conditions in crematories are inseparable from the very nature of the construction. Natural chimney draft, operating with equal force in all parts of the interior and drawing cold air in through the many doors and other openings, does not exert the same power for combustion of material upon a grate as does a forced draft powerfully applied under the limited area of the burning fire surface. In the one case the fire is at one end of a long series of grates piled with wet material, over which the heat is drawn by chimney draft. In the other case the heat is increased by forced draft below each grate to such an extent that the waste is consumed without other fuel. The calorific elements of the waste are utilized, combustion is accomplished in shorter time and at far higher temperature than in the first example.

The second group of crematories used in American disposal work is composed of those whose construction follows the cell type and are largely imitations of the British cell destructors of an early date.

They are built with partitions or divisions between the fuel grates, and with sloping drying hearths to receive the initial charges of waste. They proceed by stoking down the waste when partially dried to the first division of the fire bars, and complete the combustion on the second or lower set of bars, withdrawing the ashes through the front clinkering doors. Additional fuel is supplied to the second set of fire bars when needed. The smoke and gases from the furnace pass through side flues to one main flue and thence to the chimney. No fume cremator or secondary fire-box is employed.

The heat in this large main flue is not sufficient to raise steam in a boiler, and no forced draft can be obtained from the combustion of the waste. The chimneys are necessarily of extreme height, since the unconsumed smoke and gases must be discharged at a high altitude to avoid cause for complaints of nuisance.

The rate of combustion per square foot of grate surface is low, and a long time is required to consume a charge by natural draft. This compels a greater number of cells, with a corresponding increase in the cost of the plant in order to destroy a given quantity per day.

CREMATORS AND DESTRUCTORS COMPARED.

The differences pointed out between the cremators and destructors, and the comparison of the results of the work of each, are obviously in favor of the destructor system of disposal.

This statement is made, not with the purpose of unfair criticism or harshly condemning the work of the past years of American furnace builders. The author has been identified with a large number of these crematory installations in many varied forms, and knows at what cost of money, time and earnest effort they have been built and operated. But taking the record of the years past and comparing the results accomplished with the expected and promised returns, it must be admitted that there is a failure to achieve anything more than a partial success. The future of this work as at present carried on does not offer an encouraging outlook, and it seems absolutely necessary that a change be made, and some better form of apparatus be brought into service. The experience of other countries should be brought to our aid, now that we know the conditions of the American communities are almost identical with those existing abroad, where successful methods of destroyal of municipal refuse by fire are in use.

In the past two years there have been four destructors installed that have met the guarantees made for their performance, and proved their ability to deal with the municipal waste of the country precisely as is done by other destructors in more than three hundred installations in other parts of the world.

This has led to the thorough examination of the subject by engineers sent from this side, and in four cases these destructor methods have been adopted by American and Canadian cities. Other cities are engaging competent engineers to examine and report upon their own requirements with the intention of adopting that method which may be most suitable for them.

All this means progress; it means the application of the best engineering talent obtainable and the permanent establishment of durable and successful methods; and let us hope, it also means the end of the crooked and doubtful ways of obtaining concessions and contracts that react alike upon the builders and the towns and are a reproach and a menace to all who are connected with this work.

PART III.

THE DISPOSAL OF WASTE BY BRITISH DESTRUCTOR SYSTEMS.

CHAPTER X.

High Temperature Refuse Destructors.

Mr. W. Francis Goodrich, the well-known English writer on destructors and their work, gives the following three classes into which refuse destructors may be divided:

First, 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.

Second, destructors provided with artificial draft, and, therefore, more efficient *as destructors,* by reason of the higher temperature obtained, and greater destroying capacity, but which only provide power for work purposes or clinker utilization, and

Third, destructors of modern types providing the *maximum* amount of power available from the refuse, and available for the generation of electricity, for pumping sewage, for gas works or other municipal purposes for which power is required.

Mr. Goodrich further says:

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.

The above description of results obtained by the early forms of the British destructor may be applied to the present forms of crematories and incinerators used in this country, without the change of a single word. That this description was true of the first installations in England is agreed to by all writers who have published accounts of the work of destructors abroad. That it is true of the results obtained by prevailing methods and apparatus in this country will be equally obvious to anyone who will note the beginning, progress and present state of disposal of municipal waste by fire.

We are practically at the point in this country that they were in England when the "fume cremator," or secondary fire, was established as a necessary accessory to the furnace.

If, after experience of more than twenty years and the construction of nearly two hundred different furnaces by more than fifty different builders, we have not succeeded in evolving a satisfactory and efficient means of consuming wet fuels, despite the repeated attemps made to do so by means of inadequate apparatus, it would seem that it is high time for a change in methods in one direction or another. Either let us give up the question as one impossible to deal with, bring forward some new furnace of more powerful design than its predecessors, or adopt the methods and apparatus which have been proved to be satisfactory in nearly parallel conditions.

The foregoing characterizes our present position in waste disposal work. A point has been reached where to go back means defeat, and to go on with the appliances of to-day means simply a continuation of past results. The alternative is to bring the experiences of other nations to the aid of American communities and achieve an advance that will be radical and permanent.

American Conditions.—When considering the situation here as compared with that of English towns we must take into account the varying nature and proportions of the waste with which we have to deal, and we must also accept the conditions imposed by the communities which ask help in the matter.

The English method of procedure is to collect all kinds of municipal waste (except night-soil) in one receptacle with no separation, and to burn this mixed mass at one operation, utilizing the power when practicable, or allowing it to go to waste, when necessary. There is no attempt to separate the wastes; nor in any place, except in a limited way in some of the largest cities is any effort made to recover anything for market. Probably this is because the population is more economical in habit and less wasteful than that of the American communities.

But here the conditions are somewhat different. Unless there is a practical and unmistakably evident way in which power derived from the combustion of its waste can be employed a town does not usually elect to dispose of its waste by the use of a destructor. Garbage is burned, refuse or rubbish is now also being burned, but ashes are conveyed to dumps or used for making land and roads.

The separation of garbage from other forms of waste is rightly considered a necessary step to secure sanitation in the household; it is also a convenience to the towns, because where this system obtains, garbage can be handled by itself, apart from the volume of ashes which forms the largest portion of town waste. Hence the need of furnaces that deal with garbage alone, or garbage in conjunction with rubbish, ashes being entirely eliminated. The crematories do this by using coal to burn wet masses of garbage by itself; also by the building of larger furnaces to receive the rubbish, employing it as fuel as far as possible. Because of the limited draft obtained through the chimney there is slow combustion and low temperature, causing frequent objection on the score of nuisance.

Manifestly, an improved means of disposal by fire must deal with conditions as they are, and must be prepared to destroy the separated waste when it is not mixed with large amounts of ash.

These are the conditions confronting the engineers that have the special cases of various cities in hand, whose specifications for the construction of disposal plants contain precisely this feature, the cremation of garbage and rubbish that is practically without the admixture of ashes.

The preceding tables of calorific values of American wastes prove that waste is auto-combustible when fired under favorable conditions. The reports of operating destructors in this country show that waste containing the largest proportions of wet garbage mixed with rubbish is destroyed without fuel, with steam developmen of reasonable power.

As far as we have gone the results have been satisfactory, not perhaps equal to all that was expected, but still up to the standard set by the makers of the destructors, and in every case, so far, exceeding the guaranteed capacity and power development.

This practically fills the description by Mr. Goodrich of the destructor operating *as a destructor,* and destroying a greater quantity at a higher temperature than can be done by furnaces without the special features of a destructor. This authority says:

> 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 super-

seded by artificial draft. 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. . . . Instead of the slow, low temperature distillation of the gases, or cooking of the material, the fires were now made 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.

Destructors in American Practice.—When the destructors are required to furnish power for works purpose only, that is, for forced draft for the furnace, and for driving mortar mills and crushing machines for preparing the clinker for tile or bricks, the boilers are smaller than when power is to be developed for electric lighting. An example of this is at Vancouver, B. C., where the destructor deals with the garbage, refuse and a limited quantity of ashes having a low calorific value. Here the boiler is 65 horsepower instead of the usual 200 horsepower commonly installed with a 50-ton destructor.

At Seattle, Wash., and at New Brighton, N. Y., the destructors are at present operated for disposal only, no use being made of the power, although each of these installations has a 200 horsepower B. & W. boiler, with all accessories. The purpose is to employ power at these plants later on.

A good example of the advantages of an installation for disposal only, and the subsequent utilization of the power for the production of revenue, is at Prahran, Australia, where at first the power was not employed, but was subsequently found to be of sufficient value to nearly defray the operating expenses of the plant. (See Chapter XI, Prahran Destructor.)

DESTRUCTORS OF MAXIMUM POWER.

The third classification made by Mr. Goodrich, of destructors of the modern type providing the maximum amount of power, available for many municipal purposes, is well illustrated in American practice by the work of the Meldrum Simplex Destructor at Westmount, Canada.

This combined electrical and refuse disposal station was designed for the utilization of the steam power to be had from the waste as auxiliary to the regular boiler equipment of the station. The reports for two years show that the disposal of the town's refuse in an unseparated condition is perfectly done; that the steam power has an annual value of $5,000, and that the operating expenses are brought down to a figure lower than the average cost of disposal at any other place of corresponding size. There is besides an annual decrease of the previous cost of collection and transportation expenses, due to the central location of the plant.

These successful examples of disposal by the destructor system have been noted by many engineers, and several of the large cities are preparing specifications for the installation of destructors to dispose of the waste, and are considering means for the use of the derived power. It is no longer an experiment, but an accomplished fact that American city waste can be destroyed with absolute sanitary protection, with a certainty of obtaining results in efficiency and a durability of construction heretofore impossible.

The Two Types of Destructors.—The prevailing forms of British destructors in present use are broadly divided into two groups or classes, differing in forms of construction and in means of utilizing the heat obtained from the combustion of the waste.

First. group, the *Cell Destructors* follow the original cell, or separate burning chamber type.

Second group, the *Continuous Grate furnaces,* with burning chamber common to all the grates. The whole list of destructors operating by high temperatures can be classed in these two types, and it seems desirable to give brief descriptions of these in order that a clear idea may be formed of their relative value when applied to the disposal of American municipal waste.

THE CELL DESTRUCTOR.

The Cell Destructor.—Figs 55-59, consists of two or more cells completely isolated from each other, but discharging into a common combustion chamber. This construction of cells in pairs is together called a unit. Each is charged, fired and clinkered by itself. One cell cannot be of assistance to its neighbor, except so far as the gases from both commingle after leaving the cells. The arrangement of the cells may be side by side or back to back, or built in rows, with a combustion chamber or large flue common to all, but for the utilization of heat to produce steam power there are usually one or more units of two cells with a boiler common to both. Some makers place the cells on each side of the boiler. Others arrange them in rows with the main flue beneath. These arrangements, though apparently different, are for the same purpose—insuring the destruction of the gases from fresh charges of waste, so that these in turn shall be made to pas over hot surfaces or be mixed with hot gases.

Each cell has a fire bar area of at least 25 square feet, where the actual combustion takes place, and at the back of the bars a

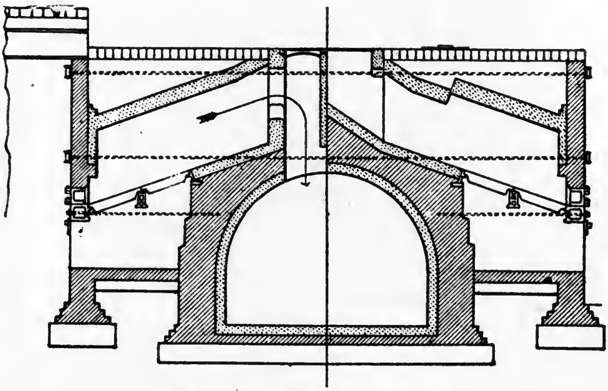

FIG. 55.—THE FIRST FRYER CELL DESTRUCTOR.

sloping, drying hearth of fire brick, upon which the fresh charge is received. The area of this hearth varies with the style of destructor, and may be made larger or smaller, according to the character of waste consumed. This hearth is usually inclined at an angle of 25° to the horizontal, but may be varied as desired. The fire bars, as a rule, are heavy, solid cast or wrought iron plates, set edgeways with very narrow spacing to admit the steam or air blast from beneath and not permit the passage of clinker or ashes. Some makers use a short rocking grate at the front of the furnace with larger stationary bars behind.

The Air Supply to the Cells.—The ash pits of all forms of destructors are closed air-tight and made capable of sustaining pressure, and the air for combustion is delivered to the ash pits below the grates, passing up through the waste upon the fire bars. Each ash pit is thus divided from its neighbor, and in each the forced draft may be applied or discontinued at will. This, of course, is when forced draft by steam or air is a part of the particular construction.

The air supply is one of the most important points in connection with the cremation of municipal waste. With a limited supply the combustion is delayed and temperatures are low. With a too abundant volume, the available fuel is consumed to heat the air, which leaves the furnace too rapidly to destroy the waste.

In cell destructors a pressure of one-half to one inch water gauge, equivalent to 2.6 to 5.2 pounds per square foot of grate is

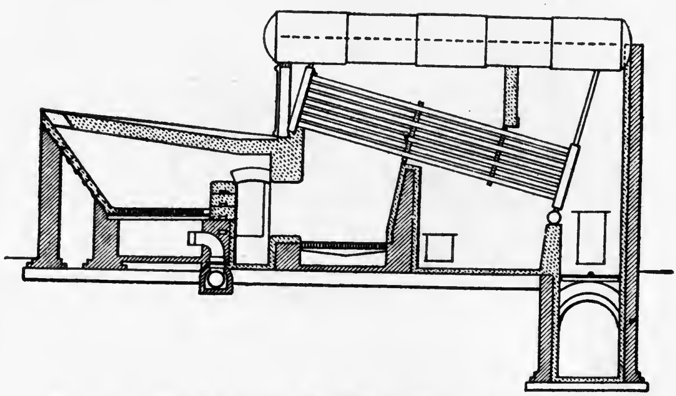

FIG. 56.—THE BEAMAN & DEAS CELL DESTRUCTOR.

the most desirable medium. While a certain quantity of air is necessary for the combustion, and while this varies according to the calorific value of the material destroyed, if a larger volume at greater pressure be supplied, there arise different conditions which materially affect perfect combustion. With the oxygen of the atmosphere is mixed four times its weight of nitrogen, a gas perfectly inert for assisting combustion, but having its own specific ability to absorb heat.

The surplus volume of oxygen not actually required for combustion, united to the correspondingly larger volume of nitrogen, rapidly takes up the available heat, and the whole uncombined volume is carried off to the chimney, lowering the temperature of the burning mass upon the grates. Hence the admission of a larger volume of air than is actually needed for combustion is as detrimental to successful work as is the limitation of the air supply.

Heating the Air Supply.—The heating of the air supply is another important consideration as affecting the rapidity of combustion. When air at atmospheric temperature enters a furnace it must be raised to the temperature of the incandescent carbon in the fuel with which it is to combine before it can aid com-

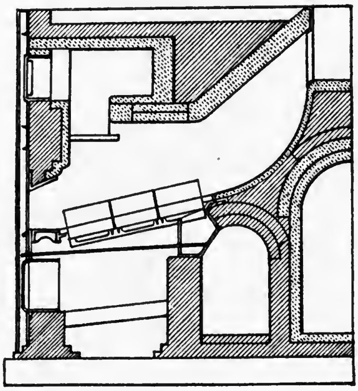

FIG. 57.—THE HORSFALL CELL DESTRUCTOR.

bustion, hence a certain amount of heat that has been generated is delivered to the incoming air, and the temperature of the burning mass is lowered to that extent. For the ordinary refuse-burning furnace, this means a loss of efficiency and an increased quantity of fuel. For destructors with forced draft that must maintain high temperatures, this is a more serious matter, and in the most efficient destructors there are arrangements for heating the air supply. In one destructor of the cell type the air is made to pass through flues alongside the main chimney flue, and thence to the furnace through iron boxes built into the sides of the furnace at the level of the grates. But most destructors of this type do not provide for heating the air, but force it at the temperature of the outside air by fans or steam jets into the ash pit and up through the fire bars. Whatever be the means for obtaining the forced pressure of air supply under the fire bars, the result is the same in all methods, a continuous current of air, which is at all times under control and may be increased or diminished according to the conditions required, and the character and amount of waste charged into the furnaces at different periods of

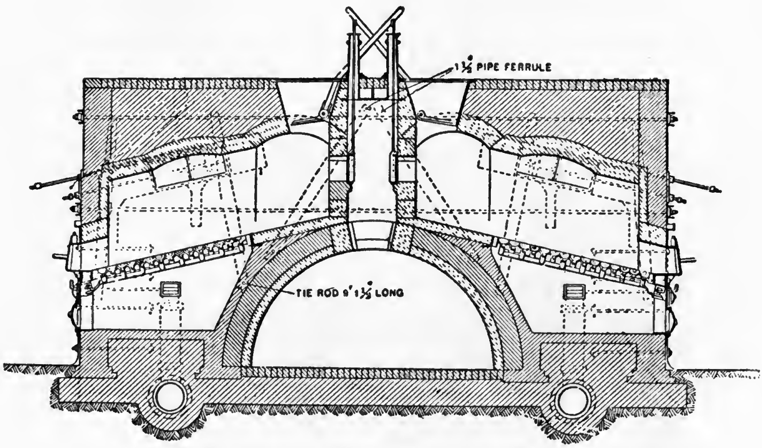

FIG. 58.—THE WARNER CELL DESTRUCTOR.

time. This is especially desirable when destroying bodies of animals.

Utilization of the Heat Generated.—In all installations of the best destructors, the heat generated by the combustion of refuse is utilized in one or another way. The general use is for generating steam in a boiler, the power from which is employed, first for the operation of the destructor itself and the surplus for any work where it can be used to advantage.

The type of boiler is commongly a water-tube so placed behind the combustion chamber that the gases pass directly to the tubes with no loss of heat. A Lancashire boiler with large flues is frequently employed on account of the heat stored in the volume of water. The horizontal multi-tublar boiler of large size set in the main flue to the chimney was formerly used, but now discontinued as an obstruction to the free passage of the gases.

The best efficiency of a destructor demands that the temperature from the combustion of refuse shall be at least 1,500° Fahr. This is the point at which all injurious organisms in the waste and the inflammable gaseous carbon compounds resulting from imperfect combustion are destroyed. A lower temperature would permit these to pass through the boiler and chimney flues and be distributed from the chimney top through the surrounding air. A higher temperature, 1,800° to 2,500°, not only gives better boiler efficiency, but also positively insures destruction of all noxious gaseous and organic elements. Hence the efforts of all destructor

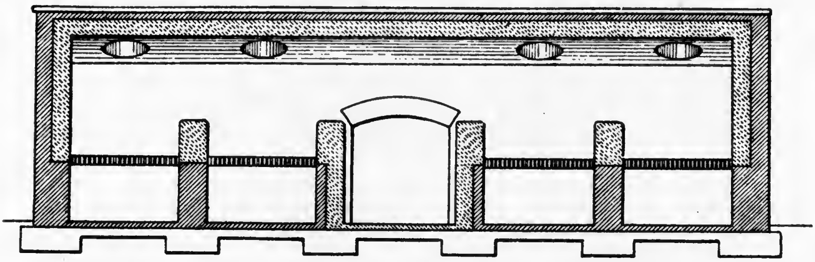

FIG. 59.—THE STERLING DOUBLE CELL DESTRUCTOR.

builders are directed to the production and maintenance of the highest possible temperature within the furnace and in the combustion chamber or flues immediately adjoining. This naturally leads to the development of the greatest boiler efficiency and the use of this power for returning a revenue in some form to the advantage of the town.

But it must always be noted and remembered that *the first consideration is the disposal of objectionable matters.* This is the purpose of a destructor—the main object of its installation. Whatever power may be obtained is a side issue, a by-product, to be utilized if possible; if not, then to be ignored until an opportunity offers.

If this power, obtained from waste that would cost large sums to dispose of in other ways, can be employed, then the town is so much to the good. If it cannot be at once profitably employed, the waste is still disposed of at no greater cost and with the certainty of perfectly sanitary destruction, and permits the eventual use of the power and the clinker.

UTILIZATION OF HEAT FOR AIR SUPPLY TO THE FURNACE.

After the gases have passed the boiler there is still a large amount of heat remaining in them which should be utilized. In practical service the cell form of destructor has heretofore been unable to conserve this heat for its subsequent use. In one form only has this been tried, and the results claimed are equal to the best designs of the continuous grate destructor, which are better adapted for this purpose, but no results from actual practice have yet been reported.

Manifestly the heating of the air supply is a gain to the general efficiency of combustion too important to be ignored. When the air is raised to 350° to 400° Fahr. before being supplied to the grates, there is a corresponding gain in the time and the force of combustion upon the grates. The method of air delivery is by two different forms of apparatus.

The cell destructors, as a rule, use a fan driven by a motor, delivering the air at atmospheric temperature under the ash pits at any required pressure. In this case the temperatures of the current are those of the volume entering at the fan and but slightly above this at the grates, and the air has to be heated to the furnace temperature to continue the combustion.

In the continuous grate system the gases from the boiler are drawn by the chimney draft down through a series of iron pipes, entering at an average of 691° and leaving these pipes at 359° Fahr. The difference between these figures represents the temperature of the current of air drawn between the rows of pipes and by steam jets forced into each ash pit and up through the fire bars.

This is the regenerator system of the continuous grate destructors which deliver the air for combustion at 350° to 400° instead of at 70° to 80° as furnished by the fan system. There is an obvious advantage by this means not obtained in the other cases, and the most recent plants of all types generally adopt the steam forced draft.

THE SECOND GROUP OF DESTRUCTORS.

Continuous Grate with one Burning Chamber.—The destructors built upon this principle (Figs. 60-65) differ from the cell construction in several particulars. Instead of separate and distinct cells isolated one from the other, there is one long chamber common to all the grates, but divided below the grates into separate ash pits.

There may be a number of grates, each of approximately 25 square feet of surface, arranged side by side, and offering a continuous area of burning surface the whole length of the series,

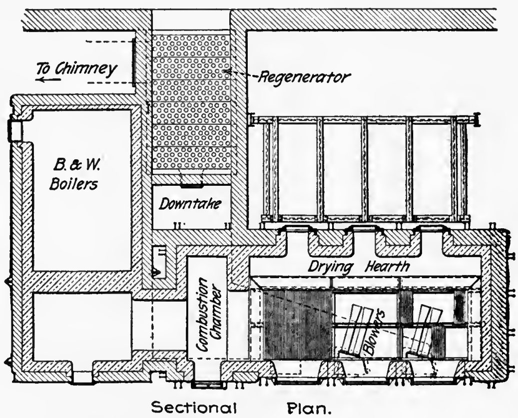

FIG. 60.—THE MELDRUM CONTINUOUS GRATE DESTRUCTOR.

which may be two, three, four, five or six, as the conditions require.

Since each grate has its own ash pit and its separate forced air supply, each may be operated separately, precisely as is done in the single cell, with no interference or interruption with the work of its neighbor. As the grates are charged periodically, there is always one or more at the highest point of temperature in full working, while the adjoining one is being supplied with green material. Thus, there is no loss of time or temperature in the immediate destruction of smoke and gases thrown off from the fresh charge, since the active grates supply the heat necessary to continue the combustion and maintain the average temperature in the combustion chamber.

The continuous grate is better adapted to the various forms of feeding or charging of the waste, since it may be charged from the top through the roof, from the back through charging doors, or from the front through the larger clinker doors.

Choice between these various methods depends largely upon the character of the waste—the purpose for which the power is used, or the location of the several working parts of the destructor. In each case the arrangement may be made to conform to the special conditions, and any well-designed destructor may be adapted to the site.

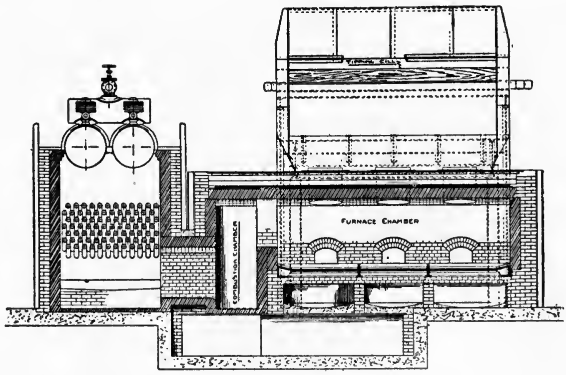

FIG. 61.—THE MELDRUM CONTINUOUS GRATE WITH BOILER. (LONGITUDINAL SECTION.)

Regenerator System of Heating Air for Combustion.—The first practical application of air regeneration to the destructor practice was in connection with a continuous grate destructor of the Meldrum type, at Darwen, in 1897. The use of this system has in effect changed and revolutionized the art and made it possible to destroy waste of low calorific value, and obtain a higher temperature with a corresponding increase in rapidity of combustion and boiler efficiency. By this method of drawing the air for combustion through the series of pipes comprised in the "regenerator," aided by the action of the steam jet blower, the exhaust heat from the boiler flues heretofore wasted has been saved, and the saving brought to the aid of the furnace.

The method of supplying this heated air after its passage between the vertical tubes of the regenerator is by means of steam jets. Underneath each of the grates in the enclosed ash pit is placed a short tube of cast iron which is connected at one end with a small pipe direct from the boiler—the other end, expanded in area, terminating under the middle of the fire bars. The steam, in its passage through the blower, carries a volume of heated air from the hot air duct, which is forced up between the grates and through the mass of material thereon. Thus the air for combustion is supplied at a temperature of nearly 300° above

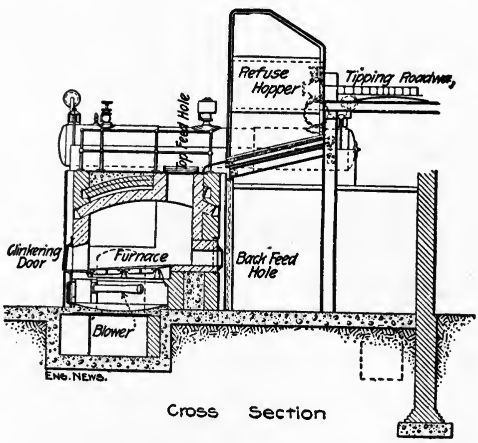

FIG. 62.—THE MELDRUM CONTINUOUS GRATE.

the normal temperature of the current which would be supplied by a fan blast.

Nor is this the only advantage of the steam jet system. In passing upward through the bed of fire upon the grates, the steam is decomposed and "water gas" is formed, consisting of hydrogen and carbon monoxide. Both of these gases are burned when they enter the main chamber, increasing the temperature at that point where it is most wanted, while the oxygen, which is set free by the decomposition in the early stage of this process, assists the combustion of the refuse.

Again, the formation of water gas in the bed of incandescent fuel on the grate greatly assists in the removal of the clinker, and in some instances exhaust steam is admitted under the grates for this purpose. The under side of the clinker thus formed has a clean and vitreous appearance, leaving the fire bars with comparative ease, making the work of clinkering less arduous and prolonging the life of the fire bars.

The Chimney and Dust Prevention.—High chimneys are not wanted in connection with forced draft destructor installations. If the chimney be of small diameter and of unusual height, the gases, in their passage, acquire a considerable velocity and carry with them a larger proportion of dust. On their arrival at the

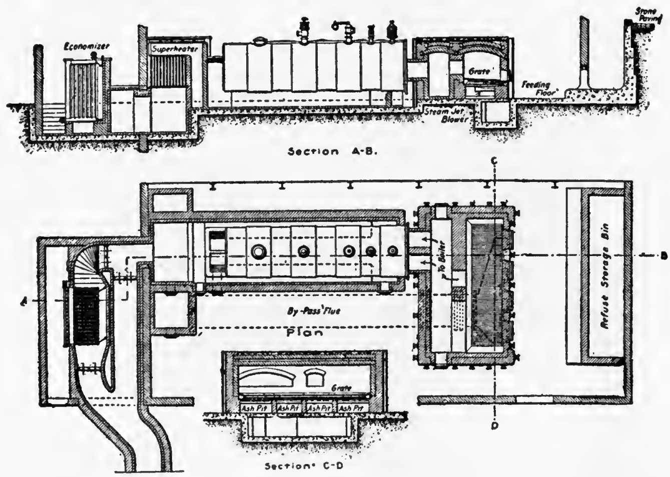

FIG. 63.—THE MELDRUM GRATES WITH LANCASHIRE BOILER.

top, the spreading of the gases issuing from the confined area lowers their velocity, precipitating the dust on the ground and and buildings in the neighborhood. But with a chimney of lower height and larger internal area, the ascent of the gases is slower and the velocity at the top no greater than in the interior, and the dust precipitation is minimized. There are several devices for intercepting the dust on its way to the chimney. In one destructor installation there is a brick chamber, or "dust catcher," immediately before the chimney, comprising two concentric circular chambers with an annular space between. The gases enter the outer chamber, and in passing around this acquire a whirling, circular motion. The centrifugal force imparted causes the dust, as the heavier substance, to move to the outer wall, the lighter gases passing into the inner chamber and thence up the chimney. This device has been employed in a few installations.

A better method is an expanding settling chamber interposed

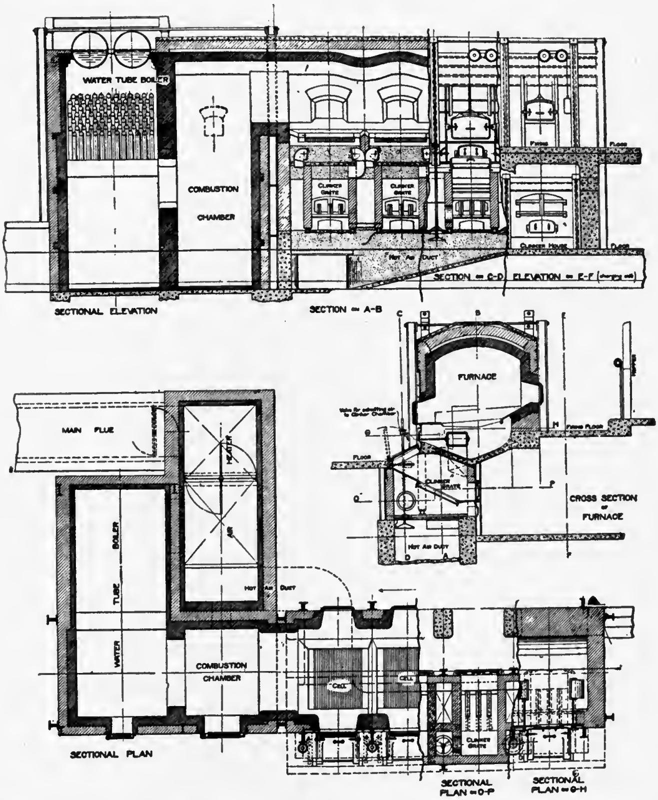

FIG. 64.—THE HEENAN & FROUDE CONTINUOUS GRATE DESTRUCTOR. (PLAN AND SECTIONS.)

in the path of the gases, delaying their passage and causing a deposit of the dust after their velocity has been much reduced. This is an important feature in the continuous grate type of destructor.

Delivery of the Waste to the Destructor.—There are several methods of delivering the waste, dependent largely upon the special character of the material to be destroyed.

The destructors, as a rule, deal with mixed or unsorted waste—the miscellaneous collection as it comes in the city carts. The proportions of each class, garbage, ashes and refuse or rubbish, to which may also be added street-sweepings and the carcasses of animals, are dependent upon many varied conditions, only to be determined by special survey or inspection. Some of the more common conditions attending the usual collections of American municipal waste have been alluded to in previous chapters, and so far as can now be done, the proportions of each class have been defined.

Following the practice of those towns where these various

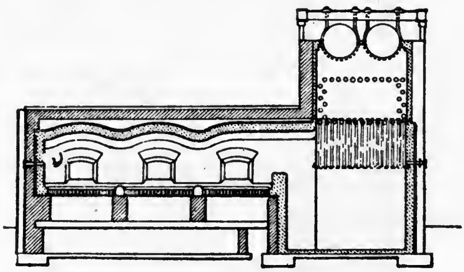

FIG. 65.—THE HEENAN & FROUDE CONTINUOUS GRATE DESTRUCTOR.

forms of destructors are used, and employing the same method of a mixed, unsorted collection of the wastes, it may be positively stated that the American municipal waste can be destroyed successfully with apparatus similar to that used abroad.

Not only can American municipal waste be burned economically with no noxious results, but there can be obtained power from this waste, in exact proportion to the calorific value of the waste.

But when the several classes of American municipal wastes are separated at the houses and the garbage, ashes and refuse are separately collected and brought either singly or together to the destructor, the means of disposal must be adapted to the character of the waste to be consumed. Here lies one of the chief points of advantage of the high temperature destructor systems.

The furnace may be so designed as to cremate one class or kind of waste and yet be capable of consuming other kinds or classes without change in construction and with only changes in method of charging and operating. The addition of power supplied by its own boiler provides an accessory impossible to furnaces not equipped with this aid.

In most American towns the custom is to separate, in the households, the garbage from the refuse and ashes and bring this to the crematory for destruction.

This led to the introduction, at first, of a special form of crematory to burn garbage only, and in the older forms of furnaces this is all they can accomplish. Subsequently the rubbish and refuse upon the dumps became objectionable and the crematories were enlarged in area to burn this also. The bodies of the smaller animals are included and very infrequently the carcasses of the larger animals must be destroyed.

As the quantities of garbage, rubbish and animals increase, the crematories must be made of larger capacity. Because of their operation by slow natural chimney draft, the rate of combustion cannot be increased, and the installations must be made of larger size, or more numerous, which, of course, means greater expense to the towns.

If the cost of operating were lowered with the proportional increase in size, there would be some reason for this, but this is not the case, for the larger the plant, the more men needed to work it, with a corresponding increase in the payroll, to which is added the larger amounts of fuel.

An illustration of this is one incinerator, which in 1902 began its work by the installation of a plant costing $31,000 which destroyed 100 tons daily, followed in 1904 with a plant having a capacity of 120 tons at a cost of $70,000, and in 1907 a plant of 140 tons capacity was contracted for at a cost of $126,000. The reported cost of operating, for fuel and labor at this latest plant is more than double that at the first installation.

Since the practice of many American towns is to make separate collections of the wastes, and since this requires the destruction of these separately, the destructor builders have now designed the apparatus to meet this demand. For the disposal of very wet substances there is a drying hearth of greater or less area, which receives the charge of fresh garbage and by its radiated heat united to the high temperature of the radiant heat of the destruction chamber, the moisture is driven off and combustion begins almost at once.

This change in the forms of destructors has been noted and provided for in the designs of the builders in this country. There are many instances of destructors dealing with the most refractory classes of wet refuse, like sewage sludge and wet trade waste, with nearly the same efficient results as though there was present a greater calorific value. The development of steam power is not so large, but the destruction is equally efficient and the results quite as free from offensive odors and gases.

The method of supplying the waste to destructors is then determined by the character of the material. If it be wet and difficult to handle, the charging may be done by special cars or chutes direct to the drying hearth. If more free from moisture, there is provision for tipping into receiving hoppers or storage bins that will retain a day's collection without nuisance. Should these wastes be comparatively dry and homogeneous in character, they may be fed by hand firing as coal is fed to a furnace. Thus the means of feeding the waste, and the construction or arrangement of the destructor is governed largely by the special conditions of each case, insuring economy of labor and expense, and producing the best results in efficiency.

The Disposal of Residuums.—It has been noted previously that the ash of American crematories is not in a perfectly vitrified form. There is present a considerable proportion of organic matter, mixed with fine ash from substances that burn more freely, and with the débris and fragments of incombustible matter which the low temperatures of the crematory cannot affect. This ash has little or no value, except as a surface fertilizer for top dressing, and therefore must be removed to dumps.

But the clinker or hard vitreous matter from the combustion at high temperatures of a destructor is residuum of quite another character. The anaylsis of the two ashes given previously shows clearly the difference. The value of clinker when thoroughly calcined, lies chiefly in its ready use as foundation for roads, walks, and all forms of municipal service where concrete is employed. It is also used in many kinds of private contract work, where broken stone is costly or unattainable. It is also found to be suitable for the covering for sewage filter beds and is used for under drains. It may be ground up for mortar or mixed with cement, formed into slabs or bricks or in many ways and forms used in various industrial enterprises. A market can nearly always be found for this destructor product, and it is an important asset in the accounts of all waste disposal work.

The Quantities of Waste Consumed.—The early forms of cell destructors destroyed daily from five to eight tons of refuse per cell, or about twenty-two pounds per square foot of grate area per hour, but these are now mostly changed or improved by the addition of forced draft, and their power for combustion greatly increased.

The continuous grate destructors burn from twelve to twenty tons per grate daily, contingent upon the character of the waste, the average being fifteen tons. This is at the rate of fifty-six pounds per square foot of grate per hour, and may perhaps be taken as the average destroyed for these forms of grates. This is exceeded in some of the later types of destructors, where the amounts run from sixty-four to one hundred and three pounds per square foot of grate area. The work of an English destructor in this country, burning American mixed waste, was 58.7 pounds per square foot of grate per hour.

THE LOCATION OF THE PLANTS.

This is the most important, often the most difficult point to determine in a proposed refuse disposal station. Since the repeated failures in this country of crematories and incinerators because of nuisance, there is prevalent an idea that all waste-consuming plants must necessarily be offensive in their operation; thus the authorities nearly always meet with opposition no matter where they select a site, ending sometimes in abandonment of the scheme.

Economy in the collection service demands that the location shall be central with respect to the collection district, as this reduces the haul to the shortest distance; also that the road grades for the loaded teams shall not be too steep. As the average cost of hauling one ton of garbage one mile is from 60 to 80 cents, according to the number of horses and men employed, the saving in distance of transportation is an important consideration.

In most American towns there is no site at the geographical center that would permit the establishment of a refuse disposal station except in the neighborhood of dwellings, and in this case the cost of ground is frequently excessive, and the opposition of property-holders very strenuous. Usually a point (preferably on the northern side of a thickly populated district) can be had, where the collection carts will not be so much in evidence, and where the work can be done with lessened chances for complaints. When a suitable location can be found within reasonable distance, the objections and arguments against it should be carefully stated and fully considered. Opposition for sentimental reasons or through ignorance of the facts involved should not be allowed to outweigh the mature judgment of those best acquainted with the subject.

NUISANCES DEPENDENT UPON TEMPERATURES.

The discharge of offensive gases from a chimney of a refuse disposal plant is caused by incomplete combustion of organic matter. Ths gases thrown off are oxygen, O, nitrogen, N, carbonic acid, CO_2, carbon monoxide, CO, and water vapor or steam. In theoretically perfect combustion the carbon monoxide burns by uniting with oxygen, leaving the nitrogen—which is inert and incombustible—to be discharged from the chimney. But, in practice, this perfect combustion is rarely reached, hence the proportion of the empyreumatic gases, present in larger or smaller amounts, that are capable of being burned but still are not destroyed, must be taken as an evidence of the character of the work.

A competent authority says: "On heating organic compounds, decomposition takes place which is known as destructive distillation. Many of the resulting gaseous compounds have a more or less objectionable odor. When such an admixture of gases is exposed to a higher temperature—which has been fixed at 1,500° Fahr. as the safety point—they are themselves dissociated or decomposed, and the resulting simple gases are without odor."

Another writer says: "It may be stated as an absolute principle, that the destruction of organisms must be done within the furnace itself. If any of the gases are allowed to escape, with the organisms in suspension, the destructor ceases to be of any value if it does not become an actual source of danger."

This is perhaps an extreme view of the case, but it emphasizes the fact that the temperature must in the first place be high enough to destroy all forms of organic life, and that once begun the work must go on to the end at a temperature at or above the point of safety.

GRADUAL DEVELOPMENT OF HIGH TEMPERATURES.

It is in the particular feature of temperatures that destructors with forced draft differ so widely from the usual form of crematory and incinerator used in this country. The evolution of the modern destructor from the early cell type was comparatively slow until the introduction of forced draft. For years the cells continued to burn small quantities by natural draft with repeated complaints of nuisance. The introduction of the "fume cremator" by Mr. Chas. Jones, of Ealing, England, was a step in the right direction and materially advanced the work. This was a wide "fuel box," placed in the main flue of the chimney outside the cells, or sometimes in a detached chamber, and was kept supplied with coke or good coal. All the gases of combustion from the cells were made to pass over this live fire.

It was not until 1897, when this method was abandoned in favor of a powerful forced draft under the fire-bars, that real progress was made. At the present time all destructor builders guarantee a positive temperature maintained within the furnace, and, as a rule, fifteen hundred degrees in the combustion chamber is the point below which the temperature must not fall. One set of specifications issued by an English city provides, "that the general arrangement of the grates and flues shall be such that the whole of the gases generated in the process of combustion shall be submitted to a temperature of not less than 2,000° Fahr. for a sufficient time to allow the noxious germs to be destroyed."

The reports of the trials and continuous operation of the destructors abroad, now invariably contain accurate and extended data of the temperatures in various parts of the destructor and flues. These serve a double purpose, since they show the absolute destruction of offensive gases to the entire satisfaction of the town authorities, and also, by comparison of the temperatures taken at the same points in the several installations of the builder, it is possible to detect a failure of any part to come up to the general standard.

These temperatures range from 1,500° to 2,800° Fahr. A table made by a well-known engineer of twenty-six towns with installations of six different makers, shows the average temperatures in the combustion chambers immediately before the boilers to be 1,900°, and at the base of the chimney 600° Fahr. Some destructors, fitted with economizers, feed-water and super-heaters, obtain a still greater heat, instances being recorded of the fusing of wrought iron in the combustion chambers at a temperature of 3,000° Fahr.

HIGH TEMPERATURES NOT ATTAINED IN AMERICAN PRACTICE.

In American practice this requirement of temperature is seldom or never made in specifications drawn up by municipalities, nor is it brought prominently forward by the furnace builders. Whatever form of "fume cremator" or "smoke-consumer" the builders may propose is assumed to afford sufficient protection for the town. Hence the result of the work of the crematory or incinerator so far as relates to the destruction of obnoxious gases is often unsatisfactory. Smoke is unconsumed carbon, and when discharged from a garbage crematory loaded with the unconsumed gases from the destructive distillation of the organic matter at low temperatures, these gases will invariably cause nuisance in their gradual descent to the ground.

Any one desirous of obtaining data upon the temperatures of the American crematories, would have to experiment for himself. In all the years this work has been going on there has been but one accurate report that can be quoted. This is by Professors Holman and Wendel upon the Brown Crematory, Boston, Mass., 1893, and is the only one, so far as known, that gives anything of value as regards temperatures. In this case the trial was made to determine the quantities and cost of burning the garbage with oil as fuel; the temperatures were a secondary consideration.

In the same year the work of the Engle Crematories at the World's Fair, Chicago, Ill., for six months established the fact that high temperatures could be maintained by oil fuel, with a forced draft, with a combustion chamber of large size and a 50-foot chimney. Unfortunately there was no official report of this published until long afterward, and there were never technical and authoritative reports from competent engineers that would have directed attention to this most successful work, and perhaps have brought about better designed furnaces and more efficient results in the subsequent installations of American crematories.

It is largely because of this particular feature of low temperatures that the garbage cremating furnaces in this country fail of success. Formerly, and but few years ago, it was held by all the furnace builders that high temperatures were not necessary except at the fire-box, and this erroneous idea is still advocated by many. They rely upon a secondary fire, placed under some division of the garbage grates, or at the rear end of the main chamber, or in a small compartment cut off from the main chamber by a division wall, or else in a separate and detached chamber not a part of the furnace. There is no combustion chamber in the true meaning of the term; all these substitutes are merely secondary furnaces for reheating the incomplete products of combustion from the furnace proper, and all, without exception, must use extra fuel.

A reference to the preceding descriptions of American crematories will make it clear that this principle of this second fire is a necessary part of all the various types of American crematories and incinerators.

There are many points in which the cremator and the destructor vary widely, but in none is there so wide a divergence as in the means for producing and maintaining a high temperature necessary to destroy the offensive gases. From a personal experience in the construction and operation of both, the author is of the opinion that that will be the most successful furnace which can develop the temperature necessary to destroy municipal waste and, at the same time and with the same operation, consume the offensive products of combustion thrown off by the waste within the furnace itself.

OPERATION WITHOUT NUISANCE.

The operating works of the British destructors seem to be almost completely free from complaints of nuisance from the chimneys. From an extended examination of the statements made by the local engineers, surveyors and superintendents in charge of these plants, it appears that there are practically no complaints on the score of noxious odors from the waste, either in the process of charging or in its combustion in the furnace.

In some instances notes are made of the fine dust in the charging rooms when the fires are clinkered, but the later installations are provided with a system of ventilating ducts connected with the the air supply to the grates, which in a large degree remove this objectionable feature. Probably the most reliable accounts on this point of nuisance in the work of these destructors is from those American engineers who in the past two years have had opportunities to inspect closely the English installations.

One observer in visiting destructors in four London boroughs where the plants were almost completely surrounded by dwellings, found the dust at one point, Shoreditch, very annoying, "but no odors were noted, and the chimney was free from smoke." At Wandsworth "the plant was in a generally clean condition and only a small amount of light smoke was visible at the chimney top." At Westminster "no odor was noticed and but little of light smoke was coming from the chimney." At Battersea "there were no indications of nuisance of any sort in or about the destructor, and the chimney top was free from smoke." (From "Notes on British Refuse Destructors," by M. N. Baker, Associate Editor, *Engineering News,* New York.)

Another experienced engineer says: "In our country odors from such works have been complained of in many instances, and a number of crematories have been abandoned as nuisances. In England, however, such has not been the case. Furnace extensions are built every year. Complaints are rare. In Hamburg, Germany, where is the largest garbage plant in existence, this is giving no offense, although adjoining a built up section of the city." (Mr. Rodolf Hering, in *Proc. Amer. Soc. Civil Eng.,* Vol. 29, No. 1.)

The conditions attending the work of an English destructor in this country, burning the mixed waste of the town of Westmount, Canada, a surburb of Montreal, are stated in the Report of the Consulting Engineers to the City Council at Westmount, upon the Combined Refuse Disposal and Electric Lighting Station. "The first piece of apparatus put into operation was the refuse destructor, which was tested May 5, 1906. Since that time the destructor has been in continual operation, successfully destroying with absolutely no smell or smoke, whatever has been brought, varying in quantity from fifty tons per day down to five tons."—Ross & Holgate, Consulting Engineers, Montreal, Jan. 1, 1907.

BRITISH DESTRUCTORS IN AMERICA.

The first installation of a British destructor for the disposal of American municipal waste was at Westmount, a surburb of Montreal, P. Q., where a Meldrum Simplex Destructor was erected in 1906. This was followed in 1907 by a Heenan and Froude destructor at Vancouver, B. C. The success of these two installations in Canada led to a thorough personal examination of the destructor systems of England by the City Engineer of Seattle, Wash., Mr. R. H. Thomson, and by Mr. J. T. Fetherston, Street Cleaning Commissioner of the Borough of Richmond, New York City.

The city of Seattle accepted the tenders of Messrs. Meldrum Brothers, Manchester, and a destructor was installed by them which went into operation in January, 1907, and was transferred to the city in February.

The tenders of Messrs. Heenan and Froude were accepted by the Borough of Richmond, and a destructor installed in 1907 began work in March, 1908, and was accepted by the borough in May.

These four installations are at present the only ones operating, though contracts have been closed for a Meldrum Destructor at Schenectady, N. Y., for the General Electric Company's special service, and at Buffalo, N. Y., for a Heenan and Froude destructor for the disposal of light refuse. The following reports give the results of the work to date:

WESTMOUNT (MONTREAL), P. Q. MELDRUM SIMPLEX DESTRUCTOR.

The town of Westmount is a suburb of the City of Montreal, having its own municipal government, and being in all respects an independent borough, though really included in the area of Montreal. The population of the borough is 15,000, residential in character, with few factories or manufacturing works. In 1904 the authorities began an investigation of existing means for disposal, and received from Mr. F. L. Fellowes, borough engineer, an exhaustive report, giving full details of collection service, quantity and character of wastes, estimated costs for improved system, and recommending the use of a parcel of land owned by the borough at St. Catherine's street and Rose avenue, for the erection of a combined electric lighting and refuse disposal station.

The most modern and best approved types of generators, boilers and destructors were recommended, the whole equipment to be of the highest class, with provisions for additions to the plant for future extension of the lighting service. With this report were submitted plans and estimates for the installation of the various units of power, including a Meldrum Simplex Refuse Destructor suited to the work required.

The authorities called into consultation Messrs. Ross & Holgate, Engineers, Montreal, and with them contracted for the building of the plant, specifying that the Meldrum Destructor should be furnished; contracts for which were made by the author in behalf of the Meldrum Company.

The excavations for the foundations were begun in October, and the work was continued through the winter of 1905-6, under the many difficulties attending the construction of brick-work in Canadian winter climate. The large brick building containing the Meldrum Destructor and Boilers, with the Alphons Custodis stack, 150 feet high, were finished about the first of April.

Upon the completion of the plant in May, 1906, the official test was conducted by Messrs. Ross & Holgate, Engineers, the results of which are shown in the following report:

TABLE L.—OFFICIAL TEST WESTMOUNT DESTRUCTOR, MAY 3, 1906.

Duration of test	8 hrs. 32 min.	
Number of cells	3	
Total grate area	75 sq. ft.	
B. & W. Boiler, heating surface	2,197 sq. ft.	
Refuse consumed (composition of waste material):		
Garbage, manure and leaves		15%
Ashes and unburnt (anthracite) coal, cinders, etc		65%
Iron, wood, bottles, tins, leather, etc		5%
Refuse, including paper, branches, old furniture, etc		15%
Total		100%

WEIGHTS.

Unscreened refuse, rubbish, garbage, manure, etc	38,090	lbs.
Tins, etc., not burned	540	"
Net amount consumed	37,550	lbs.
Refuse consumed per hour	4,402	"
Refuse consumed per hour per sq. ft. of grate	58.7	"
Weight of clinker remaining after combustion	15,880	"
Percentage of clinker and ashes to refuse consumed	42.1%	

WATER EVAPORATION.

Total water evaporated	41,991	lbs.
Water evaporated per hour, actual	4,920	"
" " " " from and at 212° F.	5,970	"
" " " pound of refuse, actual	1.12	"
" " " " of refuse, from and at 212° F.	1.36	"
Water evaporated per pound of refuse from and at 212° F. and per sq. ft. of total heating surface per hour	2.72	"

PRESSURES AND TEMPERATURES.

Temperature of the outside air, average	55° F.
Barometric pressure, average	29.5 ins.
Average steam pressure	123.5 lbs. sq. in.
" pressure in ash pits	1.74 ins.
" vacuum at chimney base	9-16 in.
" temperature of combustion chamber (by Watkins heat recorders)	over 1,994° F.
Highest temperature of combustion chamber	over 2,318° F.
(Copper melted in $1\frac{1}{4}$ minutes—wrought iron was also fused.)	
Lowest temperature in combustion chamber	1,742° F.
Average temperature of air entering regenerator	75° F.
" " " " leaving regenerator	206° F.
" " " gases entering regenerator	427.5° F.
Average temperature of gases leaving regenerator	333.7° F.
Average temperature of feed water	47° F.

GAS ANALYSIS.

Percentage of CO_2 average of six readings	10.9%
" " " highest reading	13.6%
" " " lowest reading (clinkering fires)	4.5%

TIMES.

