Porto Rico Health Review

Official Bulletin of the Department of Health
Published monthly by the Department of Health of Porto Rico.

VOL. I SAN JUAN, P. R., AUGUST 1925 No. 2

A STUDY OF REFUSE INCINERATORS

By CARLOS DEL VALLE, Consulting Engineer.

The constant development of the principal cities of Porto Rico, where modern ideas and methods of sanitation are being adopted with increasing enthusiasm, gives evidence that the people will soon realize the necessity of finding a definite solution to the problem of municipal refuse destruction as the chief means of averting propagation of flies and the spread of transmissible diseases. The necessity of solving this important sanitary problem scientifically will be felt more intensely each day in this Island and the time will come when its solution will become imperative, especially in the larger cities. These observations and the fact that considerable time has been devoted to the investigation and study of the various systems and methods employed for the disposal and final treatment of refuse, have made it possible to present a detailed account of the study carried out, in the belief that the information obtained may be utilized for the future benefit of the Island.

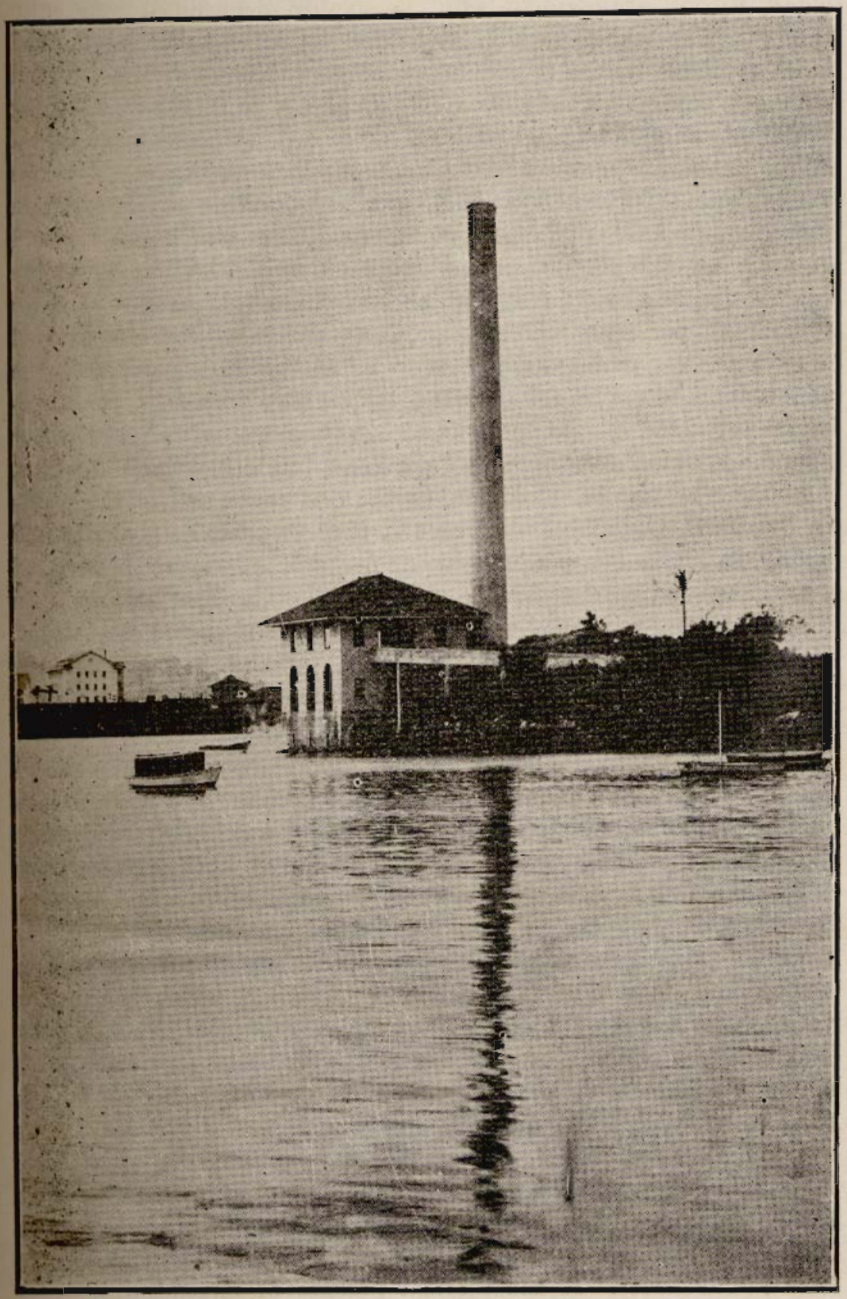
There are several methods that are sanctioned by those who have made a study of this matter, which have been adopted in different countries. Before successfully applying any of these methods it is necessary to make a thorough study and investigation of the quantity of garbage and refuse, of the physical and chemical analysis of same, and of the means at the disposal of the municipality to effect an economical treatment in relation to local conditions. On the application of any of these methods to a particular case the following conditions must be strictly observed. First, the method used must comply with sanitary requirements and regulations. Second, this method must be economical, both from the standpoint of its initial cost and from the cost of operation. Third, access must be had to an adequate place in which to dump the garbage and refuse of the community and by means of scientific treatment prevent organic decomposition and consequent bad odors; either by converting the organic matter into by-products for commercial use or through complete destruction of such garbage and refuse

by cremation, utilizing its calorific value to generate steam, thus leaving only inorganic residues that cannot be the source of a public nuisance.

There are two types of industrial plants that are constructed for the application of these methods. The first is the one known as "Reduction Plant" which saves the residue and is applicable only to the treatment of garbage and dead animals. In these plants the process is effected in "rendering tanks" which convert the organic matter into by-products for the market, such as fertilizer, tallow, etc. The second kind is the type of plant intended for the incineration of garbage and refuse by cremation in specially designed furnaces. Into these furnaces currents of air are mechanically forced and the atmospheric oxygen combined with the calorific elements of the refuse activate combustion, with a resulting temperature of 1,250° F. to 2,000° F. thus causing the destruction and volatilization of the organic matter contained in the garbage and refuse leaving as a result of the cremation only ashes and inorganic matter.

The garbage-reduction plants intended for the utilization of garbage require the installation of costly and complicated machinery and economic results can only be obtained when these are installed on a large scale. On account of this and due to the fact that it is necessary to separate the refuse from the garbage, and also to sort it in the plant, this type is in no way adaptable to the municipalities of Porto Rico. The incineration plants of mixed refuse are adaptable to the needs of Porto Rico and these are being used successfully in different parts of the world. In Europe, for example, and especially in England where incineration was first practiced in 1874, the development and perfection of this method has been enormous during the last twenty-five years and up to the present time there are 250 cities successfully operating incinerators many of which are used to generate steam and electrical current utilizing, by combustion, the calorific value of the refuse without the use of additional fuel. These incineration plants were first constructed in the United States and Canada in 1885 and since that date their use has been generally adopted.

Personal investigation of these incineration plants which are now used in various cities has proved by practical demonstration the excellent results that can be obtained from utilizing the calorific value of the refuse. The thermal potence or value contained in a given kind of refuse and garbage depends mainly upon its composition. It is difficult to exactly calculate in advance this calorific



View of the Incineration Plant at Balboa, Panama.