Time taken to clinker one grate	$10\frac{1}{2}$ min.
" between clinkerings	2 hrs. 48 "
Times each fire was clinkered	Three

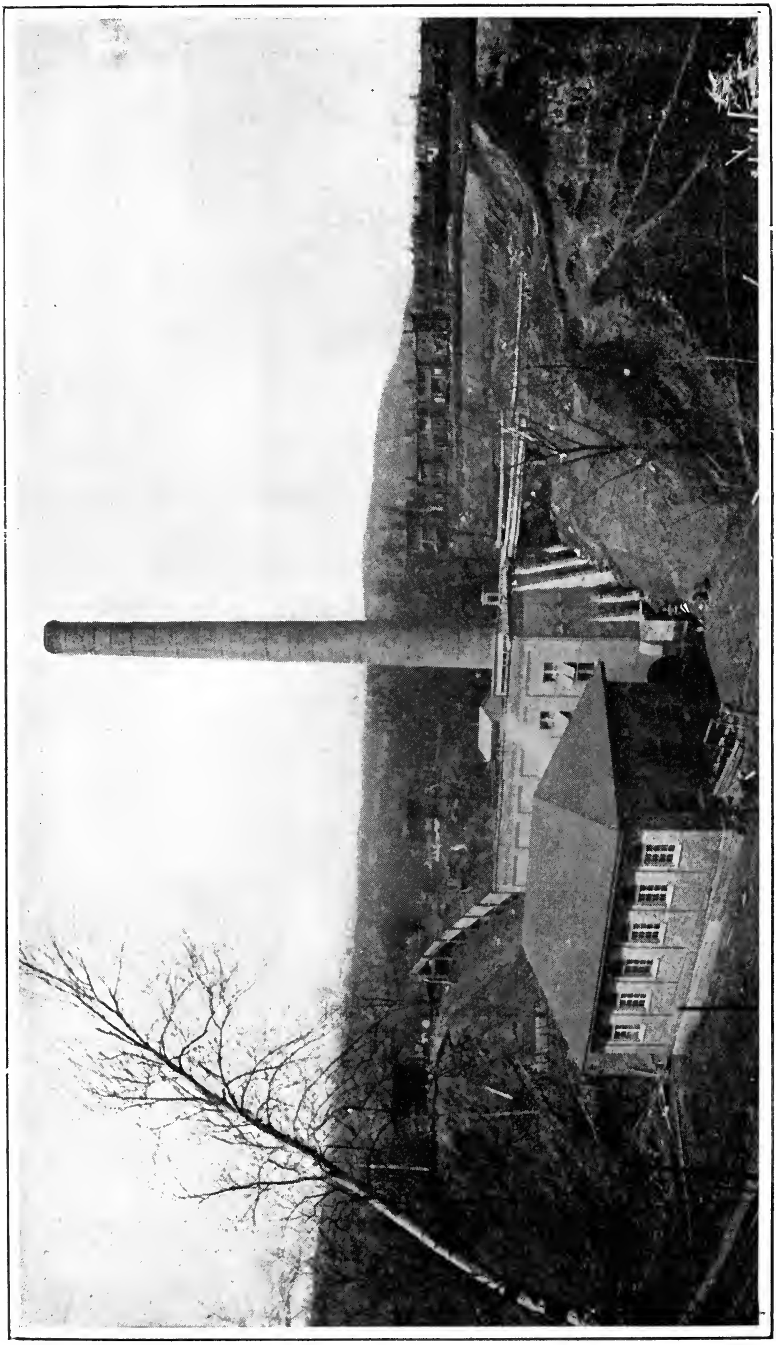

FIG. 66.—EXTERIOR OF ELECTRIC LIGHTING PLANT AND MELDRUM DESTRUCTOR, WESTMOUNT, CANADA.

FIG. 67.—REFUSE HOPPER AND CHARGING HOLES, WESTMOUNT DESTRUCTOR.

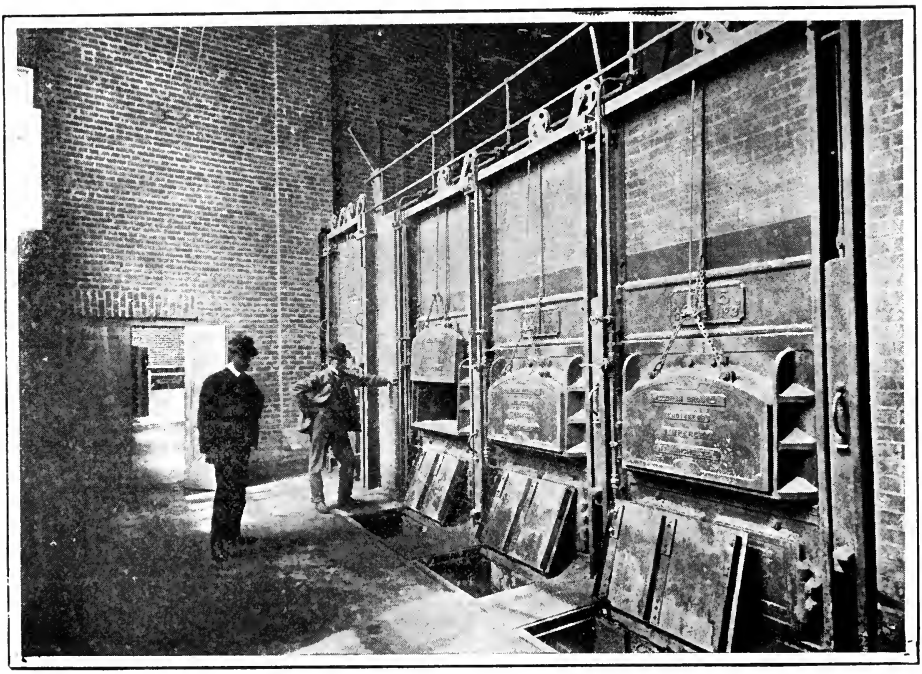

FIG. 68.—FRONT OF DESTRUCTOR, WESTMOUNT.

The destructor forms one part of a combined Electrical Lighting and Refuse Disposal Plant used to supply electric power for lighting the town. The surplus steam from the destructor boiler is utilized as auxiliary to the regular boiler plant, and at times

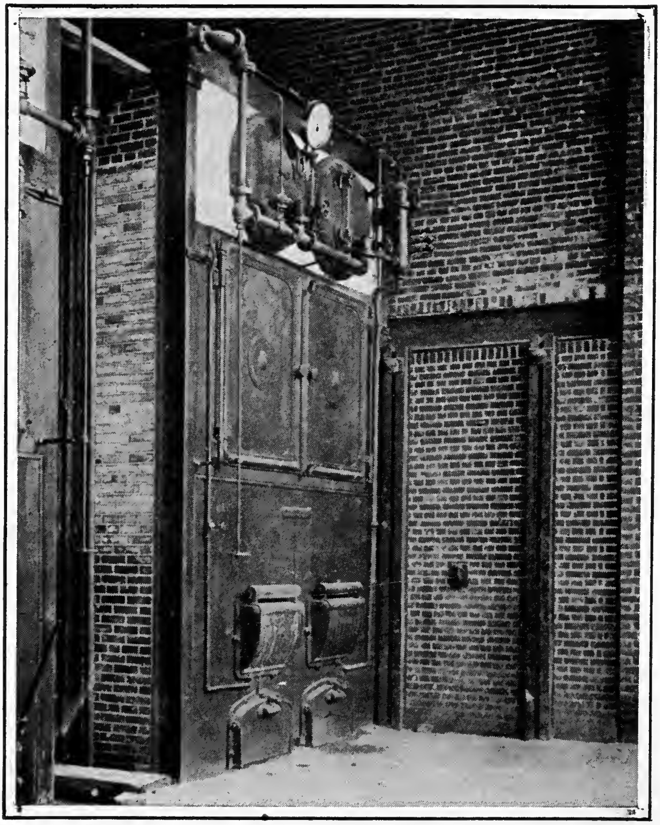

FIG. 69.—BABCOCK-WILCOX 200-H.P. BOILER CONNECTED WITH DESTRUCTOR, WESTMOUNT.

has been sufficient to furnish all the power required for the electric lighting of the whole district. The operation of the destructor for two years past is thus reported by the engineers, Messrs. Ross & Holgate:

The quantities and seasonal variations in composition of Westmount waste are approximately as follows:

TABLE LI.—OPERATING COSTS, WESTMOUNT DESTRUCTOR, FOR TWO YEARS.

Quantity 1906— 8 months — over 3,000 tons
" 1907—12 " —about 8,000 "

COMPOSITION.

Items	Summer.	Winter.	
Garbage	60%	20%	(including
Ashes	20%	70%	much fine
Refuse	20%	10%	dust.)

Daily quantity destroyed, Summer, 15–20 tons
" " " Winter, 30–40 "

Estimated coal equivalent per ton of waste (average) (Coal cost at $5.00 per ton)	58c.
Total return in cash credited to Destructor, 1906	$3,090.00
" " " " " " " 1907	4,636.00
Total net operating costs and fixed charges, 1907, including interest 4%, depreciation 4% and sinking fund 1% (after crediting sale of steam to electrical plant)	6,055.00
Total net operating costs and fixed charges per ton, 1907, after crediting sale of steam	75c.
Total net operating costs, 1907, after crediting sale of steam	2,423.00
Total net operating costs per ton, 1907, after crediting sale of steam	.30
Temperature in combustion chamber	1500°–2000°F.

Hours of operation, Summer, 7 A.M. to 7 P.M.
" " " Winter, 7 A.M. to 7 P.M.

Because of the unusually large percentage of absolutely valueless fine dust-like ash mixed with this refuse, especially in winter, due to the great number of sifting furnaces installed in Westmount houses, and also because of the much higher rate of wages paid for operators, the cost per ton is higher than the average figures from English destructor service, but with the fine ash screened out (as is now contemplated) much larger quantities of refuse can be handled, and far better results obtained; the cost of operation per ton could also be much reduced if the refuse were fed to the destructor furnaces as fast as it would burn, instead of being fed comparatively slowly as at present.

It will be clear that a destructor plant operated for power, with small amounts of waste, will be more expensive in its work than the same plant operated for disposal only, for then the conditions of labor are changed and a smaller number of men at less wages are employed. The regular supply of the waste in the largest amounts is a most important factor in this calculation. During several months when the quantities approached

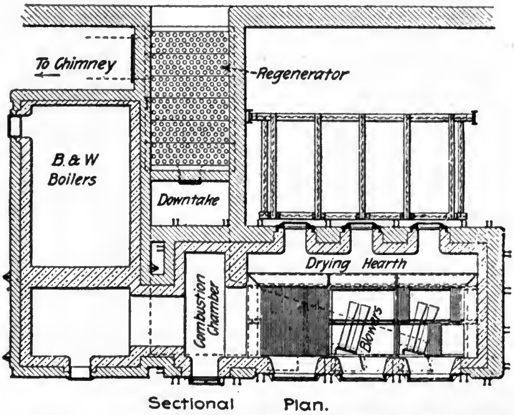

FIG. 70.—PLAN, MELDRUM DESTRUCTOR, WESTMOUNT.

something near the capacity of the destructor, the net cost of operating were 7 cents, 15 cents, and 27 cents per ton, instead of 30 cents. When power is not to be utilized a destructor can

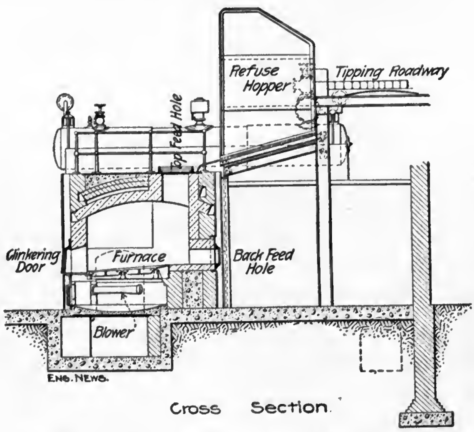

FIG. 71.—CROSS-SECTION, MELDRUM DESTRUCTOR, WESTMOUNT.

be operated as cheaply as any crematory or incinerator of the same relative capacity.

SEATTLE, WASHINGTON. THE MELDRUM SIMPLEX DESTRUCTOR.

In 1896 Mr. Reginald H. Thomson, City Engineer of Seattle, Wash., was instructed to visit American and foreign cities and examine their methods of sewage disposal, and those used for the collection and disposal of refuse and garbage, together with

FIG. 72.—EXTERIOR, MELDRUM DESTRUCTOR, SEATTLE, WASH.

the cost of maintenance, with a view to the adoption in Seattle of plans for these purposes. He undertook an extended journey, visiting the chief refuse disposal plants in the United States, and spending nearly four months investigating the systems of disposal in use in British and European cities.

In his report he says: "After mature reflection upon all the information gained, I am clearly of the opinion that the best refuse destructor in service at the present time is that made by Messrs. Meldrum Brothers, of Manchester, of the accumulative heat type heretofore described. * * * Under all of the existing circumstances I have unhesitatingly recommended to the City of Seattle the erection of this plant, and have heretofore

FIG. 73.—FRONT OF DESTRUCTOR PLANT, SEATTLE, WASH.

submitted to your honorable body an estimate of its probable cost."

This report was adopted by the city government and a contract was made with Meldrum Brothers, Manchester, England, for a four-grate destructor embodying some special features; the destructor and regenerator only to be built by Meldrum Brothers, and the boiler foundation, enclosing building, chimney, approaches and platform to be built by the city. Under this contract the iron and a large part of the fire brick were prepared in England and brought by ship to Seattle. Construction of the plant was begun in November, 1907, and finished in January,

1908. The fires were started immediately, and the plant has been in operation from January 27; and after a preliminary trial of thirty days the plant was taken over by the city.

This destructor is of the Meldrum Simplex type known as the "continuous grate" as distinguished from the cell system, which is of single cells or chambers acting in pairs. Photographs herewith give a clear idea of the exterior of the house, both front and rear, and of the front and one end of the destructor. There are two inclined approaches of broad timber planking which lead to the hopper on the front of the house where wagons tip their loads into the receiving bin below.

The chimney is of reinforced concrete construction 80 feet

FIG. 74.—THE MELDRUM DESTRUCTOR, SEATTLE, WASH.

high. The house, which was built by the city, is of corrugated iron construction, with an adjoining smaller office building which contains the weigh-beam for platform scales which loads coming to the destructor pass over, the weights thus obtained being recorded.

This is the first plant of its kind erected in the United States, and it includes the most up-to-date arrangements of the special ventilating ducts, of the offal hearth for burning very wet material, and the carcass cremation through special charging hole, all of which are entirely new ideas first introduced abroad by the Meldrum Company and included in this installation by request of Mr. Thomson.

TABLE LII.—CITY OF SEATTLE. REFUSE DESTRUCTOR NO. 1. REPORT FOR MONTH ENDING JUNE 30, 1908. TWENTY-SIX DAYS' ACTUAL OPERATION.

REFUSE DESTROYED

	Ash	*Manure*	*Garbage*	*Rubbish*
Per cent	37.8%	18.7%	22.2%	21.3%
Tons burned	666.6%	329.2%	390.2%	378.0%

Total tons refuse consumed	1,764.0 tons	= 3,528,000 lbs.
Average daily consumption	67.846 "	= 135,692 "
Total water evaporated	437,890 gals.	= 3,650,075 "
Average daily evaporation	16,842 "	= 140,372 "
Pounds of water evaporated per pound of refuse burned		1.035 "
Average horse-power per hour evaporated from and at 212° F.		200 H. P.
Wages as per pay roll		$1,248.25
Cost of burning per ton		.71
Total number of loads consumed		1,500
Average number of loads per day		57.7
Average weight of loads		2,356 lbs.

AVERAGE TEMPERATURES FROM DAILY READINGS

Ave. Temp. of Atmosphere at Time of Reading	*Ave. Temp. of Combustion Chamber*	*Ave. Temp. at Base of Stack*	*Ave. Temp. of Inlet to Regenerator*
62.5° F.	2369.° F.	537° F.	86.3° F.

Ave. Temp. of Outlet from Regenerator	*Ave. Gain in Temp. in the Regenerator*	*Ave. Gas Analysis from Daily Samples*		
		CO_2	*O*	*CO*
313.6° F.	227.3° F.	8.3%	9.1%	.24%

AVERAGE WATER GAUGE, FROM DAILY READINGS

Water gauge readings at base of stack without forced draft, 5-8 inch.
Water gauge readings back pressure of ashpit door, No. 1 grate, 1 1-8 inch.

The destructor has a Babcock & Wilcox water tube boiler of 200 horse-power. At the present time this power is not utilized, but it is expected that it will be employed in the municipal service at a later date.

Reckoning this power at the average value in Seattle of $50 per horse-power per annum if this be placed to the credit of the station the operating cost will be reduced to approximately 28 cents per ton. This corresponds very closely with the cost of operating at Westmount, where the net operating costs are 30 cents per ton.

MELDRUM SIMPLEX DESTRUCTOR, SCHENECTADY, N. Y.

The latest installation of the Meldum destructor is now under construction at the works of the Edison General Electric Co., Schenectady, N. Y., by the Universal Destructor Company of New York City, agents for the Meldrum Brothers in the United States and Canada.

In the course of business this company—one of the largest industrial organizations in the United States, whose works cover 130 acres of ground, with 15,000 employees—there is produced a large amount of refuse of various sorts from the different departments of the works. The removal and disposal of this has heretofore been a matter of some difficulty, and a contract was made with the Universal Destructor Company to install a Meldrum destructor of three grates in connection with a 250 horse-power Babcock & Wilcox boiler. The quantity of garbage which comes from the restaurants being small, the plant was primarily designed for the disposal of the combustible refuse, including wood, shavings, sawdust, sweepings from the shops with a great amount of box material, barrels, etc., which could not be profitably treated in any other way. The débris and leavings from every department of the works is to be all brought to this destructor.

The area of the grates is somewhat larger than in the ordinary Meldrum two-grate destructors, and there will be included an extra charging hole for the reception of sawdust and shavings brought over by conveyor from the carpenter shops. The charging is all done from the top, with the exception of long pieces of wood, for which a special door in the end is provided.

It is expected that the heat realized from twenty or thirty tons per day of the material to be destroyed in these works will be equal to the evaporation of two to three pounds of water to one pound of waste consumed. This ratio of evaporation has been obtained by other Meldrum destructors at the Dock Yard

Works in Chatham, England, and the great ship building establishment of Messrs. Harlan & Wolff, Belfast, where a similar kind of material is brought for disposal. This is the first instance of the utilization of the British destructor system for private business purposes in the United States, and its operation

FIG. 75.—HEENAN & FROUDE DESTRUCTOR, VANCOUVER, B. C.

will be watched with a great deal of interest by other business corporations where the same trouble in the disposal of their waste and refuse are encountered.

HEENAN & FROUDE REFUSE DESTRUCTOR, VANCOUVER, B. C.

The city of Vancouver, B. C. (population 60,000), contracted in October, 1906, with the Heenan & Froude Destructor Company, of Manchester, England, for a refuse destructor of 40 tons capacity, with covering house, chimney and accessories. (Fig. 75.) The plant went into operation in November, 1907. The following report, condensed from the official reports for five months (January 1 to May 31, 1908), gives the details of the working of this plant:

TABLE LIII.—REPORT OF OPERATION, HEENAN & FROUDE DESTRUCTOR, VANCOUVER, B. C.

Character of Refuse Estimated by Weight		Collection Cost per Ton	
Household garbage	82 %	(a)	$1.55 not deducting revenue
Trade refuse	12 %	(b)	1.15 deducting revenue.
Decayed fruit and vegetables	3 %	*Average Number of Animals*	
Manure	1.5%	Horses	14
Meat and fish offal	1 %	Dogs	27
Sawdust	.5%	Cows	1
	100%		

APPARENT VALUE AS A FUEL

From residential quarters very good, about one-half ashes; business sections good; light refuse. Chinese and Japanese section poor, large percentage vegetable.

No fuel of any kind used except what is contained in refuse.

LOCATION:

Central; 200 feet from main street, and with buildings on three sides.

TYPE AND DESCRIPTION:

Heenan and Froude.

One unit. Three cells. 65 H.P., B & W. Boiler. Combustion chamber. Chimney 120 feet (circular). Fan draft. Heated air. Partial exhaust to chimney.

RATED CAPACITY:

50 tons (2,000 pounds) per 24 hours.

APPURTENANCES:

Fan engine. Feed pump and steam injector. 65 H. P. B. & W. boiler. Washington-Lyons steam disinfector (single cradle). Two disinfecting rooms. Brick building. Cement floors.

POWER UTILIZED FOR:

Fan engine and feed pump. Steam disinfector. Installation of electric plant—500 lights, under consideration.

COST OF CONSTRUCTION:

(a)	Building	$11,500.00
	Extras	4.543.30
(b)	Chimney	3,900.00
(c)	Destructor plant, with boiler and accessories, includings team disinfector	21,250.00
(d)	Complete	$41,193.30

TABLE LIII.—(Continued.)

COST OF OPERATION: Per Ton of Refuse Destroyed—
(*a*) 46 cents per ton, deducting revenue.
(*b*) 56 " " " not deducting revenue.
(*c*) 91 " " " counting in interest and sinking fund.

STAFF:

1 engineer	at	$85.00	per month
2 firemen—qualified engineers	"	75.00	" "
4 firemen	"	70.00	" "
1 dumpman	"	60.00	" "

Above, except dumpman, work 8-hour shift.

REFUSE BURNED: Per Man Per Hour—
1.04 tons (6 men—8 hours each).

SPECIAL NOTES ON PLANT:
Combustion chamber for incinerating dead animals.
Storage Hopper—capacity 30 tons—brick sides—cement floor—with swill hopper and steam jet. Well lighted and roomy. Driveway for teams with dead animals for combustion chamber.

OPERATION OF PLANT: Feeding and Stoking—
Back-hand feed. Stoking through clinkering doors. Clinkering—from front of furnace into hand barrows.
Character of clinker—33% of refuse destroyed. Very hard, black, well burned.

GENERAL NOTES:
Destructor operated chiefly to incinerate decaying vegetable and animal matter formerly hauled to general dumping ground.
Approximate temperature of main flue and combustion chamber 1,500° to 2,000° F. (vide Electric Pyrometer Jan. 27, 1908—1,765° F). Forced draft 511°–600° F.

REPORTED EVAPORATION:
.52 pounds of water per pound of refuse. (½ pound of water to 1 pound of refuse.)

NUISANCES:
None.

UTILIZATION OF BY-PRODUCTS:
Clinker—reclaiming tide lands west side of incinerator. Under experiment as road bottoming
Flue dust—used with clinker for binding and rendering surfaces smooth.
Tins, etc., at present no value—hauled to dump.

HEENAN & FROUDE DESTRUCTOR, WEST NEW BRIGHTON, N. Y.

In December, 1906, the Borough of Richmond, Staten Island, one of the subdivisions of Greater New York, contracted with the Heenan & Froude Destructor Company of England for the installation of a destructor at West New Brighton having a capacity of 60 tons in 24 hours of mixed municipal waste. Under the terms of this contract the company furnished the destructor and boiler, the city providing foundations, chimney and covering house, all of reinforced concrete construction.

The plant was finished for preliminary test in March, was officially tested in May, and accepted by the city in June, 1908. The following description of the destructor is furnished by the builders:

The parts being all plainly marked in the figure, it will be easy for those interested to follow the details on the plan. The rubbish is dumped into a

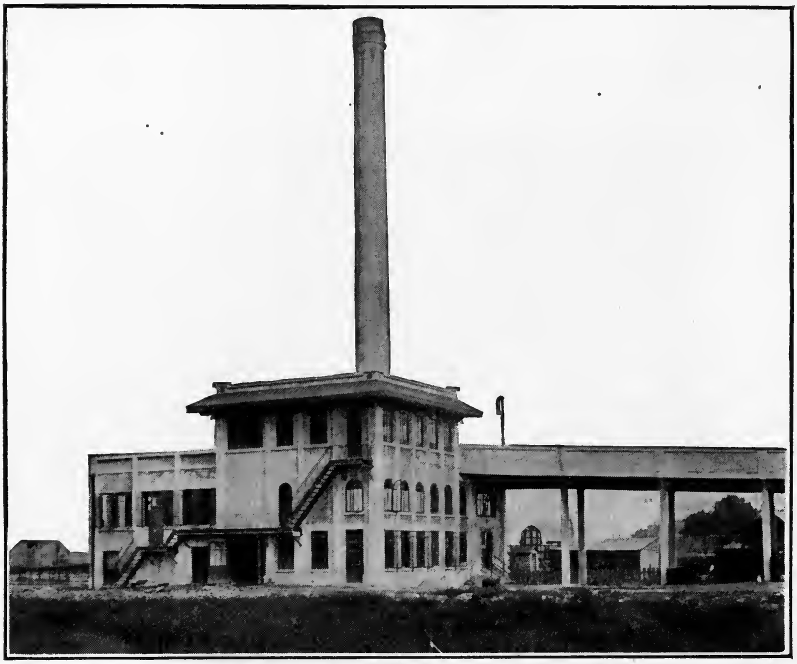

FIG. 76.—HEENAN & FROUDE DESTRUCTOR, NEW BRIGHTON, N. Y.

hopper back of the grate cells, large enough to hold one day's collection. From here it is fed to the special grates of the furnace. Each cell has a reverberatory type arched roof and a separate feeding door. Each also has its own clinkering door on the opposite side from the feed door, while the individual grates are partially separated by low iron ridges. Apart from this all the cells together form one furnace chamber, in that the gases from the further cells pass through those nearer the dust settling or combustion chamber, and consequently over the burning fuel which they contain. The reason why the refuse is shovelled into the cells by hand instead of being dumped directly into them is that, in order to secure complete combustion, a reasonable amount of selection should be practiced, preventing, for instance, a whole load of wet, raw garbage coming into one cell while its neighbor had perhaps nothing but paper and dry rubbish in it. Some care in stoking must be exercised to secure good results.

The success of the Heenan Destructor is largely due tc the complete arrangements for perfect combustion. Forced draught is used to accelerate and regulate burning; and is furnished by a fan and engine, so as to be under complete control. Each ash-pit is separately enclosed, so that air pressure may be carried higher in the grate most recently fired. The air heated to several hundred degrees F. is driven through valves in the ash-pits, and thence through the grates and fuel. The reverberatory arches also greatly facilitate the burning of poor fuel by reflecting back the heat upon their own grates and those adjoining. By this means an average temperature of 2,000° F. can be maintained in the cells with ordinary refuse.

When the refuse has been completely burned it forms a hard vitreous clinker, which is broken up with steel slice bars and drawn out of the clinkering doors on the opposite side of the cell from the feed doors.

FIG. 77.—FRONT OF DESTRUCTOR, NEW BRIGHTON, N. Y.

Here it drops into wheelbarrows or through clinker traps to mechanical conveyors for removal from the plant.

The hot and burning gases from the cells next pass through the dust settling or combustion chamber, where the usual temperature is maintained at about 1,800° F. Here combustion is completed, and all smoke, smells and combustible particles consumed, so that when the gases pass under the boiler in the next compartment all flame has disappeared. As all objectionable matter, whether solid or gaseous, is subjected to this temperature, no further decomposition and consequent nuisance can result. Carcasses of dead animals may be dropped into this chamber whole, and in an incredibly short time they will have been completely consumed, leaving but a handful of ashes. Another function of this chamber is to remove from the flue gas all non-combustible dust, by settling. Passing through the boiler, the heat of the gases generates steam, at the rate of one or two pounds of water evaporated for every pound of refuse consumed.

Next the gases pass through the air heater, where all available heat units are delivered to the air blown through the cells as forced draught. Thus heat otherwise wasted is re-delivered to the furnace to facilitate combustion. The average temperature of the forced draught should be about 300° F. Finally, the expended waste gases escape through the flue to the chimney.

A high speed, completely enclosed steam engine is used to drive the blower for the forced draught. The steam taken from the boiler for this purpose does not exceed about 5 per cent. of the total steam generated. The air for the forced draught is drawn from the feeding and clinkering

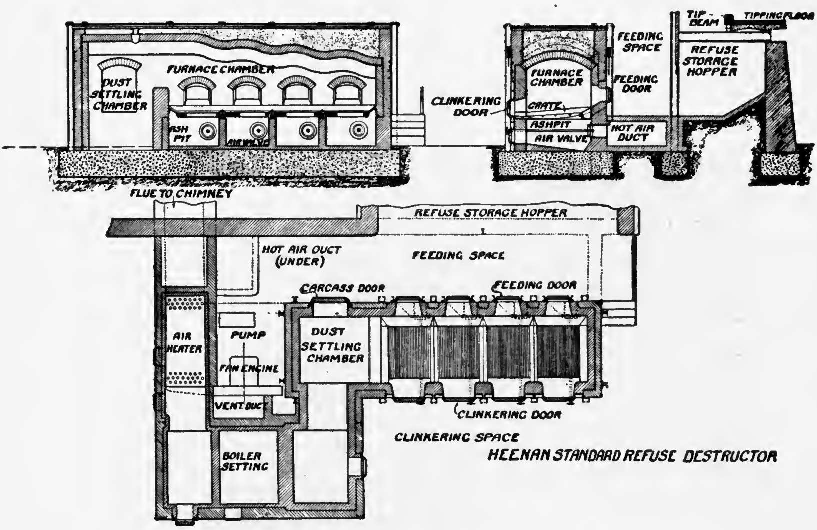

FIG. 78.—PLAN AND SECTIONS OF DESTRUCTOR, NEW BRIGHTON, N.Y.

rooms, thus removing all the dust or smells that may be liberated in this part of the plant and preventing their escape into the open.

The following extract from the advance sheets of the official report made to Hon. George Cromwell, President of Richmond Borough, by Mr. J. T. Fetherston, Superintendent of Street Cleaning, gives additional details of this plan. Table No. LIV is a summary of the official tests of the West New Brighton Refuse Destructor:

The summary in the table gives a number of features which may prove of interest to those concerned in the disposal of refuse. Of course, the trials indicate the capabilities of the furnace under the conditions existing, and undoubtedly the results obtained in such a trial are rather better than may be expected in ordinary practice. The operating force engaged in the work at the plant during the trials consisted of one steam engineman and four stokers or firemen. Three of these men were employees of the local bureau who had never before worked about any steam raising plant and had never had any experience in high temperature work. They had received only two months' training in the work about the furnace. Undoubtedly, with more experienced men, even better results could be obtained than those indicated in the summary of the tests.

After the furnace had satisfactorily met the conditions and requirements of the contract and specifications, it was accepted, and on May 21st it was taken over by the city. It has continued to satisfactorily dispose of mixed refuse during the trying period when the garbage contained was very high, and bids fair to satisfactorily perform its duty in the future, though, of course, until the plant has been operated for at least one year its shortcomings and reasons therefor will not be known.

Costs

The capital costs of the plant were as follows:

Land (100′ x 300′)	$5,000
Foundations, building, chimney, runway, retaining wall, etc.	39,500
Furnaces, boiler, etc.	23,995

There are perhaps more inquiries made concerning costs of disposal at the new plant than any other factor connected with it. In every case it has been stated that until the plant has been operating continuously throughout a refuse cycle, which really covers a period of one year, it will not be possible to give any reliable cost data regarding maintenance charges. There are still many factors concerning the more effective disposal of mixed refuse at the new plant, such as the benefit derived from the heat abstracted from the clinker in the cooling chamber, the ordinary amount of power produced under average operating conditions, the best utilization of such power and the most economical treatment of the other by-products, including clinker, tins, dust, etc. No decision has yet been made regarding the use of the by-products, and it is deemed prudent to postpone such a decision till sufficient information has been secured to wisely determine the most economical use of the by-products.

TABLE LIV.—SUMMARY OF OFFICIAL TESTS, WEST NEW BRIGHTON.

Test No.	Date of Test 1908	Refuse Burned				Hrs. of Test	Total Refuse Handled Tons	Refuse Burned Tons	Refuse Burned per sq. ft. of Grate per hr. lbs.
		Description	Composition, Character						
			Components	*%*	*Lbs.*				
1	May 6	September Mixture as per Specifications	Garbage........	46.6	19,875	8	21.325	20.802	52.0
			Fine Ash........	21.7	9,255				
			Coal & Cinders...	7.7	3,284				
			Clinker.........	0.6	256				
			Glass, Metal, etc.	8.5	3,625				
			Rubbish........	14.9	6,355				
			Total.......	100.0	42,650				
2	May 8	Refuse as Collected	Wet from rain; Sample dried gave 38% moisture.........			6½	16.315	16.145	49.7
			Components	*%*	*Lbs.*				
3	May 13	February Mixture as per Specifications	Ashes..........	79.5	31,881	8	20.051	19.827	49.6
			Garbage........	11.8	4,732				
			Rubbish........	5.3	2,125				
			Glass, Metal, etc.	3.4	1,364				
			Total.......	100.0	40,102				
4	May 15	Refuse as Collected	Wet from rain of previous day.......................			5½	17.430	17.235	62.7
5	May 16	Refuse as Collected	Relatively dry, representative material....................			8	23.847	23.673	59.2

Test No.	Residual						Evaporation per Lb. Refuse Burned		
	Clinker, Lbs.	Ashes, Lbs.	Dust (Approx.) Lbs.	Tins, etc., Not Fired, Lbs.	Total Lbs.	Percentage of Original Refuse	Gross Actual Lbs.	Gross Equiv. From and at 212° F., Lbs.	Net Useful Steam for Pow'r from & at 212°F.
1	10,930	787	426	1,046	13,189	30.9	1.17	1.41	1.31
2	8,390	787	326	340	9,843	30.2	1.03	1.25	1.16
3	11,460	1,978	401	448	14,293	35.6	1.10	1.33	1.24
4	12,965	669	349	389	14,372	41.2	0.91	1.10	1.02
5	17,344	913	477	349	19,083	40.0	1.00	1.21	1.12

Test No.	CO_2			Temperatures in °Fahr.							Average Steam Pressure in Lbs. per Sq. In.	Fires Clinkered	Average Clinkering, Min.
	% Average	% Max.	% Min.	Combustion Chamber Aver.	Combustion Chamber Max.	Combustion Chamber Min.	Chimney Gases	Outside Air	Air Leaving Heater	Feed Water			
1	12.2	17.0	6.0	1,846	2,210	1,526	393	48.5	306	55	137.4	9	9.0
2	12.3	16.5	8.0	1,715	1,922	1,526	380	51.5	287	55	133.2	8	8.4
3	12.5	17.0	6.0	1,637	1,940	1,382	364	83.9	268	56	130.5	10	11.9
4	12.4	17.6	8.6	1,698	1,904	1,526	397	50.6	288	54	136.4	7	12.3
5	12.9	16.3	7.6	1,792	1,940	1,634	.....	.....	.....	54	137.4	5	8.2

The agent of Heenan & Froude Destructor in the United States is *The Power Specialty Company,* 111 Broadway, New York.

CHAPTER XI.

British Destructors Throughout the World.

SPECIAL ARTICLE.

BY W. FRANCIS GOODRICH, A.I.MECH.E., F.I.S.E.

Having in mind the splendid services which Colonel Morse has rendered in the cause of sanitary reform for many years past, I gladly respond to his invitation to present the existing situation in the United Kingdom, British Colonies and Europe, in so far as the final and sanitary disposal of refuse is concerned.

Thirty years have passed since the late Mr. Alfred Fryer erected the first furnaces for burning refuse, coining the term destructor, which is now universally understood in all countries as the only satisfactory means to an end, the sanitary desideratum —disposal by fire.

While in America from the Atlantic to the Pacific during the past twenty years not much real progress has been made, it is possible to record in Great Britain steady and consistent progress, with but very few failures. I shall be well within the mark if I say that less than ten destructors have been pulled down or abandoned in Great Britain during the past thirty years. The earliest destructors erected in this country are still in daily use in Manchester, Birmingham, Leeds, Hull and other cities, and although they suffer by comparison with modern installations in these same cities, yet in fairness it must be said that they have done, and continue to do, that work for which they were erected.

Those American writers who have attributed the progress which has been made in Great Britain to the fact that refuse disposal has been treated as an engineering problem may rest assured that they are correct. For many years past a few well-known engineering firms in England have devoted very close attention to those combustion problems and other problems involved in the designing and erection of destructor furnaces of the highest all-

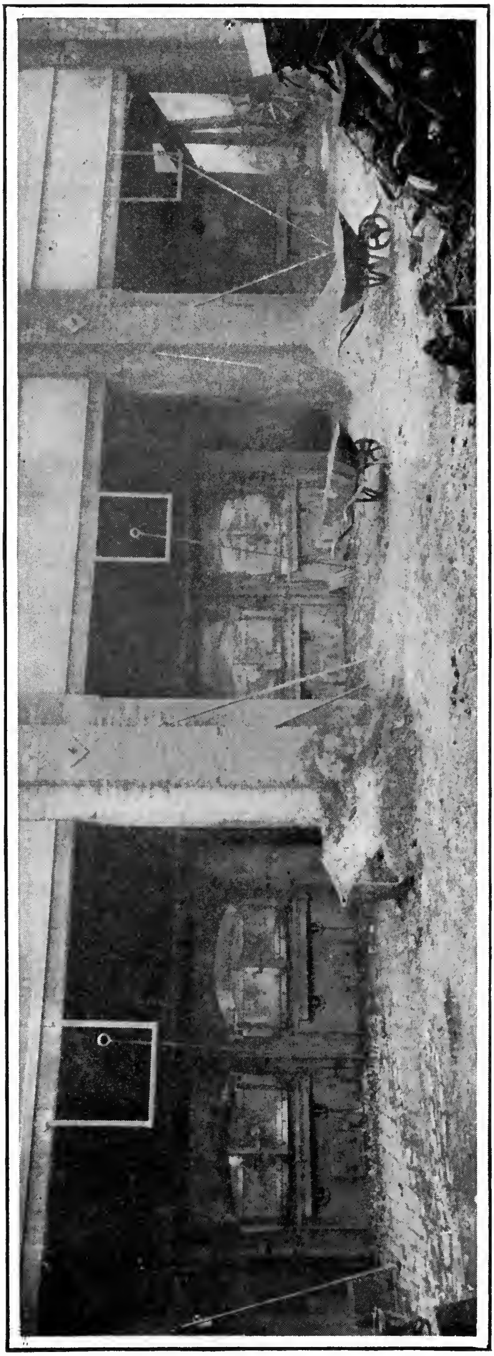

FIG. 79.—FIRST SIX DESTRUCTOR CELLS IN GREAT BRITAIN, MANCHESTER, 1876.

round efficiency, with the result that finality in the essential principles has now been reached, and the only possible improvements in the future will be in details affecting the labor cost for operation, the clinkering process, and the profitable treatment of the residuals. Those who have closely followed the progress in final and sanitary refuse disposal in Great Britain will agree that the demonstration of the fuel value of refuse has been a potent factor making for the sanitary ideal. While there must ever be a constant striving after the highest efficiency in sanitation, yet it would be idle to pretend that nearly 250 municipalities in Great Britain would at this time have had destructors in operation had the power aspect not been so clearly and conclusively demonstrated.

Many worthy councilors with but a very hazy notion of sanitary necessities have been fascinated with the possibilities of power production; to their credit it must be said that they have grasped the economic aspect, and realizing that the sanitary ideal could be reached without any material addition to the rates they have, in not a few instances, led the municipal engineer instead of being led by him.

I have already observed that some 250 municipalities in the United Kingdom now have destructors in operation; in about 130 cities and towns the destructors are either combined with electricity works, sewage works, water works, or other municipal undertakings, providing power which would otherwise involve a definite expenditure for coal, gas or oil, as the case may be.

Fig. 78 illustrates the first six destructor cells erected in Great Britain, these being the original Fryer cells erected at the Water street depot of Manchester Corporation in 1876.

Still in daily use it is interesting to add that within the past three years Meldrum's forced draught and grates have been added to this battery of cells at this depot, materially increasing the temperature and destroying capacity.

Fig. 79 will serve to convey to the reader what has been accomplished in the thirty years which have passed since the late Mr. Alfred Fryer erected his first destructor cells.

This diagram will serve to show (1) the total number of installations, (2) the number of plants erected by each maker, (3) destructors combined with sewage works, (4) with electricity works and (5) with water works, as also the proportion of idle or semi-idle plants (*i.e.*), destructors from which the power is either only partially utilized for works purposes, or allowed to go to waste.

While the proportion under the latter category may seem high it must be remembered that many of these plants are old, being erected long before the power aspect of refuse disposal had received any serious consideration.

Any contribution concerning the present position of refuse disposal in Great Britain would be incomplete without some reference

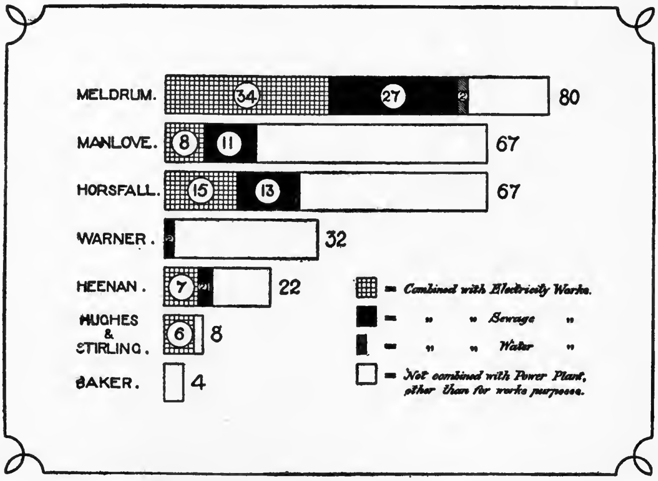

FIG. 80.—DIAGRAM—THIRTY YEARS' PROGRESS WITH BRITISH DESTRUCTORS.

to the main combinations of destructor and power plant, which have played an important part in the later development of British refuse destructors. We will, therefore, briefly review the combinations of destructors with sewage works, electricity works and water works.

Destructors Combined with Sewage Works.

This desirable combination has found much favor, and at the present time some forty-five installations are in operation in various parts of England and Wales, while many similar works are projected.

In not a few towns the sewage works are so located that the combination is an impossible one because of the cost of haulage. This obstacle, as also the fact that at many sewage works gas engines or oil engines are employed, has operated against the more extensive adoption of destructors, and, to some extent, will continue so to do. To utilize the available power from the solid refuse of a community to pump its liquid refuse—the sewage, and further to utilize the residual clinker from the solid refuse for the bacterial treatment of the sewage, appeals to many as an ideal combination—as indeed it is.

To the Cathedral City of Hereford belongs the credit of installing the first destructor in conjunction with a sewage works. This destructor of the Meldrum front-fed type has now been at work daily since 1897. About one and one-half million gallons of sewage is pumped to a height of 36 ft. in a ten-hour day, the total cost of the destructor installation was about £1,200, and a coal bill of about £400 per annum has been entirely saved, not one pound of coal having been burned since the destructor commenced work, the total cost of repairs and maintenance during nine years has been £34 only. Ten tons of refuse are burned daily and, in addition to pumping, steam is also provided for operating sludge presses, lime mixers and other auxiliary plants.

The vexed question as to whether or not it is possible for a destructor to be operated as a financially reproductive undertaking has been clearly disposed of in so far as combined sewage and destructor works are concerned.

In fact, they have exceeded all expectations in most cities where an account has been kept of operation and other data of the plant. In America there is no doubt as to their success, while in Europe and other countries each year generally shows an increase in saving when properly managed. There should be little hesitancy on the part of wide-awake municipalities in adopting this plan, judging from the results which have so far been attained.

The following table, No. LII, clearly sets forth what has been done at twelve combined works. It will be observed that in no less than seven towns a net annual surplus in relief of the rates is shown after meeting all capital and standing charges.

TABLE LV.—TWELVE COMBINED DESTRUCTOR AND SEWAGE WORKS.

Town	Weight of Refuse Destroyed Daily	Gross Annual Saving	Labor Cost Per Ton of Refuse Destroyed	Capital Cost of Destructor and Steam-Raising Plant
*Aldershot	14	£568	9d.	£1,200 exclusive of boilers and chimney
East Ham	30	1,000	1s. 7d.	£12,600 including buildings and chimney
*Eccles	28	750	11½d.	£4,500 exclusive of boilers and chimney
*Epsom	10	556	11d.	£4,510 including buildings and chimney
*Hereford	10	400	1s	£800 exclusive of boilers and chimney
Leamington	35	183	....	£6,310 excluding chimney only
Luton	23	500 est'd	1s. 3½d.	£5,000 excluding chimney and one boiler
*Lytham	12	370	8d.	£2 400 including building and chimney
Taunton	20	=118.16.7	8½d.	£4,000 including building and chimney
Talthamstow	60x	650	1s.	£6,000 including buildings and chimney
*Watford	25	=893	1s.	£6,800 including buildings and chimney
*Weymouth	18	†451	11d.	£4,600 excluding one boiler and chimney

*A net surplus available after meeting all capital and standing charges.
= 1904 Figures.
x 40 tons of refuse and 20 tons of sludge.
†Not including £234 per annum saved in cartage cost.

TABLE LVI.—WATFORD URBAN DISTRICT COUNCIL COMBINED SEWAGE AND DESTRUCTOR WORKS.

Statement showing saving effected by *Meldrum Destructor* for first two years working compared with the previous cost when burning Steam coal, together with the report of the Medical Officer of Health for 1905.

	Coal Tons	Coal Cwts.		
Year ending March 31st, 1904: *Before* erection of Destructor	1,068	5	@ 17-8 =	£943.12.7
" " " " 1905: *After* erection of Destructor	183	8	@ 17-5 =	159.04.5
" " " " 1906: *After* erection of Destructor	274	16	@ 17-1 =	235.12.7

1st year's working of Destructor: Saving in coal bill	= £783.18.2
Add revenue from sale of clinker	= 101.08.9
Sale of old tins	= 8.02.4
2nd year's working of Destructor: Saving in Coal Bill	= 708.00.0
Add revenue from sale of clinker and residuals	= 202.06.6
Total saving for two years	£1,803.15.9
Total cost of repairs and maintenance for two years	= £16.19.0

The following interesting figures are available from *Eccles* for the past year, these being extracted from the annual report of the Medical Officer of Health, Dr. W. M. Hamilton, M.D., D.P.H.:

TABLE LVII.—REPORT ON ECCLES DESTRUCTOR.

Total weight of refuse destroyed	10,975 tons
Average weight of refuse destroyed daily	29.79 "
Labor cost per ton of refuse destroyed	11½ d.
Total water evaporated	20,429.360 lbs.
Daily evaporation	66,550 "
Average evaporation throughout the whole year per lb. of refuse destroyed	1.002 "
H.P. developed continuously at 20 lbs. per H.P.	138 H.P.
Total weight of clinker	3,464 tons 12 cwts.
Percentage " "	32.57
Revenue from "	£433 1s. 4d.

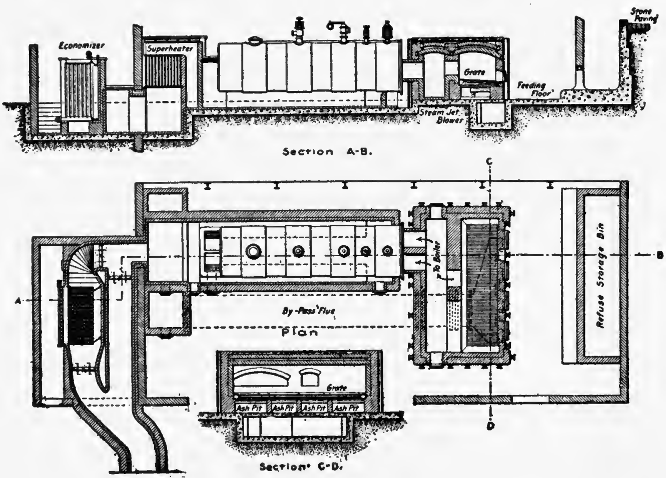

FIG. 81.—PLAN AND SECTIONS, MELDRUM DESTRUCTOR, WITH LANCASHIRE BOILER, WATFORD.

"The pumping and treatment of the sewage of the borough has been carried on without intermission the whole year through. The destructors (Meldrum's front-fed type) have also been in continuous operation. The whole of the steam required for the pumping engines has been evaporated by the refuse destroyed in the destructors."

THE WATFORD DESTRUCTOR AND SEWAGE PLANT.

One of the most successful combined sewage and destructor works is that of the Watford Urban District Council, situated about 17 miles north of London.

Here a Meldrum front-fed regenerative destructor deals with an average of about 27 tons of refuse daily, working continuously for about 150 hours per week. Steam is supplied at a pressure of 120 pounds to Worthington pumps and air compressor engines.

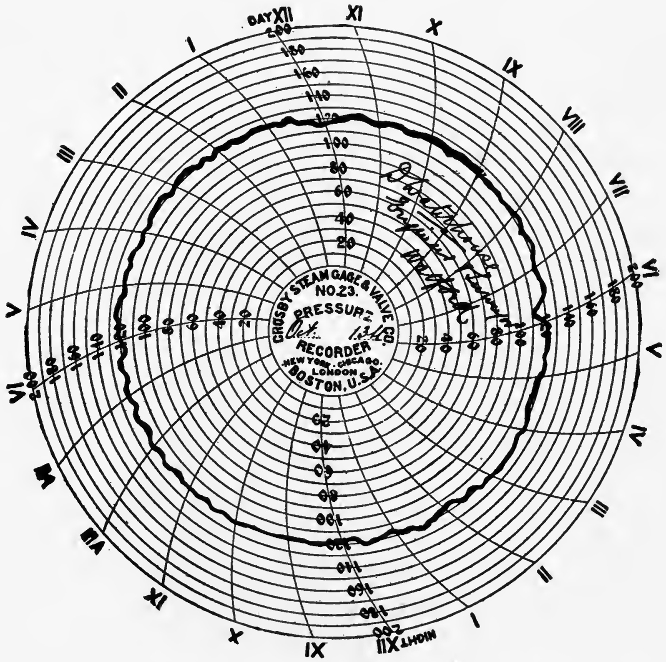

FIG. 82.—DIAGRAM—ONE DAY'S RECORD OF STEAM PRESSURE, WATFORD.

About one million gallons of sewage is pumped every 24 hours to a height of 84 feet, while an additional half million gallons is dealt with by the air compressors and ejector plant.

The destructor was started on March 31, 1904, and the foregoing figures (Table LVI) covering the first two years of working, are perhaps without parallel among combined works of the kind.

After meeting all capital and standing charges, there remains a *net* surplus in relief of the rates of about £150 per annum.

Fig. 81 illustrates the general arrangement of the destructor plant at Watford; it will be observed that in addition to steam generation the hot gases after passing the boiler are further utilized for heating the air for combustion in a Meldrum regenerator and also for heating the boiler feed water in a Greens economizer, the temperatures being respectively about 300° F. and 250° F., the heating surfaces of the boiler, regenerator and economizer reducing the temperature of the gases from an average of 1,800° F. in the combustion chamber before the boiler, to about 400° F. at the chimney base.

Fig. 82 is reproduced from steam pressure recorder diagrams and clearly shows how steadily the pressure is maintained throughout one day's ordinary work. The diagrams of a week's work are almost exactly identical with this.

CLINKER FOR FILTER BEDS.

The value of destructor clinker for bacteria beds has now been clearly established and there is an enormous and constant demand for large quantities all over the country.

It is no exaggeration to say that in good vitreous clinker has been found the most suitable material yet discovered. At Aldershot Urban District Council Sewage Works some beds made up with destructor clinker over five years since are still in use with the original material, while at these works, coke which was previously used has disintegrated, and after being removed as useless it has been passed through the destructor with refuse, emerging therefrom as a useful clinker to be again used in a changed form for the same duty.

A year since, when the writer was invited to give evidence before the Royal Commission on Sewage Disposal concerning the cremation of sludge, he was also requested to lay before the Commissioners some evidence regarding the combination of destructors with sewage works.

Some very exhaustive tables prepared by the writer for this purpose will be found in the next report of this Commission, and to those especially interested in combined destructor and sewage works these tables should be exceedingly useful, bringing together a mass of facts and figures in concise form.

What the recommendations of the Royal Commission on Sewage Disposal will be concerning this combination remains to be seen; it has been facetiously suggested that ere their labors are complete every sewage works will be a combined undertaking.

Destructors Combined with Electricity Works.

During the past ten years some 70 municipal authorities have adopted this combination, generally speaking, with very satisfactory results. While the production of electric light from refuse has held many Councillors with a peculiar fascination, it never has appealed to the Electrical Engineer, and although many are now disposed to adopt a more friendly attitude towards the combination, it is no exaggeration to state that the progress which has been made is, on the whole, not due to the Electrical Engineer, but rather in spite of him.

Electricity works are usually centrally located and their position offers an ideal site for the destructor from the point of view of haulage costs. As the cost of refuse collection and haulage has nothing whatever to do with the electricity department, the Electrical Engineer cannot be induced to consider this factor—an all-important factor from the ratepayers' point of view.

The view of the Electrical Engineer has been purely departmental or personal; he does not want the destructor; why should he have it? The question of cartage costs or power utilization, both of vital importance to the ratepayers, do not, as a rule, appeal to him, although he is their servant.

While this narrow and illogical view has not been without its effect in thwarting the adoption of destructors in combination with electricity undertakings, yet very satisfactory progress has been made. It is not possible to include figures such as those in Table No. LII or similar to those available and here included in connection with combined destructor and sewage works, not because the destructor is minus a satisfactory financial side, but rather because accounts are not kept in that clear and separate form which is so desirable with every municipal undertaking.

While a steady pumping load is undoubtedly the better load for a destructor, yet the work which is being done both at lighting and power stations, as also at traction stations, is very satisfactory, and perfectly justifies the combination of destructors and the fullest possible utilization of the power.

At the present time about 4,500 tons of refuse are being destroyed daily at such works, the electrical output per ton of refuse destroyed varying from 25 to 100 Board of Trade units. The highest recorded results are set forth in Table No. LVIII and may with advantage be compared with the recent results obtained at Westmount, Montreal, which are also included.

TABLE LVIII.—SOME RECENT RESULTS IN POWER PRODUCTION AT COMBINED ELECTRICITY AND DESTRUCTOR WORKS.

WORKS	Duration of Test	Water Evaporated Per lb. of Refuse from and at 212 F. lbs.	Electrical Board of Trade Units per Ton of Refuse
Stoke-on-Trent	15 hours	2.6	108.1
Nelson	8 " max'm	2.35	.....
"	5 weeks avg.	2.12	104
Todmorden	11 hours	2.09	.....
Burnley	1 ord'y week	2.00	.....
Bangor	7½ hours	1.98	.....
*Cambuslang	6 "	1.92	97
†Woolwich	24 "	1.917	100
Preston	9 "	1.7	100.24
Westmount	8½ "	1.36	.....

*Temperature of combustion chamber at start 750°F. feed water 460°F.

†Test conducted by the National Boiler Insurance Co. Ltd.

PRESTON COMBINED ELECTRIC TRACTION AND DESTRUCTOR WORKS.

The Combined Electric Traction and Destructor Works at Preston are among the most interesting and convincing in Great Britain. Here for the past eighteen months the entire traction service of this important town has been operated from the town's refuse alone, not excluding Sundays and holidays.

Some thirty cars are in operation for about seventeen hours daily over about nineteen miles of track, and as much at £1,000 per week has been taken in fares. About 21,000 Board of Trade units are generated every week from refuse alone, or an average of about 60 units per ton of refuse destroyed.

The destructor plant comprises 4.4 grate Meldrum front-fed regenerative destructors, total capacity about 250 tons daily, 4.30 x 8 ft. Lancashire boilers for 200 pounds pressure, regenerators, and Greens economizers. A special feature of this installation is the special offal charging arrangement and also the unique provision made for cremating large carcasses without handling.

At Swansea (South Wales) a five-cell back fed Horsfall destructor is combined with a sub-station and provides power for traction purposes. During a recent test an evaporation of 1.20 pounds of water per pound of refuse was obtained, about 60 tons of refuse is destroyed daily and an electrical output of 32 units per ton of refuse destroyed has been obtained.

This plant can, however, scarcely be compared with that at Preston, as although the weight of refuse destroyed daily is similar at Swansea, coal firing is there arranged for in connection with the destructor boiler, while the track at Swansea is only 4½ miles (route length) as compared with over 19 miles at Preston.

ELECTRIC LIGHTING AND DESTRUCTOR WORKS AT STOKE-ON-TRENT.

It has already been observed that at Preston the whole of the power required for the operation of the electric traction service is provided from refuse alone. At Stoke-on-Trent it is possible to record over a period of nearly two years a similar result in connection with a combined lighting station; from about thirty tons of refuse daily sufficient steam is produced to supply all demands for public and private lighting, no coal whatever being used, in fact no coal-fired boilers are installed. The destructor and power plant which is similar (although smaller) than that at Preston is illustrated in Fig. 83, while Fig. 84 illustrates the large plant of twelve grates of the Meldrum type combined with three 250 h.p. Babcock & Wilcox steam boilers, at the Borough of Woolwich, London.

Nothing can be quite so convincing either among combined sewage or electricity works as those few works where no coal whatever is burned, and where no supplementary coal-fired boilers are installed; where refuse is relied upon as the only fuel, there can be no criticism, and such instances afford a very conclusive answer to those who still doubt the fuel value of refuse.

The latest combined electricity and *destructor* works is that at H. M. Royal Dockyard, Chatham; the destructor is of the Mel-

FIG. 83.—DESTRUCTOR AT STOKE-ON-TRENT, ENGLAND.

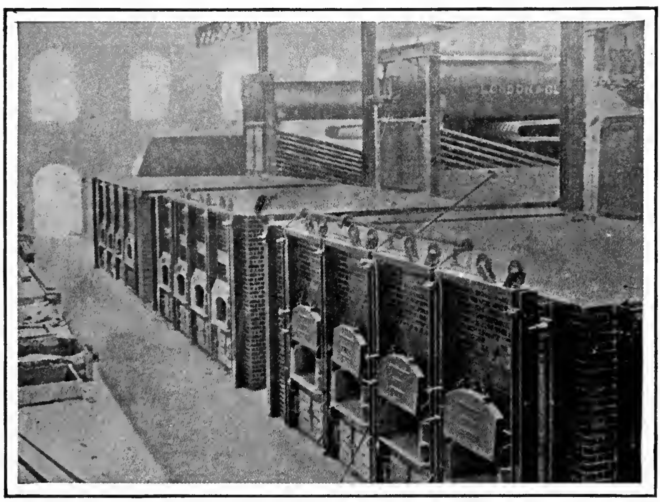

FIG. 84.—DESTRUCTORS AT BOROUGH OF WOOLWICH, CITY OF LONDON, ENGLAND.

drum regenerative front-fed type and will deal with about three tons of refuse per hour for eight hours daily, supplying steam at

200 pounds pressure to the adjoining main generating station recently constructed by the Admiralty.

In thus deciding to utilize a large quantity of refuse, the British Admiralty have followed the lead of many municipal authorities. The results at Chatham Dockyard, owing to the character of the refuse, will, in all probability, be far better than anything yet recorded in connection with combined undertakings.

DESTRUCTORS COMBINED WITH WATER WORKS—SHEERNESS.

Among destructors combined with water works, the most successful example in this country is that at Sheerness, a plant which has been inspected and was favorably commented upon by some few American engineers. Here for three years past the destructor has shown a *net surplus* in relief of the rates of over £400 per annum, the total cost of repairs and maintenance being less than £10.

The destructor is of the Meldrum regenerative front fed type, and deals with about fourteen tons of refuse daily; the total cost of the plant, excluding the chimney only, was £3,600.

Only two other works of this kind are in operation, a small plant at Hunstanton and a large plant at Blackburn. It is a combination which does not attract, owing to fear of contamination, but in cases where the reservoirs are not located at the pumping station or where covered reservoirs are used, with a well-designed destructor plant no trouble need be feared.

While the water works at Sheerness are in a very central position, water works as a rule are even further removed from inhabited areas than are sewage works, and for this reason, if for no other, the erection of destructors at water works will be limited.

CLINKER UTILIZATION.

Having destroyed, or rather changed, the nature of the refuse, we now have, according to the season of the year and other conditions, from 22% to 35% of vitreous clinker, free from organic matter and useful for many purposes. In so far as this country is concerned the writer is still firmly convinced that where a good vitreous "commercial" clinker is produced there is not, nor has there ever been a "clinker problem." Where an unsatisfactory clinker is produced, due either to an inefficient destructor or inefficient handling of a good destructor, the authorities can only blame themselves if they are faced with what they are pleased to term a problem, and have to pay to get rid of a useless material.

Whether their choice of a destructor was at fault or, on the other hand, whether their management is loose, they are to blame. In a few cases of this kind the clinker is a source of trouble and expense, but these are isolated cases, few and far between. Generally speaking, clinker is a good asset, and in many cases it is a very material source of revenue.

Whether plant of any kind be installed or not for treatment of the clinker must always be determined by the local conditions. It is, for instance, a sheer waste of public money to install a plant of any kind if the clinker can be sold at a good price as it comes from the destructor.

At the destructor works of the Metropolitan Borough of Wandsworth, London, all the clinker is thus sold just as it comes from the destructor at 1s. 9d. per cubic yard, and so great is the demand for it that all day long it is being shoveled into carts long before it is cold.

At Watford Destructor Works, all clinker is similarly sold at 1s. 8d. per ton on the ground just outside the works. Under such circumstances it would be folly to incur a large expenditure for brickmaking plant, or even the moderate expenditure involved in the purchase of a mortar mill or a crushing and screening plant; their products are not wanted, while the untreated clinker is, and the revenue is accordingly a net one.

In many towns there is a great demand for destructor clinker mortar, and at the present time over 300 mortar mills are in daily operation at such works; in every case there is a net profit, while the mortar is considered by some to be too good for ordinary building purposes.

Where clinker can be utilized for bacteria beds, or where it can be best sold graded, crushing and screening plants have been installed. Some twenty-five works in this country now have crushing and screening plants in operation.

The utilization of clinker for bacteria beds has already been referred to; the sale of clinker for this purpose or its utilization instead of coke, coke breeze, ballast and other media is in many cases a source of considerable revenue.

Some twenty municipalities are now operating clinker paving flag plants with excellent results; given a good clinker, very durable flags are produced at a saving to the ratepayers. Naturally the most convincing figures in this connection are those from the larger towns and cities, where the demand is such that the plant can be operated continuously. Clinker brick-making plants have now been installed in some half dozen towns in England and very fine bricks are being produced.

The manufacture of mortar, paving flags and bricks from clinker has met with much opposition in this country from those who are generally opposed to municipal trading. Such opposition is perhaps the most convincing testimony as to its success.

It is contended that mortar must not be made and sold by a municipality in competition with a ratepayer, that a local authority should not even be permitted to make paving flags or bricks, because by so doing established industries are threatened. The height of absurdity has perhaps been reached when those who manufacture and sell carbolic powder protest against the use of flue dust as a base for carbolic powder, although the municipality purchases the carbolic acid.

Hampered thus on every hand, remarkable progress has been made, and greater progress will undoubtedly be recorded in the near future.

CONTINENTAL PROGRESS.

On the Continent refuse disposal is now engaging the attention of many municipal authorities and, in spite of the activity of German engineers, British destructors are likely to be extensively adopted. The Herbertz destructor, designed to some extent on the lines of the most successful British types, has been adopted at Fiume, Austria, and very satisfactory results are reported, but there is no reason to suppose that this destructor can show such efficiency as may be obtained with British destructors properly adapted for dealing with the varying refuse of Continental countries. The Horsfall Destructor at Hamburg (Bullerdeich) which has been considerably altered during the past few years, is reported to give much satisfaction. Destructors of the same type have been erected in Zurich and Brussels. Russia can now boast of two destructors, one at Czarskoe Selo, the other a small experimentary plant at St. Petersburg, both of the Horsfall type, and curiously enough, after years of contemplation, both destructors were erected during the past year, when that unhappy country was in the throes of revolution.

At Fredericksburg (Denmark) a destructor of British make has been erected, but at present there is no sign of further progress in Scandinavian municipalities.

During the present year the first destructors to be adopted in France will be erected in Paris, comprising three distinct installations of the Meldrum patent regenerative top-fed type.

Each of the three works will be equipped with 3.4 grate destructors, Babcock & Wilcox boilers, 9.4 grate plants in all, having a combined total destroying capacity of between 500 and 600 tons daily.

The town of St. Etienne has ordered three Meldrum destructors having a total capacity of over 200 tons per day.

Holland, Greece and Turkey cannot report progress at present; in the former country British destructors are now being considered for some of the most important municipalities. In Greece there is not a whisper of sanitary refuse disposal. Turkey is equally apathetic; the dogs of Constantinople, ever multiplying, continue to account for the garbage of this interesting and historic city whose authorities at present seem quite content to avail themselves of the services of these willing and unpaid scavengers for all time.

What has been accomplished in Great Britain has not been without its effect upon municipal engineers in Continental Europe; there are abundant signs on every hand that when the present unsatisfactory methods of refuse disposal no longer satisfy, British destructors will be favored as offering a definite solution of what must everywhere become a serious problem.

PROGRESS IN THE EAST.

In Cairo a four-cell Horsfall destructor was erected about two years ago. Alexandria, the Egyptian city of scarcely less importance, has recently decided to adopt a British destructor.

Further east, in India, but little progress can be reported. A Baker destructor has been erected in Calcutta, which plant deals with about 130 tons daily. At Karachi, in the Punjab, are two Warner destructors, erected some few years ago, now operating.

At Singapore (Straits Settlements) a four-cell Horsfall destructor will be erected during the present year.

Nothing has yet been done in Japan, but coincidently with the advance of Western civilization there will surely be a decided demand for sanitary improvement. In China, notoriously dirty, no progress can be recorded; even in the important cities of Hong Kong and Shanghai disposal by fire has yet to be adopted. It is, however, but fair to add that the garbage of the latter city is in constant demand for manurial purposes.

Kipling has said that "East is East and West is West, and never the twain shall meet." In final sanitary refuse disposal they certainly will meet; with advancing civilization and a growing demand for sanitary reform there is not the slightest doubt that the time is coming when the ideal of the West will be the ideal of the East.

Progress in Australasia.

In Australasia progress is somewhat slow, but interesting developments may be looked for during the next few years. The important municipalities of Australia have moved very cautiously, notwithstanding the constant trouble arising from the tipping of refuse. In Sydney is a six-cell Warner destructor erected four years ago; a new plant of greater capacity was projected two years since, but tenders have not yet been accepted. A Manlove destructor was erected in Melbourne (South) several years ago, and the authorities of this important Victorian city are likely to erect a modern plant in the near future. The municipality of Perth have recently decided to erect a Horsfall destructor; other cities such as Adelaide, Brisbane and Newcastle continue to contemplate cremation as the only way out of an ever-increasing difficulty.

At Toowoomba, near Brisbane, a Meldrum destructor of the Beaman & Deas type was erected about three years ago, specially arranged for the cremation of refuse and excreta. Annandale and Leichardt, two small townships on the outskirts of Sydney, have a Meldrum regenerative front-fed destructor, which deals with the refuse of both towns, some 25 tons daily.

New Zealand has, perhaps, a better record than Australia, viewed from the standpoint of modern British practice. At Christchurch a Meldrum Beaman & Deas destructor was erected about

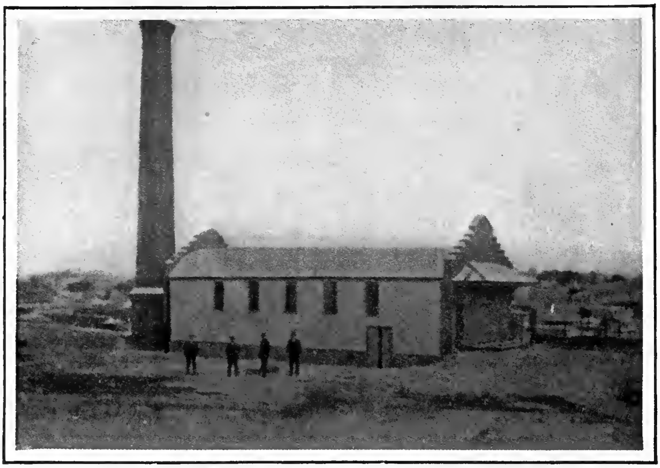

FIG. 85.—DESTRUCTOR AT ANNANDALE, AUSTRALIA.

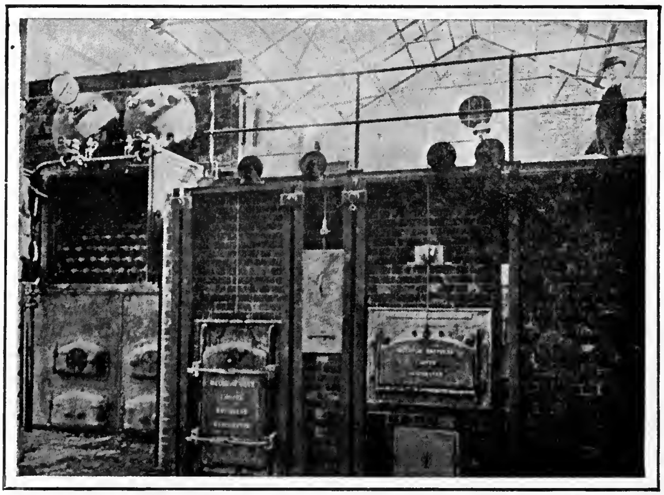

FIG. 86.—DESTRUCTOR AT CHRISTCHURCH, NEW ZEALAND.

four years ago in combination with the municipal electricity works (Fig. 86). The city of Auckland also has erected a three-grate Meldrum regenerative top-fed destructor in conjunction with the electricity works. This plant has been in operation for some few months past and, like the Christchurch plant, with very satisfactory results.

Wellington has a destructor of the Fryer type, erected several years ago; a modern destructor of British make has recently been decided upon and will be erected in the near future.

South Africa.

At East London and Durban (Natal) destructors of the Warner "Perfectus" type were erected some years ago, and these, the first destructors in South Africa, required the use of coal as a

FIG. 87.—MELDRUM DESTRUCTOR, JOHANNESBURG, SOUTH AFRICA.

supplementary fuel. Within the past two years a Horsfall three-cell destructor has been erected in Durban, a plant of the same type and size at Bloemfontein, and a two-cell Horsfall destructor at Lorenzo Marques.

At Kalk Bay (Muizenberg), "the Brighton of Cape Colony," is a Meldrum two-grate plant which is operated in combination with a large generating and main drainage works. Johannesburg has three four-grate Meldrum patent regenerative top-fed destructors, which deal with nearly 200 tons of refuse daily; here, as at Kalk Bay, the power is fully utilized. It is worthy of note that the clinker at Johannesburg is a source of revenue, large quantities having been sent even as far as Bloemfontein sewage works for the bacteria beds there. The municipality of Pretoria has recently decided to install a Meldrum regenerative top-fed destructor to dispose of some 40 tons of refuse daily. The plant will have a capacity of 60 tons daily.

THE GENERAL DISTRIBUTION OF DESTRUCTORS.

It will now be clear that the British refuse destructor is an established success in many countries. The many foreign and colonial installations are shown in the following table (No. LIX), and it must be obvious that the experience gained in the treatment of a great variety of waste in a number of countries has placed the leading makers of destructors in England in a very strong position.

It is but fair to argue that those destructors which are successfully dealing with a variety of waste in tropical and other countries could be readily adapted to the requirements of American municipalities and in the treatment of the waste of such municipalities a useful experience would be brought to bear upon the problem.

There are obvious difficulties to be faced in connection with the choice of the site; there ever will be; ignorance has always to be combated, but those who have the interests of the ratepayers at heart must be prepared for opposition. With well over 100 destructors in operation on central sites in the United Kingdom, very few complaints have been made.

Needless to add to insure such a result the destructor must be well designed, contained within suitable buildings, efficiently operated and carefully supervised. Under favorable conditions it should then be, if not actually self-supporting, at any rate such a small charge upon the rates as would pass unnoticed by the intelligent citizen who realizes to the full the great sanitary gain.

The method of disposal by fire may be accepted as the most satisfactory and universal way of dealing with all forms of worthless matter, and it is interesting to note that the beginning of the movement in the United States and Canada is announced by the installation of four British destructors, all of which have been entirely successful in their performance. A contract has also been recently closed for another. At the present writing the American towns are asking for additional information regarding the operation and capacity of these destructors. With the better knowledge of the efficiency and capacity of these furnaces as applied to American conditions there will undoubtedly be an expansion of this business such as has attended the growth in Great Britain and the Colonies, and the continental countries within the last six years.

TABLE LIX.—BRITISH REFUSE DESTRUCTORS THROUGHOUT THE WORLD.

MAKER	Great Britain and Ireland	Continental Countries	Australasia	Egypt and South Africa	South America	Far East	Canada	United States	Totals
Meldrum Bros...	77	6	7	4	2	2	1	2	101
Horsfall Des. Co.	60	7	2	5	2	2	..	..	78
Manlove, Elliott & Co.........	63	1	2	1	2	..	..	..	69
Heenan & Froude.......	35	2	1	..	..	..	1	1	40
Goddard, Massey & Warner.....	28	..	1	2	..	1	..	..	32
Hughes & Stirling Co.......	7	1	0	..	..	..	..	..	8
Jos. Baker & Sons.........	1	..	..	..	2	1	..	..	4
									332

NOTE—This paper was written by Mr. Goodrich in 1906, and all statements refer to the conditions at the end of that year.
The table LIX is compiled by the author from available data—ED.

PRAHRAN, AUSTRALIA. THE MELDRUM SIMPLEX DESTRUCTOR AT PRAHRAN.

In 1907, Mr. W. Calder, City Engineer of Prahran, Australia, was instructed to proceed to England and examine the several types of refuse destructors in view of an installation for the city of Prahran. After inspecting a very large number of installations he contracted for a Meldrum Simplex Destructor with some special features of the latest design. This destructor was built in the latter part of 1907, and has been in operation since the spring of this year. It is probable that Australian conditions are very much more similiar to our own than they are to those of England, and the reports that followed the first operation of this destructor will be of interest to all American readers.

Prahran has 40,000 population and is to some extent a residential suburb of Melbourne. All the refuse of the town was previously dumped, after being hauled a long distance, which disposal created objectionable nuisance. The recent composition of the refuse we have no record of, but in 1900 that of Melbourne and Prahran was reported to be as follows:

COMPOSITION OF TOWN'S REFUSE.

	Melbourne	*Prahran*
Cinders, coke and ashes	26.55	43.08
Sweepings, fine dust, sand, etc.	42.81	26.23
Vegetable matter, garden refuse, etc.	14.31	17.57
Paper, wood, straw, combustibles	11.57	9.25
Rubbish, glass, iron, incombustibles, etc.	4.76	3.87
	100.00	100.00

The plant just completed comprises two independent units of two grates or cells each, and two Babcock & Wilcox boilers, each of 200 horse-power. The enclosing structure is all of brick with a brick chimney, 135 feet high, and the tipping floor is reached by a ramp, a substantially built incline of earth between two retaining walls. The advantage of the two independent units is the opportunity offered to clean the flues and furnaces without any cessation of destruction and resultant accumulation of refuse, which would be very objectionable in this residential locality.

The amount of refuse destroyed is about thirty tons per day. In the summer season this is of less calorific value than in winter, because of the large proportion of vegetables, garden refuse, tree cuttings, etc. One unit operating 24 hours usually disposes of all the refuse. It was originally intended to heat the air used in combustion by passing it over the hot clinkers, and the plant was designed to permit of this. A short trial, however, indicated that little benefit was derived from this and it has been discontinued.

The clinkers are now carried directly to the yard, where they are crushed and used for the paving of roads and footpaths.

A local paper remarks concerning the surroundings: "Trees, flowers and shrubs are being planted, and the place in time should present an attractive appearance to the eye, especially to passengers

FIG. 88.—THE MELDRUM DESTRUCTOR, PRAHRAN, AUSTRALIA.

who travel on the Hawkburn railway line. The site of the destructor is in the center of the city, surrounded by dwellings, where any nuisance or failure in its proper working would be a serious matter."

The following report of the operation of the destructor during a test made in May, 1908, is furnished by Mr. Calder:

TABLE LX.—PRAHRAN REFUSE DESTRUCTOR TEST, MAY 21, 1908.

BOILERS:	
Time of test	9:45 a.m. to 10:15 p.m.
Duration of test	12½ hours.
Weather conditions, etc	Fine. Wind North to Northwest.
Number of Cells	2
Total Grate Area	50 square feet.
One Babcock-Wilcox Heating Surface	1,426 square feet.

TABLE LX.—(Continued.)

REFUSE:				
Nature of Refuse	House and Garden Refuse.			
Amount of Moisture contained in Refuse	42.86%			
Total Weight of Refuse delivered	21 T.	10 C.	1 Q.	14 lbs.
" " " " as fired	20	13	0	4
" " " Tins, bottles, etc.		17	1	10
" " " Refuse destroyed per hour	1	13	0	5
" " " " " " sq. ft. per hr.		..	.	74.016 lbs.
WATER:				
Total weight of water evaporated	47,067.5 lbs.			
" " " " " per hour	3,765.4 "			
Water evaporated per pound of refuse	1.019 lbs.			
" " " " " " from and at 212 degrees	1.188 "			
CLINKER:				
Total weight of clinker	5 T.	0 C.	3 Q.	21 lbs.
Proportion of clinker to refuse fired	24.4%			
Total weight of ash from ashpits	9 C.	0 Q.	7 lbs.	
Proportion of ash to refuse fired	2.19%			
STEAM PRESSURE:				
Steam Gauge—Average	172.3			
" " Highest	185			
" " Lowest	115			
Ashpit Draught—Average	(No. 1) .69″ (No. 2) 1.35″			
TEMPERATURE:				
Combustion Chamber	Copper melted 3 times.			
" " Maximum (Watkin's Recorder)	2,174 degrees.			
Before Regenerator—Average	694.08 "			
After Regenerator "	551.5 "			
Hot Air Conduit "	347.6 "			
Building "	62 "			
Feed Water "	82.1 "			

For the utilization of the power developed by the destructor a contract has been made with the Electric Lighting & Traction Company, which is a private corporation, and from which the city receives payment for the surplus electricity at a price based upon the present rate paid by the company for fuel for the operation of their own works. The power developed during the day by the destructor is sent through the high tension main of the electricity works, passing through a meter for measurement. It is estimated that this will bring in a revenue of £600 per annum. The city council has ordered an additional cell for one of the plants, and when this is installed the working force will be reduced to two shifts of five men instead of six men in the twenty-four hours, as formerly.

There is also a use found for the clinker, which is crushed and made into paving slabs to be used in municipal work. The illustrations herewith show a mortar mill and crushing and grinding machine with screen for separating the fine dust from the clinker. It is expected that when all these revenues are put together the cost of operation of the destructor will be brought down to less than £20 per annum. At the present time the expenditure in working the plant amounts to about £920 per year.

This will be reduced to £900 when the new grate is at work, and the cost of maintenance greatly reduced.

This plant is an illustration of what can be done by a modern destructor of the best type when operated under the care of an ex-

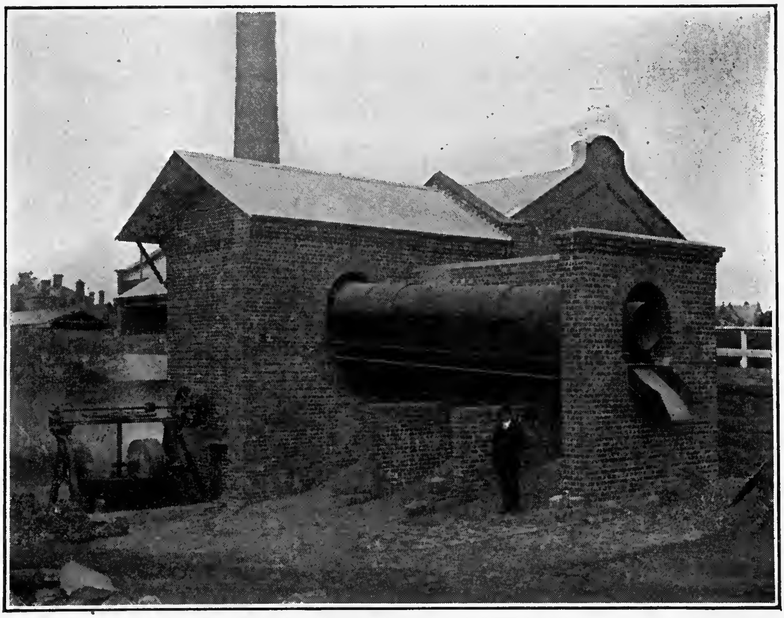

FIG. 89.—MORTAR MILL AND CLINKER SEPARATOR, PRAHRAN, AUSTRALIA.

perienced city engineer, and from which revenue can be had not only through the power but also from the by-products by practical utilization. The conditions in Prahran are very much like those in an ordinary northern American town, and there is every reason to believe that similar results can be obtained here by using the same methods.

REFUSE DESTRUCTORS IN PARIS.

The Meldrum Destructors in Paris.—As previously noted Paris had for centuries disposed of all its refuse for agricultural purposes, but early in 1907 a contract was made for the installation of three destructor plants in different parts of the city, which should have a combined capacity of 700 tons daily.

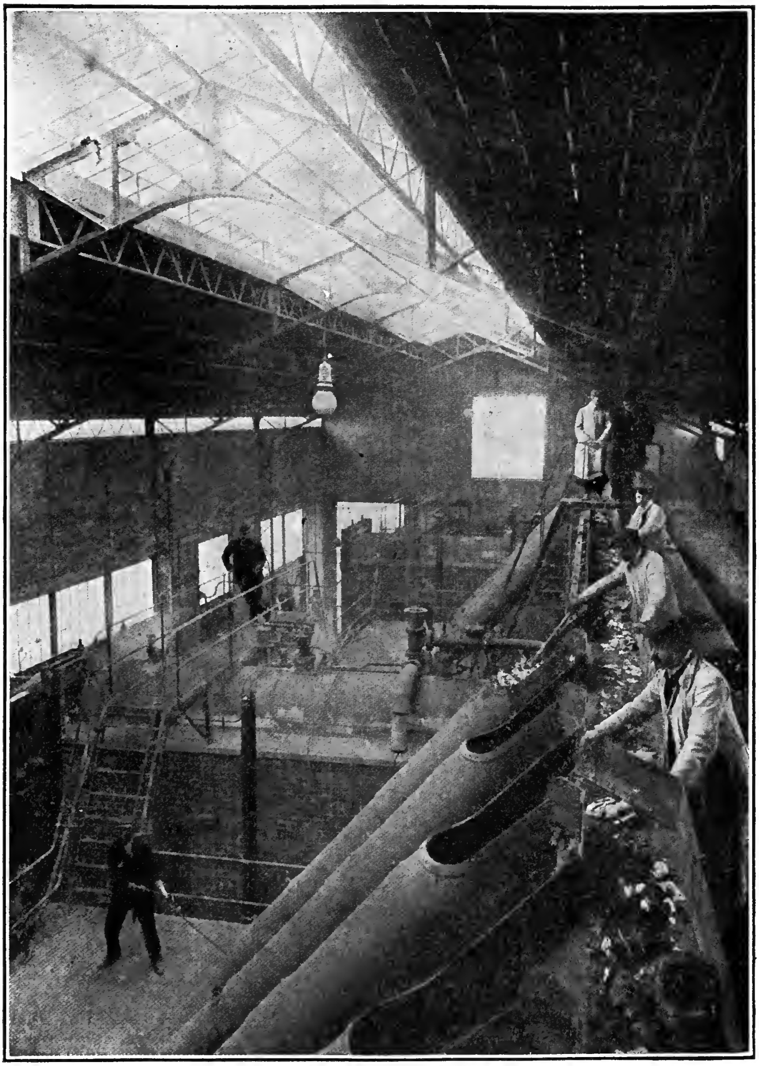

FIG. 90.—MELDRUM DESTRUCTORS, PARIS.

These destructors are of the standard Meldrum top-feed type, in three installations at Issy-le-Moulineaux, Romainville and St. Ouen. Each plant comprises three units of four grates, making a total of 36 grates, or cells. Babcock & Wilcox boilers are used.

The accompanying illustration gives an excellent idea of the construction of the stations, and of the method of charging the destructors, by means of conveyor belts which bring the refuse to chutes connected with the charging holes of each destructor.

In 1906 the total number of British destructors operating throughout the world was estimated at 282. Since then the increase, as shown in the preceding table, is estimated at 50, making the total 332. These figures are given as an indication of the growth of the destructor system in almost every country in the world. Besides the makers named there are some four or five other builders in Germany and Italy of furnaces which follow very closely the lines of the British destructors. Undoubtedly there are many other furnace builders whose acquaintance we have not yet made.

PART IV.

THE DISPOSAL OF WASTE BY REDUCTION AND EXTRACTION PROCESSES.

CHAPTER XII.

The Processes of Reduction and Extraction in the U. S.

The movement for the improvement of sanitary conditions in American towns actively began in 1887. While there were already in existence many State medical associations which dealt with public hygiene as particular phases of epidemics were reported by the members, prior to this year, no general attention was paid to the subject of municipal sanitation as represented by the sanitary treatment of city wastes.

The leading national societies, the American Medical Association, the Mississippi Valley Sanitary Society and the Association of American Railroad Surgeons, did not concern themselves with prevention of diseases that might arise from unsanitary waste disposal methods. The health officers of towns and cities were struggling with the difficulties that arose, but without the knowledge of suitable methods and apparatus for improving conditions, they were content to follow precedents and dispose of waste by the easiest available means.

The first steps for general improvement were taken by the American Public Health Association, when, in 1887, at the meeting in Milwaukee, there was read a series of papers describing the work of certain garbage crematories in Wheeling, Des Moines, Milwaukee, Minneapolis and Montreal, by which city refuse of every kind was destroyed by fire. This led to the appointment of a special committee to investigate and report on the subject, and this committee has been continued for nearly twenty years. Papers published in the official reports of the association tabulated the progress of the work, definitely defined the constituents of waste, and from time to time gave statistics from many cities and towns, advocating impartial consideration of the subject with a view to the improvement of sanitary conditions. These reports gave descriptions of methods and apparatus, and generally included an indication of the approximate costs.

But in 1888-89 the subject came more prominently to the front, through an epidemic of yellow fever in Florida, which awakened widespread interest in the practical question of protection by quarantine, and the necessity for controlling the progress and finally stamping out the cause of the plague. Among the questions pertinent to the subject was that of the disposal of city waste, a serious problem in the affected communities in which there was no sewerage system, nor any method, except the most primitive, for disposing of household refuse.

The demand for the safe and instant disposal of dangerous matter was met by the erection of cremating furnaces in which night-soil, garbage, dead animals and combustible refuse were destroyed. At Jacksonville, St. Augustine, Tampa, Fla., Brunswick, Savannah, Atlanta, Ga., and Birmingham, Ala., the most dangerous forms of waste were consumed by Engle cremators, which were invaluable aids in restoring confidence in the efficient administration of the Health Departments. All these installations, with one exception, were made after the design and under the supervision of the author. While none were of large capacity and all were hastily built with the material at hand, they were all on the whole quite satisfactory in operation, and for temporary service admirably answered the purpose. The subsequent growth and progress of this means of waste disposal by incineration has been previously described.

THE REDUCTION AND EXTRACTION METHODS FOR THE TREATMENT OF GARBAGE.

The reports upon crematory work published by the engineering press and in the papers of the American Public Health Association gave some idea of the composition and relative quantities of American city waste. It was observed that the garbage was larger in amount in this country than in English towns, where the work of disposal by fire had been carried on for several previous years. The reports of experiments made in European cities established the fact that this item of waste contained a certain proportion of grease or oil that was valuable for many uses, and that there remained, after this oil was extracted, a residuum that could be still further utilized.

THE MERZ PROCESS OF REDUCTION.

In 1886 the "Merz" process, first experimentally known in Vienna, Austria, was introduced into America by Mr. H. A. Fleischman, who in May of that year organized, at Buffalo, a company "to manufacture grease and fertilizer from city refuse." The contract with the city of Buffalo provided that the city should collect the garbage, separated from all other refuse, and deliver the same at the company's works.

The statement made by Mr. Fleischman before the committee of the Boston City Council in March, 1893, gives a concise account of the first "Merz" Extraction Process. Mr. Fleischman said:

> We put up the first plant in the city of Buffalo, and I thought there would be a barrel of money in it; and I went before the city council and said, "Gentlemen, I will take your garbage for nothing. I do not want any compensation for it." We put up the first plant, gentlemen. Our company and our friends invested $55,000 and we received the garbage for a year and a half, and after this time we found out we had lost $18,000, and the people who had invested their money in the garbage business thought they had better buy some other stock than garbage stock. Finally we closed it up voluntarily.
>
> Now, gentlemen, if all you would know the trouble we had, the injunctions that came in by the dozen before we built a plant, anybody would be tired of going into the garbage business. Well, after the plant was closed for about a year, about five different parties came there and made a bid. The cremation parties and other parties had some scheme to put it on the ground and put some chemicals on it.
>
> Finally the people of Buffalo were satisfied and thought we had lost our money, and they gave us a contract for two years, $20,000 a year, and our stockholders were delighted. We have worked that plant for two years. . . . We get the common garbage from the city, and after two years' work, we didn't make much money—we made in two years $5,460.
>
> Finally we went into another competition. The two years were out—the city advertised again. . . . The Sanitary Committee of the City of Buffalo unanimously accepted my bid of $125,000 for five years.

This second plant of the Buffalo Reduction Company was built at Checktowaga, outside the city limits, about six and one-half miles from City Hall.

The construction and operation of the original plant cannot be accurately described, owing to the numerous changes that have been made, but the following description of the second plant, which information was obtained by a personal inspection of the works in 1892, is believed to be correct.

The city garbage carts deliver their loads upon an upper platform where the tins and other foreign substances are recovered by hand. The garbage is then charged into horizontal tanks or digestors of about 6,000 pounds capacity. Extending through these digestors is a hollow shaft with projecting arms which is rotated by power, steam at high pressure being forced through the shaft and arms. These cylindrical digestors are jacketed to prevent the radiation of heat. The cooking process continues for from six to eight hours, during which the bulk of the garbage is reduced 65 per cent. by the escape of water which is allowed to drain from the digestors. The remaining 35 per cent. of matter is removed to closed steel tanks which are then flooded with naphtha. This fluid holding the grease or oil is then removed by presses and the residuum or "tankage" dried in rotary cylinders and ground for fertilizer. The separation of the grease and water is then complete, and the naphtha, with a loss of 15 per cent. to 20 per cent. is recovered and used again. The oil obtained by this process is a dense, semi-liquid brown or black mixture containing many impurities and a considerable percentage of naphtha. It is barrelled and sent to market in this crude form. The quantity is about 3 per cent. of the total amount of garbage treated, equivalent to approximately 60 pounds per ton of garbage.

There is required 250 horse-power of steam and the continuous labor of twelve or fifteen men to carry on the work. With the exception of a storage house and the chimney stack the construction is wholly of wood.

In 1890 this company made several experimental attempts to manufacture a fertilizer from night-soil by means of a huge rotary drying cylinder, but the process was so offensive and expensive, and the results so uncertain that the attempts were abandoned.

The company continued the work of garbage disposal up to September 30, 1900, when the works were almost entirely destroyed by fire. Pending the reconstruction of the plant, the company demanded and obtained a change in the contract whereby they received a somewhat larger amount of money, with additional yearly increase.

When this contract expired, the Board of Works advertised for bids. As stated by Mr. Drake, chairman of the board:

The reduction works that had been enjoying the contract for $35,000 per year put in a bid for $45,000 a year. There were three bids, however, the lowest being for $15,000, and after weeks of delay and a bitter fight, the contract was let to the lowest bidders. Within three days thereafter the highest bidder, the reduction works, came with the successful contractor and asked the board to consent to the transfer of the contract to the reduction works; and to-day (September, 1899) they are reducing the garbage for $15,000 per year, the former cost being $35,000.

The present contract, dating from June, 1903, is with the Buffalo Sanitary Company, which has the contract for the collection and disposal of the city garbage, refuse and ashes. The treatment of twenty-five thousand tons per year is performed for the sum of about $18,000, the reduction company receiving all the product of the work. This is a rate of 61.2 cents for disposal only. The company makes collections and delivers at the works. This contract expires in 1909, when it is probable that some other method which will be less expensive will be used for transportation and treatment.

THE NEW MERZ PROCESS.

When rebuilding the Buffalo works after the destruction by fire, many changes and alterations were made, and later on more improvements were introduced.

The present Merz process as carried on at Checktowaga is thus described by a competent authority:

The building contains three large ovens, in each of which are six revolving cylindrical dryers. These are 48 inches in diameter, 13 feet long, inclined, and supplied with hard coal grates, 15 square feet in area. The heated gases pass around the dryers and are then drawn through them by mechanical contrivances. Outside the building is a cooling tank, 7 feet diameter, 10 feet high, furnished with a 1½-inch water spray pipe and drain, and a large vertical discharge fan 78 inches in diameter, of 25,000 cubic feet capacity, speed 280 revolutions per minute. The fan is connected with a steel stack 80 feet high by 5½ feet in diameter. The remaining apparatus includes four 125 horse-power boilers, four grease extractors, two engines and an electrical generator.

The garbage is dumped into a large hopper and taken by conveyor to the second floor where it is ground into pieces of one cubic inch. It then passes through the same breeching that conveys the gases to the cooling tower, into the rotary dryers where it remains for one hour and a quarter. During this time it slowly passes the length of the dryers, subjected to the heat all around the cylinders; the hot gases are also returned through the dryers and brought into direct contact with the garbage. All animal life is now destroyed and a large part of the moisture driven off. The garbage is then conveyed to the Merz Grease Extractors and the grease removed by a solvent of benzine. The tankage is ground and stored for market and the grease separated from the naphtha, which is recovered with about 15 per cent. loss. These gases discharged in the drying process deposit a large amount of watery vapor in the cooling tower and are sucked into the stack, passing over a furnace in the bottom of the stack which destroys any remaining offensive odors. Although the plant has reduced as much as 175 tons per day, with 80 per cent. of moisture, equivalent to 140 tons of water, the gases discharged from the top of the stack were odorless and almost invisible.

The amount of garbage handled varies from 50 tons per day in February to 140 tons in September. To reduce this amount of garbage the plant consumes about ten tons of coal per day for the steam boilers which furnish power to operate the plant, and for the heating and evaporating of the naphtha, and four tons of coal per day to heat the rotary dryers, also 100,000 gallons of water per day for steam and condensing purposes, and about 50 gallons of naphtha per day to replenish losses.

This is the method at present in use, a radical departure from the former method of reduction by steam to pulp before applying the solvent, and is the result of experiments extending for a number of years.

It will be noted that the great difficulty in reduction methods has been that of drawing off the moisture contained in garbage, which averages nearly 85 per cent. When this is separated by steaming there is at one stage of the process a volume of water that it is almost impossible to dispose of except through sewers.

This procedure invariably gives rise to nuisance, as the water contains the most offensive and most quickly putrefying elements of the garbage. The evaporation of the water at a temperature sufficiently high to vaporize it would avoid the after difficulties of dealing with this waste, and would deliver the residual in condition to be treated by the solvent without loss of the valuable volatile elements of ammonia and phosphate, which would remain in the tankage after the solvent had carried out the grease.

From the first, complaints of the operation of this plant have been received. During the summer of 1904 a strong effort for its discontinuance was made by the authorities of Checktowaga, but without avail, the argument of the city being that the work was one of necessity and that no other means of disposal was available.

Milwaukee.—The Merz process was introduced at Milwaukee, Wis., in 1888, a local company capitalized at $500,000 having been formed to take over the patents and do the work. This company obtained a contract for three years and erected its works in the city limits upon ground in the neighborhood of fertilizer factories at a cost of $100,000.

The city paid $15,000 per year for disposal, collecting the garbage for delivery to the company. The same apparatus as that installed in the first Buffalo plant was used, although the quantity of garbage was small, being about 50 tons per day.

Complaints of nuisance were made from the beginning and continued for the duration of the plant's operation. The Health Officer, Dr. Wingate, says in one report:

In the summer of 1891, it became evident to the Health Department that the plant was being overworked, the water supply was not sufficient for condensing the gases properly; the building had become shaky and the machinery was not working properly; offensive gases were escaping and creating a nuisance, and not from the fault of the process, but from the location, construction and management of the plant, it was deemed advisable to close the plant a few months before the expiration of the contract.

In June, 1892, the city contracted for five years with the Wisconsin Rendering Company for the disposal of garbage and dead animals.

The collection was to be made by the company in steel air-tight tanks and conveyed without nuisance either by boat or on cars to the plant, which was located at Bartels, about fourteen miles outside the city limits. The collections were made three times per week in summer and twice a week in winter from residences, and daily from hotels and restaurants. Dead animals were removed upon notification to the company. The city was to pay for collection, transportation and disposal, the sum of $68,000 for the first year and a yearly increase of $2,000 per year for five years, when a new contract could be made or the works purchased by the city.

The amounts in 1890 were 15,000 tons per year or about 48 tons per day, with 15,943 small dead animals and 660 dead horses. This is about $4.53 per ton for collection and disposal or approximately 26 cents per capita. At the expiration of this contract it was not renewed.

Milwaukee's experience in the various methods of waste disposal covers all the stages of progress known to this country. In the earliest years, and until it became impracticable, the garbage was dumped at convenient places adjacent to the city limits. In 1887-8 the first crematory furnace was built by Mr. Forrestal, a contractor. This was a crude form of the English Beehive destructor, using coal as fuel and destroying a part of the garbage.

In 1887-8, the Engle Sanitary and Construction Company, of Des Moines, Iowa, installed a cremator of small capacity which operated for a few months. This was acquired by the Merz Reduction Company and was discontinued when in 1888 they obtained their contract for disposal by reduction.

After the suspension of the contract with the Wisconsin Rendering Company in 1897, the city authorities went back for nearly two years to the old system of dumping, but in 1902, compelled by increasing public dissatisfaction with prevailing methods to effect a change, they contracted with the Engle Sanitary and Cremation Company for two large furnaces, each rated at 100 tons daily capacity. These were built under the patents and the supervision of Robert Robinson, associated at that time with the Engle Company, and were placed upon an island in the river in an effort to avoid complaints of nuisance. The city paid $12,500 for the right to build under the patents and the sum of $29,160 was appropriated for special machinery required in construction. The ultimate cost for the construction and equipment of the crematories was upward of $80,000.

The contract provided for a maximum cost for operating, but the plant being under political control, a large number of unnecessary employees found easy berths. The fuel expense was large, making the cost of operation excessive. Many expensive repairs to the furnace were made, and these, taken with the cost of transportation by water, which was necessary because of the isolated situation of the plant, made the cost of operation considerably larger than that of any other garbage crematory in the United States. This plant is still operating, pending the adoption of other methods.

REPORT OF MR. RUDOLPH HERING.

In 1907 the city authorities commissioned Mr. Rudolph Hering to make an examination of the present conditions and to formulate a report upon the costs of collection of the varied classes of city waste and the methods by which they should be disposed of in a manner most sanitary and advantageous to the city.

An excerpt from Mr. Hering's report is made as follows. (Condensed from the Municipal Sanitary Engineer, February 12, 1908):

The engineer considers at length both reduction and incineration systems. His final conclusion is, that, since reduction works have invariably been offensive they should be located outside the city, other large places having placed these at a distance of five to fifteen miles from the populous districts. On the other hand, there have been no complaints from the present crematory, and in some instances similar plants have been operated in built-up sections without serious nuisance—it was, therefore, concluded that an incinerating plant of the best type could be placed within the city limits.

During 1906 the cost of collections and disposal by the crematory was—taking the year through:

Total public collection	38,212 tons	
Total private collection	263 "	
Total dead animals	75 "	
		38,550 tons
Cost of collection, per ton		$1.66¾
Cost of disposal, per ton		1.35⅔
Largest quantity—September—in tons		3,969
Smallest quantity—February—in tons		2,368

The cost of hauling per ton mile obtained from an average of seventeen representative districts was:

Average distance for each collection daily..................	7.2 miles
Each load averaged .796 ton..................................	1,594 lbs.
Average for each collector, 2 loads per day, 3,184 lbs., or...	1.592 tons
On a basis of $2.50 per day, the cost of collecting per man employed was 22c. per ton-mile, or 1.58 for teams only.	
Mixed loads of ashes and rubbish measuring 2.5 cubic yards weighed 2,601 lbs., or, per yard.........................	1,040 lbs.
Dry material, 2.5 cubic yards weighed 2,425 lbs., or, per yard..	970 lbs.
Ashes alone, 2.5 yards weighed 3,025 pounds per yard.........	1,210 lbs.
Rubbish alone, 2.5 yards weighed 1,625 lbs. per yard..........	650 lbs.

In connection with the burning of ashes mixed with garbage, he argues as follows:

If coal is worth $3.75 per ton, then, as the amount of coal in domestic ashes can be safely taken at 20 per cent. of the whole, the fuel value of a ton of ashes in an incinerator which is kept at a temperature of at least 1,200 degrees F., when all coal would be consumed, is worth 75 cents. If we reckon the expense of hauling at 25 cents per ton mile, it would pay to haul such ashes three miles. On the other hand, there is a fill value to ashes, but this is maintained after complete incineration. And there is the expense of a larger grate area for adding ashes to the incinerator, which must also be considered in the cost estimate.

If rubbish is burned, then, as it has a calorific value in American cities of about one-fifth that of coal, and if coal is worth $3.75 a ton, we can value a ton of rubbish also at $0.75, and it will pay to haul it as far as the ashes, if it were not a sanitary requirement to destroy it by fire even at a greater cost.

If garbage is burned with other refuse, separation is not customary, and, at first glance, seems to have no advantage. In my opinion, however, garbage should continue to be separately collected and delivered. As garbage should at some seasons be collected daily, while the other refuse can be collected at longer intervals, there is an advantage in limiting the more frequent service to the single material which requires rapid delivery. There is also the advantage of expelling some of the free water of the garbage (according to Prof. Sommer, about 9 per cent.), by the pressure of its own weight. There is also the advantage of evaporating an additional amount of water at the works, as done at your furnace at present, in a more economical manner than if garbage, rubbish and ashes were at once mixed. In the latter case, the water is at once absorbed and only slowly evaporated, perhaps not until this is done by the fuel contained in the refuse, which should be utilized rather for maintaining the highest practicable degree of heat in the furnace.

Whether the collection is of garbage or of other refuse if the roads are good and if the collection is mainly down-hill, as in Milwaukee, it will be cheaper to have double teams with two men than single teams with one man. The tare weight of a double team wagon is not nearly twice that of a single team wagon, and the saving of weight can be utilized for an additional amount of refuse to be hauled by the same team. There is further economy in the fact that two men together can collect more rapidly than two men singly.

It is hardly necessary to state in this city that the collection of all classes of refuse is better done by city employees than by contract. There may be exceptional conditions where this is not so, but the exclusive custom in Europe and the experience of most of the best managed public works in our own country have amply indicated that, ordinarily, where a question of nuisance is concerned and where the convenience and comfort of the people is first considered, the contract system has, as a rule, not given the same degree of satisfaction as municipal operation.

Concerning the utilization of the heat, Mr. Hering states:

From the examinations that have been made, it is safe to guarantee a pound of steam per pound of refuse during the fruit season, when the degree of moisture in the refuse is greatest, and 1¼ pounds of steam per pound for refuse in the winter, when the discarded coal in ashes is greatest. . . The practicability of utilizing the resulting heat has been amply demonstrated by experience in many cities. It has been used to operate the plant, to furnish power for pumping, for repair shops, for breaking and grinding clinkers, and chiefly for driving dynamos for electric lighting.

He estimates the investment cost of plants as follows:

1.	Reduction of 150 tons of garbage	$225,000
	Incineration of 100 tons of rubbish	89,000
	Total for 250 tons refuse	$314,000
2.	Incineration of all refuse, 450 tons	307,000
3.	Incineration of 300 tons	200,000

The operation costs, including interest and depreciation, are estimated as follows:

		Per Day	Per Ton
1.	Reduction of 150 tons of garbage	$55.00	$0.37
	Incineration of 100 tons of rubbish	37.73	.38
	Total cost for 250 tons rubbish	$92.73	$0.37
2.	Incineration of all refuse, 450 tons	47.53	.11
3.	Incineration of 300 tons of refuse	79.01	.26

From this summary it will be seen that the reduction project is the more expensive one. The larger of the two incineration works is cheaper per ton of material burned than the smaller one, due to the fact that practically no ashes would be hauled to the latter and therefore no value is derived from the heating power of the unburned coal contained therein, which is found to be considerable, but which could be utilized as the area of grate surface available at the plant would be increased.

Preliminary to the report of Mr. Hering, an investigation was made by Prof. R. E. W. Sommer upon the constituents of garbage that brought out some facts which, though not altogether new, were stated in a more definite form than had been previously done.

The method of proceeding is interesting and one that can be easily followed by any place which desires to obtain similar information.

In order to obtain an average sample the city was divided into five districts, according to the wealth of the population. It was ascertained how many team loads were collected during the same length of time (one month) in each of these five districts. When the teams arrived, September 9, 1907, there were taken as many unit measures (garbage cans) of the garbage of each of the five districts as the district gave teams within the same time. The garbage was poured upon a sloping hard floor and well mixed with a spade.

In order to determine the amount of liquid which is pressed out by the own weight of the garbage, a weighed quantity of the mixed garbage was filled into a barrel having a double perforated bottom and allowed to stand for twenty-four hours, and the liquid which was drained off was weighed.

The larger quantity of the mixed garbage was piled up and quartered down, just as miners do in order to obtain an average sample of ore. After each quartering the garbage was comminuted with knives and the quartering and comminution continued until twenty-five pounds of garbage were obtained. The liquid pressed out by these processes ran down the sloping floor and was collected, measured and each time calculated in the right proportion. The remaining twenty-five pounds of mixed comminuted wet garbage was brought to the chemical laboratory. Here the quartering was continued until about two pounds were obtained.

The approximate two pounds were accurately weighed and heated on a water bath for some days, until they appeared dry, and the drying process continued in a drying oven at 105 degrees C. until constant weight. The loss of weight plus the weight of the liquid (proportionately calculated for two pounds) which was squeezed out by the process of comminution gave the total amount of water.

The dry garbage was poured in an iron mortar and gave a coarse, brownish-black powder, somewhat resembling ground coffee. The chemical analysis was made with this powder.

Since one pound of dry garbage gave 4,522 B.T.U. and the 22 pounds of dry matter in the 100 pounds of wet garbage gave 99,484 B.T.U., it was concluded that after the 9.33 per cent of free water had been removed by its own pressure, garbage should burn itself under perfect conditions with no additional fuel.

These examinations of the garbage constituents are exceedingly valuable for the general information of other communities where the same methods can be used and the results obtained in the same manner.

Comparison of the reports of Prof. Sommer with those of Mr. B. F. Welton on garbage from West New Brighton, N. Y., and expressing the results in equivalents of coal, will make the matter clearer to lay readers.

TABLE LXI.—EQUIVALENT COAL IN ONE TON OF GARBAGE, DEDUCTING FREE WATER DRAINED BY NATURAL MEANS.

	Original Per Cent. Water %	Per Cent. Drained	Per Cent. Water Remaining	Per Cent. Pounds in Water Solids	B. T. W. per Pound	Total B. T. U.	Equivalent Coal
Milwaukee.....	78	9.33	68.67	1,374,626	4,522	2,807,222	217
New Brighton..	73.26	9.33	66.43	1,328,672	4,274	2,872,128	220

Coal is assumed at 13,000 B. T. U. per pound.

If we assume that 9 pounds of water to be evaporated by one pound coal under the best conditions, then the evaporation of 1,328 pounds of water would require 147 pounds coal, leaving 70 pounds for loss. This would mean an efficiency of about 68 per cent. in the furnace necessary to do the work, which might be taken as the standard of efficiency required from the furnace when garbage alone is to be destroyed. With coal at $3.75 per ton, the value of this fuel would be about 46 1-2 cents per ton, or about 1-9 of the coal value of fuel.

These conditions apply when separated garbage unmixed with other matters is dealt with. When refuse or rubbish is burned with garbage the conditions are far more favorable.

Dry refuse (rubbish, as termed by the engineer) contains a coal equivalent of approximately 1,298 pounds coal per ton of refuse, and if this be added in the same proportions as are usually collected, and burned without sorting, the evaporation power will approximate 500 pounds of coal per ton of mixed garbage and rubbish.

It would seem that the estimates of power to be developed are well within the mark, and that the combustion will be done without other fuel than the garbage and refuse of the usual collections.

When the collections contain ashes and manure mixed with garbage and refuse, the evaporation is still greater. For comparison with the actual work done under these conditions, reference is made to the report from the Meldrum Destructor at Westmount.

TABLE LXII.—AVERAGE DAILY QUANTITY, IN TONS, OF GARBAGE FROM THE WHOLE CITY OF MILWAUKEE, AND OF ASHES AND RUBBISH FROM WARDS 1 TO 7, INCLUSIVE, COLLECTED EACH MONTH DURING THE YEAR 1906.

The quantity of manure shown is figured to give a total daily quantity of refuse of 300 tons.

Month	Quantity		Tons per 24 Hours	
	Garbage	Ashes and Rubbish	Manure	Total
January	95	197	8	300
February	91	170	39	300
March	110	170	20	300
April	93	105	102	300
May	116	150	34	300
June	161	124	15	300
July	156	102	42	300
August	170	104	26	300
September	153	102	45	300
October	133	114	53	300
November	114	142	44	300
December	92	171	37	300

NOTES:—Garbage weighs 1,200 pounds per cu. yd.
Ashes and rubbish mixed weigh about 1,040 pounds per cu. yd.
Manure weighs 970 pounds per cu. yd.

TABLE LXIII.—PERCENTAGE OF GARBAGE, ASHES AND RUBBISH AND MANURE IN THE AVERAGE DAILY QUANTITY OF REFUSE FOR EACH MONTH AS COLLECTED IN THE YEAR 1906.

Month	Garbage Per Cent.	Ashes and Rubbish Per Cent.	Manure Per Cent.	Total Per Cent.
January	31.7	65.6	2.7	100
February	30.3	56.7	13.0	100
March	36.7	56.7	6.6	100
April	31.0	35.0	34.0	100
May	38.7	50.0	11.3	100
June	53.7	41.3	5.0	100
July	52.0	34.0	14.0	100
August	56.7	34.7	8.6	100
September	51.0	34.0	15.0	100
October	44.3	38.0	17.7	100
November	38.0	47.3	14.7	100
December	30.7	57.0	12.3	100

The calorific value of these materials as collected may be taken as follows:

Garbage (as collected)........1,500 B. T. U. per pound
Rubbish and ashes mixed......5,000 B. T. U. " "
Manure.....................2,000 B. T. U. " "

The preceding report made by Mr. Rudolph Hering to the City Council of Milwaukee was filed in January, 1907. The council deferred action until October, 1908, when, after due preparation, specifications were prepared calling for tenders for the *Erection and Completion of a Refuse Incinerator.*

This movement for a better system of waste treatment in Milwaukee is due largely to the efforts of Dr. H. A. Bading, Commissioner of Health. From the date of his appointment in 1906 he has earnestly advocated this much needed improvement which now seems likely to be brought to a satisfactory conclusion.

THE CHICAGO MERZ REDUCTION PLANTS.

The sanitary work of Chicago, Ill., as connected with waste collection and disposal, has from the first been until within two years in a condition of chronic negligence and resulting constant complaint.

Within a radius of from six to eight miles from the city were a series of great pits or excavations made by removing clay for bricks used in building the city. After the layers of clay were removed to a depth of from twenty to sixty feet these pits were filled with mixed refuse of all kinds, and have for years been the only means of waste disposal. The clay was used to make bricks to build the city, the city filled the pits with refuse and then built houses thereon, and the process was repeated until the hauls have become so long and the cost of transportation so great as to compel other courses. During all these years many efforts have been made to establish better means of disposal. The crematories built by Anderson, Heavey, and others, proved inadequate. A traveling crematory was tried and abandoned. The practical example of the destruction of the refuse and sewage sludge of the World's Fair in 1893 by the Engle crematories with entire sanitary success and at a moderate cost was permitted to pass without notice, and even when these furnaces were offered free to the city, on condition of their removal and re-erection on the city's ground, this was declined without thanks.

The collection service has always been by contract. Either a definite territory or ward has been let for a specified time at a given price, or the carts have been hired from contractors and the collections made by the city employees. In either way it is a most expensive, unsanitary and unsatisfactory work, a striking example of the power of contractors who own their plant to compel the city to accept their terms for poor work.

This whole subject has been examined and reported on, and recommendations for municipal service have been made by competent men trained in the work, all without avail. The influence of the contractor has been stronger than any consideration of economy, decency or sanitation.

The Merz Reduction Process was established at Chicago in 1888, the first city to adopt this method after the installation made in Buffalo. The contract was made with the city by a stock company organized by owners of the Merz patents, and a large plant was built, at a cost of $100,000, at a remote point near the boundary line of the city. The city was to pay at the rate of 50 cents per ton for all garbage treated, and to collect and deliver the garbage at the works. This payment was found to be insufficient to produce a revenue. The garbage was mixed with a large amount of foreign matter impossible to completely separate at the works, while the city did not enforce the ordinance for separation at the houses.

No details of the working of this plant are to be had, but it is known that an experiment made for a short time showed that under prevailing conditions the plant could not be made to produce a revenue. The work was discontinued, and shortly afterwards the buildings were destroyed by fire.

The Second Merz Plant.—Up to 1906 the garbage had been dumped with the other forms of waste. In that year the city contracted for the separate treatment of this with the Chicago Reduction Company, a corporation formed to receive the garbage from the city teams at one central station and to treat it for the recovery of the grease and tankage.

The garbage, separated by the householders from other substances, is collected by the city, and taken direct to the plant from nearby localities, or to three shipping docks on the north and south branches of the Chicago River. The collections are made in 600 steel boxes on racks, or wagon bodies, holding four cubic yards each, watertight, with sectional lifting lids, concealing two-thirds of the contents while loading. The boxes are lifted from the wagon bodies to the decks of three scows for transportation by water to the reduction plant. One of these scows has power, and serves the double purpose of a lighter and a tug for the others.

The garbage collection service of the city does not include that from the hotels, boarding-houses, restaurants, commission and market houses, all of which is collected by private contractors. There are still about twenty-five tons of household garbage dumped with the ashes and refuse in remote districts. About 300 tons are daily (except Sundays) delivered to the reduction plant.

The plant is located at Iron and 39th streets, four and three-quarter miles to the southwest of the center of the city, with a frontage of 380 feet on the Chicago River. There is a railroad connection with the belt line encircling the city, and also with the street car lines.

The grounds cover three and one-half acres, of which the receiving dock occupies an area 120 by 80 feet. The buildings are the receiving building, milling or grinding building, boiler house, naphtha storage building, naphtha extra extraction building, dryer building, shops and office, occupying altogether 30,860 square feet of ground, or about three-quarters of an acre.

The boxes of garbage are discharged into concrete hoppers outside the receiving house, and are then cleansed and sterilized and returned to the scows.

From the hoppers bucket elevators lift the garbage to the upper floor of the receiving building where foreign matter is removed by hand picking.

The subsequent processes of crushing, drying, extraction of grease in percolating tanks flooded with naphtha, separation of grease from the naphtha, which is recovered and returned to the storage tanks, and the barreling of the grease for market are successive steps of the work as previously described in the Buffalo plant. There appears to be a more thorough treatment of the tankage than in other plants, as this is reported to contain less than ten per cent. of moisture and one per cent. of grease when ready for sale. The grease is sold for the manufacture of cheap grades of soap and candles, and the tankage to jobbers for a filler or base in compounding fertilizers.

The sanitary conditions of the plant are described as excellent. As far as possible the process is automatic. The floors are concrete, well supplied with water for flushing. The day's collection of garbage is disposed of promptly. The location of the works is immediately adjoining the packing house district, where the odors (though believed to be so disposed of at the plant as to be not perceptible should they escape) cannot be distinguished from various odors emanating from the stock yards.

The contract with the city, which went into effect on November 1, 1906, for a period of five years, provides among other things, that the city shall have the right to purchase the plant at the end of that time, that the city shall deliver all garbage collected free of cost to the company at its plant, the delivery shall be made in metal boxes constructed for dumping, and that these shall be sterilized at the expense of the company, that the garbage shall be disposed of by reduction, and that the company shall receive the sum of $47,500 per year for five years, provided that the work be performed in strict compliance with the specifications of the contract.

On the basis of 300 tons per day, the present quantity treated, for 300 working days the cost for disposal is 52.77 cents per ton.

No figures are obtainable as to the costs of operating the works or of the percentages of grease and tankage obtained from the garbage.

A serious explosion occurred in these works on May 1, 1908, which is thus reported in the public press:

NAPHTHA BLOWUP.

CHICAGO, May 2.—The desolate district back of the stock yards on the "bank of Bubbly Creek" was visited last night by an accident in which at least one man was killed, five seriously injured and eight reported missing. The police believe the eight may have lost their lives in the accident. The cause of the disaster was the explosion of a large tank of naphtha in the plant of the Chicago Reduction Company, the concern which handles the city's garbage.

The roof of the four-story brick and concrete building soared skyward, and the inhabitants of the sparsely settled neighborhood were terrified by a terrific flash and roar. There was a rain of burning naphtha which rendered "Bubbly Creek" a river of flames. Fragments of concrete torn from the steel framework were precipitated for blocks around; freight cars were blown from tracks, and the big plant was a blazing mass of ruins within a few minutes. Andrew Marcullus, 30 years old, who was working at the vat, is the man known to have perished.

In 1892 and 1893 several forms of garbage crematories were brought out in Chicago. One of these, known as the Heavey crematory, operated by liquid fuel, and as far as its limited capacity went appeared to be efficient. But the cost of the petroleum for fuel, and the difficulties of consuming the waste owing to its mixed character made the operating cost excessive, and the crematory was abandoned after six months' trial.

A large and elaborate construction was the Anderson incinerating furnace. This was built on the principle of a long narrow brick furnace with perforated walls through which flames from a series of oil burners were directed upon masses of garbage placed upon cars and slowly carried the length of the furnace. By indirect draft the smoke and gases were gathered at one end of the long construction, and air for the purpose of combustion admitted through small openings on a level with the top of the garbage cars.

It was expected that the high temperature combined with the slow rate of progress of the cars would completely calcine the garbage. A special form of poker, uniting a moveable steam jet with a stirring implement was used to turn over the heaps of garbage and expose fresh surfaces to the action of the flames. The result of the first week's trial was the destruction of the cars and of the interior walls of the furnace, the garbage masses passing through the ordeal comparatively unburned. This crematory was abandoned shortly after the first experiments.

CHAPTER XIII.

THE MERZ PROCESS.—*Continued.* THE SIMONIN PROCESS.

St. Paul.—The Merz reduction process was introduced in St. Paul, Minn., in 1889 by an offer on the part of Mr. H. A. Fleischman, proprietor of the United States patents, to construct a plant of 60 tons daily capacity upon the flats below the town within the city limits. The price of the plant was to be $100,000 and it was to be operated by the company at a cost of $15,000 per year to the city, all by-products to be the property of the company. This cost was then at the rate of 83 cents a ton; collection and delivery of the garbage to be made by the city. The fate of this plant is thus graphically described by a competent authority:

> This investment proved to be a very unfortunate speculation for stockholders. The price on the fertilizer and grease product dropped so there was no money in shipping it and the company undertook to carry on a sort of rendering establishment for rendering dead animals, etc. As the plant was located on the flats near the river, the rendering became an intolerable nuisance; in fact, I lived on the bluff at least a mile and a half from the plant, and when they were operating it the stench was fearful, so the matter was brought before the Common Council, and they were forbidden to use it for rendering purposes.
>
> With the rendering cut off, I understood they were running at a loss, and after a while the whole thing providentially burned down and we have not had in St. Paul a rendering plant since.

The methods of disposal that have obtained and are now in use in St. Paul are those ancient ones of feeding garbage to swine and tipping the ashes and refuse.

These methods are set forth by the health officials as being those most sanitary, efficient and economical, and they are vigorously advocated to the exclusion of all others.

Denver, Col.—In 1889 a company built a plant, called the Sanitary and Fertilizer Works, for the reduction of garbage, dead animals and other offal and converting them into commercial fertilizers and to grease for soap and lubricants, under the Merz system. The only available account of this plant states that "the plant was a money-maker, but the land upon which it stood ultimately became so valuable, and the original owners had done so well in the enterprise, that on being offered a large profit on the realty, they disposed of it and retired from the business."

This somewhat surprising statement comes from a source identified with several unsuccessful attempts to install reduction processes and must be taken with a large leeway for accuracy. The facts appear to be that the plant was built under the same conditions as other Merz plants in Buffalo, Milwaukee, and Detroit; that it duly went into operation, but continued only for a short time; the works being given up, were either removed or destroyed.

Had this been a successful plant with remuneration as claimed by the first quoted authority, the chances for its continuance must have been sufficiently good for its perpetuation. That it did not continue was owing probably to the same unfortunate combination of conditions that terminated the career of all the earlier plants built under this process.

Since the demise of this plant, the city has resisted all efforts made for sanitary progress, and continues to feed the garbage to swine and dump its refuse and ashes upon unoccupied ground.

Paterson, N. J.—A modified and imperfect form of the Merz reduction process has been employed here for some years. In 1894 a contract was let by the city to the Paterson Sanitary Company for the disposal of ashes and garbage at $34,300 per annum. This company erected works south of the city on the Passaic River, calculated to destroy 50 tons daily. The plant was partly destroyed by fire two years after construction, but it was rebuilt and the work continued on a modified scale. It is believed that the process of grease extraction is not carried to the full extent, but that a portion of the by-products are recovered, the tankage being sold at low prices. The revenue of the company was derived from the high price paid for the work by the city, and not from the value of the manufactured products.

St. Louis, Mo.—This city was one of the three first places to acquire a Merz reduction process plant. In 1889 the city received bids through the Department of Health for the sanitary disposal of the garbage either by incineration or reduction to the amount of 100 tons daily. The bids for cremation were at the rate of $1.00, and for reduction at $1.80 per ton. The contract for 10 years was awarded to the St. Louis Sanitary Reduction Company at $1.80 per ton for disposal only.

In 1891, the first plant was put at 22nd Street, following the general construction of the first Buffalo plant, and specially treating the dead animals as well as small amounts of garbage.

In 1892-3, the second and largest plant was built at 28th Street and St. Louis Avenue, in the southern part of the city near the river. This was a very extensive and costly installation, comprising a building 250 feet long, 80 feet wide and two stories in height.

The general construction and arrangement of apparatus in this plant was much the same as in the first Buffalo installation, with probably some modification of the dryers, which were of an improved pattern, perfected by Mr. George Wiselogel, then Mechanical Engineer of Construction in the employ of the Merz Company.

The quantity of garbage treated at this plant has never been made public. In 1902, the Health Officer reported 43,000 tons treated from April to October—seven months. In 1893, Mr. H. A. Fleischman stated that the company received at the rate of $800,000 for 10 years' contract, and that the tankage brought $6.80 per ton.

The city reports give no statement of amounts, nor any except the most general costs for collection and disposal. This contract was terminated about November, 1904, but a temporary contract at somewhat lower figures was continued for two years, pending some action to be taken by the City Council upon the whole subject.

In 1906, the Public Sanitation Committee of the Civic Improvement League of St. Louis published a report upon "*The Disposal of Municipal Waste*" after an extended investigation covering a period of three years. The estimated quantities and the cost of collection and disposal were tabulated as follows:

Amount of garbage per year	70,000 tons
Cost of collection at $1.67 per ton (actual rate)	$116,900
Cost of disposal at $1.00 per ton (dumped rate)	70,000

Estimated Total Amount Combined Waste

Garbage	15%	70,000 tons
Rubbish	10%	46,660 "
Ashes	75%	349,950 "
Total quantity		466,610 tons

The report reviewed briefly the various systems in use for disposal elsewhere; gave some slight idea of the values of waste in sorting for market; compared the systems of incineration and reduction, and gave a comparative cost of each as applied to St. Louis, showing that "by these estimates, based upon experience of other cities, St. Louis can collect and dispose of her garbage by reduction and her rubbish by burning for $100,000 less than by attempting to dispose of it collectively by the incineration process within the city limits." They also add, "if the disposal (not the collection) can be more economically and efficiently done by contract, then the franchise should provide for purchase of the plants whenever the city is in a position to assume control."

The recommendations of this committee provide for separate receptacles for garbage, ashes and rubbish,—the householders to make separation, daily collections of garbage in summer, special steel collection carts and receiving stations, transportation by steam or electric road to places of final disposal, the erection of a garbage plant outside the city limits, the sale of marketable parts of rubbish, the erection of destructors for generation of power for heating and lighting public buildings, and the sale of manure and street sweepings to farmers.

During the latter part of the time covered by this investigation the garbage was taken to an island in the Mississippi river below the city and fed to swine, the rubbish and sweepings being dumped into the river from special scows. The reported quantity thus dumped overboard in 1906 was 171,000 loads. The ashes were used for fill on low grounds.

For some time after the report of the committee of the

Civic League was made no action was taken by the city authorities. In January, 1907, the Board of Public Improvements received contingent or preliminary proposals from five different companies. Two of these were for reduction, two for incineration, and one for continuing the hog feeding on Chesley Island. All were rejected. Subsequently, in December, 1907, new advertisements appeared calling for proposals for a reduction plant, and provided a set of specifications under which tenders were to be received. Briefly, these were as follows:

Garbage is defined as all organic matter and small dead animals, and all other refuse of vegetable or animal foodstuffs, collected by the city garbage collection wagons, and may contain some foreign substance.

The collection made by the city wagons is to be delivered at the loading stations. These stations must be within defined localities, must each have a capacity of 300 tons a day, to be fireproof and be kept in a strictly sanitary condition, with suitable approaches, unloading platforms and roadways. The garbage of each day to be removed before midnight by the contractor and in such a manner that it will not give offensive odors.

The reduction plant shall be located not less than one mile outside the city limits, upon property comprising five acres of ground, upon one of the railroads, or above the flood limit if on a river. The buildings must be of fire-proof construction, the plant to be fully completed within twelve months of contract, and to have a capacity of 400 tons per day.

Hydro-carbon solvents shall not be used in the process of reduction of said garbage matter, and no process shall be used that is not continuous and does not confine the garbage from exposure to the air from the time the garbage is placed in the conveyor until it is completely and finally reduced. Nor shall the products nor the process of handling or disposing of this garbage be productive of offensive odors.

A penalty of $10 per ton is to be assessed against the contractor for each and every ton of garbage tendered by the city or its agents which he does not accept or treat as provided for by the contract. Ten thousand dollars is to be deposited and maintained, from which sum the penalties are to be paid. The term of this contract is for ten years, the work to begin within one year after approval of bond and contract by the Council.

The contract was awarded to the *St. Louis Standard Reduc-*

tion Company in February, 1908, at the price of 27 cents per ton. This company includes capitalists who own or control the Flynn process of reduction used in Pittsburg, and are now reported as trying to secure ground, but find difficulty in securing a desirable location owing to the usual opposition to such plants.

In commenting upon these specifications, one leading engineering journal makes these pertinent observations:

> It may be said that, since the city is possibly to purchase this plant, it is perfectly proper that it should specify beforehand any of its essential features which it may desire to. But the exclusion of hydro-carbon solvents and the provision for continuous treatment would exclude bids from certain companies. Even though those having this matter in charge may, from their investigations have concluded the processes which they have excluded possess undesirable features, such information could be used as well after bids were received as before, and it cannot be certainly known beforehand that these clauses might not exclude other processes, unknown at present to the authorities, which might otherwise have met with their approval. We believe the better plan in all such applications is to carefully define the results to be obtained—in this case presumably disposal without creating a nuisance—and then use such knowledge and judgment as is available in determining which of the various propositions is most likely to meet these requirements.

It will be interesting to note the working out of the specifications, especially in the point of allowing foreign matters to be gathered with the garbage, and requiring the contractor, under penalty, to accept the collected load from the city. This is one of the chief points of difficulty in reduction work, only to be overcome by strict ordinance, defining the possible admixture of foreign substances within certain proportions and by the aid of the police and the courts, enforcing this.

Unless the proportions are settled at first, there is no standard fixed, and it will be hard for the collector to judge what he shall admit and what reject, and worse for the contractor, for he cannot afford to haul to the works and sort out the worthless matter for 27 cents per ton.

Columbus, Ohio.—A reduction plant employing the Merz process was installed in Columbus, Ohio, in 1896. The ten-year contract given by the city to the Columbus Sanitary Company was for the collection and disposal of garbage and dead animals at the price of $15,800 per year. In 1904, the amount of garbage collected and treated was 16,221 tons, the cost to the company being reported as $20,000. Assuming a population of 160,000 the cost of collection and disposal is less than 10 cents per capita, much lower than in other cities of the same size.

Before the expiration of the contract, the Columbus Sanitary Company found itself in difficulties, as the payments from the city and the revenue from by-products did not afford a profit, but, on the contrary, the operation of the plant is reported to have resulted in a yearly deficit of $5,000.

While no accurate description of the works is available, they are believed to have been similar in construction and operation to those of the early Merz methods in Buffalo and St. Louis. The conditions early in 1906 are thus described:

> The company collects the garbage in iron wagon bodies, and hauls it to a loading switch on the T. & O. R. R. at West Mound Street, where the iron tanks containing the garbage are removed from the wagons and loaded on flat cars. Each morning these are hauled to the works of the Sanitary Company, located on the west bank of Alum Creek, four and a half miles southeast of the Capitol. Dead animals are hauled in wagons to the works. There is no thorough collection made at present, as any increase over present quantities would mean a net loss to the company. This condition of affairs is unsatisfactory. The collections are irregular, the intervals between them long, the routes are not well-defined, and the householders are forced to employ private scavengers to remove the garbage. No attempt is made to collect from restaurants and hotels. Commission houses, tradesmen, etc., haul and dump their own waste, aside from that which is thrown carelessly into the streets and alleys. The city collects the waste from the public markets.
>
> The conditions at the reduction works have given cause for complaint, partly through odors emanating from the digestors and the tankage, but mainly from the pollution of Alum Creek, into which greasy water is discharged. Owing to the breakdown of the drier it has been impossible to dry the tankage and make it suitable for shipment to fertilizer works, and during the last season it has been allowed to accumulate in a large pile just south of the works. Aside from its unsightliness, this accumulation of the tankage cannot be said to be a nuisance.

In 1905, Mr. Rudolph Hering made a survey of the conditions in Columbus and submitted a short report advising the collection of garbage and rubbish and its disposal at a general station by cremation. The estimated cost of a garbage and rubbish crematory and building was $100,000 to $125,000. No system for the collection or treatment of ashes was suggested, except that they be used for filling. The output of ashes in Columbus is relatively small because of the use of natural gas. Subsequently, in January, 1906, Mr. J. H. Gregory, Assistant Chief Engineer of the Board of Public Service Works of Columbus, reported in detail upon the methods in use, the quantities of waste, the approximate cost to the householders for imperfect scavenger service, together with detailed engineering estimates for providing the city with a complete plant for the collection and disposal of each class of refuse.

The following excerpts from a synopsis of Mr. Gregory's report are taken from the Engineering News of March 15, 1906, Vol. LV:

The chief points included in his recommendations are that the city collect the garbage, rubbish and dead animals by its own employees and equipment; that it build a crematory for disposal of collected material; that the collection of night-soil be continued by scavengers, to be disposed of in connection with the new sewage works; that street sweepings be continued to be dumped on low ground; that municipal collection and disposal of ashes be postponed, and that municipal collection and disposal of stable refuse is neither desirable nor warranted.

TABLE LXIV.—COLLECTION STATISTICS, COLUMBUS, O.

The populations and the tonnage of various wastes, both estimated, for 1905 and for future years are given as follows:

Periods	1905	1907	1910	1915	1920
Population	160,000	176,000	202,000	254,000	320,000
Ashes....(tons).	64,000	70,400	80,000	101,000	128,000
Garbage. "	17,600	19,400	22,200	27,900	35,200
Rubbish. "	8,000	8,800	10,100	12,700	16,000
Manure. . "	45,000	47,000	50,000	55,000	60,000
Night-soil "	3,900	4,500	5,000	5,600	6,000
Carcasses	350	380	420	470	500

Mr. Gregory's estimate of the cost of construction is based upon permanent fireproof plants to include crematories having a capacity of 175 tons per day of twenty-four hours, with chimney and building to contain a plant of 250 tons capacity, together with all the necessary equipment for the collection of garbage and refuse, and a building for the disposal of night-soil, including all expense for operation, maintenance and fixed charges. These items may be thus condensed:

TABLE LXV.—SUMMARIZED ESTIMATES OF CONSTRUCTION AND OPERATING EXPENSES.

CONSTRUCTION

First Cost:		
For collection of garbage and rubbish	$116,050	
For disposal of garbage and rubbish	168,300	
For disposal of night soil	5,500	
Total		$289,850

OPERATING EXPENSES.—1907

Fixed Charges:		
Collection of garbage and rubbish:		
Interest	$4,642	
Sinking fund	3,897	
		8,539
Disposal of garbage and rubbish:		
Interest	$6,732	
Sinking fund	5,652	
		12,384
Disposal of night soil:		
Interest	$220	
Sinking fund	185	
		405
Total interest	$11,594	
Total sinking fund	9,734	
Total fixed charges	$21,328	$21,328
Maintenance and Operation:		
Collection of garbage and rubbish	$53,720	
Disposal of garbage and rubbish	32,020	
Disposal of night-soil	1,200	
		86,940
Total cost, collection of garbage and rubbish	$62,259	
Total cost, disposal of garbage and rubbish	44,404	
Total cost, disposal of night-soil	1,605	
Total operating expenses	$108,268	$108,268

Operating Expenses Per Capita for Collection and Disposal of Garbage and Rubbish and Disposal of Night-Soil in 1907.

	Fixed Charges	*Maintenance and Operation*	*Total*
Collection of garbage and rubbish	$0.049	$0.305	$0.354
Disposal of garbage and rubbish	0.070	0.182	0.252
Total	$0.119	$0.487	$0.606
Disposal of night-soil	0.002	0.007	0.009
Grand total	$0.121	$0.494	$0.615

Operating Expenses Per Ton for Collection and Disposal of Garbage and Rubbish in 1907.

	Fixed Charges	Maintenance and Operation	Total
Collection of garbage and rubbish.........	$0.303	$1.905	$2.208
Disposal of garbage and rubbish..........	0.439	1.135	1.574
Total........................	$0.743	$3.040	$3.782

Operating Expenses Per Cubic Foot for Disposal of Night-Soil in 1907.

	Fixed Charges	Maintenance and Operation	Total
Disposal of night-soil....................	$0.0032	$0.0093	$0.0125

Cremation, in theory and practice, is discussed at some length in the report. The absence of coal ashes at Columbus, as in other cities in the natural gas district, gives the refuse a distinctive character. The garbage and dead animals in the refuse delivered to a crematory in Columbus would be from 65 to 70 per cent. of the total, instead of 8 per cent., as in England, and

70 to 75 per cent. of the garbage will be water, and the calorific value of the remainder will be so low that the garbage cannot be consumed without previous drying or the addition of fuel.

Then follow other data to show how different is the material brought to English furnaces from that to be expected in Columbus, after which Mr. Gregory says:

The calorific value of the combined refuse, garbage, dead animals and rubbish of which a crematory in Columbus must dispose will not average above 2,000 B.T.U. per pound of refuse, and the total amount of water, the free water and that liberated by the breaking up of the carbon-hydrates, etc., will amount to about 0.8 lb. per pound of refuse. The proportion of water will run much higher than this in the summer months, and the calorific value will be correspondingly reduced. In burning this low class of fuel a larger percentage of excess of air will be required than with a good fuel, and it is probable that more than 100 per cent. excess of air will be required rather than less with 100 per cent. excess of air, with perfect combustion and with no allowance for losses by radiation, etc., the maximum furnace temperature possible is 1,100 degrees F. By extracting 25 per cent. of the water before burning, the theoretical temperature would be increased to 1,450 degrees F., which is still much below that temperature to which it is desirable to heat the gases to prevent any possible emanation of noxious fumes.

I am firmly, therefore, of the opinion that additional fuel must be burned in order to reach the desired furnace temperatures, providing that the garbage is not previously dried out by the waste heat from the furnace gases, the expense of which treatment might be greater than the cost of additional fuel.

The evaporative power of English town refuse is quoted (from Dawson) as from 2 pounds of water evaporated from a 212 degrees F. per pound of refuse fuel, for "screened ash pit refuse," to 1 pound and even 0.75 pound inferior "unscreened ash pit refuse." These are not the net evaporative efficiencies available for power production in English furnaces, since from the figures given must be deducted about 0.125 pound of steam for forced draft. In the New York furnaces for rubbish, only, evaporation on test, with fan blast, did not exceed 1½ pounds of water to 1 pound of refuse.

At Columbus, even after adding to the refuse the fuel which it appears will be necessary to get a sufficiently high temperature for combustion of the refuse, Mr. Gregory thinks "it is unlikely that an evaporation of more than 0.5 pound of steam per pound of refuse can be obtained."

In reviewing and approving Mr. Gregory's report, Mr. Hering stated that in designing garbage furnaces for Columbus provision should be made for operation with and without drying the garbage preliminary to burning, thus making it possible to defer the decision whether fuel should be used to dry the garbage or to burn it. Likewise the decision as to heat utilization, beyond that for works purposes, may be postponed. Heat utilization, if practiced at Columbus, would be "but a secondary consideration," and could not be expected "to reduce the expense otherwise necessary for burning garbage."

A separate collection of garbage and rubbish at Columbus is advisable, because if dumped in the same wagon the rubbish would absorb much water which might be drained off from the garbage alone, before putting the latter on the fires. Moreover, different types of carts can be used advantageously for garbage and for rubbish, and the latter need not be collected so often as the former. It is possible, also, that refuse sorting may prove advisable at Columbus, if refuse and garbage are collected separately.

As to the apparently high cost of garbage and refuse disposal at Columbus, shown by the estimates, it must be remembered that much of the similar work elsewhere is imperfectly done and is generally less comprehensive there, and that the data and estimates for Columbus are unusually complete.

Mr. Hering suggests that the city prepare a design for furnaces, "in accordance with the best knowledge and practice," and that in view of the large and successful experience of European cities with the burning of city refuse both American and the more prominent English firms building such furnaces be given an opportunity to submit designs and bids, "as well as bids to supervise the operation for one year, guaranteeing the results to be obtained thereby." In view of the unsuccessful results obtained with many American furnaces heretofore, the need for great care in the Columbus designs is apparent. It will also be necessary to employ a high grade of operators when the furnaces are put in use.

In examining this report it would seem that the estimates for specified capacity of the crematory and the enclosing buildings are needlessly large.

The actual quantities estimated for 1907, the first year when the plant would be available, are 19,200 tons of garbage and

8,000 tons of refuse, or about 85 tons to be burned in a furnace of 175 tons capacity enclosed in a building of 250 tons capacity. Undoubtedly the quantities would increase considerably, but the maximum would only be reached after fifteen years, and, in the meanwhile, the maintenance and capital charges compounding each year are a heavy tax to pay upon unused equipment.

The charges for engineering service also appear to be very great, considering that the plant is charged with superintendence supposed to be sufficient for carrying on the work successfully.

The calculation as to the calorific value of waste and the resultant steam power to be had is too low. At that time (Jan., 1907) there was no plant in the country of the English destructor type, as the Westmount Destructor did not begin work until May, 1907, so that there was no standard for measurement for American Engineers except the reports and opinions of British Engineers, and the deductions to be made from these for American work on similar lines.

Since then the four destructor plants operating under American conditions have proved that not only no fuel is needed, but that the evaporation of water instead of being .05 lbs. is nearly 1.33 lbs. of steam per pound of refuse destroyed.

The New York test of burning rubbish only in incinerators is hardly comparable with destructor work when the design and construction of the New York incinerators are taken into account.

Mr. Gregory's reference to the recently completed reduction plant at Toledo, which was found to be "conducted with remarkable freedom from any objectionable features," is not particularly fortunate, as these works were closed in July, 1907, for reasons of nuisance and inability to do the work in a manner satisfactory either to its stockholders or to the city authorities.

The marketable values of rubbish were not considered, as all of the combustible matter was to be burned. The estimated quantity of 8,000 tons per year seems to be too small. In any place where natural gas is used in the households the light refuse is greater in amount than in other places where coal is the usual fuel, and, therefore, the quantity in Columbus would appear to be greater than the amount given. The value of at least 60 per cent of this refuse which can be recovered for sale without serious objections, would, if saved, give a return in cash nearly equal to half the cost of operating the plant.

As Columbus was the first city of the United States to undertake a thorough examination of conditions and to report upon an engineering basis with the assistance of skilled experts, it is interesting to note the concluding and expected results.

This report was submitted early in 1906, and on December 6, 1906, was approved by the Board of Public Service. Shortly after, this Board was retired from office for adequate reasons, and a new Board was installed. A resolution was offered providing for action by the Common Council to advertise for bids for the plant, but this resolution was not passed. Opposition was made to the plans and estimates on the ground that no opportunity was offered for tenders for any means other than cremation. Later, in January, 1908, the city advertised for bids for the disposal of garbage by reduction methods only, but received none that were acceptable.

In May, 1908, revised forms of specifications for tenders for reduction works were again issued by the city calling for bids on June 24th.

These specifications are written with the advantage of the knowledge gained in noting the operation of the present reduction plant and the experience acquired in the two previous unsuccessful efforts to obtain bids. Briefly stated, they contained the following details:

> The contractor is to design, construct and deliver complete reduction works, which will dispose of garbage and dead animals, with the emission of no offensive odors or gases, or other obnoxious wastes, solid or liquid, except those which are inseparable from the handling of raw garbage or dead animals, and from the finished products of reduction under the best and more favorable methods now employed, and without the pollution of the Scioto River.

The prices are to be stated separately for material and for labor, and the total (this is a requirement of the State law). The bidder must specify the amount of labor and the quantity of coal used to reduce one ton of garbage and animals. He must give a list of operating reduction plants similar to the one proposed, with capacity of works, amount of garbage yearly disposed of, and reasons for discontinuance of plant, if not now at work. A bond in the sum of fifty per cent. of the amount of the contract will be required for faithful performance of contract.

The specifications provide in detail for the plans for design and construction of the buildings, the capacity to be one hundred tons in twenty-four hours, with provision for increase to one hundred and fifty tons, the machinery and equipment to be in units of suitable size to permit economical operation with small amount of material, and to provide for repairs. All gases are to be discharged through furnaces and all tank water evaporated. Provision is made for storage of grease and tankage to avoid spontaneous combustion, naphtha to be stored in steel tanks placed not less than one hundred feet from the buildings. There must be suitable means for separation of tins, bottles, etc., and for sterilization by steam of rooms for receiving and storing the garbage.

The waste is to be handled by machinery; the power obtained from generators driven by the steam from the boiler of the plant; all work is to be done, where practicable, by this same electrical power. The buildings are technically specified in every part of construction at great length and detail.

The test shall be a trial of sixty days by the contractor at periods to be fixed by the Engineer of the city to determine the capacity and efficiency of the works.

To determine the fulfillment of labor and fuel quantities, the works are to be operated four weeks continuously, during which time accurate measurements of quantities and conditions of garbage, the hours of labor on all classes of the work, the weight of coal and all the factors for making up the cost of operation per man-hour, and for fuel, are to be noted.

The total number of man-hours of labor and the total weight of coal shall be divided by the total number of tons of garbage and dead animals treated, to find the man-hours of labor and the weight of coal, respecively, required for the reduction of one ton of garbage and dead animals.

If the results of this test fail to fulfill the requirements of the contract a penalty is provided of $1,000 for each one-tenth (0.1) man-hour ton by which the cost shall exceed the guarantee, and $50 for each pound of coal per ton by which the guaranteed amount is exceeded, provided that for a maximum of two man-hours per ton, or two hundred pounds of coal per ton in excess of the contract requirements, the works will be rejected.

These specifications are the most comprehensive, exact and stringent that have yet been drawn up for reduction work. If a contract had been secured, it might have determined many questions of capacity, quantities, values and costs that now are not accurately known.

There was no award of contract on the bids received under these specifications. The city is now preparing specifications for its own reduction plant to be built by arrangements with the companies or persons controlling the designs and apparatus to be employed.

THE SIMONIN PROCESS OF EXTRACTION.

Providence, R. I.—The Simonin process for the disposal of garbage was first presented by I. M. Simonin, of Philadelphia, Pa., who had large works for the manufacture of fertilizer in that city. In 1888, active work connected with the reduction process was begun by Mr. I. M. Simonin, who, in 1890, built his first extraction plant in Providence, R. I. The works were placed on ground in the southern part of the town, near the railway, and conveniently located for short transportation of garbage.

The buildings were of wood, and the operating power was generated by two 100-horsepower boilers separated from the main works. The garbage collected by a city contractor was received upon a concrete floor, where the cans and rubbish were removed and the water permitted to escape by sewer to the river near by. The garbage was then placed in shallow iron pans and these in successive tiers in wire baskets which were run upon trucks into a horizontal cylinder 18 feet long and 6 feet diameter, and sealed. The cylinder was then charged with naphtha and left for some hours, or until the solvent had penetrated to every part of the garbage. The naphtha was then vaporized by steam introduced in coils of pipe and carried with part of the water to a condenser where separation was made and the naphtha recovered. The grease and water was drawn off at the bottom of the extractor and separated by settling tanks. In the operation of the Simonin reduction system this process is repeated with successive charges of garbage, until the naphtha becomes surcharged and concentrated. It is then forced into the settling tanks and again recovered for use. After the extraction process is completed the tankage is steamed until all trace of naphtha is removed, and it is then carried to another building where it is ground and screened.

For one charge the duration of the process is about four hours and a half for extraction and four hours for steaming, which, added to the time consumed by the settling and preparation of tankage, occupies from 32 to 36 hours.

The works comprised two steam boilers, six extractors, two settling tanks, two stills, and a small separated building for naphtha. The tankage shows five to fifteen per cent. of bone phosphate, three to six per cent. of ammonia, and one per cent. of phosphate. It was very dry and found a ready sale.

The actual cost for operating this plant were estimated to be equivalent to 15½ cents per capita per annum of the population of the city, and this amount has since been assumed as the cost of disposal, and continued to subsequent contractors.

The Providence works were built and operated by a company comprised of local capitalists. Their operation continued for about three years. Nothing was paid by the city for the disposal of this garbage but the collection was made at the cities expense by contractors. During this time many complaints of nuisance were received and in 1893 the removal of the works was judged necessary. No reports in regard to the financial standing of the company are obtainable, and there are no reliable records of the quantities and values of the grease and tankage.

The Simonin process is one of extraction of the grease by powerful solvents, with no preliminary process of maceration or steaming to break down the fiber of the animal and vegetable matter. Thus the method requires a longer time for each step, and a large quantity of solvent, all of which renders the work costly. Necessarily a large volume of gaseous products accompany each stage of the process, requiring special care to prevent explosions and resultant disasters. The products of grease and tankage retain a considerable percentage of naphtha, which diminishes their marketable value.

In 1894, the city of Providence returned to its former method of garbage disposal. A contract was yearly made with local parties who provide garbage wagons of approved type, and make daily collections for a part of the city, bi-weekly and tri-weekly collections for the remainder. The garbage is carried outside of city limits and fed to swine. The argument in favor of feeding to swine is ably stated by one of the foremost sanitarians of New England.

(Dr. C. H. Chapin, Providence, R. I., Proceedings A. P. H. Association, Vol. XXVIII, 1902:)

For ten years or more the removal (at Providence) was in open dump carts—a method which caused much nuisance along the road. Nearly one-half of the quantity was sold to farmers at 25 cents per cubic yard and transferred to their wagons in the city, a practice which was very objectionable, and afterwards stopped. The collections are now made in water-tight wagons, kept covered in transit and unloaded only at the place of feeding. On the large farm where most of the garbage of Providence is fed to swine, the land is divided into woodland and open, where the swine roam at will, having plenty of room. The garbage is scattered about on the ground, and is consumed so quickly and thoroughly that very little odor arises, and as the feeding grounds are away from roads or dwellings, little nuisance results.

In considering garbage disposal (as distinct from its collection), it is seen that for the last fifty years it has never cost the city a cent, but, instead, has at times been a considerable factor in lessening the cost to the city of the collection.

The cost to the city for collection and removal for the past thirteen years has been 15½ cents per capita per annum, which, I am sure, does little if any more than pay the contractor for collecting.

(Quotations of collection costs per capita per annum in twelve New England towns, prior to 1889, are as follows: Boston, 20 cents; Cambridge, 29 cents; Brockton, 19 cents; Lynn, 19 cents; Fitchburg, 9 cents; Haverhill, 7 cents; Portland, 10 cents; Holyoke, 2 cents; New Haven, 5 cents; Lawrence, 10 cents; Somerville, 25 cents; Worcester, 15 cents. This cost was (in 1901) reduced by the sale of garbage fed pork in Worcester to 4 cents, and Brockton to 8 cents. In Lynn, Lowell, Brockton, Somerville, Cambridge, Springfield, a considerable revenue is derived from the sale of garbage, and formerly this was the case in Boston.)

There is no doubt that the value of the grease and fertilizer ingredients of garbage is from two to three dollars per ton, but, unfortunately, no one has yet found an economical way to reduce it. The food value of garbage is probably much less, but this value can be utilized. Garbage can be fed to swine at a profit, and thus the net cost of its collection can be much reduced. Health Officers and Engineers have, almost without exception, opposed this, the only method by which garbage can be disposed of without cost.

The general public is also, to a considerable extent, prejudiced against feeding garbage to swine, and the writer formerly shared this prejudice, but has been led to modify his views.

The objections to feeding garbage to swine are made upon two grounds.

First—It creates a nuisance. It is indeed true that this practice does, as a rule, create a nuisance; but so does every other method of garbage disposal. The writer has seen crematories and reduction works which were every bit as bad as any hog farm. The only difference is that the reduction works cost money, while the hog farm yields a profit.

The writer then quotes instances of nuisance caused by the first reduction plant in Boston, and the crematories in Trenton, N. J., and Montreal, Canada, and continues:

There can be no doubt that there are many cities near which there is land available for raising swine, and where the business can be done with very little or no nuisance and with profit.

If attention be given to transportation and feeding, and the best methods are employed, this can be done. Slipshod methods will result in nuisance and failure. Of course, very many cities are so situated that feeding to swine cannot be done, and other and more expensive methods must be adopted.

Second—It is claimed that the feeding of swine with garbage is dangerous to health. It is said that the pork is likely to be diseased, and the disease be transmitted to human beings. Practically the only disease likely to be transmitted is trichinosis, but this is a rare disease, and can be avoided by avoiding raw pork. * * * Considering the rarity of this disease and the ease with which it may be avoided, this supposed danger does not deserve further consideration.

The pork is said to be of poor quality and to bring a low price in the market. As a matter of fact, garbage-fed pork is not as hard as corn-fed pork, and often brings a little less in Eastern markets. But no evidence has ever been adduced to show that this pork is in any way unwholesome. It is not unlikely that by better methods of feeding, perhaps by cooking the garbage and skimming the grease, or by getting fresher garbage by daily collections, the pork might be much improved.

Probably the chief reason that the feeding of garbage to swine is objected to is that the filth theory of disease continues to exert so much influence. We have been so long told that filth and foul odors are the cause of sickness that it seems to be very hard for the public, and even alleged sanitarians, to give up the idea. Because garbage smells bad and hog pens smell bad, they are supposed to be unwholesome. This is pure fiction. There is no reason whatever to suppose that sickness ever comes from such causes. It makes no difference to the health of the town how its garbage is disposed of or how it is collected, or, in fact, whether it is collected at all. It is not a question of health, but one of comfort. Garbage removal work is not for the Department of Health, but for the Department of Public Works. What is needed is the advise of engineers, not of medical men. Garbage should be collected with the least public nuisance, and disposed of with the least possible nuisance. But it should be done with some regard for economy. It would, in Providence, cost many thousands of dollars more each year to dispose of garbage in any other way than by feeding to swine, and there is no reason to believe the method would be any more satisfactory to the citizens, and would certainly have no effect upon the public health.

These arguments for the disposal of municipal garbage by feeding to swine have been given at length because of their influence upon this subject from the standpoint of economy as against the more vital question of sanitation.

There are probably very few sanitarians who would agree to the proposition, that the presence of filth and the odors from decaying animal and vegetable matters make no difference with the health of a community, and there are still fewer persons who would accept the dictum that it makes no particular difference to health conditions if garbage is ever collected at all.

That it is a question of individual comfort is indisputable, and as health depends very largely upon agreeable and salubrious surroundings, personal comfort becomes a large factor of this equation, and this of itself is one of the strongest elements for a treatment that should induce a more comfortable and hence a more healthful state in the community.

Hog feeding by contract or by municipal agency may not be more offensive than a poorly designed and operated reduction or cremation system, but unless it can be made better than the other means, it has no right to continue even though it be at less cost.

Things that do not go forward in sanitary movements are things that are left behind, and while swine feeding may be a temporary measure for economy's sake, it cannot be held to be inoffensive, healthful or comfortable for the people. Nor should it become a permanent continuous occupation of any American municipality.

Sentimental Opposition.—There is one objection frequently encountered by those who deal with the garbage disposal problem, and which may be called "sentimental opposition." It is a stumbling block in the path of progress invariably placed by those who are ignorant of facts, and who oppose everything connected with the disposal of waste, on general principles. Their attitude is thus described by one who has had a long and strenuous experience as Health Commissioner in a large city:

It is my opinion that there are one or two disposal systems that are all that is claimed for them. But I would earnestly advise that while you may claim for them everything in sight, if you are thinking of locating one in your respective location—just go a little way out of town with it. Why is this? My experience has taught me that the nomenclature is wrong. You attach the word "garbage" to a brand new, empty, covered wagon, allow it to stand in a street in a thickly populated district, and I firmly believe that in a very short time a large percentage of that adjacent population would be under medical treatment or threatened with some dreadful pestilential disease: the air would be full of petitions to the Health Department, injunctions, threats, etc. This is not overdrawn, for I have witnessed just such a performance as I have described. So, until the names can be changed, dispose of your garbage and refuse material on the outside.

Cincinnati, Ohio.—This city has contributed but little toward the solution of the problem of general waste disposal, but in dealing with the garbage, their experience has been not unlike others where the early and experimental methods have failed and been succeeded later by more successful ones.

From the first the organic waste was thrown into the Ohio River, as is still done with the sewage, but in 1872 a contract was made by which the garbage and dead animals were taken on boats three miles below the city limits. This defined garbage as "vegetable garbage" or kitchen offals unmixed with ashes, and "animal garbage" as soap grease, slaughter house offal and dead animals. The contractor paid householders for the soap grease, and for the carcasses of animals, according to the then market prices for live stock. The price paid was $15,000 per year and included the collection.

This contract was renewed after ten years, with the Cincinnati Desiccating Company, but the price paid was $2,500 per year, not including collection. During this period much of the vegetable garbage was dumped into the Ohio River until this was prohibited by the U. S. Government.

In 1892, a ten-year contract was granted to I. M. Simonin for the disposition of the vegetable garbage in a manner, scientific and sanitary, and not injurious to health and comfort. By the terms of the contract, the city was to pay $25,000 per year for the disposal, the vegetable garbage was to be collected by the city and delivered at the Company's boat at the foot of Main street, but the Street Cleaning Department that did the hauling found it much easier to haul the garbage mixed with ashes to the dump than to haul the long distances to the river. In consequence of this the Simonin Company, instead of 35,000 tons per year, got less than 15,000 tons.

The works of the Simonin reduction process were built about five miles below the city and were fitted up with much the same equipment as the plant at Providence, R. I.

Shortly after granting the contract for the disposal of the vegetable garbage, the city entered into an agreement with the Jones Fertilizer Company, for ten years from July, 1893, for the collection and disposal of the animal garbage, by which the contractor was to make no charge for removal of dead animals and receive no pay for the privilege of doing so. Both these means of disposal continued in force until 1902, when the city advertised for bids for the combined service for five years for the vegetable garbage from June, 1902, and for four years for the Jones contract from July, 1903. Proposals were accepted from another reduction company and the Simonin Company discontinued its work and disposed of its plant.

The work of the Simonin Company was conducted at a disadvantage because of the relatively small amount received from the city's carts and the admixture of ashes and foreign substances, the cost and difficulties of transportation by water on a swiftly moving river with ice obstructions in winter and floods in spring, and more than all the absence of the animal matters, which were the property of another company.

The quantities received were in 1898 reported by Chapin to be 15,000 tons—that were disposed of at a cost of $1.62 per ton.

New Orleans.—The third and last plant built under the Simonin patents was in New Orleans, La., in the summer of 1894. This was a costly and elaborate installation, designed with the benefit of all the experience derived from observation of the working of the previous plants, and it was expected to produce far better results. But the city ordinances for the separation of garbage from foreign matters were inadequate or else were not enforced. After a few months of unsuccessful efforts the contract was abandoned at great loss to the investors. The city resumed its former method of disposal by dumping into the Mississippi River, a method which prevails to this day.

CHAPTER XIV.

The Arnold Process in Boston and New York.

The first plant of the Arnold process for municipal service was at Boston, Mass., in 1895. This was located at Mt. Vernon Street, Ward 20, Dorchester, and comprised an engine house 50 x 40 feet, and main building 120 feet square. The construction was from the plans of Mr. C. Edgerton of Philadelphia, Pa. The contract was taken by the New England Construction Company, operating under the Arnold process, and was for a period of ten years, the city granting the land rent free, delivering the garbage daily, and paying $2,500 yearly and 25 cents per ton on all quantities above 20 tons per day. The plant began work in January, 1895, and in February was notified to abate nuisance of odors from digestors, and the offensive water from condensers which was discharged into the sewers. The nuisance continued, and on March 21st the license was revoked, and subsequently the plant discontinued.

The second Boston plant under the Arnold process was built by the New England Sanitary Product Company in 1898, at the Cow Pasture, a point of land one-half mile wide and one mile long, extending into Boston Harbor from the town of Dorchester. There is, within a radius of two miles, a population of 50,000 to 75,000, and as this plant represented the improved methods of the Arnold process, a particular description is added. This was written when the question of renewal of the plant was under consideration.

The works cost, to erect and equip, upwards of $300,000—the ground being city property, 200 x 120 feet. The buildings were 120 x 80 feet, containing digestors, boilers, engines, settling tanks, etc. The machinery comprised a 200 horse-power engine, engine for pumps, conveyors, presses, condensing pump, etc. Twenty-five men are employed during the day and four at night, besides ten on scows.

The city collects the garbage from a population of about

400,000 and dumps it at Fort Hill wharf, through openings in the platform, into scows lying below. These scows are owned and operated by the Garbage Reduction Company. The scows are towed to the works and, by conveyor, the garbage is carried to the upper story of the digestor room. These digestors are thirty-two in number, in two rows of sixteen each, and further divided into eight sections of four each. Each section contributes to a single receiving tank. The digestors have a capacity of eight tons each, are conical at the lower end and are fed by the traveling conveyor from the scows. After being filled, steam is admitted at about 60 lbs. pressure, the cooking process continued from ten to fourteen hours, according to the season and the character of the garbage, when the steam is shut off and four hours allowed for the contents to cool.

The digestors are dumped into the receiving tank below. The contents consist of solid matter with five or six inches of water lying above it and the oil or grease floating on the water.

The receiving tanks drain into gutters, and the solid matter is passed through a rotary pressing machine, the Edgerton press. The pressure is controlled by 10-ton springs, allowing the passage of cans, bricks, stove lids, etc., without injury to the press. The liquids and grease pressed out pass to the gutters. The water and grease run along the gutter to the grease room, depositing more or less sand, dirt and finely divided parts of the tankage.

In the grease room the water and fats pass through a series of square catch-basins, connected by openings in the lower part of the partitions between them, which results in the accumulation of oil or grease on the surface of the water in each basin. This oil is skimmed out by hand with long scoops into a receiver and pumped to sedimentation tanks on the floor above, from which it is drawn down into a large iron tank furnished with a depression along the centre of the bottom, where the water and sediment may collect.

The oil or grease is piped off into barrels from a point a few inches above the bottom of the tank. It is a slightly turbid, dark brown liquid, and without any offensive smell. The water remaining in the catch-basins escapes into the sea. The pressed solid matter, known as tankage, is carried by the conveyors to the engine room, where it is burned in the furnaces under the boilers.

The weight of a cubic foot of garbage is from 45 to 56 pounds, or a maximum of 1½ tons for each 56 cubic feet. The garbage contains from 7 to 10 per cent. of foreign matters, and the quantities are from 140 to 150 tons daily. The yield of grease is 2 per cent. and the tankage 10 to 12 per cent.

The tankage used as fuel to the amount of 35 to 40 tons daily is said to replace about five tons of coal, and must, therefore, be worth about 50 cents per ton as fuel.

Measure for Suppressing Odors.—The steam from the digestors is conveyed by pipes to a Buckley condenser, where it meets with a current of sea water and is carried off into a "hot well," whence part of the odor is carried by the water into the sea.

Part, however, escapes from the hot well and is conducted to a Bunsen burner at the foot of the chimney, where it is intended that it should be consumed. The odors from the digestors and grease room are collected by means of hoods arranged one over each press. These hoods lead by vertical pipes into a horizontal pipe furnished with exhaust fans, and the odors are thus carried to the furnaces and there supposed to be destroyed. While the liquids are running from the receiving tanks and presses, the gutters are covered with iron plates.

In and about the buildings, a strong caramel odor is detected continuously during operation and is derived probably from the tankage after dumping the digestors. This odor naturally escapes by open doors and windows and is distributed by the wind. The well-known raw garbage odor is also noticed when the scows are being unloaded, but its range is very limited.

The third and most objectionable odor is traced to the chimneys of the plant. It is not observed near the plant, but is carried to a distance by the winds and on a cloudy day is especially likely to be carried downward to the ground level, where it is extremely offensive. There were complaints of odors from this plant early in 1899, and hearings were held in June and July of that year. The evidence went to show that the odor complained of was distinct from the sewage pumping station and to the gas works; both of which were near the garbage plant.

In the spring of 1900 there were renewed complaints and hearings, and a second exhaustive investigation by the Board of Health led to a second formal declaration that the garbage plant constituted a nuisance, and in August an effort was made to abate it as a nuisance under the provisions of the contract.

The matter was taken to the courts, and finally settled by the removal of the plant to Spectacle Island, about three miles further down Boston harbor. By the terms of the contract, the city paid $140,000 to the company for the costs of removal.

THE SEMET-SOLVAY PROCESS FOR RECOVERY OF AMMONIA FROM GARBAGE TANKAGE.

The use of by-product ovens as means of recovering ammonia from garbage was the idea of Dr. Bruno Terne, U. S. Pat. 619,055, while chemist of the Sanitary Product Company of New York, which controls the garbage reduction process in use at New York, Philadelphia and Boston. He saw an opportunity to utilize the solid and liquid residuum to better advantage than previously possible, and for obtaining from them a large part of their nitrogen in the more available form of ammonium sulphate, or crude liquor.

The project was brought to the notice of the Semet-Solvay Company of Syracuse, N. Y., and tests were made by them of twenty tons of pressed tankage in their coke ovens at Syracuse. These tests showed that from one ton of tankage containing 40 per cent. of water, there were obtained approximately 164 pounds of ammonia, reckoned as sulphate, 488 pounds of carbonized tankage, and 4,000 cubic feet of gas of about 300 B. T. U., together with a small quantity of tar. On the basis of these results, the construction of a coke oven plant to work in conjunction with the garbage reduction plant at Boston was undertaken.

The reduction plant was installed at the extremity of Old Harbor Point, Dorchester. The building was brick, 120 feet square, divided by a partition wall into two equal parts. One part contained the digestors, thirty-two in number, and conveyors, and was open to the roof. The other portion, having a second story, contained, on the lower floor, the evaporators, boilers and engines.

The coke ovens, condensing and washing plant, ammonia concentrator, and dryers, were placed in a wooden mill construction, 45 x 54 feet, immediately adjoining the main building. The by-product coke ovens were in a construction off this ell, 54 x 45 feet, enclosed in a steel frame with galvanized iron covering. There was a saparate steel chimney for the coking plant, 80 feet high, 4 feet diameter. The coke ovens were of the Semet-Solvay type—seven in number, 30 feet long, 7 feet high, 18 inches wide; a long narrow high chamber with charging hole on the top, the sides of the chambers lined with fire brick, with double walls forming flues through which the heat and flame from the gas burners passed. These flames and heat completely enclosed the ovens and finally passed beneath them to the smoke stack. There were doors at each end of each oven, lined with fire brick, one set of which was raised by hydraulic power.

The gas evolved in the operation of coking, was, in the Syracuse test, about sufficient in calorific power to supply the heat, but for starting, and to bridge over any irregularity in supply, two gas producers were installed. The dry tankage was charged into the ovens through the openings on top and leveled off to uniform heights.

The residue from the carbonization or coking process, was a light granular substance, somewhat resembling ground coffee, only darker in color. It was withdrawn from the ovens by a mechanical extractor, consisting of a scraper bucket conveyor, traveling on a steel beam, 40 feet long. This was carried on a frame running on wheels.

The carbonized charge was received in a car and by elevator raised to the floor above, where it was screened and mixed with the requisite portion of "stick" before passing through the Anderson dryer, emerging in its final form as a fertilizer base.

The gas from the retorts or ovens was passed through a water-sealed hydraulic main, placed on top of the ovens, and then through a pair of tubular surface condensers cooled with sea water, to the exhauster, which forced it through a compartment washer, where the ammonia was removed by absorption in water.

The exit gas from the washer was led to the oven burners:

and the ammoniacal liquor, after passing through a gravity tar separator, was collected in storage tanks. From these it was pumped to the concentrator feeding tank as required.

The ammonia concentrator was of the tower pattern, consisting of a dozen or more flanged cylindrical cast-iron plates, 40 inches in diameter, bolted one on top of the other. Each contained a baffle-plate of the mushroom type covering an outlet in the middle so as to form a water seal. The live steam admitted at the bottom of the column forced its way up through the water seals which were maintained by the weak liquor fed into the top of the column and passing from section to section, the ammonia being drawn off as the liquor passed down.

The gaseous ammonia and steam passing up through the column were cooled by contact with a series of pipes enclosed in a continuation of the tower, at the same time heating the weak incoming liquor, and passed over to the final condensing worm, where they were condensed, passing thence to the storage tanks in the form of crude strong liquor.

Apparatus for the manufacture of sulphate of ammonia was also provided on the upper floor of the condensing house. This comprised lead-lined saturating tanks, acid tanks, drainage bins and piping. Storage tanks for acids were on the ground floor near the water front, and an air compressor and auxiliary tank were provided to lift the acid to the saturators.

The plant was started in November, 1898, and continued until February, 1899, when, with the reduction works, it was partially destroyed by fire.

Mr. Terne says: "The difficulties unavoidably attendant upon the working out of a new process prevented the immediate realization of the results obtained in the preliminary experiments, but there is no doubt that they would have been fully reached had not the disaster intervened."

When the reduction plant was removed, by order of the courts, and rebuilt at Spectacle Island, three miles further down the harbor, the ammonia saving process plant was not included. No apparatus of this kind for garbage or tankage treatment is now in use.

The Third Boston Plant.—The removal and establishment of the reduction plant under the Arnold system from Cow

Pasture, Dorchester Point, to Spectacle Island, on the Boston harbor, about three miles further down, was made in the year 1906. The works erected included a house enclosing sixteen digestors on the upper story, beneath which were the four rotary presses, and connected with these were the gutters which received the water and grease and conducted them to the settling basins. The garbage was taken from the scows by a traveling conveyor, and by means of a chute placed in each digestor, according to the quantity required.

Besides the rotary presses, a powerful hydraulic press is also used for the final recovery of grease and water from the finely divided portions of tankage gathered from the gutters.

At the time of the examination by the writer, in 1907, the plant was handling upwards of 100 tons per day in an efficient manner. The tankage at this time was burned under the boilers, as no process had been established for its treatment and manufacture as a fertilizer, but it was understood that additional works were being constructed about three hundred yards away from this building, which would receive the tankage, recover the 15 per cent. of grease which it contained, and manufacture the residuum for the fertilizer market.

Subsequently, in the summer of 1907, many complaints were made against the works on the score of offensive odors carried to nearby dwellings in the summer, since Spectacle Island is nearly surrounded by the seaside residences of Boston people. In every direction except one, if the winds were favorable, these odors would be carried long distances, and would become highly offensive. Under the contract with the city the company has still one and one-half years for its contract to be continued.

General Disposal Work in Boston.—Before the establishment of the reduction plants in Boston, the garbage of the city was separated by the households, then was delivered to contractors, who carried it long distances in the country for feeding to animals. In 1893 and 1894, the city derived a revenue of $20,000 from this source, but conveyance by steam cars was objected to on the score of nuisance, and the handling of garbage at the various depots where it was sold to the farmers for feed was exceedingly offensive. This practice of selling the garbage was abandoned as soon as the reduction plant was established, and only in some portions of the outlying suburbs, as at Brighton, Roxbury, Dorchester, etc., is the garbage now disposed of in this way.

Light Refuse.—In 1888 and 1889, at the request of the Board of Health, tenders for contract were asked for by the city for the construction of a refuse disposal plant upon city property adjoining Fort Hill Wharf. After some delay a contract was granted to the Refuse Utilization Company, a corporation formed for the purpose, which erected a plant and received all the light refuse and rubbish collected from an area of about ninety miles of streets, and containing approximately 200,000 people. The city by this contract paid $5,500 per year, and furnished the grounds for the company free of rent.

Since the plant is in the hands of a private company, which has jealously guarded its commercial work, no exact information is obtainable as to the value of the product recovered for market, or the cost of doing the work. The operation of the plant was described and illustrated in a previous chapter.

In the year 1907, the Mayor appointed a commission to consider the general question of the collection and disposal of the municipal refuse of the city. This commission comprised Prof. Sedgwick of the Boston Institute of Technology, Mr. X. H. Goodnough, Chief Engineer of the Massachusetts State Board of Health, and Mr. Wm. Jackson, City Engineer of Boston. This Commission has been for some months obtaining data and visiting all the principal installations throughout the country and is about to formulate a general plan for some economical collection service in the city proper, and also in adjoining wards, which include Dorchester, Roxbury, West Roxbury, Jamaica Plains, New Brighton and East Boston. This plan will include complete methods for the collection and the disposal of the general refuse by methods and systems suitable for each individual case.

It is understood also that the recommendation has been made for the construction of an enlarged and perfected utilization plant to be built in the place of the present plant at Fort Hill Wharf, and to be operated for the benefit of the city instead of a contracting company.

The preliminary report of collections, quantities, proportions and present methods of disposal, by Mr. X. H. Goodnough, is condensed in Chap. VII.

EARLY METHODS OF WASTE DISPOSAL IN NEW YORK CITY.

In tracing the development of the methods of garbage disposal by the reduction processes in New York City, it will be of interest to briefly outline the earlier history of the subject, with some account of the attempts to better the sanitary conditions, as carried on under the advice and suggestions of advisory boards by the successive Commisisoners and Superintendents of Street Cleaning Service.

The organization of the street cleaning service as a separate branch of the administration work dates from the year 1881, prior to which time the collection and disposal of waste was done by contractors under the direction of the Police Department.

The city acquired teams, built or rented stables, organized the force for cleaning the streets, for the collection of household wastes, procured scows, and tugs for towing these outside the harbor limits.

The practice was to dump overboard, nominally at a point below Sandy Hook, but as a matter of fact the scows were unloaded at any place where it could be done without observation by the officers of the Government in charge of the care of the harbor.

For several years this service for collection and disposal was continued with great complaints from the citizens for unsatisfactory collection and with repeated protests from the propertyholders on the shores of Long Island and New Jersey. After ten years of complaint and remonstrances an Advisory Commission was appointed to inquire into the defects of this method and recommend some better system.

This Commission, appointed by Mayor Grant in 1891, included Messrs. Morris K. Jessup, Thatcher M. Adams, Prof. C. F. Chandler, D. H. King and Gen. F. V. Greene. The report was devoted chiefly to the collection of the wastes, and established some principles defining the character and treatment of general refuse, which became a basis for after Commissions to extend and amplify. It was reported that street sweepings were not of enough value to pay the work of transportation; that garbage, when kept separated, is valuable for fertilizer or for feeding swine; that coal ashes, when free of other matters, make good filling, and that these three forms of wastes, when mixed, lose their pecuniary value, unless for filling behind bulkheads, or on land remote from dwellings.

The Commission also found that the Department of Street Cleaning was badly managed; that the laborers were inefficient and held their places by political influence; that the plant of the Department was insufficient and poorly located; that the manner of disposal of refuse was unsatisfactory; that the co-operation of the other departments of the city—Police Justices, Health and Police—was largely lacking, and that the management of the Department required men experienced in the control of transportation means and executive capacity of a high order.

The practical effect of this report was the reorganization of the Department by Legislative enactment in 1892, with increased appropriations, but little real progress in improving the conditions. There was still the appointment of officers and force for political purposes, the work of the Department being a secondary consideration.

Later, in 1892, the inquiries into this subject were continued by Messrs. Theo. F. Meyers, the Comptroller, and Edw. P. Parker of the Board of Estimates. They took firm ground against sea-dumping, and strongly recommended cremation as the best means for disposal, but as it might be some time before a cremation system suitable for the city's needs became available, they advocated the deposit of the waste to make ground about Riker's Island. The adoption of this method a year later gave rise to a nuisance of offensive odors, and subsequent legislative action prohibiting the dumping of mixed refuse, containing garbage, at Riker's Island.

This was followed in 1894 by the appointment by Mayor Gilroy of a second Advisory Committee, composed of ex-Mayor Franklin Edson, Thomas L. James, Lt. Comr. D. Delehanty, U. S. N., Hon. Chas. G. Wilson, President of the Board of Health, and Mr. W. S. Andrews, Commissioner of Street Cleaning.

The members of this Board, in person and by representatives, made an extended examination of all methods in use for garbage disposal in this country, one member visiting Europe for a survey of the means there used.

They did not find cremation methods altogether satisfactory, as no plant of any considerable size was then in operation. They also reported that reduction processes were "thoroughly sanitary, and although not free from offense, can doubtless be made so." The Board declared that light refuse could not be deposited at sea at a less distance than 200 miles from the harbor without contaminating the shores.

To obtain some data for further recommendations the Board invited proposals or plans for final disposal of the waste of New York.

There were seventy different plans submitted. Of these forty-nine were considered practicable, and were classified as follows: Eighteen proposed to burn all the waste, six to burn garbage only, two others had a separation process with utilization of the valuable parts and burning the rest, seven advocated reduction, four would employ self-dumping boat for long sea conveyance, and twelve were included under miscellaneous or undefined plans. Leaving aside the miscellaneous list, twenty-six were in favor of cremation, seven of reduction and four of continuing sea-dumping. Many of those who presented plans were afforded an opportunity to explain to the Board in detail what they proposed and the results to be expected.

The author's contribution to the literature of the Advisory Board was contained in a small pamphlet advocating the disposition by fire by two alternative methods:

First—By several plants placed upon wharves at different points, from ten to twelve in number, at which the putrescible organic waste would be destroyed in furnaces of approved design, the power developed by this combustion to be employed for sorting out the marketable parts of the refuse and for conveying and loading the residuum remaining and the great bulk of household ashes into scows for conveyance to Riker's Island.

Second—The disposal of the garbage at Riker's Island by establishing a large cremating plant for destroying the putrescible matter, the power derived therefrom to be used for conveying and distributing the ashes of the city for making new ground.

The pamphlet gave a short account of the English destructors, their capacity, cost of operating expenses, of construction and other details of some fifty installations, out of about 125 then in use in Great Britain. There was added a comparative cost for a plant to be established in New York for similar work, with some indication as to the saving in annual cost to the city, as against the disposal of the garbage only, by reduction, or the continued disposal by conveyance in self-dumping steam lighters at sea.

Mayor Gilroy's Advisory Board finally recommended:

That dumping into the harbor or its tributary waters should cease.

That the householders should be requested to separate kitchen garbage from the ashes and other house refuse.

That the collection should be made in iron vessels with tight covers.

That the daily garbage collections should be delivered into storage bins or self-dumping propelled boats of approved type.

That the garbage should be disposed of by reduction, and the city should invite bids from companies controlling these systems.

That a separate collection should be made of other refuse not otherwise provided for, which should be taken to Riker's Island, or elsewhere, and that the conveyance of this should be by self-propelled boats to be constructed and owned by the city.

If there was any market value to street sweepings for fertilizers, they should be sold if worth more than for filling purposes.

This last named recommendation of the Advisory Board, which was adopted and followed out by the city authorities, committed the city to one particular method that treated only one-twelfth of all the refuse, as against the cremation system that disposed of the whole. It established a monopoly by contract, which has been perpetuated, and from which the city has since never been able to free itself. It further denied the right of competition by any form of disposal by cremation means, and offered no opportunity to show what might be done by the use of apparatus that was entirely successful in other great cities of the world.

While condemning the dumping at sea, it still recommended this be carried on at greatly increased cost for transportation with no guarantee that it would be any more successful than in the past.

At that time there were only three reduction and extraction companies at work. The quantities of garbage treated by these were insignificant compared with the amounts to be handled here. Several plants had failed or been closed by reason of nuisance, and the whole work in this direction was largely experimental and undetermined. This unwise recommendation of a body of estimable gentlemen, acting upon information, and not upon practical engineering knowledge or any previous acquaintance with the questions, did much to delay the progress of the general question of a satisfactory disposal of the communal waste of American towns.

INVESTIGATION AND EXPERIMENTS OF COL. GEO. E. WARING, IN NEW YORK CITY, UPON GARBAGE TREATMENT, BY THE METHODS OF EXTRACTION AND REDUCTION IN 1895.

When Col. Waring became Commissioner of Street Cleaning of New York City, in January, 1895, the wastes of the city were towed to sea and thrown overboard. This had been the practice for years, one that is both wasteful and objectionable, but no better means had been found available. In 1895, Col. Waring made inquiries into the methods in use in all civilized countries for waste disposal, visiting Europe himself for this purpose, besides carrying on an exhaustive survey by competent assistants in this country.

The claims made for sanitary treatment and economy in the disposal of garbage when separated from other forms of refuse were brought strongly to his attention, resulting in an invitation to the various companies engaged in this work to present informal bids naming the prices at which they would be willing to receive and dispose of the garbage of the city.

Twenty-six answers were received. The average cost per ton from those proposing to destroy by incineration was 90 cents, and the average for utilization by the several extraction and reduction means was 55 cents per ton, but of all these bidders only one-half were believed to be sufficiently experienced and responsible to make offers which would be acceptable to the city. Under these circumstances, it was thought advisable to make an independent investigation of the various methods, and a series of examinations was proposed in the city's behalf which should include the cost of operation. the value of the commercial products, and the adaptability of each process to the needs of the city. This invitation was accepted by several companies, and in the summer of 1895 more than 3,000 tons of garbage in the cities of New York, Brooklyn, Buffalo, Philadelphia and St. Louis were treated by different methods under the supervision of the inspectors appointed by Col. Waring.

These trials of apparatus took place as follows:

Merz Universal Extractor and Construction Co.	Buffalo	June
Merz Universal Extractor and Construction Co.	St. Louis	July
The Sanative Refuse Co., Process No. 1	New York	August

At these three plants, the grease was extracted by the use of hydro-carbon solvents, and the remaining solids converted into fertilizer base.

The Preston Process	Brooklyn, N. Y.	July
The Bridgeport Utilization Co., (Holthaus Process)	Bridgeport	February
The American Incinerating Co. (Arnold Process)	Philadelphia	July

At these three plants, the grease was extracted by cooking and mechanical pressure and the solids made into fertilizers.

The Sanative Refuse Co., Process No. 2 (Pierce)	New York	September
The American Reduction Co.	Brooklyn	May

Both of these companies made the garbage into complete fertilizer, but the first extracted the grease by solvents, while the second used acid.

In method No. 1 of the Sanative Refuse Company, the raw garbage was placed in steel tanks and covered with naphtha, the tanks then being tightly closed and heated by steam. After five hours of this cooking in naphtha, the liquid was run off and its constitutents separated, while the tankage was taken out and dried. From New York summer garbage this method extracted an average of 2.4 per cent. of grease and left the wet tankage almost odorless. The process was rather wasteful of naphtha, but most satisfactory from the sanitary standpoint.

Method No. 2 of the Sanative Refuse Company completed the utilization process by making the tankage into a finished fertilizer.

The American Reduction Company made a complete fertilizer by cooking the garbage in dilute acid and then adding the other necessary ingredients, drying and grinding.

The Standard Construction and Utilization Company, Philadelphia, August.—This company did the preliminary cooking in steam jacketed digestors, the grease afterwards being recovered by pressing and separated by flotation and skimming.

The information obtained by the Department was in the nature of confidential communications, and so far as is known has never been made public, but from the subsequent action taken, it would appear that some of the processes either did not comply with the requirements of the city or were unable to offer advantageous terms for the work.

This inquiry touched on many important facts in connection with the subject, dealing with the seasonal variation in character and quantities, the system of collection by contract or by city agency, the admixture of foreign matters when treatment by extraction or reduction is to be used, the quantities of water present as affecting results in manufacturing, the destruction of noxious gases by condensation or cremation, and the use of disinfectants in collection work.

The report also included a general description of the apparatus employed in each process of extraction or reduction, with a brief account of the final means of drying, grinding and preparing for market, used by all the companies.

The selling value of a ton of summer garbage was thus stated:

Grease,	40 lbs.	at 3c.	$1.20
Tankage—			
Ammonia,	13 "	" 8c.	1.04
Phosphoric Acid,	13 "	" 1c.	.13
Potash,	3 "	" 3½c.	.10
			$2.47

Appended to, or included in, Col. Waring's reports were examinations made by his assistants upon the disposal of garbage from the hotels of New York, not a part of the city's work, but taken by private collectors and fed to animals outside the city.

Garbage grease, its quantity, uses and value, was also considered, as well as the fertilizer trade in general and the probable effect of a large new supply that might result from the general adoption of these new methods. There was also an estimate of the junk trade in marketable parts of the city's refuse collected by cartmen throughout the town.

All these facts, concisely put, gathered in one small volume, form a history of what was then the situation, the possibilities, and to some extent a prophecy of the future work to be done in this line of waste collection and disposal such as has not been repeated in this country.

The thoroughness which characterized all of Col. Waring's municipal work, and the able assistance of Messrs. M. Craven, H. Hill and C. H. Koyl, together united to give definite form and a fixed method to what had, up to then, been uncertain and indefinite, in the investigation of the proper methods of disposal of municipal waste.

BEGINNING OF GARBAGE REDUCTION IN NEW YORK.

Pending the close of the examination of the possibilities of the reduction method, Col. Waring issued advertisements calling for bids for the disposal of the combined city waste by any method that could be shown to be sanitary and efficient. Several bids were received in December, 1895, but these upon examination appeared to be deficient and they were rejected.

The next advertisement, February, 1896, asked for bids for the disposal of garbage only. The replies received were all considered unsatisfactory, and they were rejected. In March another call was made for tenders for garbage, and also for the disposition of ashes and street sweepings. The bids received for the disposal of ashes and street sweepings were rejected. The proposal of the Merz Extracting Company in the sum of $90,000 per year was accepted by the Commissioner, but was not accepted by the Board of Estimate. Subsequently, in June, the bid of the Sanitary Utilization Company of New York was approved by this Board, and the company was granted the contract for a term of five years at the annual rate of $89,990, to date from August 1, 1896. It will be noted that this price was $10 less than that tendered by the Merz Company. The contract price included furnishing scows for the transportation of the garbage and its final disposition in an unobjectionable manner. The quantity for the old city of New York, now the Borough of Manhattan. was estimated at 500 tons per day for 313 working days, or about 156,500 tons per year. This was at the rate of approximately 57½ cents per ton for transportation and disposal.

"Garbage" was defined as meaning the refuse of all organic nature, not including street sweepings, collected by the city carts or by duly authorized private carts, and delivered at the dumps or other places of final disposition, and containing not more than 10 per cent. by weight of other refuse.

In November, 1896, the city of Brooklyn granted a contract for five years for the collection, transportation and disposal of the city garbage by the Brooklyn Sanitary Utilization Company, one of the provisions being that the company should receive the garbage at its plant up to May, 1897, after which there should be ready a separate plant for the disposal of the Brooklyn garbage. The quantity of garbage was estimated at 250 tons per day. The maximum capacity of the new Brooklyn plant was to be 500 tons per day.

THE BARREN ISLAND REDUCTION PLANT.

The New York Sanitary Utilization Company was formed by capitalists from Philadelphia who controlled the Arnold process of garbage reduction under a corporation known as the American Sanitary Product Company. This is the parent company that controls or is interested in all the various companies operating under the patents of this process in Philadelphia, New York, Brooklyn, Boston, Baltimore, Washington, Newark, and Atlantic City.

The combined plants for New York and Brooklyn were built in 1895-6 at Barren Island, a small island at the mouth of Jamaica Bay, on Rockaway Inlet, in the rear of Rockaway Beach. The distance of this location from the City Hall in New York City is twelve miles by land, and about twenty by water.

The garbage is dumped by the city's collection carts into the company's scows at five wharfs, three on the North and two on the East River. The average towing distance from New York is twenty-two miles, and about eighteen miles from Brooklyn. The scows carry an average of 300 tons of garbage, and one tug tows two scows.

The quantities collected in tons for three years were as follows:

	New York	*Manhattan and Bronx*		*Brooklyn*	*Total*
	1897	1898	1899	1899	1899
	158,500	142,400	151,600	104,000	255,600
Quantities per day.....	500 tons	455 tons	484 tons	333 tons	817 tons
Cost per ton...........	57c.	64c.	59c.		

The scows were formerly unloaded by buckets and scoops, discharging into a hopper from which the garbage was carried by a conveyor to the digestors. The present method is by stationary conveyors or continuous steel troughs, with connected scrapers or drags, carried on sprocket chains, the scows being moved forward as they are unloaded. Over each digestor are sliding doors in the bottom of the troughs which are connected with a funnel and feed pipe with a swivel joint, so that each digestor may be fed in turn. The digestors are of the usual type, vertical steel cylinders, holding about eight tons, of ⅝-inch steel plate strongly riveted, dome shaped at the top, with conical lower ends for delivery of the cooked garbage into receiving tanks.

Every four digestors are connected with one tank also made of steel plates 14½ feet long, 12 feet 6 inches wide, 7 feet high, having a bottom sloping each way to the center.

An opening is provided at the bottom for discharging the cooked garbage by means of a pipe into cars where it is built up with wooden racks and gunny sacks into layers and run beneath the screw presses. There are sixteen presses, operated at a pressure of 100 pounds per square inch on the press screw head, or platen. When this process is completed the cars are run to the end of the building, the tankage lifted to the second floor and then shovelled into the dryers.

There are twelve driers, each about 14 feet long and 5 inches in diameter, placed horizontally, carrying a charge of three tons. These driers are jacketed with live steam at 75 pounds pressure, and are provided with rotating blades on a center shaft to keep the tankage stirred up.

From the driers the tankage is discharged into cross conveyors leading to the screens. These are the usual type of rotary screens, and deliver the tankage in condition for bagging for market.

After the bones are picked out the tailings are burned or are used for filling.

Going back to the operation of the presses, the liquids from the pressed garbage fall into a system of drains beneath the press-room floor which carries the hot water and the grease from the presses into a series of shallow tanks with partitions extending only part way to the bottom. By continued circulation and movement in these basins the grease in cooling separates from the water, is removed by skimming, and finally goes into the barrels for shipment. In the evaporation process a form of vacuum pan is used. The final product, known as "stick," a heavy, dense body of fluid substances, is mixed with the highly dried tankage to form a superior grade of fertilizer.

Provisions for the prevention of nuisances incidental to the various processes are an important part of the whole when such enormous quantities of material are handled. In hot weather a deodorant known as "electrozone" was used. This is a product of hypo-chlorite of sodium evolved from sea water by powerful electrical currents, and is applied to lessen the odors from the green garbage in the scows. The scows are washed down after each trip and sprinkled with chloride of lime.

The free steam and gases in the digestor house are exhausted by an immense fan and are drawn into a long scrubber through which about 3,500 gallons of sea water are forced by pumps. The gases from the digestors, driers and evaporators are passed through spiral jet condensers; in these the gases and a jet of cold water fall together about 30 feet into a receiving tank. Uncondensed gases were formerly passed to the chimneys, entering at the rear of the boiler, but as the temperature of 600° was not sufficient to deodorize or consume these they are now discharged under water at some distance from the works.

The machinery equipment includes seventeen steam boilers of 250 horsepower each, four Corliss engines of 150 horsepower each, two smaller engines, two air compressors, three dynamos for lighting, several pumps for lifting water, and fans for ventilation.

The Brooklyn plant is practically a duplicate of the New York plant. More digestors are to be added to make up a total of one hundred and twelve, which will give the whole plant a capacity for the treatment of 1,500 tons per day. (Description condensed from the *Engineering News* of February 1, 1900.)

THE SANITARY SIDE OF THE MATTER.

The history of the Barren Island plant is one of strenuous effort to maintain its position against the determined opposition of the surrounding population while at the same time embarrassed by a series of misfortunes and accidents which were beyond the power of the company to foresee. During the summer months there are probably three-fourths of a million people residing within a radius of three miles from the island, with free range for the winds which at this season blow mainly from the direction of the south and southwest. While there are in the locality three other plants of a similar nature—P. White Sons, for dead animals; E. I. McKeever, for animals; E. Frank Coe Fertilizer Co.—it was claimed that the nauseous odors were chiefly due to the reduction works.

The people complained to the Board of Health, but met with no encouragement. They appealed to the Legislature in 1899, and a bill was passed and vetoed by the Governor on the ground that six months was too short a time for the Street Cleaning Department to provide other means of disposal. The Legislature of 1900 caused a hearing to be held at which arguments were presented resulting in the passage of a bill, which was vetoed by Mayor Van Wyck, and was repassed by the Legislature and signed by Governor Roosevelt, who at that time clearly stated the aim and purpose of this action.

On the 20th of April, 1900, he said:

> The city authorities should have presented a better plan for the disposal of the garbage to the last Legislature, but, instead, they hang back and make no effort to solve the Barren Island problem. That's the reason why these bills were passed. The city authorities evidently prefer to allow the present disposal contractors to profit by the existing methods than take the measures necessary to abate the nuisance and protect the public health. If I sign this bill it will be because they will be compelled to do something which otherwise they would not do in the public interest.

The bill allowed twelve months from the time that it became a law, April, 1900, for the securing of other means of disposal, but provided that the Board of Health of the city might extend the operation of the time to include the then existing contracts up to August 1, 1901. The Garbage Company took the matter to the courts, where, after long delay, the act was declared unconstitutional.

Under the contracts with New York City and Brooklyn the Sanitary Utilization Company carried on its work at Barren Island until 1901, when the term of the first contract with New York expired. In March a fire which originated in the storage house destroyed a large amount of manufactured stock and the buildings in which it was kept. The loss was said to be $50,000. Complaints of nuisance from odors continued, but the operation of the works was uninterrupted. The company made great efforts to install every form of ventilating and preventive apparatus that might be of service, and took all possible precautions to stop the odors. On April 16, 1903, another fire greatly damaged the New York plant, the losses being reported at $100,000. For a short time a part of the garbage was dumped at sea until repairs could be made to the works.

THE RETIREMENT OF COLONEL WARING AS COMMISSIONER.

In 1897 the city government changed politically. Tammany again came into power, and on January 1, 1898, Mr. Percy Nagle replaced Colonel Waring as Commissioner of Street Cleaning.

The three years of the administration of the Department of Street Cleaning under Colonel Waring were years of earnest and continued effort to establish a system of efficient and economical work in all branches of the service. He first reorganized the personnel of the department, then repaired and increased the equipment for street cleaning. He improved the collection service, and caused to be built necessary stables and buildings for the mechanical department, making extensive additions to these. Following the suggestions of the Gilroy Commission he installed steel storage pocket bins for receiving waste and for quick work in loading scows. The point for sea-dumping was carried nine miles further out, and two large self-propelled steel dumping boats were purchased for transportation of the waste in any kind of weather. These boats were experimental, it being the intention of the head of the department to add to these if they were found to be practical and economical. He began the dumping of ashes and refuse at Riker's Island after the establishment of the reduction plant which took care of the garbage, and this practically stopped sea-dumping.

For the light refuse disposal, Colonel Waring established the plant at East Seventeenth Street, from which in the course of three years the city derived a revenue of 61 cents to $1.10 per ton.

The Commissioner also took up the method of street cleaning by hand, which he had seen operative abroad. The streets were divided into sections each under the care of one man who was responsible for its condition, each one of the street forces being equipped with apparatus invented for the purpose of assisting him to do his work effectually.

In order to interest the people and in a measure supplement the exertions of the department force, Waring inaugurated the Juvenile Street Cleaning League, which was popular among the school children and proved to be a beneficial civic movement. Through the efforts of his assistants, under his direction, detailed information upon many subjects was collected, all of which up to the time of his administration had been neglected and ignored. Among these special reports are those upon the relative advantage and comparative costs of disposal at sea and by dumping, for the purpose of making land at Riker's Island and other points; the private collection of garbage and its use as food for animals; the garbage and tankage trade as connected with the fertilizer industry; the value of street sweepings as a fertilizer; the waste paper collection, its quantities and values; the value of household ash; the utilization of ashes and the products thereof; a comprehensive and detailed account of the cost of street sweeping, including a description of the methods and machinery employed for cleaning every variety of pavement.

There are many minor subjects pertinent in one way or another to a description of the work of this bureau that received his personal attention. Colonel Waring was always ready to listen to any new idea that promised to help out, and to give the suggestion a trial if he thought suitable.

Probably this very efficient Commissioner will best be remembered for the creation of the "White Wings," the Street Cleaning force which he formed into battalions under military discipline and rigid rules of behavior, whose annual parade in their white uniforms was a feature of the administration of Mayor Strong. The three thousand men under his control were imbued with the spirit of their chief, and inspired with personal pride in their work, all of which gave them an *esprit de corps* hitherto conspicuously absent in the department, making them better citizens and better workers.

His own estimate of the results attained at the end of his term of service may be quoted:

> The progress made thus far is satisfactory. An inefficient and ill-equipped working force long held under the heel of the spoilsman has been emancipated, organized and brought to its best. It now constitutes a brigade three thousand strong, made up of well-trained and disciplined men, the representative soldiers of cleanliness and health, soldiers of the public, self-respecting and life-saving. These men are fighting daily battles with dirt, and are defending the health of the whole people. The trophies of their victories are all about us, in clean pavements, clean feet, uncontaminated air, a look of health on the faces of the people, and streets full of healthy children at play.
>
> This is the outcome of two and one-half years of strenuous effort—at first against official opposition and much public criticism. Two and one-half years more, with a continuance of the present official favor and universal public approval should bring our work to perfection. It should make New York the cleanest, and should help to make it the healthiest city in the world. By that time the death rate should be reduced to fifteen per thousand, which would mean for our present population a saving of sixty lives per day out of one hundred and forty daily lost under the average of 26.78 (1882-94).

CHAPTER XV.

The Arnold Reduction Process in New York, Philadelphia, Baltimore and Atlantic City.

Renewal of New York Contracts.—The terms of five years' contract in New York City for the disposal of the garbage by the Sanitary Utilization Company (using the Arnold process) expired on August 1, 1901. The contract forms for a new advertisement were ready in January, 1901, but they were withheld by Mr. Nagle, and not published until June, the bids being opened on the 27th of that month.

The specifications provided for a plant of 1,000 tons capacity to be ready for work in 30 days, and to be reduction or cremation methods, as the contractors might elect, the contracts to include separate bids and plants for the Borough of Bronx as well as those for Manhattan. The following are the bids received for Manhattan:

	Per Year
David Peoples (Philadelphia)	$385,000
John McNamee	390,000
Seth L. Keeney	600,000
Sanitary Utilization Company	232,000

For the Bronx the bids were:

Sanitary Utilization Company (5 years)	$355,000
Geo. W. Hyatt (5 years)	334,000

The acceptance of the bid of the Sanitary Utilization Company for Manhattan was recommended by Mr. Nagle, Commissioner of Street Cleaning, and that of Mr. Hyatt for the Bronx. The Board of Estimate and Apportionment rejected all bids and instructed the Commissioner to prepare new specifications for bids for one year, instead of for five years. The new bids were advertised on July 20, and opened on July 30, after long controversy, and the Board of Estimate awarded the contract to the New York Sanitary Utilization Company for five years at $232,000 per year.

At the time of the award it was claimed by the Sanitary Utilization Company that the amounts of garbage had doubled, making necessary an increased capacity of their plant. This was accepted as a fact, without verification, but it was manifestly incorrect, as is shown by the reports of quantities for the previous year (1899). Assuming that an average amount of 500 tons daily for Manhattan was received, or a total of 158,500 tons for 313 days, then the cost per ton would be $1.48, an increase of 90½ cents per ton over the previous five-year contract, and a total increase of over a million dollars.

The method adopted for letting this contract one day previous to the expiration of the old contract, demonstrated the power of a monopoly in controlling the public work of garbage disposal by rings and the favor of the local authorities.

The renewal of the Brooklyn contract was obtained in a similar way, at an increased cost to the city, and the disposal of the garbage of the Boroughs of Manhattan and the Bronx by the Arnold process at Barren Island was continued. In the course of the following year the Sanitary Utilization Company contracted for the disposal of the Bronx garbage at the price of $22,500 per year, as against their previous bid of $71,000 per year in 1901.

The Accidents of Fire and Flood at Barren Island.—The ground at Barren Island was originally about five acres of salt marsh, to which about three acres more have been added by filling. Around the border of the island spiles have been driven to protect it against the wash of waves and the scour of the tideway. It has happened that the shifting sand of the bottom has changed in such a manner as to undermine the bulkhead and allow the buildings to slip over into the deep water of the channel. Such a collapse took place in 1905, involving a part of the reduction plant, which was partially destroyed. For many years parts of the island have been disappearing. Twenty years ago a breakwater was built, and since then many boatloads of stone have been dumped off the eastern end to prevent undermining by the currents.

On April 26, 1907, a part of the eastern end containing the buildings of the reduction company's plant, and nearly two hundred feet of the pier and bulkhead sank without warning.

These buildings contained the stock of oil or grease barrelled for market. A part of this was saved, but nothing of the structure was recovered. The loss is stated at $50,000. The working force of one hundred men was thrown into a panic, but they escaped without loss of life.

In May, 1907, the buildings of the main plant were destroyed by fire supposed to have originated by spontaneous combustion. Serious damage was done to the digestor plant, and the works were put out of commission at a time when the warm season was approaching and the garbage was largest in amount. For nearly three months this waste was towed out to sea and discharged near Scotland Lightship. The winds and tides carried large amounts of it to the beaches of New Jersey, where it decayed under the hot sun and gave rise to complaints of nuisance all along the coast. Remonstrances were of no avail, and the matter was taken up by Governor Stokes, of New Jersey, who called with several prominent citizens upon Acting Mayor McGowan, and were assured by him that the dumping scows would be ordered twenty-five miles out to sea instead of fifteen as had been the custom. Assurance was also given that the reduction plant would soon be ready to resume work, although at first with only sufficient capacity to handle one-fourth of the total amount collected.

During ten days street cleaners' strike of the summer of 1907 such collections as were made consisted of a mixed mass of garbage, ashes, refuse, etc., which could not be treated at the reduction plant. This material was sent out to sea, and the same remonstrances were produced from the residents of the Jersey coast as on the previous occasion. These conditions were remedied in the same way, by sending the garbage scows literally out to sea instead of only forty miles from the city wharf.

Continuation of the Garbage Disposal Contract.—In 1902 the consolidation of the municipalities was made, and the city of Greater New York came into existence, divided into the boroughs of Manhattan (formerly New York City), Brooklyn, Queens (Long Island City, Jamaica, Flushing and Rockaway), Richmond (including five towns and all the territory of Staten Island), and Bronx (including Harlem). The population of the united boroughs was, in 1906, 4,258,387; the area in square miles, 327.25.

The greater city assumed the collection and disposal of the garbage in Manhattan, Bronx and Brooklyn, leaving Queens and Richmond to deal with the problem in their own way.

Near the close of 1901 after four years of work of the Street Cleaning Department the conditions of the service had become notoriously bad. An investigation set on foot by a committee of citizens, acting on behalf of a Civic Improvement League, brought out astonishing developments.

One writer says of the work of the Department of Street Cleaning as administered by Commissioner Nagle:

> Beginning in 1898 with the inheritance of a well-organized and thoroughly equipped service, with labor and money saving devices and apparatus in running order, with plans and purposes well-defined for carrying on a practical and successful line of work in an honest and economical way, now at the end of four years, as the result of incompetent management and complete surrender to the machine politicians, the Department is in a position of absolute contempt.
>
> Every one of the means established for saving time and money has been abandoned; the pay-rolls are filled with the names of political henchmen; the streets are dirty and crowded with encumbrances; the steel dumping boards built for the Department have been sold for old junk; the refuse disposal station has been abandoned; the steam dumping boats have been thrown out and are rusting from disuse; a corrupt combination with individual contractors and corporations has been made, by which the city pays double prices for contract work; and the expenses are increased by more than one million dollars in four years. Some parts of the year's appropriations are even now exhausted, and still the demand is made for larger appropriations for next year.

The election in November, 1901, again brought the city government under the control of an administration pledged to the reform of all departments, and Dr. H. McGaw Woodbury became Commissioner of Street Cleaning in January, 1902. The contract granted in 1901 to the Sanitary Utilization Company was faithfully carried out by both parties despite the many difficulties and reverses of the reduction company.

On the announcement that tenders would be received for a new five years' contract for garbage disposal, competitors appeared. The specifications were issued for any suitable method, and time was allowed for the construction of an entirely new and complete plant. The bids received in August for a contract to begin in the following November were:

	Per Year
The New York Sanitary Product Company (The Sanitary Utilization Company and Arnold Process)	$148,000
The American Reduction Company (The Modified Flynn Process, of Pittsburg)	154,000
Darlington & Co. (supposed to be a method of incineration)	209,000
E. J. McKean (process unknown)	300,000

The award was made to the New York Sanitary Product Company, upon an estimated basis of 800 tons per year; the price for disposal was about 90 cents, a reduction of 58 cents from the last contract price.

In Brooklyn the garbage disposal contract was awarded to the Brooklyn Sanitary Product Company for five years from November, 1902.

DISPOSAL IN BRONX BOROUGH.

In the borough of the Bronx there was keen competition for the garbage disposal contract, as the conditions were favorable for the establishment of an incinerating plant, and the specifications provided for the erection of a suitable plant with a capacity of 100 tons of garbage and 100 cubic yards of refuse, other than ashes.

The bids received were as follows:

	Per Year
The Decarie Incinerating Company	$16,000
S. J. Subers	22,500
M. J. Meagher	34,500
Melrose Company	68,000
Sanitary Utilization Company (if disposed of in the borough)	17,500
The same (if disposed of by their plant at Barren Island)	14,000

The contract was awarded to the Decarie Company, which, after some opposition and some changes in regard to the proposed site, erected its plant and began the work of disposal..

The company met with difficulties from the first because of its inability to destroy the given quantity, and also because of complaints on the ground of nuisance from the chimney.

The company was given time to remedy these defects, and after many changes in the apparatus again attempted to carry out the contract. A trial of about two months' time demonstrated that the incinerator could not perform the work required of it, and that the charge of the offensive odors was a true one. The contract was terminated by peremptory action of the Board of Estimate, based upon the adverse report of the Street Cleaning Commissioner, Dr. Woodbury, but the city did not insist upon the forfeiture of the bond given by the Decarie Company in the sum of $20,000 for the efficient performance of the contract.

The mechanical equipment of the company was removed and used at another place to undergo a like failure and like discontinuance of its work.

In 1908 the garbage of the borough of the Bronx was by five years contract with the Sanitary Utilization Company taken to the Barren Island plant at a cost to the city of $15,000 up to $25,000 per year, or an average of $19,000 per year for the five years' contract. At present, under this arrangement, the refuse is picked and sorted for market, the worthless rubbish is scowed to Riker's Island with the house and steam ashes, and is used for filling.

The Garbage of the Borough of Queens.

Formerly in the towns of Long Island City, Flushing, Jamaica and Rockaway, all now included in the borough of Queens, the garbage was disposed of by tipping upon the marshy grounds adjoining the towns. This became so objectionable that in 1899 Colonel Waring accepted bids for its disposal by five garbage crematories of the capacity of twenty-five tons each, to be located in these towns, also for one at New Brighton, in the borough of Richmond.

The contract provided that the city was to collect and deliver the garbage; the contractor, Z. H. Magill, was to purchase ground and erect the crematories, receiving 45 cents per ton for the incineration of garbage with small amounts of light refuse. This undertaking was carried on for a short time only. The crematories were of the Dixon type, requiring large amounts of fuel, and the capacity was not up to the standard, the cost of operating greatly exceeded the guarantee, and the contractor lost heavily by the work. After nearly a year's effort the city was induced to purchase these plants, and a new administration paid $50,000 for the five crematories and the ground.

The crematories in Flushing, Rockaway and Jamaica were discontinued, their places being taken by other furnaces of the

La Chapelle make. That at Long Island City still continues at work, but that at New Brighton has been abandoned because of the erection of a modern destructor plant.

At the present time a small part of the garbage of Queens is taken by scows to the Barren Island works, as is also a small quantity from Coney Island, the summer resort on the shores of the bay, immediately adjoining Barren Island.

DISPOSAL OF GARBAGE IN THE BOROUGH OF RICHMOND.

The borough of Richmond includes all of Staten Island; it has a population of 78,943, and an area of 57.25 square miles.

Prior to the consolidation Staten Island was occupied by a number of corporate villages and a great many small hamlets, the latter controlled by the usual township and county system of government, the villages having a more definite form of administration by Trustees or a Board of Aldermen.

One of the towns, called New Brighton, had in 1895 erected a garbage crematory of the Brownlee type, which continued in service for only three years. Complaints were made of noxious odors, and in the effort to abate these the work of the crematory became too expensive and it was abandoned early in 1898.

In 1899 a Dixon crematory, built under the Magill contract, was located at Port Richmond, and after being acquired by the city was operated until the spring of 1908, when replaced by a modern refuse destructor. For some time after the closing of the Brownlee furnace the garbage was removed in scows to Barren Island.

Owing to the peculiar geographical conditions of the island a long narrow strip of settlements bordering on the waters of the Newark River, New York Harbor, and on the southern and eastern side of the great South Bay, the distance for transporting the garbage was entirely too great for its concentration at any one point. The attempt to deliver it to the Sanitary Company for reduction purposes was given up, and the several towns continued to deposit their garbage upon dumps.

For four years after the new charter of the borough went into effect but little was done in the direction of improved disposal methods. In 1902 the Commissioner of Public Works, Mr. L. Tribus, C. E., with the assistance of Mr. Richard Fox, Chief of the Bureau of Street Cleaning, began the needed improvements. Mr. Fox was in 1904 followed by Mr. J. T. Fetherston, C. E., as Chief of the Bureau, and the latter spent two years in a study of the local conditions and the establishment of a collection service and the necessary equipment.

In 1906 Mr. Fetherston was authorized to investigate the garbage disposal methods in use in other countries, as well as in America and Canada, and went abroad for that purpose. On his return, in the autumn of 1907, the borough authorities proceeded with the plans recommended for the erection of an improved modern destructor plant that should receive about half of the mixed refuse of the borough and destroy it by incineration.

The American Society of Civil Engineers published Mr. Fetherston's report under the title "Municipal Refuse Disposal: An Investigation," together with papers discussing it by several members of the Society and others interested in the subject. (See Vol. LX., Transactions of the American Society of Civil Engineers.)

To ascertain the quantities and composition of the general refuse the collection made by the city carts in one district of the borough, West New Brighton was selected as a representative section of the whole territory.

This district contained 4,321 houses, inhabited by 25,900 people, 90 per cent. of whom contribute waste for removal. In making observations there were noted:

First, the quantity of mixed refuse for 1,000 inhabitants by volume and by weight.

Second, the seasonal variations by volume and by weight.

Third, the components of refuse, and variations according to the seasons.

Fourth, the calorific value of refuse, both in separated parts and in general combination, according to the season.

Fifth, the incineration of mixed refuse, together with the probable temperature of the gases resulting from the destruction of refuse, and the boiler power obtainable.

The exhaustive study of the conditions above noted was published in the paper contributed to the discussion before the American Society of Civil Engineers, December, 1907. It is a most valuable contribution to the literature of the subject of municipal waste disposal and especially interesting to engineers investigating the question with view of undertaking similar studies.

REPORT OF INSPECTION OF BRITISH DESTRUCTORS.

Following the tabulated results of the preliminary examination of the conditions existing and probably to be encountered in the waste disposal of West New Brighton, it became necessary to determine by what method and with what apparatus the work should be done. During May and June, 1906, thirty-nine destructor installations in Great Britain were inspected, and in August the only destructor of British type in this country, that at Westmount, Canada. Of the forty destructors examined thirty were in England, three in Wales, three in Scotland, and one in Canada. Efforts were made to obtain data regarding the main factors in the work of mixed refuse disposal, so that the various features of each installation might be noted for comparison with others.

The results of this comparison were tabulated in a series of extended notes, observations, opinions and deductions, giving a comprehensive survey of all the plants, with data for comparison in each case. The main points included a mention of the municipality visited, its population and general character; estimates as to the quantity and character of the waste, the location, type and maker of plant; its capacity; its buildings; the use made of the power derived; construction costs and repairs; special notes and opinions on operation, clinkers and ashes, and possible causes of nuisance; the most commendable and the most obviously objectionable features, and general remarks.

Following this the author discussed the more practical questions that would concern the adoption of the destructor system at Richmond, and gives many figures and much general information bearing upon them.

In the final deduction he sums up the commendable and objectionable features in an impartially critical manner, bestowing praise and blame in about equal proportions.

His recommendations were for the installation of a mixed refuse destructor at West New Brighton, and included the following points:

1. A hand-fed destructor charged at the back of the furnace and clinkering on the opposite side or front of the furnace.

2. That refuse be stored in a bin or hopper with a door or curtain to control and prevent the escape of dust into the destructor room while the hopper is being filled.

3. That refuse be dumped into the bin or hopper behind closed doors; and that the refuse storage be separated from the destructor portion of the building.

4. That heated air be required for the combustion of refuse.

5. That a water-tube boiler be specified.

6. That a steam-jet blowers, or fan-draft, or both, be provided so that the advantage of either may be determined.

7. That the air for forced draft be drawn from the upper portion of the tipping-room and feeding or clinkering-room, so that positive ventilation may be secured.

8. That the clinkering process be arranged so that hot clinker is dropped into a pit and the heat from the clinker is utilized in raising the temperature of the air for combustion.

9. That ample working space, light, and air be provided in the building, and the plant be located so as to cause no trouble from escaping dust.

10. That a suitable mess-room, bath and toilet-room be provided for the comfort of the men employed.

11. That the exterior of the plant be made attractive in appearance.

This whole investigation is by far the most thorough that has been conducted by any American engineer. The report contains much detailed information not previously accessible and the preliminary studies and experiments are of great value. Until this work was completed we never had a clearly defined analysis of municipal wastes, nor had any accurate survey and tabulation of relative quantities and seasonable variations been made.

Mr. Fetherston has done the country a real service by this work, which is valuable not only in his own locality, but also for all American towns with anything like the same conditions. From this data any place can, by making necessary changes, calculate its own approximate quantities, with the relative composition of each item, and can then determine what will be the best way to proceed for its economical disposal.

His observations as to the construction, working qualities and relative advantages and disadvantages of each type of destructor are expressed strongly and fearlessly, and evidently without bias, and with no other desire than to tell what appears to him to be the facts.

The illustrations of British destructor plants add interest to the text, although they are not always happily chosen or quite successful in point of clearness of execution. The remaining papers discussing this report bring out no new features, most of the writers merely taking up one or another of the points already advanced by the first paper, with few original additions.

The practical result of the investigation was the issuance of specifications calling for tenders for a refuse disposal station of sixty tons daily capacity, to be built of reinforced concrete throughout, chimney included, and to have most of the special features included in the recommendation.

This advertisement appeared in August, 1907; the contract was made in September, the construction was completed in March, 1908, and the plant has been operating since that time. A complete description of this plant will be found under the heading of Destructors.

ARNOLD PROCESS, BALTIMORE.

The collection and disposal of waste in Baltimore, Md., up to 1902, was by the usual primitive methods which obtained in the early days. The collections were made by a number of contractors who took the greater part of the garbage to the wharf and sent it off in scows, but the remainder, with all the ashes and general refuse, was dumped in the city outskirts. In 1902 a movement was made towards better methods and the city advertised for bidders for a five-year contract for the collection and disposal of all the waste. It was found difficult to get satisfactory proposals, but a contract was finally awarded to the Baltimore Sanitary and Contracting Company, a local business corporation. The contract was for ten years from October 20, 1902; the price paid for garbage collection and disposal was to be $147,300 per year.

The system of garbage disposal was the same Arnold process then in use in New York and Philadelphia, having the same general features of construction. The specifications of the city provided for certain points relating to the reduction process, as follows:

> The system of final disposition shall be through thorough sterilization of all material by the use of live steam at a temperature of 292° F., and it must be enclosed in steam-tight vessels at a pressure of 60 pounds for eight hours. All vapors and gases are to be drawn off and condensed.
>
> From the time that the material is delivered into the enclosed vessel it shall not be handled in the open air until after it has been pressed so

that the solid parts of the material shall contain moisture not exceeding 50 per cent., after which it may be destroyed by cremation, acidulation or reduction to commercial dryness for use as a fertilizing material.

Later, in January, 1904, this same company acquired the contract for the collection of the ashes and rubbish for seven years at $54,500 per year, with an annual increase of $3,000 per year.

The cost of the garbage plant was reported to be $250,000.

The work performed under this contract was not satisfactory either to the contractors or to the city, and the contract was terminated in 1907, the city agreeing to purchase the plant and the equipment of the company for the sum of $372,888.19, payments to be made in cash and notes for one, two, three and four years.

The city then readvertised for bids, and after it had awarded the contract to one company it was declined. Subsequently satisfactory proposals were received from a new corporation. The Baltimore Products Company's bids were accepted, by which this company was to reduce the garbage for ten years for $45,000 per year, to remove the garbage plant to Bear Creek, five miles from the city, and to purchase for $100,000 the buildings and machinery of the old company. A bond for $100,000 was required for the performance of the contract. This company was also granted the contract for the collection and removal of ashes and refuse, the total sum for the disposal of all the waste being $587,000 per year for ten years.

Meanwhile, however, opposition to the proposed location developed, and a bill was introduced in the Legislature prohibiting the site to be less than fifteen miles from the city. This distance was afterwards reduced to nine miles. These changes entailed greater cost, and a final proposal was made by the Baltimore Products Company to the effect that the price be increased to $52,000 the first year, for garbage disposal only; $58,000 for the second year, and $2,000 per year additional until the expiration of the contract in 1917. This proposal was accepted by the city and the new disposal works are now being erected. The *Arnold-Edgerton reduction process* is the method to be used.

On January 1, 1908, the city began the work of collection of ashes and rubbish by its own equipment and finds this more satisfactory than having this work done by contract. For 1907 the total number of loads removed of garbage was 81,319.

ARNOLD PROCESS, PHILADELPHIA.

The city of Philadelphia has for many years let yearly contracts for the collection and disposal of its waste. There is a peculiar provision, or an interpretation of the law, which prohibits a contract for a longer period than one year. This has undoubtedly retarded the adoption of improved means of disposal, as few contractors or companies would undertake the risk of constructing large disposal plants for the short time allowed for their assured employ. On the other hand, this short-term contract at first brought keen competition for the work, so that presently the smaller contractors were eliminated, and the bidding was concentrated among half a dozen contracting firms who were provided with the capital and equipped with the teams for the proper performance of the service.

Thus it happened that to-day the collection and disposal is in the hands of a few contractors who divide among themselves the five collection districts, and year after year secure the renewal of contracts at practically their own figures. As a natural result the cost of this branch of city work has increased until at present the expense is relatively greater than in any other large city in the country.

The garbage collection and disposal is a part of the yearly contract service. It was begun in 1894, when a company known as the American Product Company secured one street cleaning district, under competitive bidding, for the collection and disposal of garbage only.

A plant was built on the Schuylkill River, near Gray's Ferry, about a quarter of a mile from any dwelling. The capacity of the plant was not great, as the garbage from one city collection district only was treated. In later years other districts were secured, and the capacity of the works increased. In 1902-3 the whole service of garbage collection and disposal for the city, except one small outlying district, was concentrated under the control of the American Product Company. The increased quantities handled, the better prices obtained for the service, the experience gained through improved methods and apparatus, together with the advantages of large equipment for collection and disposal gave the corporation a decided pull against competitors for the yearly contract.

The gradual increase in the cost to the city is shown by the following table:

TABLE LXVI.—THE COLLECTION AND DISPOSAL OF GARBAGE IN PHILADELPHIA, 1894 TO 1909.

Year	*Company*		*Collection and Disposal*	*Tons*	*Cost Per Ton*
1894			$294,879	....	.....
1895			295,140	....	.....
1896			289,000	....	.....
1897			322,500	....	.....
1898			330,000	....	.....
1899			358,000	....	.....
1900			398,000	....	.....
1901	Am. Pro. Co.		448,000	224,256	$2.00
	Am. Con. & Mfg. Co.		333,800	252,238	.....
1902	Am. Product Co.		440,833	280,000	.....
1903			488,830	....	.....
1904			516,700	300,000	.....
1905			560,000	340,000	.....
1906	Jas. Curran	$529,000			
	Am. Pro. Co.	479,000	479,000	....	.....
	Penn. Red. Co.	399.575			
1907	Penn. Red. Co.		418,500	378,964	.....
1908	Penn, Red. Co.		488,988	....	.....

This table includes the total cost for the garbage during the years named. Not all of this for all the years was destroyed by the reduction company. In 1894 the garbage was destroyed in a Vivarttas crematory in one district, and in 1894-5 still another portion of the garbage was burned in a Smith-Siemens crematory at Twenty-fourth and Callowhill Streets. Both these crematories were discontinued later, as the contracts for the collection and disposal were acquired by other contractors who employed reduction methods. The Smith-Siemens furnace was later in temporary use, at a time when the reduction plant had been crippled by fire.

The competition for the contracts of 1901 made no change as to the final results. The award to the American Contracting and Manufacturing Company at the lowest bid, $333,800, had been made, but after a struggle against adverse conditions and inadequate equipment the contract was surrendered to the American Product Company at the bid of $448,000.

In 1903 an offer by responsible parties to pay the city for the garbage collected and delivered at a plant to be built was received but not acted upon.

After the bids were received in July, 1906, suit was brought by the American Product Company to restrain the Mayor and the Director of Public Safety from awarding the contract to the lowest bidder, the Penn Reduction Company. The judge in dismissing the suit said: "The plaintiffs' point is extremely narrow and technical. They ask for the intervention of a court of equity to prevent the lowest bidder from getting a contract fairly won in competition." The performance of the contract awarded the Penn Reduction Company was begun by the erection of a large plant at a point removed 1,500 feet from any dwelling, but still within the city limits. Just as the works were ready to go into operation a fire destroyed the buildings, November 1, 1906, and so crippled the company that they were obliged to surrender the contract, which was then taken over by the American Product Company at the price they had bid, $479,000.

The figures paid for this work in the years noted show a continuously increasing cost. In 1905 this cost was more than double that of the first year reported, the exact ratio of increase being 53 per cent.

The system of garbage collection and disposal as carried on in Philadelphia affords a very good illustration of the working of the short-term contract service, with a limited period of advertising in advance for the construction of a new plant, and the certainty of competition by a powerful company which has for years enjoyed a monopoly through the favor of the local authorities.

The American Product Company is the parent company of those that control the Arnold process. The first plant built in 1894 was in most respects similar to that built in Boston from the designs of the same engineer, Mr. Charles Edgerton. There is a somewhat confusing use of corporate names in this connection, which makes it difficult to distinguish the different organizations.

The Philadelphia Company actually doing the work was called the Philadelphia Sanitary Utilization Company, and its personnel included several of the prominent contractors and politicians of the city. The New York Sanitary Utilization Company, the Brooklyn Sanitary Product Company and the Boston Sanitary Product Company are all operating under the processes of the parent company in Philadelphia. This is believed to be also the case in Newark, Baltimore and Atlantic City.

Ashes and Refuse of Philadelphia.

These portions of the municipal waste are separately collected from five different districts by contractors who bid under one-year terms. Here again the work appears to be so divided that it goes year after year to the same parties at constantly increasing rates. The contracts include the street cleaning and sweeping, the removal of all household waste except garbage, and the cleaning of all private alleys and paved streets once a week. The cost of the work has steadily increased from $462,394 in 1894 to $529,889 in 1900, and $720,890 in 1902.

From a personal examination made in 1902 it was ascertained that there were approximately 823,977 tons of total waste, of which garbage was 280,000 tons; ashes and refuse 529,889 tons. The proportion of refuse was approximately 30,000 loads, or 15,000 tons. All this is dumped on low grounds below and on the outskirts of the city. These dumps are picked over by persons in the employ of the contractors who control the collection service and who recover from 30 to 40 per cent. of the light refuse for market. This refuse is roughly baled on the grounds, but much of it is in filthy and insanitary condition.

In one year there were six hundred complaints from property-holders adjoining one refuse dump at North Broad Street and Hunting Avenue. No relief was possible, as the Health Department held that the dumps did not contain organic substances that would by decay become injurious to health.

The contractor at this dump received pay from all cartmen who picked out and recovered for market a large proportion of refuse by the labor of women and children. His only expense was to deposit two feet of earth upon the miscellaneous débris brought to the ground, which assisted in the preparation of the soil as a site for dwellings to be built thereafter. The insanitary conditions attending the work, the complaints of neighbors, and the inevitable spread of zymotic diseases that flourish under just such conditions were not the concern of the contractor, nor evidently of the health department of the city of Philadelphia.

ARNOLD REDUCTION PROCESS, ATLANTIC CITY.

The question of garbage collection and disposal at Atlantic City has always been a most perplexing problem for several reasons. The population is variable—roughly, from 35,000 resident persons—at one period up to 150,000 during the crowded summer months. There is no chance for disposal by tipping overboard, nor are the facilities for feeding swine available as in other places. A summer and winter watering place must be clean, and, above all, must be sanitary, for the whole life of a town depends upon its sanitary and attractive features.

For many years the waste was taken away from the water front and tipped or buried. Then in 1894-5 the Smith-Siemens crematory was erected, and for about five years destroyed the garbage at great cost for fuel and labor. The quantity thus disposed of in 1902 was 10,000 tons—disposed of by artificial gas as fuel at a cost of $1.52 per ton.

In 1903 the city made a contract with the Atlantic Product Company, a Philadelphia corporation, of which Dr. F. H. McFarland was president, to collect and dispose of the garbage for a period of ten years. The company was to receive $20,000 per year for collection and $20,000 per year for disposal, with an annual increase of $1,000 per year. In 1906 the amount paid for both was $43,000.

The plant is located at the north end of the island near the inlet, adjoining the abandoned incinerating plant. The buildings occupy an area of 100 x 150 feet, and are said to have cost $125,000. In general arrangement and methods of operation the works are similar to Philadelphia, though some more improvements have been made over the older forms of machinery. There are twenty digestors in five groups, with five hydraulic presses, the usual catch-basins, gutters and flotation tanks for separating the grease from the water. The gases are condensed and passed over the boiler fires. The steam power is maintained by burning the tankage for fuel. The capacity of the plant is necessarily larger than the average because of the maximum population of the city for short periods.

Probably the total for the year would not exceed 20,000 tons, but on occasion there might be 150 tons per day for treatment. There are no accounts or reports of quantities or percentage of manufactured products.

THE ARNOLD PROCESS, NEWARK, N. J.

For many years the disposal of the waste of Newark had been made by tipping upon the marshy lands surrounding the city on three sides. A part of the organic waste was fed to the swine, collected by private contractors, and a still smaller part was taken outside of the city limits for ground burial.

In July, 1902, the city received tenders for the collection and disposal of all waste matters for a term of five years. It was provided that garbage should be disposed of by any means which would be inodorous and sanitary; that ashes and rubbish should be dumped at any place subject to the approval of the Board of Works.

The bids received for this work were from six different contractors and companies, ranging from $631,000 to $817,000 for the five years' contract. The contract was finally awarded to the highest bidder, Mr. Benjamin Meyer, who afterwards organized a company called the Newark Reduction Company, and erected plants under the Arnold process at a location in the rear of the city on the banks of the river. The reduction works were built under the Edgerton patents for rotary presses, and were in other respects similar to the reduction plants of the Arnold process at other places.

During the term of this contract the plant also disposed of garbage from adjacent towns—Orange, East Orange and Harrison—which was brought by wagons from these places. Upon the expiration of this contract in 1908, bids were called for by the city and the award again made to the same company for another term of five years.

WILMINGTON, DEL.

Wilmington, Del., was among the first to adopt improved methods for disposal of its garbage, and in 1893 erected a garbage incinerator under the S. G. Brown patents. This was the first water-jacketed furnace to be erected in this country, was operated by oil, sprayed by steam, which was furnished by a boiler independent of the plant.

This crematory continued at work for some three or four years, and was finally put out of commission because of the great expense of operating. It was followed by a Dixon crematory of approximately fifty tons capacity, erected on the same ground. The operation of this crematory was found to be expensive because of the large amounts of liquid contained in the garbage and the fact that this was separately collected without any admixture of refuse and brought to the crematory for disposal. Various methods of extracting these liquids were devised, but none found to be of practical service.

In April, 1906, the city advertised for bids for the disposal of the garbage under conditions which required the contractor to dispose of it in a sanitary manner, and he should also be allowed the use of the present city crematory and make such alterations therein as should be approved by the Council.

The plant was required to have capacity for the disposal of all garbage within twenty-four hours after collection. The Mayor and Council should have the option to purchase the plant at the termination of the five-year contract. This contract was awarded to a company formed for the purpose, which company employed the Arnold process, and which also had the privilege of burning the rubbish in a part of the Dixon crematory which was specially altered for the purpose. There is no report showing the quantity treated or the results of the work at the present time.

The company engaged to dispose of the rubbish as well as the garbage, and conduct their work on the same ground and include in their plant the operation of the Dixon Crematory.

CHAPTER XVI.

The Chamberlain, Holthaus, Wiseogel, American Reduction and Penn Reduction Processes.

Chamberlain Process, Detroit, Mich.

This process, known as the "Liquid Separating Process," was first used at Detroit, Mich., in 1898. The patentee and inventor was Mr. M. H. Chamberlain, who was President of the Detroit Liquid Separating Company, contracting with the city for all garbage disposal for a term of five years.

The collection was made in large boxes holding one and one-half tons each, and brought from all parts of the city to a yard adjoining the railroad station. The boxes were lifted from the cart bodies and placed on flat cars, each holding 20 boxes, and carried 22 miles on the Wabash Railroad to French's Landing on the Huron River. At the works the boxes were discharged upon a platform, the refuse picked out and the garbage shoveled into digesters of the usual capacity of five tons. The bottoms of these digesters were provided with three concentric circular cylinders with double walls closed on the top but open on the bottom, with perforated sides.

After the usual process of cooking from six to eight hours, steam at high pressure was forced into the tank above and below the cylinders, forcing these upward and driving out the liquids carrying the grease, which passed off through pipes connected with the lower section of the digesters. This pressure was continued for five hours, until the liquids were squeezed out, leaving about 30 per cent. of the original mass, which was then removed through the side doors and conveyed to steam-jacketed driers. At the close of this drying process the bulk of the material was reduced to 15 per cent. of the original measure, and was in the form of a homogeneous brown mass, which was screened and ground for fertilizer.

The pressed-out water and grease are separated, the grease collected and barreled, and the water run off into the Huron

River as a dark brown effluent that rapidly colors the water of the river. The special features of this process are the collections in closed tanks and transportation to the works without breaking bulk, steamed garbage in the digesters, and the separation of water and grease within closed tanks, the steam and gases from which were condensed or destroyed by discharge under the ash-pits of the boilers. There has never been available any analysis of the products from this process, and no comparison of the value can be stated.

This company was the first to use the system of collection in large movable boxes tightly sealed for transportation by rail. The compensation paid to the company was at the rate of $47,208 per year, which included transportation by rail to the works. No information in regard to quantities is available.

After the close of the contract the city advertised in December, 1905, for new bids for disposal.

Those received were as follows:

Dixon Sanitary Crematory Company, four 8-ton plants........	$80,000
Detroit Sanitary Works offered to sell their plant, 200 tons capacity, for........	100,000
Lewis & Kitchen, garbage crematory plants; submitted seven bids, highest........	68,879

These bids were all rejected, and the city advertised again on December 23, 1905, when the following proposals were received:

Detroit Sanitary Works, 10 years' contract, $12,000 per year.

Detroit Reduction Company, 10 years' contract for no compensation, for garbage only; also to dispose of all other refuse at 25 cents per ton, and to dispose of ashes at 20 cents per ton, and night soil at 25 cents per barrel.

The Detroit Reduction Company also offered to sell to the city at any time, on valuation.

At this time (Oct., 1908) the city collects the garbage, about 35,000 tons per year, and delivers it to the Detroit Reduction Company at a central point in the city. The company sends it by rail to the works at French's Landing twenty miles outside the city. The contract is for ten years from July, 1905.

CHAMBERLAIN PROCESS, INDIANAPOLIS, IND.

The Chamberlain, or "Liquid Separating Process," of reduction was introduced into Indianapolis in 1898. A contract for collection and disposal of garbage and dead animals was secured by the Indianapolis Sanitary Company, Mr. S. E. Rand, President.

The works were built on a farm just outside the city, the collections made in steel tanks, or wagon bodies, which were taken by rail from the central station to the plant. The process of disposal was the same as at the Detroit works, but instead of running off the foul effluent direct into the river it was heated to a high temperature and discharged on the gravel beds of the river banks, through which it found its way to the water.

This manner of effluent disposal gave rise to bitter and unceasing complaints from adjoining property-holders, and in later years the company has taken other means for the treatment of the liquids.

In 1905 the city advertised for bids for a five-year contract for the collection and disposal of garbage and dead animals.

The bids received were:

	Per Year
C. Jones (Buffalo)	$48,800
F. J. Edengarter	60,360
Indianapolis Sanitary Company	52,000

The last-named received the award. It is understood that the work is being carried on at the same plant and by the same methods as before. No reports of quantities or value of products are available.

Assuming the population to be 212,198 in 1905, and the quantity of garbage as estimated in the tables of the Government Census Reports as 30,000 tons, the cost of collection and disposal would be at the rate of $1.73 per ton, and at the rate of 25 cents per capita per annum. This does not include the ashes and refuse, for which a separate contract is made. No reports of these amounts can be obtained.

CHAMBERLAIN PROCESS, CINCINNATI, OHIO.

As previously noted, this city had in service for ten years the Simonin process of reduction for vegetable garbage and a contract with a separate company for the collection and disposal of the "animal garbage."

In 1902, when the city advertised for bids for the combined work of garbage disposal and animal collections and disposal, the bid of Messrs. M. H. Chamberlain and J. H. Corliss, afterwards known as the Cincinnati Reduction Company, was accepted for the fractional parts of the years for the two companies then performing the service. These bids were on a sliding scale of payment: 1902, part of year, $43,000; 1903, $76,000; 1904, $77,500; 1905, $78,500; 1906, $80,400; 1907, part of year, $35,000. The company was to make collections three times a week from residential parts of the city during April to October and twice a week in other months, with daily collections for markets, hotels and all places where animal food is prepared.

The company provided iron water-tight wagon bodies to be lifted by cranes to cars for transportation to the disposal works a few miles down the river.

The "liquid separation" or Chamberlain process is the one under which this company operates, the works and buildings being of the same general design and character as the Detroit plant, previously described. No reports of the exact quantities received or the value of the product have ever been obtained.

On the expiration of the contract, the city advertised for bids for five years and received and accepted proposals from the same company, the Cincinnati Reduction Company, at the following terms: First year, $80,000; second year, $91,000; third year, $93,000; fourth year, $95,000; fifth year, $97,000, contract to begin June 1, 1908.

MERZ REDUCTION PROCESS FOLLOWED BY CHAMBERLAIN REDUCTION PROCESS, WASHINGTON, D. C.

The generally unsettled state of the refuse disposal problem is well illustrated by the experiences of the Capital City in this line of municipal work during the past decade. Seventeen year ago the swill was collected in wooden barrels, in an irregular, unsatisfactory way, by the contract service. This was annulled for breach of contract, and for some months the work was done by the municipality at an increased cost, but with greater efficiency.

In 1891, under the terms of a new contract, the work was better done, the disposal being beyond the limits of the District of Columbia, being at least in theory deposited by the contractor on farm land along the Potomac River, although grave insinuations were made as to the dumping of the material into the river as soon as the boundary of the District had been passed.

In 1892 a special appropriation enabled the Commissioners to secure the removal of all garbage in inclosed tanks, and a contract was made with a company for its disposal by reduction. This was the Merz reduction system, the plant for the work being built in one of the remote and sparsely settled sections of the city.

The usual complaints were received, and a bitter controversy arose, which was settled by the accidental destruction of the building by fire. No attempt was made to rebuild, and the reduction company soon went into the hands of a receiver, who conducted the business for a short time, and finally sold it to one of the members of the company.

The service rendered was extremely unsatisfactory to the city, and, it was alleged, unprofitable to the company, because of the inability of the Commissioners to enforce separation by the householders.

This condition of affairs terminated in March, 1895, when an appropriation of $60,000 was made, and strict regulations as to the collection and sanitary treatment of the waste were authorized and made a part of the city specifications calling for new proposals, so as to bind the contractor, and were promulgated as public regulations so as to bind the householder. Each bidder was permitted to select his own means of proposed disposal. The city accepted a bid for disposal by incineration, by which the contractor was to erect two crematory furnaces in different parts of the city.

A Brown crematory was chosen by the contractor as one of the means of disposal, and a Smith-Siemens crematory selected by the Commissioners as the other. Upon trial of these two furnaces it was found that the Brown plant could dispose of far less than the quantity for which it was designed, not more than 40 per cent. of the daily output of garbage during the summer months.

In constructing the Smith-Siemens crematory, an attempt was made to do away with certain objectionable features that attended the former work of this furnace in other cities. Whether from changes incident to these, or for other reasons, the furnace built in Washington was not a success. It ran for a time on trial, but gave rise to so many complaints based on odors emanating from it, that, although it had been selected by the Commissioners in the first instance, it was never accepted by them, and never regularly went into service. Moreover, during its experimental runs it never approximated its estimated capacity.

The contract was modified so as to permit the contractor to carry all the garbage and dead animals down the river on scows, and dispose of them in the same primitive manner which had been followed under the preceding cheaper contract.

Early in 1900 efforts were made to obtain a better means for the disposal of all the city waste, and bids were invited for the collection and disposal of garbage, dead animals, night soil and miscellaneous refuse and ashes for a period of five years.

Proposals were received from responsible parties, the lowest of these being at the rate of $115,000 per year. Congress refused to authorize the contract, and requested new specifications and new bidding. When the new specifications were received, in June, 1900, separate contracts were awarded, as follows:

Contract with the Washington Fertilizer Company, for five years, for collection and disposal of garbage and dead animals for $51,600 per year, and $1,000 additional yearly for any extension of the service, but with a deduction of 50 cents per ton on all over 20,000 tons collected during the year. This company employed the method of the Chamberlain or "Liquid Separating Process" which was then in use in Cleveland.

Contract for the collection and disposal of ashes, five years, for $29,979 per year; for the collection and disposal of miscellaneous refuse, five years, $8,000 per year, and for the collection and disposal of night-soil for $17,000 per year.

These figures represent a per capita expense for each class as follows:

Garbage	$0.173
Ashes	.10
Refuse	.027
Night soil	.057

No statement of quantities per ton could be made with regard to the various classes of waste, except garbage that was estimated in 1900 at 24,339 tons, with 12,170 dead animals and 6,157 barrels of night-soil. The population of the city for that year was 278,577.

The five-year contract with the Washington Fertilizer Company expired November 30, 1905. In July, 1905, a new contract for collection and disposal of garbage only was made with the same company. New contracts for the disposal of every class of waste were also made in each case for five years.

The expenditures for collection and disposal of city refuse are as follows, for 1906:

Garbage and animals	$60,423.06
Dead animals	1,325.13
Ashes	51,137.15
Refuse	15,488.67
Night soil	16,470.00
Incidental expenses	690.10
Total	$145,554.68

In 1906 the cost of this work was at the rate of

$1.54	per	ton for garbage.
.41	"	cubic yard for ashes.
.72	"	bbl. for night-soil.
1 36	"	ton for refuse, assuming weight of 211,512 bags of paper at 150 lbs. each.

The population of the city in 1906 was 302,855.

The expense per capita per annum for the year 1906 for the whole waste collection and disposal service was 48 cents.

HOLTHAUS REDUCTION PROCESS, BRIDGEPORT, CONN.

For years the disposal of garbage in Bridgeport was accomplished by buying in the vacant ground on the Town Farm. Long trenches were dug, the loads of garbage dumped as collected, and the earth thrown back over it. This method has often caused complaint, but as a rule has been persisted in. When complaints became too pressing the Health Department made inspection and ordered four inches of earth to be placed over the trenches. The burying process is somewhat intermittent, being governed by the necessity for immediate disposal when the garbage reduction plant breaks down or burns up, a frequent episode in the history of their disposal works. What will happen when this ground is needed for building purposes in future years is a problem that the health authorities will have to solve.

Bridgeport for many years enjoyed the proud position of paying the largest sum annually of any American town for the collection of its garbage.

A contract for ten years was granted to Mr. J. D. Twohey, at a price of something like $2.60 per ton, the weight to be taken on the city scales at the entrance to the Town Farm before burial. A casual examination made in 1906 by reporters for the newspapers revealed the fact that a very considerable percentage of the garbage was water. The collection contract was again granted to Reilly & King for five years from November 8, 1905, at a cost to the city of $2.32 per ton.

A Dixon crematory was built in 1899, and operated for some time, until the expense of burning very wet swill became too burdensome.

This town was one of the first to experiment with reduction methods, having in about 1887 a plant of the Holthaus extraction system. This method used naphtha in the first stages for extracting the grease, in a manner similar to the Simonin process, although the digesters were of smaller capacity and were vertical in position instead of horizontal. The subsequent stages of the separation of the naphtha from the water, recovering the grease and drying the tankage were like those in other plants, but the machinery and equipment was of its kind more scientifically built and better arranged, and the whole plant was better constructed.

There is no available knowledge of the exact conditions of the contract with the city, but it is believed that about 34 cents per ton was paid to the company, the delivery of separated garbage being made by the city. At the time of the Waring inspection of reduction plants it was put under a month's trial by one of the Commissioner's staff, and was very favorably reported upon for its cleanliness and general good performance. But an explosion of the naphtha fumes wrecked the plant, and fire followed, which completed the almost total destruction of the buildings and equipment, and the city turned again to the town burial ground for the disposal of the refuse.

In about 1900 the work of garbage disposal was taken up by Mr. Geo. E. Winton, who had an abattoir and rendering plant, and who received 50 cents a ton for garbage disposed of. His plant also took fire and was partly destroyed, and the Dixon crematory was again brought into service. Mr. Winton resumed operations, which for some years were carried on with considerable friction, several competitors claiming that they could offer better methods and all making efforts to secure the contract.

In 1907, when new contracts were to be let, strong competition was encountered, the contract for ten years finally going to the American Abattoir and Oil Company, one that had previously had the same contract. The works of this company are within the city limits, on the line of a trunk sewer. Serious charges of nuisance were made in the summer of 1907, which resulted in the temporary shut-down of the plant, until the sewers, which the company claimed were too small, could be rebuilt with sufficient capacity to carry away the water discharged from the works.

A proposition has been made by the company to take the garbage of New Haven and several towns in the Naugatuck Valley for treatment. The plant of the company is believed to be a modification of the Holthaus method, but no accurate details can be had, as visitors are not allowed on the premises. The quantities of garbage handled are also very indefinitely known, as the records are not obtainable and no replies are made to repeated requests concerning the operation of the plant. The payment by the city is 50 cents per ton for disposal.

HOLTHAUS PROCESS, SYRACUSE, N. Y.

Up to 1899 this city made disposition of its waste by the usual primitive and unsanitary methods employed in the early history of American towns. The advertisement for disposal by incineration in 1898 produced no satisfactory results, and in the following year a contract was let to the Syracuse Reduction Company for the garbage disposal at $26,000 per year for ten years. At that time the quantity of garbage was estimated at 10,000 tons, which made the cost of disposal $2.60 per ton, the largest price paid by any city in the country for any form of reduction, extraction methods.

This contract expiring in July, 1908, on May 10 the city issued specifications for bids for disposing of the garbage and dead animals in a sanitary manner for five years from July 1, 1908. These specifications provide:

The contractor to erect his plant on location to be approved of by Board of Public Works.

The quantities of garbage were: 1904, 8,279 tons; 1905, 9,257 tons; 1906, 9,285 tons; 1907, 10,624 tons.

The system or process must have been in use for two years preceding date of bid.

Pending time of completion of plant, contractor will be permitted to dispose of garbage and animals by burial.

This also to be permitted in case of temporary suspension of plant. The plant to be designed in units to permit cleaning or repairs with no interruption of work.

The disposal to be innocuous and without nuisance, all liquids to be evaporated and gases passed through fire.

Large dead animals to be collected by contractor.

City to purchase plant on expiration of contract on six months' notice.

The bids received under these specifications were:

Syracuse Reduction Company (present contractors)	$17,000
Municipal Contracting Company	14,989
Albert Gaffey	18,896
H. Bromner	24,000

These bids were rejected as being too high and new specifications, on same terms, except that the bids will be for periods of 5, 6, 7, 8, 9 and 10 years, the plant to be retained by the contractor, at the expiration of contractor's term. The alternative proposition is identical, except that the transfer of the plant to the city at the end of contract term will be made without cost to the city.

The award of the contract to the Syracuse Reduction Company for ten years was finally made, at $13,975 per year for disposal only.

The original Holthaus system, as operated at the Syracuse plant, is thus described by an observer in 1900:

The garbage is collected in barrels and from these is dumped into a car on an elevator which carried it to the top of the building. The car is dumped into the digester with 30 per cent. of water added and the garbage digested by steam in the usual manner.

The digesters arranged in groups of four, discharge into a press, where the water and grease is pressed out and allowed to run into the separating tank, from which the grease is drawn off and barreled.

The tankage falls into the dryers below, and after passing these is carried up to the second floor, where it is ground and screened.

The whole process from the time the garbage is put into the digesters till the dry tankage and grease appear, is conducted in apparatus which is securely closed.

Pipes lead from the different parts of the apparatus to a vacuum pump which draws off all gases through a condenser and then passes them through the fire. All water vapors from the drying and rendering process is condensed and all water evaporated and then condensed so that all liquid wastes from the works are free from offense.

In this description there is no mention of the use of naphtha at any stage of the work, and this appears to be a departure from the first plant at Bridgeport, which employed naphtha for extracting the grease after maceration of the garbage by steam. The present Syracuse plant has undergone many changes and improvements that have made the work less expensive and more sanitary.

A fire destroyed a part of the buildings in January, 1903.

THE HOLTHAUS PROCESS, NEW BEDFORD, MASS.

One of the earliest municipal reduction processes was that of the Holthaus system in New Bedford, Mass., about 1893-94. The city had contracted with a private company for a five-year term for the garbage collection and disposal. The corporation was formed by local investors, headed by Mr. James Gannon, the contractor who had previously held the contract for collection of the garbage. The works of the company were placed at a point just within the city limits, about three miles from the City Hall. These were much the same construction as the first plant of this system at Bridgeport, and included the use of naphtha for extracting the grease from the tankage after previous boiling.

At that time the reduction methods were not well understood. The difficulties encountered, together with the continuous complaints of nuisance, and the small price paid for the work made the venture unprofitable.

An explosion and fire partly destroyed the plant, which was not rebuilt. After about three years of unsuccessful effort, the contract was given up and the city continued the primitive means of disposal by tipping and feeding swine.

But little is known of the details of this plant, but it was presumed to have followed the same methods of construction and working as the first plant of the Holthaus system at Bridgeport.

WISELOGEL PROCESS, VINCENNES, IND.

The work of Mr. Frederick G. Wiselogel covers a long period of time and connection with many forms of apparatus for treatment of waste matter. He installed the Simonin process for extraction of grease by naphtha from abattoir tankage, in 1872, at Chicago, and was connected, as engineer, with several fertilizer companies up to 1887, when he joined the Merz company, as chief construction engineer in the mechanical department of the works at Buffalo. In 1889, he built the Merz plants at Denver, and subsequently the works at Paterson, Detroit, Milwaukee and St. Paul. In 1891 he installed the first plant for the St. Louis Sanitary Company, followed in 1892 by the plant at Bartels, near Milwaukee, and in 1893, the second installation of the St. Louis plant.

The Wiselogel reduction process or system probably came first into use at Indianapolis. The first plant at this place did not continue, and was subsequently replaced by the Chamberlain liquid separating process, then used in Detroit. The plant at Indianapolis was popularly known as a "Wiselogel," but how far this was due to the methods of Mr. Wiselogel, and what part was done by the methods of Mr. Chamberlain is uncertain and of little interest. The first distinctive installation of the Wiselogel system was at Vincennes, Ind., in 1902.

The Star Tankage and Fertilizer Works obtained the contract from the town for reduction of its garbage and erected a plant at an approximate cost of $30,000.

The apparatus is thus described by the secretary of the company subsequently organized in Boston:

In further consideration of your valued favor of the 16th inst., we take pleasure in submitting the following facts regarding the "Wiselogel System" for the disposal of municipal waste.

The chief claims of our system of reduction, as applied to garbage, over that of any other, are that it is ECONOMICAL, AUTOMATIC and ODORLESS.

Our apparatus consists of a self-contained, rendering tank and dryer combined. It is a steam-jacketed cylinder of cast iron, 5 feet internal diameter and 12 or more feet long, provided with a shaft and reel to stir the mass within. The material to be reduced is fed in at the top of the tank to which an air or vacuum pump is attached, and, being constantly in motion produces an inward draft while the tank is open, thus preventing any odors from escaping.

When the tank is filled, the door is closed and clamped, steam is admitted and the reel is set in motion, the air pump and condenser still being in operation. The water, together with the grease, assembles in the bottom of the machine, and is pumped into the cooling tank, where the grease is drawn off into barrels and is ready for market. The water is led off as a harmless effluent into the sewer. Relieved of the water and grease, the residuum is dried in this same machine, and during the entire process, by the aid of the vacuum pump, all vapors and gases are drawn from the machine and forced through a condenser and separator, where the vapors are condensed and the gases diverted to a specially constructed consumer. When the residuum or tankage is thoroughly dried, it is discharged from the machine a commercial fertilizer. This whole operation consumes about eight hours' time.

The material suffers no exposure from the time it is fed in at the top until it is discharged a dry and odorless product, ready for shipment.

The buildings of the plants under this system are usually two stories in height, constructed of any good building material, upper and lower floors of concrete faced with best cement, sloping toward the center and "splashed" up at the sides, posts, etc., at least six inches, so that they can at all times be kept scrupulously clean with soap and water. The machines are set in the basement, the feed pipes extending through the second floor. All the material to be reduced is brought up an inclined driveway and discharged into the tank, as above described.

This system being composed of units of reduction, each tank representing a unit and holding about 10,000 pounds of wet garbage per charge, it is but a matter of more machines for a twenty- or thirty-ton plant. The same number of men, engine and boiler, with but little more fuel, will operate six machines as well as one.

Our new combination tank and dryer, supplied with an extra large vacuum pump and condenser, placed in the basement or outhouse of a large hotel or apartment house, is fully guaranteed to reduce all swill, table and kitchen refuse, and so do away with the nuisance of garbage cans, flies, bad odors and the inconvenience and annoyance attending the removal of cans.

We also make a machine for the sanitary disposal of night-soil, which is operated under vacuum, all gases and vapors being conducted as described above in our combination machine.

One plant at Jacksonville, Fla., is equipped with such a machine as above described called our Economy No. 2. The Star Tankage and Fertilizer Works of Vincennes, Ind., built in 1902, is also operating under our patents, having our separate digester and dryer and is unqualifiedly endorsed by them.

The capacity of this first Wiselogel plant at Vincennes has never been known. As the town, with a population in 1903 of 10,669, could not at best have produced over five or six tons of garbage per day, it seems probable that only one dryer unit of five tons capacity was used.

The difference between the Wiselogel system and that of the Merz process is in the form of the digester, which in this case is a cylinder, steam-jacketed and placed horizontally, instead of vertically, and has a specially powerful cross-armed stirrer for thoroughly breaking up and macerating the contents. The subsequent operation of drying the tankage remaining in the jacketed cylinder after the water and grease has been run off, is also a point of difference between this and other forms.

The operation of the Wiselogel systems are under three patents: No. 442,298, December, 1890—Apparatus for heating garbage. No. 536,677, April, 1895—For dryer. No. 554,206, February 4, 1896—Apparatus for reducing garbage for fertilizers. Other patents are reported as pending. There are no obtainable reports as to the percentages of grease and values of tankage under this process.

The Vincennes plant was reported as injured by fire on November 2, 1901, and was completely destroyed by fire on the night of February 26, 1908. It is reported that contracts have been let for the rebuilding of the plant at a cost of $35,000.

In 1902, the patents and business of Mr. Wiselogel were taken over by a corporation formed in Boston under the name of the International Waste Utilization Company, with a strong board of directors from prominent business men of the city of Boston, Taunton, Lynn, Brockton, Springfield and Providence.

The active work of this company was in the hands of the Sanitary Reduction and Construction Company, a Boston corporation with offices at Indianapolis, Ind. There was also a third corporation, known as the American Underwriting Company, which published its intentions to revolutionize the whole work of garbage collection and disposal throughout this country by this system, and whose prophet and apostle was Mr. Louis H. Schneider, president of the company. His campaign throughout the West will be remembered for the extraordinarily brilliant promises made and the absolute lack of performance in any city where contracts were said to have been made.

Meantime, the Standard Reduction and Construction Company obtained permission for an experimental plant at Jacksonville, Fla., which was installed in a small building adjoining the Dixon crematory.

This Jacksonville plant comprised one small unit of the same dimensions and capacity as at Vincennes, but had also a boiler, fired with dry refuse from the city and burned in the Wiselogel destructor, a new form of crematory.

There are no accurate reports of this work obtainable, but after a precarious and intermittent existence for a few months,

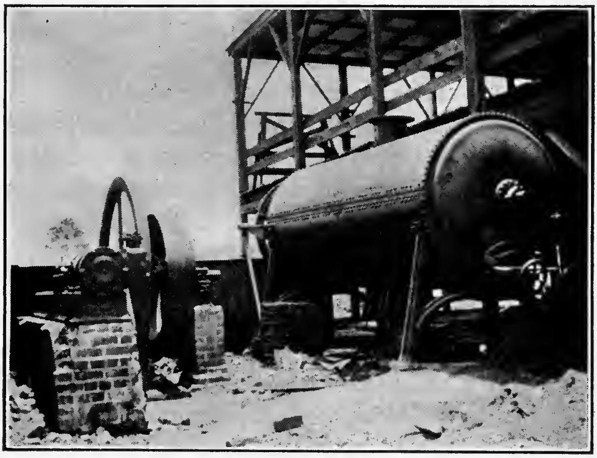

FIG. 91.—THE WISELOGEL REDUCTION PLANT, JACKSONVILLE, FLA.

a fire occurred which burned the enclosing building and damaged the apparatus. The city would not contract for the disposal of garbage separately collected and the enterprise was abandoned.

These two examples of the practical operation of the Wiselogel garbage reduction system are believed to be the only ones built in this country for municipal service.

AMERICAN REDUCTION PROCESS, READING, PA.

The experience of this city with garbage disposal methods has not been of a pleasing nature. The first attempt to improve existing methods was in 1897, when a contract was made with the Davis Garbage Crematory Company, of Lancaster, Pa., for a furnace rated at 80 tons capacity, at the price of $9,850. Upon the completion and trial the furnace was found not to meet the terms of contract in point of capacity and operation and the plant was abandoned.

In the fall of 1898, the city contracted with the General American Reduction Company, a company organized under New Jersey State laws, for the disposal of garbage for a term of five years by some satisfactory reduction process. The City Trust Deposit Company, of Philadelphia, became the bondsman on behalf of the company. The company was to receive 65 cents per ton for disposal, and pending the erection of their plant were to rebuild the Davis crematory.

The company occupied a brick building at Millmont, a suburb of the city, which was equipped with reduction apparatus. After a year's effort the company ceased work and abandoned the plant to the city, basing this action on the claim that not enough garbage was being delivered to enable them to operate at a profit. The city, viewing the matter as a breech of contract, brought suit against the reduction company and their bonding company in 1902. The latter went into the hands of a receiver, with no recoverable assets. The reduction company claimed the machinery in the plant, but was enjoined from removing it. The matter was compromised by paying the company $500 and allowing them to remove the machinery and restore the building to its former condition.

The method employed was that of the American reduction process, but no details as to the quantities handled or the value of the products can be had.

The Arnold Process.

There was formed another company, about 1902, which was called the Reading Sanitary Reduction Company, and which had a contract for the collection and disposal of the garbage for a period of five years at the rate of $2.24 per ton, by reduction. The plant of this company is at Grill Post Office, another suburb of Reading, and is said to be now operating. The Arnold methods in a modified form are used, but no reports of quantities or costs are given. The plant is in operation with apparent success, and there are few complaints of imperfect collection.

AMERICAN REDUCTION PROCESS, YORK, PA.

The population of York, census 1905, was reported at 38,258, but the present figures are claimed to be nearly 50,000. There has been in this city the usual experience with various means of garbage disposal, beginning first with removal to outskirts and dump-tipping, collections of garbage by private parties and farmers for stock feeding, and a Dixon garbage cremator of twenty-five tons capacity, built in 1896 and discontinued 1904. For about two years the York Chemical Works had the contract for disposal, but the process or method employed was either not profitable or was unsatisfactory. At the expiration of this contract the city advertised for bids for collection and disposal of the organic garbage, ashes and refuse. The amount of garbage was estimated at 3,000 tons per year.

A proposition from a Philadelphia contractor to establish a "feeding plant" for hogs and sheep was not accepted.

The bids for ten-year contract for collection and disposal of organic and inorganic matters were:

G W. Ruch & Co., Philadelphia	$18,405.12
Jno. A. Rayling & Co., York	19,000.00
Chas. C. Fischer, Reading	16,260.00

The bid of Mr. Fischer was accepted to date from April 1, 1906, with a yearly increase for additional amounts collected. The present payment to the company is at the rate of $1,550 per month, $18,600 per year.

The York Sanitary Reduction Company was organized, and the plant for reduction of the organic waste was built just outside the city limits. The collections are made three times a week for garbage in iron wagons with canvas covers. The wagon bodies are hinged to the rear axle and discharged by hoisting blocks. The ashes and refuse are removed in wooden wagons to dumps. The company keeps a special wagon for dead animals and for the removal of any cans overlooked at any time. A fine of $1 is assessed for each complaint of non-removal three hours after complaints are made.

The reduction plant is enclosed in wooden buildings cheaply built, the whole costing not to exceed $10,000. The wagons discharge their loads into a pit provided with grated bottoms, through which the liquids are drained. From the pit a conveyor carries it to the digester floor, the glass, tins, etc., being removed while in transit.

There are four digesters of the usual capacity of five to six tons. The contractor claims his method to be the "dry" extraction process. No water is used for cooking the garbage; steam is introduced at the bottom of the digesters in such a way that it permeates the entire mass.

The pressure is said to be 40 lbs per square inch, but may be increased, if necessary. The superintendent of the works claims "that the whole secret of successful reduction is knowing when the materials are properly cooked." He says: "This is essential both for obtaining the maximum amount of grease and preventing disagreeable odors. Testing valves are placed in the base of the digesters by which the attendant may determine this, as no definite time for cooking is set. Two batches may be cooked every twenty-four hours. There is no stirring or moving the garbage when once in the digester."

Pipes from the top of the digesters carry the vapors through condensers and thence to the fire-box of the boilers. From the digesters a bucket conveyor delivers the garbage, of the consistency of soup, to the hydraulic presses, the grease and water falling into flotation troughs or basins, and separation is made in the usual way, by skimming. What disposition is made of the water is not known. The tankage is dried in a rotary dryer, afterward ground and sold for fertilizer base. The quantity treated daily averages about twenty-five tons.

Mr. Fischer states that there was very little profit in the operation of the reduction plant, but that it paid the expense of a satisfactory disposal. Any profit to the company comes from the collection contract.

The construction of the works and methods of operating follow those of the Reading reduction plant where the contract for disposal is held by the Reading Sanitary Reduction Company controlled by Mr. Fischer.

The apparatus and means employed are of the usual types of other reduction plants, using steam only for reducing the garbage. There may be some special method of introducing the steam into the digesters, or of regulating the pressure and observing the progress of the work, but these seem to be the only points of difference from others. No reports of quantities, values of product of grease, or tankage could be obtained.

PENN REDUCTION COMPANY: "BEASTON PROCESS."

Extracts from special report of E. A. Fisher, City Engineer of Rochester, N. Y., 1906:

This city made no regular collection of garbage until 1879. Prior to that time, it was taken by the farmers from a few small city districts and carried into the country in open wagons. Most of the waste was dumped upon vacant lots, or an attempt made to burn it in the open air.

In 1880, the City Council passed resolutions calling upon the Executive Board to remove garbage from the public lanes and alleys. This continued until May, 1881, when the supervision was transferred to the Board of Health, and it was collected by day labor by hired teams. In 1895 the Rochester Fertilizer and Reduction Company secured a contract to collect and dispose of all garbage, night-soil, dead animals, etc., at a cost of $28,970 per year for the first year, and additional amounts of $940 per annum for five years following 1894, and thereafter, beginning with 1900, at the rate of 19 cents per capita for the increase in the population of the city according to the City Directory.

The location of the plant was, after many objections to other sites, fixed at Waynesport, a considerable distance to the east of the city, the garbage being transported on the New York Central Railroad lines. In 1896, the Health Department reported the cost at $29,910 per year, and that neither collection nor disposal had been satisfactorily carried out by the company.

The power of the Board of Health to make this contract having been questioned, the Council, in 1899, made a private contract for the sum of $2,000 per month, which continued until 1900, when, under the new charter of the city, the work came under the charge of the Commissioner of Public Works. Bids were called for a new contract let for seven months of 1900 for $12,000. Thereafter yearly contracts were let up to 1906.

The garbage receptacles at the houses were of iron, of a capacity of one gallon for each individual in the building. The wagons were of wood covered with canvas.

The records for 1902 show that nearly all of this garbage was taken to farms outside the city lines, a part dumped into a trench and composted with horse manure.

TABLE LXVII.—QUANTITIES AND COSTS COLLECTION AND DISPOSAL GARBAGE, ROCHESTER, FIVE YEARS.

Year	Population	Quantities				Costs		
		Tons		Lbs pr Capita		Per Year	Per Ton	Per Capita
		Per Year	Per Day	Year	Day	$	$	*Cts.*
1901	165,000	16,380	52.5	199	0.64	27,856	1.70	17.0
1902	168,000	17,346	55.5	206	0.66	26,300	1.38	15.4
1903	171,000	19,026	61.0	223	0.71	27,322	1.57	16.3
1904	175,000	22,964	73.6	262	0.84	39,981	1.74	22.8
1905	181,670	21,800	70.0	240	0.77	35,615	1.63	19.6

The average for 1906 at above figures would be about 83 tons per day.

The ashes and rubbish of Rochester collected together for the period of six years are thus tabulated:

TABLE LXVIII.—QUANTITIES AND COST OF COLLECTION AND DISPOSAL ASHES FOR SIX YEARS.

Year	Population	Cubic Yards	Estimated Weight Tons	Total Cost Coll't'n and Disposal $	Quantity Per 1,000 Yards	Quantity of Population Tons	Cost Per Cu. Yard $	Cost Per Capita $
1900	162,000	206,208	94,959	76,421	1,268	584	0.37	0.47
1901	165,000	216,844	99,657	77,664	1,314	605	0.35	0.47
1902	168,000	216,912	99,888	75,948	1,291	595	0.35	0.45
1903	171,000	219,736	101,188	76,670	1,285	590	0.35	0.47
1904	175,000	324,000	108,125	93,687	1,342	618	0.39	0.53
1905	181,670	253,000	116,576	97,208	1,391	642	0.38	0.53

Estimated weight per cubic yard ashes, 1,600; of rubbish, 200 pounds. Average per cubic yard of ashes and rubbish in foregoing table—921 pounds. Estimated total amount of rubbish separated, at 125,000 cubic yards or 12,500 tons per annum.

The recommendations made by Mr. Fisher were briefly:

1. Advertisements for proposals for collection and disposal of garbage for five years; wagons to be of approved pattern; collections daily in central part of city—remainder, three times weekly.

2. Contractor to satisfy Board he has sufficient area of land outside city to bury garbage temporarily in case of breakdown of disposal plant.

3. That the contractor shall satisfy Board that the methods he intends to use are in successful operation in some city of considerable size, and that the plant has a capacity sufficient to take care of maximum amount that may probably be collected during term of contract.

4. Separation of ashes and refuse and construction of plants for burning unsalable parts of rubbish.

The recommendations of Mr. Fisher were adopted, and the work was advertised in 1906. The proposal of the Genesee Reduction Company was accepted for a term of years, from January 1, 1907, at a yearly rate of $59,770.

The estimated amount of 83 tons daily for 1906 was exceeded in the first year's work of the plant, the quantity being about 18 per cent. more, or 30,661 tons. This disposal is made at the rate of 36.1 cents per capita per annum and at a cost of $1.95 per ton.

The location of the works of the reduction company is on the west bank of the Genesee River, between the upper and lower falls. This location is within less than one mile of the business center of the city. The narrow shelf of the river bank at this point, on which the works are placed, is about 150 feet below the level of the city streets, immediately adjoining. The river cuts through a canyon below the falls, with high banks. At the bottom of this canyon, on the east bank, are the works. It is a critical location with respect to possible nuisance from odors from the chimney or the entire plant.

The reduction plant has been in operation since June 5, 1907. At first there were numerous complaints, based very largely upon prejudice against the name "garbage plant." These complaints have almost entirely ceased, and up to the present time the plant has been operated without serious offense. (Paper of Mr. Fisher in Proceedings of American Society Civil Engineers, December, 1907.)

The author made an inspection of the plant in the summer of 1906 just before it went into service. The ground is admirably suited to the delivery of the garbage, the conveyor for the digesters being but a short distance, and all the work being accomplished by the aid of gravity, no lifting or pumping being needed.

The process is said by Mr. Fisher to be a modification of the Arnold, and is called the "Beaston Process." Exactly wherein the difference lies a casual survey did not reveal. There is the usual system of digesters from which the macerated garbage is delivered into the hydraulic presses and the same system of gutters and skimming basins for the grease recovery. There was no solvent used, the whole process being like the Arnold, one of treatment by steam and the recovery of the grease by pressure, with an improved means for drying out the tankage. No accurate information concerning the "Beaston Process" can be obtained, and there are no reports as to the quantities and value of the grease and tankage.

The city engineer recommends that there be a refuse disposal plant placed near this reduction plant, at which the city rubbish may be destroyed, and that the ashes be used for filling ravines, old quarries, etc.

CHAPTER XVII.

The Edson Process—The Municipal Reduction Plant at Cleveland—Arguments in Favor of Reduction Methods.

The city of Dayton, Ohio, had, in 1896, a Dixon crematory in use—capacity, 80 tons per day. This was destroyed by fire in 1898 and not rebuilt. In October, 1903, the city received proposals from the Edson Development and Machinery Company, of Toledo, by which this company agreed to receive the garbage, dead animals and night-soil, at a point on the outskirts of the city and to dispose of this free of expense to the city.

This proposal was one of several made at different places by the Toledo Development Company, the representatives of the owners of the Edson process, by which it was claimed that the returns from the products were so lucrative that the company could afford to take the garbage free of cost. After a long delay to perfect their organization and erect their plant, the company proceeded with the contract. Difficulties were encountered from the outset, because of imperfect separation of the garbage, and irregular delivery at the point where the company received the garbage.

There has been considerable trouble with its operation because of the excessive amount of naphtha required as compared with the estimated amount on which the original calculations were made. There were many complaints from nearby residents of noxious odors, and charges were made that the location chosen was not the one originally designated when the contract was secured.

In 1907 a strong remonstrance was made by the local improvement association which led to the establishment of two loading stations by the city, at which the garbage is transferred to the company's teams for transportation to the reduction works, with more attention to abatement of nuisance.

The capacity of the reduction plant was at first sixty tons per day. No reports of quantities handled or value of products can be had. The present capacity of the plant is 100 tons daily, the cost of the works being reported at $60,000.

EDSON PROCESS, TOLEDO.

In the summer of 1903 this city received tenders for the disposal of approximately 50 to 60 tons of garbage per day. Of the four proposals received that of the Toledo Development Company, controlling the Edson reduction process, was accepted, and in July of that year a contract was signed with the Toledo Sanitary Reduction Company, a local corporation formed for this purpose, and working under the patents of the Edson Reduction Machinery Company. The city agreed to collect and deliver the garbage at the plant, and the company contracted "to do the work of disposal by the reduction process, carried on in closed digesters, dryers and percolators from which no gases, vapors or odors shall escape; and that all garbage shall be so treated and all products resulting from the same, before being exposed to the air, shall be made perfectly sterile and free from offensive odors."

The company was to receive no payment from the city, and the contract was for ten years.

Strong objections were made to the proposed location, and the final site fixed upon was at Green Street on Swan Creek, where the plant was constructed in 1904. In 1906 it was found that the quantity of garbage was lessening, owing to the fact that the proprietors of hotels, and others, delivered it to farmers for the feeding of stock. The question of the rights of the city over the collection and removal of garbage was taken to the courts, and it was decided that as the city made its own collections, under its own regulations, it had power to restrain others from collecting garbage inside the corporate boundaries. On this question the decision of the U. S. Supreme Court (199 U. S., 306, and 199 U. S., 325) affirms that household garbage is not private property which can be disposed of by the producers in a manner contrary to the requirements of city ordinances or the rules of a Board of Health.

A later decision in an Ohio Court is thus reported in a local newspaper, under date of March 31, 1908:

Refuse Disposal is in Power of City: Judge Brown rendered the following decision Saturday morning:

In the case of the Dayton Reduction Company vs. the City of Dayton, demurrer to petition overruled in all respects, and defendant ruled to answer, the court holding that the city has the right of ownership in all garbage, dead animals and night-soil within the city, and has full authority to compel the collection and disposal of such unsanitary materials under the statute, and under the general police powers of the city.

In January, 1906, the company offered to take the garbage of the city of Detroit, about 100 tons daily, and haul it sixty miles to the Toledo plant for treatment. This offer was, however, declined. In October, 1906, the company was in financial straits, and the business passed into the hands of a receiver. The capital of the company was stated to be $200,000, but only $50,000 was paid in cash. Sixty thousand dollars of bonus stock was issued, and the indebtedness was about $75,000, the bonded debt being $100,000.

In March, 1907, complaints of nuisance were made, which were justified, as admitted by the company's attorneys. In May the City Solicitor alleged that "the company knew that the system which it had installed would not do the work as promised, and that the plant has not sufficient capacity, and that the conditions were decreasing the value of surrounding property and endangering the health of the residents."

On July 13, 1907, the plant was closed by order of the court, the entry in the case also including the statement of the receiver showing that the plant was operated at a loss.

At this time the city is investigating the various methods of disposal of all classes of municipal waste by incineration.

MUNICIPAL REDUCTION PLANT, CLEVELAND, OHIO.

Combined Chamberlain and Edson Reduction Processes.—Prior to 1905 the garbage of Cleveland was collected and removed under private contract with the Newburgh Reduction Company, at an annual cost of $69,400 per year. The disposal was made by the reduction methods of the Chamberlain process at a point outside the city limits. This service was not free from complaints, and as most of the transportation was by wagons, was slow and expensive.

On January 1, 1905, the city purchased from the Newburgh company the reduction works and collection equipment, at a cost of $87,500. At that time the works had a capacity of 100 tons per day by the Chamberlain or "Liquid Separation System," employing fourteen digesters and a corresponding number of hydraulic presses, settling tanks and steam-jacketed dryers.

Upon acquiring the property, the city installed an Edson reduction equipment, adding three units, each of two digesters and one dryer, and increasing the capacity of the plant to 240 tons per day. The work of the first year (1906) was delayed somewhat by a small fire in the dryer building, also by delay of constructors in furnishing machinery not up to the standard of contract.

For the collection service is used a wagon of special design, holding about 3,500 lbs. The wagon body is hinged to the bolster and is dumped by hoisting chains attached to the front of the body that raise it to permit the garbage to fall out at the rear end. The purpose of this is to keep the load as much as possible on the front of the wagon for easier hauling by one horse. The wagons have canvas covers, to prevent noise usually made by iron covers.

The garbage is received in special steel cars, made with semicircular bottoms, thirty feet long, supported on trunnions at three points. The capacity of these cars is about forty tons, and ten are required for the service.

To unload the cars at the works, cables are passed beneath the body and, by means of hoisting blocks, the car body is tipped, unloading the garbage onto the concrete floor of the reduction works. Although the capacity of these is forty tons, but two men are required to tip them.

The loading station for the cars and stables for city teams are on Canal Road, about three-quarters of a mile from the City Hall. The reduction plant is at Willow, Ohio, outside the city limits, about nine miles from the loading station. The cars are carried over the tracks of the N. Y., P. & O. R. R. to the works.

The arrangement of the buildings is quite different from the usual design where the several steps of the work are done in the same or closely connected buildings. Here they are separated, each process having its own building.

From a description of the works, contained in a paper by Hon. W. J. Springborn, President of a Board of Public Service, Cleveland, the following excerpt is made:

The arrangement of the buildings, tracks and so forth, at the works is shown in an accompanying illustration. The railroad cars are run into a receiving building, where the garbage is dumped on a concrete floor. From this floor the garbage is shoveled into two conveyors, with 6 x 18 x 24-in. flights, which deliver it to the top floor of a digester building. These conveyors, which were installed by the Jeffrey Mfg. Co., of Columbus, Ohio, and all other machines are driven by separate motors, thus avoiding the use of main line shafts and belts. A 250-h.-p. Monarch Corliss engine, direct-connected to a Triumph generator, furnishes power to operate the works. Steam is supplied from a boiler plant containing five 80-h.-p. and two 150-h.-p. return tubular boilers.

The conveyors pass through the digester building in a horizontal position and drop the garbage through tubes directly into the digesters or tanks, where the same is cooked. Twenty-four digesters, each having a capacity of 10 tons per day, making the total daily capacity of the plant 240 tons, are installed. The digesters are 14 ft. high and 54 in. in diameter. When the digesters are filled, steam is turned into the material at a point near the bottom of the tank and the garbage allowed to cook from six to seven hours, 70 lb. steam pressure being used. When the cooking process is completed, the steam is shut off at the bottom of the tank and turned in at the top, the pressure thus produced driving off the free water and some of the grease through a draw-off pipe at the bottom. In order to prevent the material from passing out with the water, a strainer and strainer-plate are used. This mixture of water and grease is pumped into settling vats and allowed to cool, after which the grease is skimmed off the top. The solids remaining in the digester are removed through an opening in the side of the tank about 12 in. from the bottom and deposited in a small car, which is equipped with a worm conveyor, automatically unloading it into a drag conveyor that takes the material to the dryers. It is first put into a steam-jacketed dryer 14 ft. long and 5 ft. in diameter. This dryer has a shaft through its center with paddles attached. As the shaft rotates the paddles lift the material, breaking it up and at the same time evaporating some of the moisture. This type of dryer is equipped with two manholes underneath it, through which the material is dropped into still another conveyor and conveyed to a combination steam and hot air rotary dryer, which was designed by Mr. E. S. Peck, Superintendent of the plant. The cylinder of this dryer is 30 ft. long, 57 in. in diameter, with a 2-in. space between the inner and outer shell for the admission of steam. There is also a 14-in. steam pipe running through its center. To the sides of the inner shell are attached flights, 4 in. in width, which lift the material as the dryer rotates.

The dryer is set on a grade of a ¼-in. per foot, and the tankage (as the material is called) is fed in at the upper end and discharged at the lower, the process being a continuous one. At the lower end of the dryer is a series of steam coils with an attached blower, which forces the air around these coils, heating it to about 230° F. This dry air then passes through the dryer, absorbing the moisture from the tankage as it falls from the flights referred to.

About 50 ft. distant from the dryer building is located the percolator building, to which the material is next conveyed, and where the grease is extracted by the use of naphtha. In the upper part of this building there are three bins for the storage of tankage. Under each of these bins is a tank 8 ft. high and 6 ft. in diameter, which is called a percolator. The material is put in through an opening in the top. When filled, the percolator is sealed and naphtha or gasoline is pumped in at the top and allowed to percolate through the material, being drawn off at the bottom and carrying with it the grease. The grease and naphtha flow to a treating tank in which there are steam pipes, where it is heated sufficiently to vaporize the naphtha and leave the grease in the tank. The vaporized naphtha passes through a condenser, restoring it to its liquid form, and from which it is again pumped into the percolator. After all of the grease has been extracted from the material left in the percolator, the flow of naphtha is turned off, and in order to recover such of the naphtha still remaining in this material, steam is injected into the tankage, vaporizing and driving off the naphtha. This mixture of steam and naphtha vapor also goes to the condenser and thence to the storage tank. The water produced by the condensation of the steam is drawn off from the bottom of the storage tank.

To reduce the condensation of steam to a minimum, it is first admitted into the tank at a point near the top of the percolator. When the material about this point has been heated and the naphtha vaporized, steam is turned in at about the middle of the tank, and afterward at the bottom, repeating the process until all the naphtha has been vaporized. The loss of naphtha by this system is about 2½ gal. to the ton of dry tankage. The openings in the percolator, through which the grease and naphtha escape, are covered with perforated plates and pipes designed to prevent carrying the tankage through same. The material is removed both from the side and the bottom of the percolator, placed in a conveyor, and sent to a small building about 20 ft. distant, in which it passes through a hexagonal revolving screen, taking out rags, tin, pieces of crockery, glass, and so forth. From here the finished product is conveyed to the storage house and there loaded upon cars for shipment.

The taking out of the material from the above type of percolator and replacing the small perforated plates and pipes through which the grease escapes, involves considerable time and labor. Mr. Peck has invented a new type of percolator, which Mr. Springborn believes will overcome these objections, and at the same time greatly reduce the loss of naphtha and leave the material much dryer. This percolator is similar in design to the dryer designed by Mr. Peck, except that it is but 14 feet in length and 8 feet in diameter. It is placed in a horizontal position, has a steam jacket, and is constructed to rotate in the same manner as the dryer. The material is put into this percolator through two manholes in its upper side. The pipes for the admission of gasoline are also connected through the covers in these manholes. The grease and naphtha escape through three openings in the lower part of the tank, and in order to hasten the process of percolation the pipes can readily be disconnected and the percolator rotated so as to mix thoroughly the entire mass of material with the naphtha or solvent used.

In order to recover the naphtha after the grease has been extracted, steam is turned into the drum and jacket and the percolator made to revolve, thus while heating the material, also moving the same sufficiently to release quickly all of the solvent contained in the tankage. By this method no moisture is added to the material nor steam mixed with the vapors, which go to the condenser and thence to the storage tank. By the use of this type of percolator, it is thought the loss of naphtha will not exceed the one gallon per ton of material treated.

The naphtha storage building is constructed of concrete, the tanks being placed below the ground level, with only the roof of the building projecting above the surface.

In the old process formerly used, the grease was extracted by means of hydraulic presses, the tankage being placed between burlap on racks in layers of 3 inches thick and 5 feet square. The cylinder of the presses was 14 inches in diameter, and subjected to a pressure of 3,500 pounds to the square inch. By this means the liquids were squeezed out of the material, carrying the grease with same to a vat, where, after cooling and settling, the grease was skimmed off. The tankage produced by this method is not as desirable to the trade as that which is being made from the new process. There is about 12 per cent. of grease left in the pressed tankage, whereas in the other there is only about 2 per cent. The grease being the most valuable part of the product, makes it desirable to recover as large a percentage as possible.

TABLE LXIX.—COMBINED INCOME AND EXPENSE STATEMENT, CLEVELAND REDUCTION PLANT, FOR SIX MONTHS ENDING JUNE 30 AND DECEMBER 31, 1907.

GROSS INCOME

	6 *Months* *June* 30, '07	6 *Months* *Dec.* 31, '07	12 *Months* *Total*
From sale of product	$60,514.61	$55,809.85	$116,324.46
From inventory of product	6,473.75	5,504.92	11,978.67
From sale of raw material	237.50	241.55	479.05
From rents	46.00	54.51	100.51
From miscellaneous income:			
Collection Department	318.95	29.00	347.95
	$67,590.81	$61,639.83	$129,230.64

TABLE LXIX.—(Continued.)

EXPENSES

AT WILLOW OHIO (DISPOSAL PLANT):			
Labor at plant	$20,612.72	$23,572.55	$44,185.27
Coal at plant	9,050.57	7,319.18	16,369.75
Superintendence and clerk hire	1,721.70	1,775.04	3,496.74
Repairs and renewals to plant	5,396.03	2,680.30	8,076.33
Press cloth	1,267.65	1,893.41	3,161.06
Press racks	427.48	538.02	965.50
Insurance	124.50	62.35	186.85
Office supplies	104.47	281.96	386.43
Oil, waste, telephone, water, etc	3,488.29	1,843.60	5,331.89
Taxes	193.40	265.90	459.30
Commission, analysis, weighing cars, etc	325.91	145.66	471.57
Freight on product, purchase dead animals, etc	795.70	1,407.28	2,202.98
	$43,508.42	$41,785.25	$85,293.67
AT CANAL STREET (COLLECTION PLANT):			
Labor, teamsters, etc	$25,180.77	$28,919.47	$54.100.24
Feed	7,896.94	8,743.04	16,639.98
Freight on garbage	2,837.77	2,986.03	5,823.80
Superintendents and clerk hire	1,290.00	1,140.00	2,430.00
Shoeing	1,480.65	1,651.85	3,132.50
Repairs and renewals to freight cars, wagons, etc.	2,441.40	3,129.35	5,570.75
Repairs to harness	490.51	698.55	1,189.06
All other sundry expenses not itemized above:			
Supplies for barn, light, etc	1,673.95	1,546.07	3,220.02
Insurance	224.94	301.18	526.12
	$43,516.93	$49,115.54	$92,632.47
EXTRAORDINARY EXPENSES:			
Auditing	$150.00	$150.00	$300.00
Losses on horses, cars, etc	400.00	276.00	676.00
Losses on bad accounts	....	21.00	21.00
Depreciation on machinery, plant and equipment at Willow, O., at 10% per year	4,072.11	5,829.69	9,901.80
Depreciation on wagons, horses, stable and other equipment at Canal St., at 10% per year	2,105.43	2,694.10	4,799.53
	$6,727.54	$8,970.79	$15,698.33
TOTAL EXPENSES:			
At Willow, O.	$43,508.42	$41,785.25	$ 85,293.67
At Canal Street	43,516.93	49,115.54	92,632.47
Extraordinary and depreciation	6,727.54	8,970.79	15,698.33
	$93,752.89	$99,871.58	$193,624.47
Total income	67,590.81	61,639.83	129,230 64
Net operating expense	$26,162.08	$38,231.75	$64,393.83

TABLE LXX.—SUMMARY OF PRODUCT, SALES AND INVENTORY, CLEVELAND REDUCTION PLANT.

JANUARY 1, 1907 TO JULY 1, 1907

Quantity	*Article*	*Average Price*	*Amount*
1,225,290	lbs. grease	@ $4.25 cwt.	$52,068.44
2,756,281	lbs. dry tankage	@ 7.85 ton	10,816.14
2,439,010	lbs. pressed tankage	@ 2.47 ton	3,011.61
181	lbs. hair	@ .20 lb.	36.20
115	tails	@ .30 each	34.50
220	hides	@ 4.65 each	1,021.47
	Total first six months, 1907		$66,988.36

JULY 1, 1907, TO JANUARY 1, 1908

Quantity	*Article*	*Average Price*	*Amount*
1,140,980	lbs. grease	@ $4.298 cwt.	$49,042.40
836,406	lbs. dry tankage	@ 6.888 ton	2,880.81
6,353,518	lbs. pressed tankage	@ 2.50 ton	7,943.25
342	lbs. hair	@ .1442 lb.	49.30
307	hides	@ 4.496 each	1,380.41
62	tails	@ .30 each	18.60
	Total last six months, 1907		$61,314.77

TABLE LXXI.—COMPARISON OF GARBAGE DELIVERED AT CLEVELAND REDUCTION PLANT AT WILLOW, O., DURING THE YEARS 1906 AND 1907.

Month	1907 *Lbs.*	1906 *Lbs.*	*Increase Lbs.*
January	6,402,000	4,784,000	1,618,000
February	5,512,000	3,994,000	1,518,000
March	6,067,000	4,520,000	1,547,000
April	6,144,500	4,694,000	1,450,500
May	6,139,000	5,430,000	709,000
June	5,719,000	5,936,000	*217,000
July	5,895,400	5,464,000	431,400
August	6,130,700	8,024,000	*1,893,300
September	7,038,000	7,478,000	*440,000
October	7,494,300	7,098,000	396,300
November	6,156,700	6,204,000	47,300
December	6,512,900	6,156,000	356,900
Total	75,211,500	69,782,000	5,429,500
Average per month	6,267,625	5,815,167	452,458

*Decrease.

The preceding tables give the figures of income and expenses for the year 1907, the values of products sold, the amounts of garbage per year, and a summary of the financial statements for three years:

FINANCIAL STATEMENT, CLEVELAND REDUCTION PLANT.

TABLE LXXII.—COST OF COLLECTION AND DISPOSAL PER TON.

Condensed from auditors' reports for years 1905-6-7:

Year	Amounts Tons	Cost Collection	Per Ton	Cost Disposal	Per Ton	Total Cost Ton
1905	30,382	$62,803.78	$2.05	$54.449.88	$1.79	$3.85
1906	34,891	74,334.32	2.13	83,383.98	2.39	4.52
1907	37,605	92,632.47	2.46	85,293.67	2.26	4.72
ADDING EXTRAORDINARY EXPENSES, DEPRECIATION, ETC.						
1905	30,382	65,989.03	2.17	60,690.37	1.99	4.16
1906	34,891	79,232.86	2.27	87.377.00	2.50	4.77
1907	37,605	98,419.00	2.62	95,195.55	2.50	5.12

INCOME FROM DISPOSAL PLANT

1905.	From sale of products, inventory, rents, etc.		$65,881.14
	Total operating expenses	$54,449.38	
	Extra expenses and depreciation	6,310.99	
			60,760.37
	Net profit not including interest charges		$5.120.77
1906.	From sale products, inventory, rents, etc.		$106,990.41
	Total operating expenses	$83.383.88	
	Extra expenses and depreciation	3,993.25	
			87,377.13
	Net profit not including interest charges		$19,613.28
1907.	From sale products, inventory, rents, etc.		$129,230.64
	Total operating expenses	$85,293.67	
	Extra expenses and depreciation	9,901.80	
			95,195.47
	Net profit not including interest charges		$34,035.17

Assume value of plant in 1905 at $70,495.37. The returns are approximately 7.2 per cent. on investment.

For 1906, at a valuation of $146,297.18, the returns are 14 per cent. on value of investment.

For 1907, returns on total investment at valuation of $222,-726.92 is 15 per cent., and on disposal plant alone, $173,855.92, is 20 per cent.

These details respecting the Cleveland reduction plant are given at some length, as this is the first of the process methods to be operated by any municipality, and now, for the first time, after twenty years of work by reduction means, we are fully informed as to the costs of the work and the value of the products.

These results have been obtained after persistent effort on the part of the President of Board of Public Service, Mr. W. J. Springborn, backed by a public-spirited Mayor and City Council.

The record stands in sharp contrast with the operation of many private plants where the work is done for a large bonus paid by the city, together with a still larger revenue derived from the sale of the manufactured waste.

THE AMERICAN EXTRACTOR COMPANY PROCESS, NEW BEDFORD, MASS.

For some years after the closing of the Holthaus reduction plant at New Bedford, the waste of New Bedford was treated by the usual means of dumping and feeding to swine.

In 1904, a new contract was made by the city with the New Bedford Extractor Company, a local corporation working under license from the American Extractor Company, of Providence, owners of the Wheelwright hot water reduction process, a new form for treatment of garbage by reduction.

This contract was for a term of five years, at the rate of $25,000 per year, and included the collection and disposal of the garbage and dead animals. The collections were made by a sub-contractor, in metal wagons holding about two cubic yards each. They are weekly from May to November and bi-weekly for the remainder of the year. Each wagon makes two trips a day.

The works of the New Bedford Extractor Company are located on the same ground as the abandoned Holthaus plant, three miles from the city center. There are three separate buildings—the garbage house, the extractor house and the boiler house, together occupying about 250 x 100 square feet of ground.

The garbage house is a brick building and contains four bays, which allow four wagons to be unloaded at once, and during this time the doors are kept closed to prevent escape of odors. The wagons are discharged onto a grating, through which the liquids

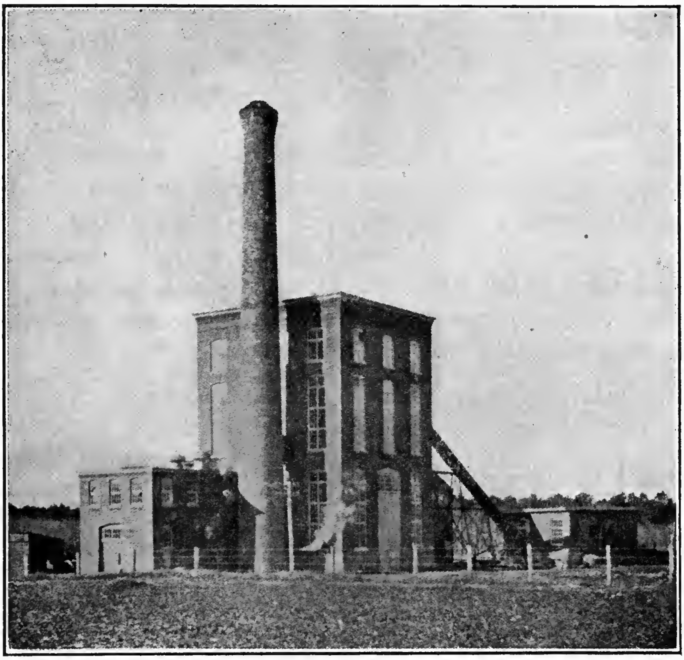

FIG. 92.—THE REDUCTION WORKS OF THE AMERICAN EXTRACTOR COMPANY. NEW BEDFORD, MASS.

pass to a cistern below, the metals, rubbish and foreign matters are removed by hand.

The water drained from the garbage is pumped to a hot-water tank, from which it is fed into the digesters as needed. The inclined steel tube contains a drag chain conveyor which elevates the garbage to the upper floor of the main building. This tube also acts as an exhaust pipe for drawing foul air from both floors of the garbage house. Conected with this, is a second exhaust pipe that withdraws the gases from the feed opening of the digesters.

The garbage is delivered through the pipe and deposited in the digester at the rate of from six to ten tons per hour as required, this being precipitated with a small amount of boiling water in the bottom of the digester.

The main building of the plant is of brick and steel construction, 60 x 80 feet, and 74 feet high. The stack is 125 feet high. This building contains the apparatus for the treatment of the garbage, the first of which in the series of operations are the digesters. There are two of these, each weighing forty-five tons empty and ninety-five tons loaded, and with a capacity of thirty tons per day. They are made of cast gun-metal, two inches thick, and corrugated on the inside to prevent the sticking of the garbage to the sides. In the bottom of each digester are four 1½-inch steam nozzles, through which enters the steam for cooking the garbage.

When ready to be loaded the digesters are partly filled with hot water, and then garbage from the conveyor is dumped in until they are filled. During the filling the steam jets are operated just enough to keep the water at the boiling point. After a digester is charged it is sealed and the steam pressure gradually raised to twenty-five pounds, at which it is held for a period of two and one-half hours. The garbage is cooked under pressure for three and one-half hours in summer and four hours in winter.

After the cooking is completed the steam jets are closed and the pressure gradually lowered. The steam from the digester is blown into the hot-water tank, where it is condensed and at the same time heats the garbage water contained therein. The use of the garbage water for cooking saves the expense of providing other water and at the same time makes it possible to extract the grease from it.

At this point occurs an important operation in the process, called the flotation of the grease. Water is pumped into the bottom of the tank, and the grease, which floats upon the surface, is removed by a pipe at the top of the digester to an oil separator. The solids are prevented by a grating from getting into this pipe. After going through the separator the oil is run into settling tanks in an adjacent building and finally into a storage tank. A 3-inch pipe runs from the storage tank to a railroad switch near by, where the tank cars are loaded. The oil is forced through the pipe under fourteen pounds air pressure, and 27,000 pounds can be loaded into a car in one hour.

When the oil has been completely removed the water is drawn off, and then the discharge pipe at the bottom of the digester is opened and the solid matter pases to the extractor. This consists of a 16-inch revolving worm inside of a casing, which is tight except for openings to carry away the water as it is pressed out. The pressing is done by means of mechanically operated fins, which press into the threads of the worm, forcing the solids against the hub and thus extracting the liquor. This is quite different from the method usually employed of pressing out the liquid by means of a hydraulic press in an open room, whereby odors are occasioned.

The water thus obtained is conveyed to a settling tank and the grease removed by flotation. The solids are carried by a closed conveyor to a double steam-jacketed dryer five feet in diameter and ten feet long.

After being dried the tankage, which is brown in appearance and somewhat caked, is placed on a conveyor that takes it to a disintegrator, where it is finally ground, and then passes to a bagging machine, where it is packed ready for shipment.

The power plant consists of two Kendall boilers of 125-horsepower capacity, working under a pressure of eighty pounds; one vertical Westinghouse, Jr., 94-horsepower engine, making 320 revolutions per minute; one 350-gallon Knowles service pump and one 500-gallon fire pump of the same make. A Green economizer heats the water for the boilers, spring water being used for this purpose and stored in a 10,000-gallon tank. Water used for other purposes is supplied by artesian wells and is stored in a 30,000-gallon tank. Between fourteen and fifteen tons of coal are used per week.

A most important feature of this plant is that all apparatus from which disagreeable odors might arise are connected to a Sturtevant blower. The vapors pass through a condenser and thence to the stack, where they mingle with the hot gases and from which they emerge high in the air.

The Superintendent and General Manager of the Company, C. K. Wheelwright, gave the following information concerning the operation of the plant:

Besides the men who accompany the wagons, eight are employed at the plant during the day and two at night, with which number we could easily handle twice as much garbage as is now received, and would be glad to do so because of the increased profits from the by-products. The plant is designed to handle 60 tons per day, but at present receives on an average only about 18 tons.

The population of New Bedford is about 80,000 (74,362 in 1905, by the State census). There should, therefore, be about 25 tons of garbage a day, according to figures obtained in other cities where careful investigations have been made. The apparent deficiency is stated to be due to the extreme economy of the foreign-born laborers, who constitute a large percentage of the population.

From each ton of garbage treated there is obtained 400 to 460 lbs. of tankage and from 53 to 60 pounds of grease. The tankage is sold to fertilizer companies as a base for fertilizer, and brings from $4 to $12 per ton, depending upon the amount of ammonia present. The grease is sold to soap companies, and is used in the manufacture of the finest soaps. In addition to the money derived from the sale of the by-products, the company has a contract with the city whereby it receives $25,500 per year for the removal and disposal of the garbage.

(Condensed from Municipal Journal & Engineer, Feb. 26, 1908).

The cost of collection and disposal at New Bedford, allowing 6,000 tons of garbage to be gathered annually, is at the rate of $4.16 per ton, or about 31.2 cents per capita per annum. This appears to be the highest cost of any city in this country using the reduction methods.

The value of the by-products and the cost of operating, according to the statement of the officers of the company September 5, 1907, is as follows:

The New Bedford Extractor Company's plant, working under license from the American Extractor Company, has a daily capacity for reducing 60 tons of garbage in 24 hours. Owing to the requirement of the city it was necessary for the company to agree to its contract that the capacity should be double the supposed collections, *i.e.*, 30 tons per day.

The average delivery of garbage to this plant has been only 20 tons per working day, but the operation expense is as much as if 30 tons per day had been reduced.

Taking the market prices of the by-products of September 1, 1907 (greases and tankage), a ton of garbage as delivered at the plant equals in value	$4,282.00
Actual cost of reduction at New Bedford plant of one ton of garbage	1,995.00
Gain per ton	$2,287.00
Twenty tons, 312 days	14,350.88
Depreciation on 25-ton plant, credit sinking fund	6,500.00
	$7,850.88

Yield of grease	3.34%	
Yield of tankage	15.00%	
Coal per ton garbage reduced, 284 pounds.		
On 30 tons per day cost of reduction per ton would not exceed..		$1.50
On full capacity of plant it would not exceed		1.00

AMERICAN EXTRACTOR COMPANY,

Charles S. Wheelwright, President.

The statement has been made that the cost of erecting a 15-ton plant, not including the ground, is about $40,000. It is not the intention of the American Extractor Company to erect a plant or make money from their construction as builders, but to grant licenses to those who do, supplying all necessary plans and superintending the erection.

GARBAGE DISPOSAL BY REDUCTION METHODS.*

"* * * These percentages vary greatly with the geographical location of the community, with the season of the year, and with the particular kind of season; that is, whether rainy or dry, hot or cold. In fact, every change in the natural order of living affects to a greater or less extent the above values and their relation to one another. For instance, the percentage of ashes in our Southern cities is very much lower than in our Northern cities; in our Northern cities it is a great deal higher in winter than in summer, while in the South it is a fairly constant quantity throughout the year.

Then the percentage of garbage will increase materially in the summer because of the large increase in vegetable matter containd therein. In our Southern cities the percentage of grease in the garbage is very low because of the small proportionate consumption of meats.

The kind of season influences particularly the quantity of garbage; it also influences somewhat the quality of the garbage. If for any reason the weather conditions have interfered with the growing of melons, sweet corn and fruit, the amount of garbage in July, August and September will decrease surprisingly. On the other hand, if the season has been favorable the

*Condensed from paper before The Franklin Institute, Philadelphia, by Robt. Yarnell, C. E.

vegetable matter assumes prodigious proportions in these months.

It is interesting to note the difference in the quality of the garbage in our Eastern cities, its physical as well as chemical changes.

The material collected in Baltimore is very inferior, indeed. It contains but a small percentage of grease and a very large percentage of rubbish and objectionable matter. Baltimoreans seem to live largely on fish foods—oysters, crabs, etc. At certain seasons the crab shells assume surprisingly large proportions; in fact, often at a distance a load of garbage has a decided pink color due to the crab shells.

Philadelphia garbage is in a very much better mechanical state than that of Baltimore, but the percentage of grease is much lower than in some of the other cities, such as Newark, N. J., New York and Brooklyn, although much higher than in Baltimore. The reason for this comparatively low percentage of grease in Philadelphia is to be found in the non-enforcement of an ordinance barring private collectors of garbage. A recent Supreme Court decision has sustained such an ordinance. The "hog feeders" go from house to house in the best sections of town and to most hotels and boarding houses and collect only the best of the material for feeding their swine, and leave for the regular collectors the poorer materials, from which material only a small percentage of grease, as above stated, can be extracted. This practice should be stopped at once, not only because of the poor quality of pork produced by swill-fed hogs, but because by so doing the city will be able to obtain lower bids on the scavenger contracts if the material is to be reduced.

The garbage collected in New York City is the cleanest—containing the least amount of refuse—in any city in the East. The reason for this condition is found in the rigid enforcement of the law governing separation of the three kinds of waste. The fact that the material is richer—that is, contains more grease, ammonia, potash, etc., per ton—in New York City than any other Eastern city, with the possible exception of Atlantic City, is because of the barring absolutely of all private collectors, and also because of the great number of hotels and apartment houses from which the waste of foodstuffs per capita is much greater than from private households, or from a less thickly populated community where there is an opportunity to scatter the material, feed domestic animals, etc.

It is interesting to note that the garbage collected in New York City is comparatively dry and can be stacked on scows like hay.

The garbage from Boston is very wet and sloppy The scows which transport the material away from the city to the reduction plant have to be provided with high sides to keep the material from running into the bay. It is difficult to explain the reason for this condition, but it must be because of some method of doing the work about Boston kitchens which differs from that employed elsewhere; perhaps the dishwater is added to the garbage. The yield of grease from the Boston garbage is considerably less than the yield from New York, but is greater than the yield from Philadelphia, perhaps because of the greater consumption of fish foods, which are poorer in grease than other meat foods.

Concerning the relative merits of incineration and reduction methods for the final disposal of this objectionable material much has been said and written. The problem is a very complex one, indeed. What is a merit in one case is a demerit in another. What is advantageous in one city is utterly out of place in another. But there are certain facts which largely govern a decision in all cases.

Generally speaking, in a city whose population is under the 100,000 mark, the returns from a reduction method of disposal are too small to warrant building a plant, unless the contract price paid by the city for the work is high, and the term of contract long—ten years or more. For such cities cremation is unquestionably the method to adopt.

Again, generally speaking, in a city whose population is over 100,000 reduction should be the method adopted if the cost alone is considered.

Referring for a moment to the sanitary advantages of the two systems, it has been demonstrated time and again that a reduction plant can be operated near a thickly-populated district without creating any offense whatever. To cite a case in point, take the old plant of the American Product Company on the Schuylkill River, in this city, not over two miles from the City Hall, and just across the river from the delightful suburban district of West Philadelphia. This plant has been in almost continuous operation for the past twelve years, and who ever heard of any complaint as to its being unsanitary or a menace to public health? If care is taken in the design of a reduction plant, and intelligence used in its operation, there is absolutely no occasion for complaint.

A crematory can also be conducted in a highly sanitary manner; but against most existing plants in this country, at least, complaints have been entered based on the fumes, or from the small particles of unburned garbage and dust discharged from the stacks.

Success of both systems, however, from a sanitary standpoint, rests almost entirely with the health officers of a city. If they are so inclined they can prevent either method from being objectionable. It is to be expected that the contractor will object to any measures imposed by the Board of Health necessitating his installing expensive vapor scrubbing or disinfecting devices. But such measures, provided they are practicable, can be enforced, and the comfort of the complaining district assured.

It is pleasing to the medical mind to consider incineration as the only sanitary method for the disposal of garbage, because by such a method the doctor is reasonably sure of destroying at once all microbic organism, together with their common feeding-ground. To support him in his theories about incineration, or rather by reason of his opinions, there are to be found a great number of reports by engineers and others, both foreign and domestic, endorsing this method of disposal. It seems to those who are acquainted with reduction methods of disposal that the opinions of these doctors and engineers have been formed in ignorance of such methods. Their ignorance is due to the fact that there is practically no literature on the subject of garbage reduction and no reliable American data regarding the exact cost of reduction, or the value and quantity of products extracted per ton of garbage treated, except in the hands of the contractors bidding for city contracts, and they naturally do not care to disclose their knowledge.

It is a fact, however, that may be stated without fear of contradiction, that the net cost of reducing a ton of garbage is less than the cost of cremating the same quantity. This should be apparent to everyone. To burn a ton of garbage, it is first necessary to evaporate the 80 per cent. of water the garbage contains. It must be remembered that less than one-third of the remaining 20 per cent. of the original ton is combustible. Now, under the very best conditions of draft and arrangement of heating surface and design of furnace in boiler practice we are able to evaporate about ten pounds of water per pound combustible. Hence, to burn a ton of garbage coal must be added to it. To be sure, it takes coal to make steam to reduce a ton of garbage, but to pay for this coal are the products extracted. It may be said that if the garbage were not separated from the other combustible light refuse it would require practically no coal to burn the mass. But, on the other hand, if this same light combustible refuse were separated and taken to the boiler room of the reduction plant it could be used to help generate steam for the latter process. There should be no uncertainty about these points. Given a specific case, results can be accurately predicted.

When all is considered, as far as sanitation goes, there is very little to choose between cremation and reduction of garbage. It must be remembered that the raw material, by reason of its origin, is subject to rapid decay, and hence in the hot season is bound to be obnoxious; and it is from the handling of the raw material itself, from the receptacle to the wagon and from the wagon to the plant, that complaints arise rather than from the plant itself, be it a crematory or a reduction plant.

It is the object of the reduction plant to obtain every pound of garbage that can be collected from the city, because the plant's profit depends upon the amount of material treated, the fixed charges being very high. Whereas, on the other hand, there is practically no profit to be derived from the burning of the garbage. The collector for the crematory will therefore do everything in his power to collect as small a quantity as possible and not be detected by the municipal authorities. The only revenue to be derived from the burning of the garbage he collects is from the sale of the ash, but in most cases fertilizer manufacturers do not consider this ash of sufficient value for them to cart it away from the plant, let alone pay a price for it, because of its poor mechanical condition.

It is apparent in the case of the reduction contractor that a premium is placed upon honest and efficient collection; whereas, in the case of the burning method of disposal a premium is placed upon dishonest service on the part of the collector. Again, does it not seem manifestly wrong to burn up a material which, if intelligently treated by an approved process, maintains in a community a thriving manufacturing plant? Moreover, is it not manifestly wrong to utterly destroy this material when a valuable fertilizer base can be extracted from it by which, after properly treating it and distributing it throughout rural communities, there may be returned to the earth a valuable plant food which in due time will bring forth an abundance of fruit—a point which will be more appreciated, perhaps, as time goes on and our soils become further exhausted?

Having decided that the garbage will be disposed of by a reduction method, it remains to be determined which is the best reduction method. All of the reduction processes are for the purpose of separating the raw material into four parts—rubbish, water, grease and tankage. An average sample of garbage, taken throughout the year, consists of rubbish 6 per cent., or 120 pounds per ton of garbage; water 71 per cent., or 1,420 pounds per ton of garbage; grease 3 per cent., or 60 pounds per ton of garbage.

The 120 pounds of rubbish is composed of a great variety of solid waste matter, such as bottles, tin cans, rags, bits of wood, shells, etc., which should have been separated and placed in the light refuse box by the householder and not mixed with the garbage; but perfect separation is well nigh impossible to obtain. The tin cans, bottles and rags are generally separated from the rubbish, as will be explained hereafter, and sold to different parties. The cans are put through a detinning and desoldering process, the tin and solder finding a ready market, and the iron remaining is melted up into sash weights. The bottles that are not broken are cleaned and sold to junk dealers to be refilled with cheap oils, ketchup, and other food products. The broken glass is also separated and is sold at so much a ton. The rags are washed, dried and sold to the manufacturers of paper. The cans, delivered, bring about $5 per net ton; the bottles about

4 cents per dozen, the broken glass $4 per ton, and the rags bring about half a cent a pound.

The net return from these marketable products is very small because of the amount of labor required to separate them and prepare them for market. The part that is not salable is generally carted away to the dumps, or at certain seasons is burned under the boilers in the plant.

The 1,420 pounds of water in the ton of garbage reduced contains a considerable quantity of glucose and suspended matter and a small percentage of ammonia, but it is of only slight commercial value and is allowed to run away into the sewer. When used at all it is evaporated to the consistency of molasses and added to the tankage just before drying, the combination making what is termed "granular tankage" as distinct from "fluffy tankage."

The sixty pounds of grease to the ton of garbage has the greatest value of any of the products of reduction. This grease is of a comparatively low grade and sells for about 3 cents a pound the year round, the price of the grease varying with the price of tallow, which, on the basis of garbage grease at 3 cents a pound, would sell at 4 cents a pound. It is of a dark brown color and has a slight odor of burnt coffee. This grease is used largely for making soap and candles. The greater part of the American output of garbage grease is shipped to foreign markets, mostly Belgium and France. It doubtless returns to this country again in forms which have successfully obliterated their origin and which we would scarcely care to own.

The remaining 400 pounds in the ton of garbage is tankage. Tankage is the term used for the solid fibrous matter left after the grease and water have been separated in the reduction process. It is used, when properly prepared, as a base for fertilizers, as it contains small percentages of nitrogen, ammonia, phosphoric acid, and potash.

All the American systems of reduction are either modifications of the Arnold, or mechanical system, or the solvent system.

The solvent system reduces the garbage by first drying it and then treating the naphtha or the lighter petroleum oils. This solvent takes up the grease in the process and the grease is then recovered by evaporating off the solvent. The latter is condensed and used over again in the process.

The liquids are pressed out through the perforations in the apron slats, and flow down into a center drain under the press and thence to the catch-basins, where the grease rises to the surface and is pumped up into settling tanks to be prepared for market.

The solid matter, or tankage, is discharged from the end of the press into a conveyor which carries it either into the boiler room, where it is used for fuel, or into the drying department, where it is dried down to 10 per cent. moisture and bagged and subsequently sold to the manufacturers of fertilizers. The analysis of this tankage varies greatly in different parts of the country and at different seasons of the year. A fair analysis taken right from the press would be:

	Per Cent.
Moisture	38 to 44
Grease	5 to 9
Nitrogen, equivalent to ammonia	1.2 to 2.2
Phosphoric acid, equivalent to bone phosphate of lime	4.2 to 7.2
Potash	.2 to .3

It is always a problem to decide what to do with the tankage at a given plant. At times when grease is selling very low and coal is high in price and there is small demand for low grade ammoniates, it pays to burn it under the boilers. Tankage, however, is decidedly inferior fuel because of its low calorific value, and also because of very troublesome clinkers that are continually forming. Tankage ash is worth $1.50 per ton delivered for the fertilizing ingredients it contains.

If there is a demand for tankage in the fertilizer market it pays to dry the material down to 10 per cent. moisture, or commercially dry, when its analysis should show:

	Per Cent.
Moisture	10.
Ammonia	2.8
Phosphates	8.5
Potash	.31

This dry tankage should sell at from $6 to $8 per net ton.

If the grease market is strong and the price of solvents within reason, under certain conditions it is advisable to extract the

6 per cent. or 9 per cent. grease which the tankage contains by percolating it with solvents, such as the lighter petroleum oils, benzine or naphtha, or by the use of carbon bisulphid, or carbon tetrachlorid. The latter solvent is non-inflammable, but unless diluted with a cheaper solvent its cost is prohibitive.

The best method of treatment is to first dry the tankage and then percolate it, using the same liquor over and over again, until it is sufficiently concentrated, when the system is allowed to drain into an evaporator which drives off the lighter solvent to the condenser, leaving the heavier garbage grease which is prepared for market. The solvent held by the tankage is recovered by the application of heat to the percolating tank. It is interesting to note in this connection that the tankage from which the grease has been extracted is now of greater value as a fertilizing material. The grease thus extracted, however, is not as valuable as that extracted by mechanical means.

The catch-basin liquor, after the grease has been taken off, has very small commercial value because it is so very dilute. It contains from .15 to .4 per cent. ammonia, and in some cases we have evaporated it down and added the concentrated liquor to the tankage during the drying process. This makes a granular tankage, which is in greater demand that the fluffy kind, but the price obtained is only a little better—in fact, is hardly enough to pay the cost of evaporation and maintain the evaporators. The cost for evaporator repairs is very high because of the acidity of the liquor, which attacks both shell and tubes, whether of iron, steel, copper or brass.

The New York garbage plant on Barren Island is the largest reduction plant in the world. In the summer months it disposes of 3,000 tons of raw material every day. One can scarcely realize the enormous bulk this tonnage represents without spending twenty-four hours on the island in August. The New York Board of Health is very vigilant in preventing obnoxious vapors arising from this plant because of its close proximity to Rockaway Beach and Coney Island. It requires the fumes to be washed thoroughly in great scrubbers before discharging them into the air.

About two years ago a disastrous explosion occurred in the Boston plant. One is never sure just what ingredients form the conglomeration with which the digesters are filled, and in this case an excessive pressure was formed in one of the tanks from an unknown cause and the explosion resulted, completely wrecking the building.

The records of the quantity of garbage treated at various reduction plants are interesting when examined together. The fluctuation in volume and character from month to month is fairly parallel—the yield highest in August and September—except in the case of Boston, where the greatest yield is in winter, due probably to the greater proportionate summer exodus of the leisure class. The antithesis of this is observed in the plotted curve of quantity at Atlantic City, which has a great peak in the middle of August, the height of the vacation season, as would be expected from such a resort.

The character of the product varies also; but, unfortunately for the reduction plant, the value of the material expressed in terms of grease is much lower per ton when the quantity handled is the greatest.

These records show that a reduction plant should be made sufficiently large to handle the peak of the load in July, August and September, although during the remainder of the year, in most cases, two-thirds of the plant must remain inoperative. Moreover, when this great bulk of garbage is being treated the yield of grease—the principal source of revenue—is least, which is certainly an unsatisfactory condition from a manufacturer's standpoint. This explains the fact that the garbage reduction contractor cannot undertake such a contract without being paid a bonus by the city.

PART V.

THE UTILIZATION OF MUNICIPAL WASTE.

CHAPTER XVIII.

Revenue from Waste Materials—Methods of Utilization.

The first question asked by a municipal officer when considering the disposal of waste is "What will it cost?" He may afterward ask what benefits are to be derived from the proposed process, but in the first instance the expense is to him the chief consideration. The Mayor, the city officials and the members of the City Council are the ones who have the control of the department of municipal work, which includes the collection and disposal of all wastes. Up to within the last few years this department of municipal service has received less attention than almost any other, but the pressure brought to bear upon these gentlemen by the people acting through the various civic organizations, leagues and other associations for the improvement of the city, have made it imperative that there should be better attention paid and more money expended for the treatment of waste than has been done in the past.

It is a gratifying instance of progress to note that many cities are really endeavoring to obtain some accurate information from the tabulation of their own statistics, and are trying to bring themselves into line with the advanced methods, which have succeeded in bettering the conditions in other towns that make a more creditable showing in this branch of civic work.

It has been said that "utilization is the keynote of successful policy in large cities," and there is no department where utilization theories can be so practically demonstrated as in the treatment of the municipal waste. It was said by Colonel Waring in relation to the wastes of New York that there was annually thrown away in the discarded matter a sum of money sufficient to pay for the collection and disposal of the wastes of the city. This was looked upon at the time as being a glittering generality impossible of realization, a mere dream that could never come to pass. But in the three years' service of Colonel Waring he demonstrated that it was not entirely a theoretical idea, but one that could be carried out if it were attempted with thorough knowledge of the requirements, a sufficient amount of money to do the work, and the aid of a Mayor and Council who would support reforms.

Utilization of refuse, which Colonel Waring began, and which in his short term of office brought in a return that was sufficient to pay the expenses of the refuse collection service in the district where this was employed, was discontinued by his successor, and was not revived until another reform administration assumed the reins of government. The efforts made in the past four years for the recovery of the marketable portions of the refuse and rubbish in New York City have shown that there is a value which not only pays expenses of recovery but returns a revenue if the work is properly conducted. This revenue can be utilized in two ways: First, by sorting it and saving such parts of the refuse as are marketable for making paper, and second, by burning the volume collected and utilizing the heat.

THE UTILIZATION OF REFUSE BY SORTING.

The actual cash value of paper stock in New York City is to-day higher than it has ever before been known to be. Everything which is valuable for turning into paper pulp is eagerly bought by the various agencies that deal in this material.

The amount of refuse and rubbish discarded from the houses in the larger cities of the United States is enormous in volume, as, for instance, in New York City it is 936 pounds per capita per annum. In Boston the quantities are about 600 pounds, and in Buffalo available records show that the proportions were still larger. These quantities will probably be found in all the larger Northern towns and increase in the places where natural gas is used for household fuel.

The value of paper is at the present time quoted at the net sum of about $4.50 per ton for the lowest grade of crushed newspaper delivered at the cars for transportation to the paper mills. The better grades of paper bring higher prices. Every form of rags suitable for use by paper makers find a ready market. There is no reason to believe that these prices will be any less, and it would seem to be a measure of economy in every city where this waste is available to turn it to some purpose of revenue, which can easily be done by following the methods already introduced in four of the largest cities of establishing refuse utilization stations.

THE SANITARY SIDE OF THE QUESTION.

Objections have been made to the separation of salable articles from rubbish on the ground of possible communication of contagion to the persons engaged in the separation. The argument is that everything that comes from the house should be destroyed in order to prevent any chance of the spread of contagious diseases, and also because the light rubbish or refuse from the houses contains a large proportion of sweepings and other dirt which must be destroyed. The records of utilization plants do not show that any disease has ever been contracted in this work, and when it is done by the aid of machinery, with the proper appliances, the employees are in no danger of contagion if the sanitary regulations for operating the plant are enforced.

THE USES OF RUBBISH FOR POWER DEVELOPMENT.

Some authorities have claimed that the rubbish and refuse from the city should never be sorted or separated, but should be promptly destroyed by fire, and the heat derived therefrom be utilized for the disposal of other parts of municipal waste. They therefore advocate a separate collection of the refuse and rubbish and its being brought to a disposal station where it may be destroyed without sorting. The work done in New York City at the two incinerators during the past four years has shown that there is undoubtedly great value in the heat to be derived from this operation, amounting to the evaporation of one and one-half to two pounds of water per pound of refuse and rubbish destroyed. Three large disposal plants in other cities are now sorting out and recovering the valuable portions of the refuse, and employ the remainder as fuel, and have been operated for four, five and ten years respectively, returning large revenues to the companies employing this means. But in the case of each of these companies the revenue comes in the largest degree from the sorting and not from the power. The value of this material as fuel depends upon its quantity, since it must be continuously on hand to be supplied to the furnace. If the refuse is very light it burns with great rapidity and the heat is passed into the chimney without being utilized. If the rubbish is wet or moist it burns more slowly and the heat-raising power is decreased. If it is received in quantities too small for maintaining continuous combustion it is of small value for raising steam, as it fluctuates greatly. At the best, refuse or rubbish in small amounts must be looked upon only as an auxiliary to be used in conjunction with more stable forms of fuel.

Whether it is equal to consuming wet masses of garbage has yet to be demonstrated. By the American crematory method of burning light refuse in a part of the furnace, there is very little actual benefit derived from the heat, which quickly passes off, acting only upon the surface of the wet masses of garbage lying adjacent. On the other hand, when refuse and garbage are mixed together and burned under the action of forced draft the combustion is much more efficient and the results in steam raising are greater. This is the method which is required by some engineers in their latest specifications for destructors burning garbage and refuse together under a powerful blast of hot air or steam. By this means all the heat units contained in the garbage, as well as those of the lighter forms of refuse, will be utilized.

THE PAPER MANUFACTURED IN THE UNITED STATES.

The United States is the greatest paper producing country in the world, the annual output being upward of 640,000 tons. In the local consumption of paper this country also leads, with an annual figure of 38.6 pounds per capita, England consuming 34.3 pounds, Germany 29.98 pounds, France 20.5 pounds, Austria 19 pounds, Italy 15.4 pounds. Nearly one-half of the paper manufactured in the world is used for printing purposes. Twenty per cent. is absorbed in the trades and industries, an equal proportion is applied for official and school purposes, and the remaining 10 per cent. serves the demand for private uses.

A late book on the manufacture of paper gives a list of 860 different substances that have been used in manufacturing paper stock. Of these the soft woods are the most valuable and easiest obtained. They are the alder, aspen, poplar, willow, fir, spruce, birch, white pine and chestnut. The amount of wood fibre or cellulose, which is the pulp-making element, ranges in these woods from 33 to 39 per cent. of the whole volume of the wood, but as this is obtained only from the trunk and larger limbs of the tree, the waste is enormous.

One writer in a monthly journal gives some startling figures showing the "Slaughter of the Trees" of the American forests for paper-making. He says "Some one has figured that a big Sunday newspaper needs twenty acres of pulp wood to make the paper for one edition. The Chicago Tribune, a chance instance, uses 200,000 pounds of paper each Sunday, or 400,000 pounds each week. A ton of paper takes about two cords of spruce in the making—to be exact, about 1,750 pounds of paper pulp—not allowing anything for waste.

"The average stand of spruce pulp wood in the regions where it is cut is probably about ten cords per acre. If it costs twenty acres a Sunday, or forty acres a week, and 2,080 acres a year to print one daily newspaper, what does it cost in acreage to print all the newspapers in all the cities and towns of America? Add to this the paper used in books and the enormous editions of our magazines and the total staggers the imagination."

A few months ago, when the advance in printing paper was made by the companies controlling the wood pulp manufacturing interests, it was claimed and shown that the deforestation was proceeding at so rapid a rate that the supply of wood suitable for manufacture in the United States would soon be exhausted. These statements emphasize the necessity for not only conserving the forest to be used in the future manufacture of paper, but also demonstrates that every form of material suitable for the manufacture of various classes of paper should be saved for this work.

In the larger Eastern cities there are many agencies for saving the paper waste. The perambulating junkman goes from house to house, begging, sometimes paying for the various classes of paper until he has collected a load. In New York City the people freely deliver it to the Salvation Army, which makes a business of collecting paper and other marketable refuse waste for the benefit of their fund for improving the conditions of the poor. A much larger percentage is annually collected than is generally known. The paper from shops and stores is largely collected by private parties who receive this as a bonus for removing ashes from the premises.

All of these agencies, taken together, are working for the collection and sale of this form of municipal refuse, and all are presumably receiving a sufficient revenue from the work not only to pay expenses but to make a profit. If the forests of the country now being swept off by the wood pulp industry shall disappear, manifestly it is only a part of municipal wisdom to turn to some useful purpose the printing and other forms of paper which have once seen service and which may repeatedly be renewed and transformed into salable forms of paper for future use

THE COMMERCIAL VALUE OF GARBAGE.

The reports of the reduction processes previously noted show there is a value in garbage of American towns when this is treated by itself for recovery of commercial products. The 3 per cent. (sixty pounds) of grease in a ton of separated garbage, with a comparatively steady value of 3 to 3½ cents per pound, makes this item worth saving, if it can be done at not too great a cost. The tankage is of uncertain value, dependent upon conditions not always under the control of the manufacturers, hence the returns from this source are not to be reckoned as constant. It has a fuel value equal to about one-sixth of its weight in coal, and can always be burned under the boilers of the plant, but with a certainty of rapid deterioration of the boiler tubes and fittings.

The chief difficulty in marketing the tankage seems to be its storage when prices are low, to await a rise. Because of its liability to spontaneous combustion when reduced by the naphtha process it cannot be long held in bulk without great danger of fire. When reduced by steam process it is probably less dangerous, but is still very inflammable and readily deteriorates and putrefies. In short, it must be used quickly if at all, or be burned for fuel if not marketed: The reports of forty or more reduction plants in this country, all with scarcely a single exception, contain records of explosions and fires, more or less costly, and seemingly beyond the power of the owners to prevent. The most rigid regulations for safety from fire appear to be of little protection. The values to be had from garbage when manufactured depends greatly upon the nearness of a market for the grease and tankage. If far distant, the cost of transportation cuts down the margins, and if the quantities produced be small, the storage and handling counts up fast against the profits.

THE COSTS OF REDUCTION.

It seems to be conceded that only when the quantities of separated garbage are seventy-five tons or upward daily, can the work be made to pay as a business venture, unless there be a subsidy from the municipality. One writer says in no place of less than 150,000 population can garbage reduction plants be operated successfully. Another puts the lowest profitable figure of population at 100,000, meaning upon a strictly business basis, without payment by the city for disposal.

These statements are borne out by the results so far as shown by the evidence at hand, since all plants where the work has been done for the profit alone have heretofore failed, and in other cases, where the quantities are small—from twenty-five to fifty tons daily—the plant must have the subsidy from the town to continue its work. This argument has always been advanced when contracts for reduction were pending, and as the costs of the work and the profits or losses were trade secrets jealously guarded, the towns have, under pull, or influence, or a carefully exaggerated idea of the great sanitary value of this means of disposal, granted concessions for a term of years at greater cost to the town than were asked by other methods of disposal.

There was at first an erroneous idea that the reduction methods were very profitable to investors, and many companies were capitalized for operating in the larger cities under concessions that required the towns to pay but a small sum—from 50 cents to 60 cents per ton—for the disposal of the garbage. It presently appeared that the returns were not sufficient to pay expenses, much less dividends, and when the works took fire, as they mostly did, and were destroyed they were not replaced.

Some of the processes that involved the manufacture of a complete fertilizer by the addition of nitrates and phosphates to the tankage could not compete with the regular standard fertilizer of the same grades, and they disappeared from the field. For nearly eight years the reduction work was in the hands of two processes or methods, alike in the main principles of treatment, but differing in minor details of apparatus, and in these years there was almost universal complaints of nuisance from the work.

Not until about 1905, when the older companies had improved their methods and apparatus, and new companies appeared with more rapid and more thorough methods of extracting the oil and drying the tankage, and with greater attention to the sanitary operation of the work, did the process methods make progress.

With improved machinery and methods there came a sharper competition. The veteran corporations that had for successive terms of years in the large Eastern cities held the undisputed control at their own figures, were opposed by the later comers, all ambitious to acquire a foothold in the profitable work.

Up to this time there was but little accurate information to be had as to the real results in a pecuniary way from the work. The contract prices at which the awards were made for five-year terms were always large enough to insure the expenses of the works, leaving the profit, which was dependent upon the quality of the oil and tankage manufactured, and the market demand for these, to represent the profit of the stockholders.

MUNICIPAL REDUCTION PLANTS AND RESULTS.

The sale of the reduction works in Cleveland, which comprised two separate processes, to the city, and the operation of the plant by the city for the last six months of 1905 greatly interested other towns that were about to install disposal works.

For the first time it was then shown that reduction methods could be made to pay the operating costs under municipal ownership. The succeeding years, 1906 and 1907, were still more successful demonstrations of the value of reduction methods honestly conducted for the benefit of the municipality. What this year will show is still undetermined, but with greater experience in management, with the improvement in apparatus already made by the city's engineers, and with a better equipment and system in collection service there is every reason to believe that the revenue from the municipal garbage reduction plant will not fall below the returns of the previous year.

This is an instance of municipal ownership and administration for the benefit of the people that may well be studied by other American cities.

The example of Cleveland is not lost upon other cities. St. Louis, that for twenty years had paid a company $1.80 per ton for reducing its garbage, now contracts for the same work under more favorable conditions for 27 cents per ton. Columbus, that for many years had a part of this work done for 50 cents per ton, at a loss to the company, and was unable to get satisfactory terms from any reduction process companies, is now building its own plant for garbage reduction.

Undoubtedly these examples will lead to the establishment of many reduction plants, the more so as the patents involved do not seem to be of any serious consideration to anybody wishing to enter the field, and it is quite possible that the earlier disastrous experiences of the experimental stages, and failures of ambitious and inexperienced builders, may be repeated. It seems almost impossible for these methods to get a foothold in the smaller towns where the quantities of separated garbage are small. During the past year three plants of small capacity have been discontinued, and none of the same capacity have been built elsewhere.

The treatment of American separated garbage for recovery of the commercially valuable constituents has now become a stable and accepted fact in American disposal work, one to be hereafter recognized as an available means for municipal service in the larger cities, and while these methods cannot always be profitably employed at all places, owing to geographical or communal limitations, it is certain they may be made useful in a large number of American towns.

THE CREMATORY METHODS OF WASTE DISPOSAL.

The primary purpose of any apparatus for waste disposal is the destruction of waste matter. From the viewpoint of most town officials in charge of waste disposal that means is best which most quickly and most cheaply does the work. Hence, anything that will give temporary relief, and push the final solution to another's shoulders, receives more attention and has a better chance for adoption than another means which is proven more efficient and will give better results for a longer term, but at higher cost for apparatus.

Thus, in American towns the destroyal of garbage by fire was at first done in small cheaply built furnaces that required constant supply of fuel, and were at great expense for repairs and renewal of plant. Afterward, when the refuse of the town was burned at the dumping places, giving rise to volumes of nauseous smoke, this waste was brought to the crematories, which were then made larger for the double work. There was still the need of fuel, for the crematory construction was not well adapted to retain and utilize the heat from the combustible matters.

The increased volume of garbage and refuse demanded much larger furnaces at greater cost for buildings and more men for operating. Thus, the expenses of the installations have nearly doubled those of the earlier years, without a proportional increase in capacity or efficiency of the plant or of its sanitary performance.

In the larger cities the disposal of garbage by the crematory has met with very unsatisfactory results. The largest plants now operating, of four different types of construction, do not give results that correspond with the contracts under which they were built. The incinerators at Atlanta and Los Angeles, built under a stipulation to burn 200 tons per day, are not able to destroy more than one-half the amount. The 140-ton incinerator at Winnipeg has never yet been able to meet the contract conditions as to quantity and cost, and is not accepted by the city.

The 100-ton plant at Tampa has never been called upon to destroy the required quantity in continuous work. The cremator at Milwaukee has never met the specifications of amounts destroyed, or costs of operating. The incinerator at Montreal does not consume the specified quantities, and the operating costs are more than double the contract's requirements. These are the largest garbage furnaces now working under municipal management, and in each case the guaranteed quantities and the operating costs have not yet been fulfilled.

The smaller crematories and incinerators are in a similar position with respect to capacity and expense of operating, though in some few cases the contract for capacity is more nearly met, but the actual operating costs are always greater than the guarantees if taken over a period of a year. When a trial under the best conditions approaches the operating costs according to contract, it is assumed that this is the operating cost for all other furnaces of this make at all places, and contracts are acquired under the promise to do similar work that never are fulfilled, nor were expected to be fulfilled when they were made.

The contractor takes the chance of getting his furnace accepted under a guarantee of low costs of operating, largely because of the indefinite way in which the amounts and character of the waste to be burned is stated by the town, or if no statement of quantities and character is given, then, upon the presumption that these will agree with his own estimate of what are the amounts and kind of waste to be destroyed. He makes his own estimate, guarantees the cost of disposal, and when he comes short of the guarantees, sets up a claim that his conditions are not met, threatens litigation, and finally compromises upon some basis that gives the town the possession of a plant that is not satisfactory. Then, the contractor having received the highest price for his plant under his promise of lowest operating cost, and usually being paid a large proportion of his price before trial, leaves the town with a more or less comfortable margin of profit, and departs to seek fresh fields and other confiding municipal officials.

Sometimes, but infrequently, this programme is interrupted by the demand of the town that the contracts be fulfilled, and then there is trouble, ending in cancellation of the contract and return of payments made or a compromise that leaves both parties dissatisfied. Better engineering advice and more care in preparing the first specifications, with more definite statements of quantities and character of waste, and more rigid and exact conditions for construction and working costs over a period long enough to get a knowledge of what is really accomplished, would go far to obtain better results and avoid the mistakes of the years past.

Disposal by crematories and incinerators is an absolute outgo for expenses of construction of large plants, for the cost of fuel and labor to operate them, with no return of anything of value from the work.

UTILIZATION OF WASTE BY DESTRUCTORS FOR STEAM POWER.

In contrast with the crematories and incinerators that receive the garbage and refuse on large areas of grate surface, that proceed by a slow process of drying and burning at low temperatures with the aid of extra fuel, and that obtain no residuum of any value, are to be placed the destructor methods that proceed by receiving and temporarily storing the same amounts of waste, either in a separated or a mixed condition, and burn this upon smaller area of fire grates, at a far higher temperature, in no longer time with no added fuel, with a residuum of vitrified clinker useful for many purposes, and with the production of steam power that, when utilized, reduces the cost of operation to a figure impossible to be obtained by any other means.

A comparison of these two methods when applied to the American conditions will naturally suggest some points common to both, which may be stated thus:

(a) Area of ground required: For destructor—20 per cent. less than for incinerators.

(b) Initial cost of plant complete: For municipal work, in quantities of 30 tons up to 75 tons daily, the cost for destructor plant is 15 per cent. more than for incinerators. This is for the added boiler and machinery equipment.

(c) Capacity of plant: A reserve capacity for the same relative quantities in favor of destructor because of storage of waste and more economical use of time in disposal.

(d) Durability of construction: Is greatly in favor of destructors, as proven by continuous work of more than 300 destructors against the intermittent work of 180 crematories or incinerators, of which over one-half are discontinued.

(e) Temperatures attained: In destructors the minimum is 1250° F., the maximum 2000° to 2700°, the average 1500° to 1900°. This destroys, within the furnace, all consumable gaseous compounds. In crematories and incinerators the initial temperature at the fire box rarely attains 1500°, with a continuous loss of heat for every foot of distance to the chimney.

(f) The addition of fuel is not required in destructors, but is a necessity in all crematories.

(g) The gases of combustion are consumed by the destructors within the furnace; in crematories and incinerators they are incompletely destroyed in their rapid passage over fume cremators.

(h) The power developed by destructors is an asset or revenue, but in crematories and incinerators the heat is passed direct to the chimney and lost.

(i) The residuums of destructor work are vitrified clinkers useful for several departments of municipal service. The soft ashes from crematories have no value except for filling ground.

(j) The scope of usefulness of destructors covers every form of municipal waste that fire will affect; the crematories can deal only with garbage, but are not able to burn or attempt to convert house ashes into power.

OPERATING COSTS.

There has been much misrepresentation of the facts concerning the operating costs of American crematories. As before stated, when preliminary trials are made under the control of the builders the expense of operating sometimes very nearly approaches the guaranteed costs, but not in many cases is this point reached. But when the cost of operating these crematories is taken for one year's time it invariably results in expenses being much greater than the guaranteed cost. An examination of the work done by the American crematories over a period of over twenty years makes it very clear that the actual cost for destroying garbage and refuse, when fuel is necessary, will approximate the sum of 50 cents per ton, and this may be taken as the lowest price which can be reasonably expected in all yearly periods of the work covering the successful operations of the garbage crematories.

Statements made that the garbage can be destroyed at 22 cents to 35 cents per ton for operating costs and labor and fuel are not borne out by facts. If we assume an average price of coal at $4.50 to $5 per ton, the costs for disposal will certainly rise to nearly 50 cents per ton for actual expenses.

The operating costs of destructors, so far as is demonstrated by the four installations now at work, run from 50 to 70 cents per ton for actual expense of labor. This is because there is required a steam engine foreman competent to run a boiler, whose wages are higher than the ordinary attendant. The report previously noted from Vancouver is an example of this case. Here the garbage and refuse is destroyed by destructor servic with no utilization of the power, and the cost approximates 56 cents per ton.

The use of the same apparatus of the modern high temperature destructor disposing of garbage mixed with refuse under forced draft will in American cities be found to perform the work at a cost not to exceed from 50 to 60 cents. Now, when a credit is made for the development of power which is produced by the destructor, the operating costs will fall from 50 cents to 30 cents or less per ton.

It must be borne in mind that these figures do not include expenses of depreciation or capital charges on the cost of the plant.

There is no doubt but what the work in this country can be brought to the same ratio of expense as is done abroad, but it must be remembered that the cost of wages here is about double what is paid to the same class of labor in England. Therefore, the operating expenses must be larger when compared with destructors in other countries.

The Utilization of Municipal Ashes.

The preceding tables and comments thereon bring out the fact that there is undeveloped value in ashes removed from the households of the people. This is particularly true of the ashes of anthracite coal. Some part of this coal is now recovered from the dumps by that class of the people who make dump-picking their livelihood. Among the many articles which can be recovered, the coal is probably the most valuable item, and of this only a small per cent. of the total quantity is saved, as the most part is in too small fragments to be picked up. But when the fine dustlike ashes are taken out by screens, and the coal and clinker afterward separated, then the volume and value of the coal is clearly apparent.

This has been tried at one city where the waste disposal works by incineration receives the mixed mass and separates the fine ash before combustion.

The real value of municipal ashes as applied to many purposes is well illustrated in the following paper by a gentleman whose labors in this field of sanitary engineering have extended over a long period, and whose opinion may be taken as the latest expression on the value and uses of this form of municipal waste.

UTILIZATION OF CITY ASHES—BY C. HERSCHEL KOYL, CONSULTING ENGINEER.

Clean anthracite ash should be an article of commerce and not a city waste.

It contains on the average 45 per cent. fine ash, 30 per cent. clinker and stone, and 25 per cent. unburned coal, much of it untouched by fire.

The fire ash can be made cheaply into excellent brick and mortar; the clinker and stone are first-class material for fireproof floors and for the frost-proof beds of sidewalks and yard pavements; the coal has a fuel value 75 per cent. that of new coal, and for some purposes is better.

The above statement presupposes the possibility of separating these substances from each other. This is no longer difficult, and no more costly than the original mining of coal and its separation from slate, while this latter separation has the advantage of being made at the doors of the market instead of a couple of hundred miles away, and of leaving no waste product.

The separation cannot well be made by the family, because of the dust and the small value recoverable from a single fire. It must be made by machinery and on a large scale. But the family can keep its ashes clean, and the city must do the same, for it is not easy to separate a mixture of ashes, street sweepings, newspapers and bed-springs. The plan is practicable in any city using hard coal, and populous enough to warrant a separate collection of ashes—say a city of 100,000 people.

Statistics of the Borough of Manhattan, New York City, will serve for general illustration:

The population is, say	2,200,000
The ashes collected, say (tons)	1,500,000
The latter consisting of:	
Fine ash (tons)	675,000
Clinker and stone (tons)	450,000
Coal recoverable (tons)	375,000
	1,500,000

The weight of each of these is approximately one ton per cubic yard.

Coal is the most valuable and most readily salable product of the separation. It is surprising to find in the ash so much coal indistinguishable from that fresh from the mine. It is of all sizes from furnace down, but is mostly nut. The mechanical process of separation is so exact that not only can the coal be separated from the clinker and stone, but the fire-marked coal can be separated from the unmarked.

Nearly half of the product is coal salable at the price of new, and I estimate the average selling price of the recovered coal at three-quarters that of new coal in the same city. The total cost of separation is less than one dollar per ton of recovered coal (the operating expenses being about twenty-five cents), and if the total cost of the separation be charged to the coal the profit will be the difference between this and three-quarters of the wholesale price of new coal in the place in question. In New York the profit should not be less than $2 per ton.

The uses of clinker and stone may be illustrated as follows:

There is necessary under sidewalks, flagging and cellar floors a substratum of loose, dry material which will not readily bring up the water of the underlying earth, and which in winter will not readily be affected by frost, since its porosity will furnish room for internal expansion. It has been customary for some time to lay such walks with a substratum of from four to eight inches of clinker, and men in the business say that nothing else is so satisfactory for the purpose, and that nothing else would be used if clinker were always available.

There is laid annually in Manhattan not far from 900,000 sq. ft. of new sidewalk, and about as much more in flagging and cement walks for rear yards; and the annual area of new cellar floor is not far from 8,500 sq. ft., which makes a total of 10,300,000 sq. ft., and this if underlaid to a depth of six inches would require 5,150,000 cubic feet, or 190,000 cubic yards of clinker.

Use in Fireproof Floors.—The most extensive present use of clinker, however, is in the construction of fireproof floors of large office buildings, warehouses, and the first stories of all apartment and tenement houses more than four stories in height. Here the steel floor-beams are from 10 to 15 inches deep to afford sufficient carrying capacity; the support is completed by brick arches which rest upon the flanges of the beams, and the upper portion of such floors, to a depth of about six inches, is filled in with clinker, preferably, and always when it is procurable. A large office building requires more than 5,000 cubic yards of clinker. The total annual amount of such new floor space in Manhattan is about 600,000 cubic yards, and there is not enough clinker to fill it.

Utilization of Fine Ash in Building.—There are several methods of making up fine anthracite ash into brick, mortar, mortar-board and material for interior decoration. The ash must be finely sifted but the results are always good. The cheapest method is to combine ash with a small proportion of freshly slaked lime, press it, and if it is properly made get *next day* a brick which in all essentials is the equal of ordinary red brick, and which makes a stronger wall because ash-mortar is stronger than lime-sand mortar. The ash must be fine, and the best results are obtained by the intimate mixture with lime by a machine, on the order of machine-mixed lime-sand mortar now so extensively used.

Of course, a new building material must win its way, but it is a safe statement that if ash-mortar proves to have greater strength and more enduring qualities than lime-sand mortar it will be welcomed as a substitute by architects, and if it can be furnished at a less price it will be welcomed by builders. The field is large because ash-lime is lighter, stronger and cheaper than lime-sand for mortar, mortar-board and plaster.

The present law in many places is that "mortar shall be made from clean, sharp sand," but this is merely a protection for the public against "mud" mortar, and if ash-mortar proves better than mortar made from "clean, sharp sand" the law can undoubtedly be amended to include also the better material.

From present indications I see no reasons to doubt the early and extended use of fine anthracite ash for various building purposes, and, as I have said in another place, "it will be the perfection of 'waste' utilization to build dwelling houses in June from the dwelling house ash of May."

UTILIZATION OF WASTE BY GAS PRODUCER METHODS.

In January, 1900, when the merger of the gas, electric light and power companies in New York City was about to be consummated, and these interests brought under one management for self-protection and to avoid competition, the question of obtaining power from the city's waste for the uses of the consolidated stations was brought forward in the public press. Many communications on the subject were printed, among them two letters from eminent engineers, which gave clear ideas of the possibilities of these means of disposal and waste utilization, and showed what might be done not only in New York but also in all the cities of this country.

The two letters referred to, those of Mr. George Westinghouse and Prof. R. H. Thurston, are given below:

THE GAS AND POWER MERGER.

To the Editor of The New York Times:

The bringing together of the gas and electric light and power interests in New York should result in great advantages to the public and to the interests so combined, provided the latest developments in gas and electric engineering are investigated and availed of. Among the numerous questions affecting the health, comfort, and convenience of the citizens of New York (and of all communities, in fact) are three of especial importance, viz.:

The disposal of garbage, the abatement of the smoke nuisance due to the increasing use of bituminous coal for steam power purposes, and the securing of an adequate supply of water.

From statistics there appear to be created daily in New York about 500 tons of garbage, or at the rate of one-half pound per capita. Such garbage is about 20 per cent. carbon and 80 per cent. water. By a process which has been well demonstrated on a small scale, and which is being rapidly brought to a commercial basis, all of this garbage can be economically, and without offensive odor, converted into a fuel gas of great value. In the same apparatus and by the same process soft coal can be made into a gas suitable for power and heating purposes.

The fuel gas made from garbage and soft coal can be used to drive gas engines with electric generators, and the electricity thus produced can be used for light and to drive motors to the exclusion of the thousands of steam engines and boilers which make such demands upon the water supply, since the gas engine central stations can be so located that the water needed for engine-cooling purposes can be taken from the river.

Bearing upon these questions, and of especial importance, are the partially executed plans of the electric power and light corporations, viz., the Metropolitan, Third Avenue, and Manhattan Elevated Railways, and the New York Gas and Electric Light, Heat and Power Company and the United Electric Light and Power Company. If their present plans, which are fairly well known to the engineering profession, are carried to completion, each will have one large steam station on the East River between Twenty-ninth Street and the Harlem River, with about 75,000 horsepower of engines, boilers, and electric machinery, making an aggregate of 375,000 horsepower, and which may be largely increased when the underground rapid transit railway is completed, and still further when the electric locomotive is used on all steam railways within the city limits.

If these corporations, which might as well buy electricity as the machinery, coal, and water with which to produce it, were to unite in a common plan to provide the electricity needed in their operations by the adoption of the best available methods, the saving to each in capital expenditure would be very great, and the decreased cost of their supply of electricity would make an important addition to their earnings applicable to the payment of dividends; while, most important of all, the citizens of New York would have solved for them the garbage, smoke, and very largely the water questions.

I believe the contemplated plans of the corporations above named, which can be shown to be based upon an imperfect knowledge of the subject, will stand in the way of vast public interests, and, so believing, I have said to representatives of some of those companies that the near future would demonstrate the projected power stations and systems of electrical distribution incidental to the character of such stations, to be as far from the best as are the old cable systems for the propulsion of cars.

I write this letter because I believe these subjects are just now worthy of investigation, discussion, and elaboration.

GEORGE WESTINGHOUSE.

New York, Jan. 9, 1900.

PLANTS FOR USING REFUSE.

To the Editor of The New York Times:

I have been much impressed by the suggestions of Mr. Westinghouse's letter of the 9th published in *The Times* of the 10th inst. It suggests thoughts far more wide reaching than at first may appear.

The primary principle which underlies its text is that of the combination of all the essential public utilities in such manner as to insure the most economical production possible. This does not, in this case, mean so much a reduction of total costs to the public as an increase of availability of the product for the average citizen. When gas is permanently reduced to 50 cents per 1,000 cubic feet we may all use it in our kitchens and to some extent for heating and in manufacturing, while the city will employ it in making more extended and efficient the public lighting outside the range of the electric light. When the electric light can be supplied at a half or two-thirds its present average cost, the urban lighting of our communities will be doubled in area and efficiency, and the comfort of honest citizens and their safety and the repression of disorder and crime will be vastly greater than now. As is almost invariably the fact, the reduction of price and costs will be met not so much by saving as by extending the benefits of all utilities. When garbage can be made to contribute to our comfort and health instead of being a perpetual menace, our householders will find comfort in that fact, and our taxpayers will be relieved.

In every city in the country this combination of all sources of power in a single center and the production of heat, light, power, and electricity, and the incineration profitably and wholesomely of all garbage should be provided for. Such a wise and sound method of engineering these enterprises would enable many a small city or even village to supply its people with water and light, and to relieve itself from the dangers of typhoid-charged water and of fever-breeding garbage, whereas it must otherwise wait many years for the comforts of modern life. The gas, electric, and water supply "plants," and the garbage incineration arrangements should all be combined, not so much to reduce costs of product and of necessary expenditures as to make it practicable for our cities to secure well-lighted streets, an ample supply of pure water—artesian if possible—for drinking and industrial purposes, a complete and useful disposal of refuse matter, and all at minimum charge in the tax levy. But it is the wide distribution of these great blessings rather than the reduction of the aggregate cost to the city of such charges that should be sought.

Mr. Westinghouse has himself done much to render this important change practicable, not simply in his contribution to the art of electric lighting, but also, and more extensively and in a more important degree than is generally realized, in his work in the direction of placing beside the steam engine as a source of industrial power a distinctly dangerous rival in the gas engine of large power, gas engines of 500 and 600, and, in a few instances, of 1,500 horsepower, and operating with exceptional economy, having already been produced. The scheme for the conversion of the potential energy of our garbage into useful power, as a part of the larger plan, is by these facts rendered so much the nearer practicable, and the day of this form of industrial extension so much the closer at hand.

We find ourselves, as Mr. Westinghouse himself has elsewhere stated it, in "A New Industrial Situation." Happily, it is one in which all parties to the present and older situation may be advantaged. The realization of this proposed modernization of the city public utilities in this manner will extend the market for the sale of electric light and for gas, and thus increase the profits, as always occurs, on the extended business. It will make our very wastes, by way of the kitchen door, a source of health and profit and free us from some of the most serious of all the risks and disadvantages of crowded city life. Where it is practicable in the usual case —in fact, to introduce the provision of needed power for a pure-water supply in the scheme, the free use of wholesome water will become a continually growing source of health and comfort and godliness.

Nowhere in the world is there a greater opportunity offered for the full exemplification of this plan and its economical advantages than in New York, and nowhere is it possible to accomplish more for a crowded population than in that city. With pure water in plenty for the poorest, liberal use of electricity for light and power, and of gas, where suitable for lighting, and in the now common and economical forms of gas engines of every magnitude, from 1,500 horsepower down, with sanitary conditions perfected by proper disposal of garbage and sewage, New York should become an ideal residence city. Nature has there done her best, and it only remains for man to do his very best in the light of modern science.

This is hardly less true of all large cities, but that is not the most or the best possible. The larger proportion of our people, so far as urban at all, live in small cities, and these may, under such ideal conditions as are here contemplated, become at a comparatively early stage in their growth well lighted, healthfully provided with water, and sanitarily insured against danger from refuse, now a source of sickness and death, and at a reasonable cost, may be given all the comforts of city life.

R. H. THURSTON.

Ithaca, N. Y., Jan. 12, 1900.

The exceptionally good opportunity pointed out by these gentlemen for refuse utilization and power production in the city of New York was never allowed to be improved. The monopolies holding the control of the gas, electric light and power interests were powerful enough not only to discourage any attempt at utilization of waste, but also to stop efforts in this direction made by private parties and the city authorities.

The situation in New York to-day is practically precisely what it was eight years ago. The city gives to a disposal company $1.25 a ton to remove the garbage from its wharves, and also gives this company all the valuable products derived therefrom. It turns over to a contractor the dry refuse, which annually amounts to 150,000 tons, for which it receives the nominal return of from $40,000 to $50,000. This item is the only one from which the city derives revenue from waste. The volume of ashes, something like 2,000,000 tons per year, is taken by a contractor from the city's wharves, at a cost of $500,000 per year to the city, and is deposited on dumps where are annually buried, beyond any chance of recovery, 400,000 tons of good coal. This procedure may be called "municipal wastefulness" rather than "municipal waste utilization."

TURNING GARBAGE INTO GAS.

When the foregoing letters of Mr. Westinghouse and Prof. Thurston were written the production of gas by the "producer" method, and the introduction of gas engines was just beginning. Since then some important advances have been made, and the use of engines driven by this power has been greatly extended. But the method of producing gas from garbage has yet to be developed. Some experiments have been made by which it is proved that gas can be made from many forms of waste products, among them being the mixed collection of municipal waste. The subjoined special article by an engineer qualified by years of practice and experience in the field of gas production gives an idea of this possible use of unseparated city refuse.

THE DISPOSAL OF CITY WASTE BY GAS PRODUCERS

BY F. C. TRYON, Consulting Engineer

The use of city waste, such as ashes, refuse and garbage in gas producers for the double purpose of incinerating the waste and utilizing the products of the process in the form of producer gas for power purposes is perfectly practical, and the process of disposal of this waste should not be obnoxious to the surrounding territory.

I have examined the tables sent me showing the calorific values of the various constituents of this waste material, which I find to be about as follows:

Taking a quantity of 50 tons miscellaneous city refuse as gathered in New York the proportions will be:

Ashes 70%	35 tons	Fine ashes, Clinker, Coal
Garbage 20%	10 tons	Moisture, Solids
Refuse 10%	5 tons	Combustible, Incombustible

Ashes (screened)	65%	22.75 tons
" clinkers	20%	7.00 "
" coal	15%	5.25 "
Garbage moisture	70%	7.00 "
" solids	30%	3.00 "
Refuse combustible	95%	4.75 "
" incombustible	5%	.25 "

From an analysis of the above we find:

Coal 5 tons average calorific value	10,000 B.T.U. per lb.
Garbage 3 tons solids, average cal. value	8,243 " "
" 7 tons moisture,	
Refuse 4.75 tons, average calorific value	8,437 " "

When the above 50 tons of waste have been screened and sorted we have ready for incinerating 19.75 tons. All the remaining 30.25 tons is in the form of fine ashes, clinker, bottles, broken glass, etc., available for filling for low lands. When separated the clinker is an excellent base for concrete streets and walks, and has a value equal to its removal expense. The 19.75 tons combustible material contains the following B. t. u.:

5 tons coal	10,000 lbs.,	10,000 B.T.U. per lb.	= 100,000,000
3 tons garbage, sols.,	6,000 "	8,243 " " "	= 49,458,000
7 tons garbage, moist.,	14,000 "		
4.75 tons refuse	9,500 "	8,437 " " "	= 79,151,500
19.75 tons	39,500 lbs.		228,609,500

Deducting the moisture, 7 tons, 14,000 pounds, will leave 12.75 tons, or 22,500 pounds of dry matter.

The 19.75 tons (39,500 pounds) of solids will carry 7 tons (14,000 pounds) moisture. This will not be prohibitory for producer practice. The proper way to handle this would be to have the whole mixed collection delivered at a dumping plant. Under such a method the ashes are elevated and dropped on to screens separating the coarse clinker, the fine clinker, coal and fine ash. The clinker and coal are then run through a jig which washes the coal from the remainder. The refuse passes over a sorting belt where articles of value and all pieces of glass are removed, and the remainder is then carried to a chopping machine where it is all cut into small pieces. This fine refuse, which is very dry, is then mixed with the wet garbage and all elevated into storage bunkers arranged above the producer plant. The coal is also stored in adjoining bunkers, and all are arranged so that the material in each plant can be spouted direct into the producer without further handling.

The 12.75 tons, or 25,550 pounds of solid matter, carries 226,609,500 B. t. u., or 8,887 B. t. u. per pound, available for use. Since this 12.75 tons is all perfectly dry refuse it is necessary to use steam in the producer to prevent clinkering of fire bed, and the usual practice is ½ pound steam to 1 pound fuel. This requires 1,270 pounds steam to the ton, therefore the addition of 7 tons (14,000 pounds) moisture contained in the garbage is not excessive to keep the heats of producer in reasonable working condition.

A down-draft producer working with open top, so that the fuel can be spouted direct to top of fire bed, will at all times have the fire under the observation of the attendant, and it can be poked and barred as necessary. All hydro-carbons are distilled from fuel at top of fire bed and drawn down through bed of incandescent carbon, passing from the bottom of the producer a fixed, noncondensable gas. The ashes from the combustion of this miscellaneous material is barred down from time to time mechanically without opening the producer to the inlet of air. This ash removal can be arranged for continuous operation, if desired, so that fuel will be flowing in at the top of the producer, ashes be taken out of the bottom, and gas drawn off near the bottom.

A producer arranged as described above would easily deliver in clean gas 60 per cent. efficiency of the B. t. u. fed to it. Thus it would produce 135,965,700 B. t. u. in gas.

If this volume were the product of twenty-four hours of incineration it would produce 5,665,237 B. t. u. per hour, easily driving 450-horsepower of gas engines to full load, supplying 330 kilowatts of electric energy. If this current were sold to an electric lighting company at its own cost of production, say 2 cents per kilowatt per hour, the income from such a plant would amount to $53,557.55 per year. The expense of installation designed to handle 50 tons of miscellaneous city waste collections per day would depend very much upon the locality where it was erected and the permanency of the plant.

Assuming a permanent fireproof building two stories high, 50 x 60 feet, on two lots 25 x 100 feet, concrete construction, the cost of building and land in a city of New York equipment would be:

TWO GAS PRODUCER PLANTS:		
Two gas engines, electric generators and necessary machinery for lifting, sorting and handling the 50 tons per day, say		$85,000.00
COST OF OPERATING PLANT:		
Interest, depreciation, repairs, taxes, and insurance, 18%	$15,300.00	
Labor, 1 superintendent, 2 foremen, 8 men to shift, 2 shifts	13,600.00	
Supplies, Water, Oil, Waste	1,600.00	
Total cost yearly operation	$30,500.00	
Electric current sold		$53,557.55
Selected waste sold, 855 tons, $2.50		2,137.50
		$55,695.05
Cost		30,500.00
Profit		$25,195.05

The above shows a fair return on the investment, and I am convinced that the materials can be utilized as described, and that the products will amply repay for the investment, even though the profits should not be quite as much as shown.

One great advantage of this manner of disposal is that there is no smoke, smell, or other obnoxious fumes from the plant. These are saved in the form of gas.

The garbage could be disinfected as delivered at the dump in a manner that would really increase its calorific value. All dust and dirt from the screening of the ashes could be kept within the chutes of the building. The selection of a site for such a plant should be at a point where the surplus refuse of fine ashes and cinders could be handled and disposed of in the least expensive manner, and at the same time the plant should be located in a place where the gathering and delivery of a certain district supplying the 50 tons daily should not have too long a haul to the dumps, also having in mind the delivery to some main line of wire distribution for the electric current to be disposed of.

The foregoing answers the inquiries usually made, and may be of use in determining one of the many ways of utilizing and disposing of the waste of a municipality.

The calculations in the foregoing statement are based upon data obtained by calorimeter tests in the laboratory. The range of these theoretical values is much higher than it is found to be in the actual work of disposal by destructor processes. In practice there is a difference of nearly one-half less in the calorific values per pound than is assumed by Mr. Tryon; consequently there would be a corresponding reduction in the results as compared with what he records. But there must be taken into account the fact that the method of the gas producer in dealing with this waste is more economical in its operation than any form of incinerator can be. It is therefore fair to assume that the results obtained from municipal waste in a mixed state by the gas producer process would be at least equally good as those developed under combustion by forced draft, and that the figures submitted in the foregoing statement, while they may appear to be rather high, will, if discounted one-half, show that this method of waste disposal is one that will return a very fair revenue, far more than sufficient for the operation of the plant. Experiments have been made with municipal waste under this form of disposal and have proved successful, although there is no gas producer operating altogether by this fuel.

UTILIZATION OF REFUSE BY CRUSHING OR GRINDING, AND MANUFACTURE INTO BRIQUETTES.

Reference has been made to the method of grinding up the refuse of the city of Paris to prepare it for use at the adjacent market gardens and farming lands. Though this method has been in use for three years in three of the city districts, there are no reports that show more satisfactory results than those from three other districts of Paris where the final disposal is made by three Meldrum destructors.

Meantime, an English town—the Borough of Southwark—placed in operation in October, 1906, an apparatus for crushing or pulverizing house refuse, practically without any previous sorting, and using the crushed material as a dressing for land. The house refuse is brought to the plant in wagons, dumped in front of the machines, and shovelled into the crushers—about 5 per cent. of large material being thrown out. From the crushers the material falls into conveyors that discharge into railway cars in which it is carried to purchasers.

They have found it valuable for use on heavy soils and grass land and the sales have increased from 203 tons in October, 1906, to 925 in March, 1908. The average selling rate is about 56½ cents per long ton, which includes hauling. During three months in 1907 it was necessary to store the material, which was sold later.

After operating for one year it was decided to double the capacity of the plant so as to deal with all of the refuse of the town. The new machines are made somewhat heavier than the first ones and it is believed that this will permit reducing the cost of beaters and grids. Operating two plants will also effect a saving on the labor of each.

The first plant consisted of two machines, which, with motors, shafting, etc., cost about $8,300, or $11,000, including foundations and buildings. At first, difficulty was experienced in the breaking of various parts of the plant by the iron and steel found in the refuse. This was overcome by replacing these parts by heavier ones.

This plant was described by the borough engineer of Southwark, Mr. A. Harrison, in a paper read at the recent Municipal, Building and Public Health Exhibition. In conclusion he stated that he preferred this plant to a destructor as it occupied very little space and crushed the refuse without the slightest nuisance from dust or smell and practically dealt with the whole of it. It has also been found that a considerable quantity of food condemned by the Sanitary Department could readily be disposed of by passing it through the crushers with the other refuse.

The material treated as above described is the ash bin refuse produced by English families, who dump ashes, garbage and all house refuse into one bin or receptacle.

The following extracts from a paper by Mr. Herbert Coales, Town Surveyor, Market Harborough, describes the machinery and his method of treating this crushed or pulverized material for manufacture into fuel:

COALESINE FUEL: UTILIZATION OF HOUSE REFUSE

The author has proposed to destroy refuse in a remunerative manner by converting it into fuel briquettes—called "Coalesine"— and burning it in works, boilers or other grates, without the construction of special furnaces. If such a hygienic and remunerative method of disposal can be demonstrated, then no pecuniary hardship will accrue to any town through any anti-tipping enactment that may be hereafter passed. Two main reasons may be indicated for converting ashbin refuse into fuel:

(1) Crude refuse is a nuisance, which may be abated by subjection to fire.

(2) Crude refuse is a fuel, which may be utilized in the production of heat.

PULVERIZATION OF REFUSE

The Patent Lightning Crusher Co., of the Southwark Engineering Works, have perfected a machine, known as the dust manipulator, which instantly converts crude ashbin refuse into a material resembling garden mould in appearance. The machine is a high speed centrifugal-force disintegrator, pulverizer and mixer combined. The hammers, weighing 50 lbs. each, of special alloy steel, are hung on an axle in a steel box; this axle makes 1,000 revolutions a minute. The refuse is fed by a shovel into a hopper, and can be passed through the manipulator at the rate of from 4 to 5 tons per hour. The Southwark Borough Council have four of these machines at work, and the facility with which they disintegrate tins, old sacking, wood and what not, is most surprising to those who see the machines at work for the first time. Such large articles as old trays or buckets are picked out from the refuse by hand, and any obstinate metal which cannot be reduced by the hammers is automatically ejected from the machine by a door at the front. It has been proposed in the past to pulverize crude refuse in mortar mills, etc., but salmon tins, old garments and books, or pieces of wire, for instance, cannot be reduced to a fine material by such means. Therefore, until the Patent Lightning Crusher Co. introduced the manipulator, there was no machine on the market to effectually reduce crude ashbin refuse to a fine uniform consistency, in which state only can it be briquetted.

COALESINE FUEL

To convert the pulverized material from the manipulator into innocuous, serviceable fuel briquettes, three things are necessary:

(1) Addition of a deodorizer.
(2) Addition of an agglutinate.
(3) Addition of an enriching ingredient.

Most fortunately for the simplicity and cheapness of the manufacture of briquettes, tar is both a deodorizer and an agglutinate, as well as a high class of fuel; 1 lb. of tar will evaporate 11 lbs. of water. By the incorporation, therefore, of about 18 gallons of tar to the ton, the pulverized refuse is deodorized, agglutinated, and enriched by one operation. The enrichment has the effect of adding 100 per cent. to the calorific value of poor refuse, and 50 per cent. to refuse of a good calorific value. But fuel in the form of slack does not give the best combustion results; it is necessary, therefore, to make the material up into briquettes, in which form it is easy to handle, to store and to burn.

The proportion of 18 gallons to the ton of pulverized material does not allow the tar to escape through the grate bars when subjected to the heat of the fire, nor to give off smoke from the chimney shaft through incomplete combustion.

The approximate cost of plant, including manipulator, mixer, briquette press, buildings, and power to convert 10,000 tons of ashbin refuse per annum into coalesine fuel is from £2,000 to £2,500; or, say, an initial capital outlay of from 4s. to 5s. per ton of refuse to be dealt with in one year.

From the tabulated statement prepared by Mr. Wm. Jones, Assoc. M. Inst. C. E., of Colwyn Bay, in October, 1907, it appears that the initial cost of installing refuse destructors complete (taking the average of sixty-nine towns) is 16s. 5d. per ton of refuse to be dealt with in one year.

The approximate cost of converting ashbin refuse into coalesine fuel, including labor, power, tar, wear and tear, and loan charges, is calculated at about 4s. per ton.

CALORIFIC VALUE OF COALESINE FUEL

When one pound of crude refuse will evaporate:

(a) 1 lb. of water, coalesine fuel will evaporate 2¼ lbs., or .25 the value of best coal.

(b) 1½ lb. of water, coalesine fuel will evaporate 2¾ lbs., or .31 the value of best coal.

(c) 2 lb. of water, coalesine fuel will evaporate 3¼ lbs., or .36 the value of best coal.

(The calorific value of best coal is taken at 1 lb. evaporating 9 lb. of water.)

Roughly speaking, then, coalesine fuel may be taken as having an average calorific value of one-third that of best coal. Where the local price of coal is known, therefore, the relative value of coalesine fuel may be easily found by dividing the price of coal by three, and comparing the results with 4s a ton (the cost of producing coalesine fuel). For instance, taking coal at 18s. a ton and dividing by three we get 6s., and 6s. less 4s. (cost of coalesine fuel) is 2s., this being the balance in favor of coalesine fuel. Where, however, at present a town is paying 2s. a ton (say) to dispose of its refuse, that town would naturally be 2s. a ton to the good if the coalesine fuel were sold merely to pay for itself.

Coalesine fuel can be burned by itself or in conjunction with coal to suit the varying steam requirements of consumers. It is obvious that the addition of coal in no way detracts from the pecuniary advantages obtained by the use of coalesine fuel, while at the same time the hygienic object is equally attained.

The figures given by Mr. Harrison as the cost of operating the original plant of two pulverizers are as follows:

The plant is driven by two 40 h.p. electric motors. The cost of power, labor and other expenses is about 37 cents per ton after taking credit for amount realized by sales. This is divided as follows: Electric power, 16 cents; labor, 27 cents; repairs, 6 cents; oil and sundries, 2 cents; total, 51 cents per ton deducting the net 14 cents realized from the sales, leaves a net cost of 37 cents per ton for disposal by the crushing process.

Now, if the method of Mr. Coales for producing a practical fuel from the crushed refuse is sound, then the returns from the equivalent coal values should be sufficient to show a large return of revenue over expenses.

The value of unseparated house refuse containing from 70 per cent. to 80 per cent. of matters which have no fertilizer properties seems very uncertain when applied directly to the ground. In certain cases of low marshy tracts which are to be reclaimed and made suitable for better cultivation, the use of such a preliminary charge of finely divided substances is undoubtedly of service, but the actual benefits to be had when applied to gardens and farming lands is still to be ascertained.

This process seems to be the latest English experiment in the utilization of the town's refuse, and has attracted a good deal of attention from engineers and others interested in the question. The work of this Southwark plant and its results will be observed with interest.

In this country many attempts to manufacture a fuel from garbage have been made, but so far as known the cost of the preliminary process has exceeded the value of the product. The experiments of Mr. Andrew Engel to mix with night-soil a deodorant, which should also give it a value for fertilizer or for fuel, have been carried on at two towns under favorable conditions, but as yet no satisfactory results are reported.

THE PRESENT CONDITION OF WASTE DISPOSAL WORK.

Reference has been made to the work of the American Public Health Association in procuring and tabulating the information of the various methods of waste disposal, and of printing in permanent form the results of investigations of the members of the associations in various towns and cities. They report only accomplished facts, and deal with these from the standpoint of the sanitarian, and are not concerned with the business side of the question.

Nine years ago at the meeting of the association in Minneapolis, papers were presented that gave a fairly accurate account of the position of this question after some ten years of effort to establish better methods of dealing with the disposal of waste in American communities.

The author's contribution was a statement of the general conditions then prevailing ending with a summary as follows:

"Ten years of garbage disposal work in American cities has seen the establishment of sixty-five furnaces in fifty-four cities and towns, besides the trial and failure of about ten experiments of one kind or another in crematory furnaces. The same period has witnessed the construction of twenty large and expensive plants for the reduction of garbage by mechanical and chemical methods. Of these, eight now survive, and of these only three or four are reported to be satisfactory and economical, among the latter being those of New York, Philadelphia and Boston.

The expense of construction in these furnaces has not been large, or the cost of maintenance excessive when compared with the results accomplished. From the beginning the tendency has been to overrate the capacity and efficiency of the furnace, and underestimate the quantity of waste produced; for it always happens that when a way is provided for disposal of worthless matters, the quantities invariably increase. When compared with what is yet to be done, what has actually been accomplished is of small magnitude. Because of the limitations of the furnace capacity in consequence of its principles of construction, there is no example on a large scale of the disposal of all classes of waste by cremation. The smaller cities and towns have found cremators useful and efficient, but limited strictly in capacity and performance. The large cities, with one exception, have not ventured upon their adoption, though there has been shown a willingness to put them to trial under conditions that could hardly be met—the destruction of all kinds and quantities of miscellaneous matters at small cost.

We have reached a turning point where some larger and more efficient means must be brought forward if the best methods are to be adopted. Clearly, the great interest shown in the subject, and the growth of public sentiment in favor of the sanitary treatment of waste has created a demand that must be met.

The example of two cities in turning to account such part of refuse as can be easily selected from the general mass, indicates what may be done in this direction. When once separation is determined upon, and the householder fully acquainted with the necessity and expediency of this measure, he readily falls into line, and cheerfully contributes his personal quota to the general reform.

We can depend confidently upon a sure revenue from what has been previously thrown out as worthless—if not in articles and substances saved and sold, then in fuel value for other uses.

While American cities have been slowly working out the problem of waste treatment, other countries, proceeding on parallel lines, with a wider experience born of stern necessity for the sanitary disposal of the wastes of a crowded population, and with far more liberal expenditure of funds for this department of municipal work, have gone more directly to the end and reached conclusions that apply equally well in both countries. Why may we not profit by the example set us, and turn into power the useless matters we are burdened with?

There is no good reason to be urged against this. The inventive genius of the American engineer will speedily find means to adapt methods and measures that are labor and money saving, and find uses for power that, so to speak, is created out of nothing. Give him a chance to do this, and the cities of America can realize the predictions of scientists who, three years ago, said that each community may be served with electric light created from the natural waste and outcast substances that we now pay huge sums to get rid of.

From a consideration of the relative methods of disposal in use in this country, and comparison with those which are found in favor abroad, we may fairly draw the following conclusions:

First: But two ways or means for dealing with this question are available, and the relative advantages and special adaptations to the local conditions can only be determined by scientific and expert investigations and comparison. The subject has gone beyond the speculative and experimental stage, and reached the point where more definite and exact knowledge is needed. This can best be had by calling in the assistance of experts who will make full examinations and submit reports covering the whole ground.

Second: The indications are that a combination of the two systems of reduction and cremation at points where the two can be advantageously combined because of the presence of sufficient quantities of municipal waste, is the ideal way in which to treat city waste. Each of these methods developing along parallel lines have come to a place where they begin to converge to a common point. Reduction has demonstrated its ability to secure a percentage of value at a greater or less cost, according to the amount of garbage treated, but it does not provide for the still greater proportion of city waste left untouched. Cremation destroys the combustible and a portion of the putrescible, and recovers little or nothing of value in the process; but the employment of the heat derived from cremation furnishes an additional source of revenue that should now be utilized.

Third: A city which has or will put into force a system of separation and collection of garbage, ashes and refuse, and will erect a disposal plant which shall proceed by treating the garbage, when in sufficient quantities, by the modern improved process of extracting the valuable commercial products, and shall operate its plant by the steam power which is obtained by the combustion of such worthless parts of the dry refuse as may be left after sorting out the salable portions, and that will, in addition, bring to this point such proportions of ashes from houses as can be utilized for fuel for the destructor, will then have all its waste disposed of in a way entirely sanitary, and will realize a profit in the operation which, in a comparatively short time will repay not only the cost of the works and their operation, but will return in steam power, when utilized for mechanical purposes, a very considerable amount of profit.

Fourth: When the quantity of garbage produced is insufficient in amount or impracticable for treatment by reduction methods, there can be erected a General Waste Disposal Station which will receive every class of waste in a mixed condition, and by employing the best available destructive agencies can transform this worthless matter into electrical energy as principal or auxiliary power for steel lighting or other useful municipal purposes.

Fifth: Any smaller city or town can employ destructive methods for its waste disposal, with guaranteed immunity from nuisance, at a smaller relative cost for operating the work than has been known since the beginning of this movement twelve years ago.

At this time (September, 1908) there have been built one hundred and eighty furnaces of various types of construction, of which one hundred and two have been discontinued and passed out of service.

Of the reduction plants, including all the various examples employed in municipal work, forty-five plants have been or are about to be erected, and nineteen of these have been discontinued or replaced by others. There are now twenty-three in active service and three others under construction.

The conclusions and deductions in the foregoing statements are still applicable to the present situations. There still remains but two ways to deal with waste in a sanitary and satisfactory way. The choice between these two means is still to be determined by the particular conditions that apply to each municipality.

There is still the need of better engineering advice to determine, in the shortest time, with the least difficulty, that form of disposal means which shall be most sanitary and most efficient for any given case.

With a more accurate knowledge of the results to be had from reduction processes, and the improvement in construction and management of the plants, the towns are now able to determine to what extent these may be employed in municipal work, either directly under municipal control or by contract for a term of years.

The disposal of waste by incineration has made slower advances than was expected, but with the elimination of the visionary, crude and vicious elements that have heretofore obstructed progress, and with a better system of accounting and publishing of results, and more than all the introduction of improved and reliable forms of furnaces and destructors proven by trial to be adapted to American work, this system of waste disposal will now be far more serviceable than heretofore.

It is perhaps inevitable that any great movement for bettering public health and public comfort and which is contingent upon its success for the favor and endorsement of the municipal authorities should be one attended with many reverses and much lost time, labor and money.

The conditions of American municipal government with the constant periodical change of authority are not favorable to the thorough investigation of this subject, and it has not received the same attention and intelligent treatment which has been given to other departments of municipal work—like water, sewage, roads or parks. But with the growth of public interest in the question, with the special study now given to public hygiene and municipal sanitation in the technical schools and colleges, and, more than all, with the demonstrated public benefit to be had from the adoption of these better means for caring for the worthless and dangerous matters that must be removed from the life of the people, we may hope for more rapid progress, and far more beneficial results to the great number of American municipalities.

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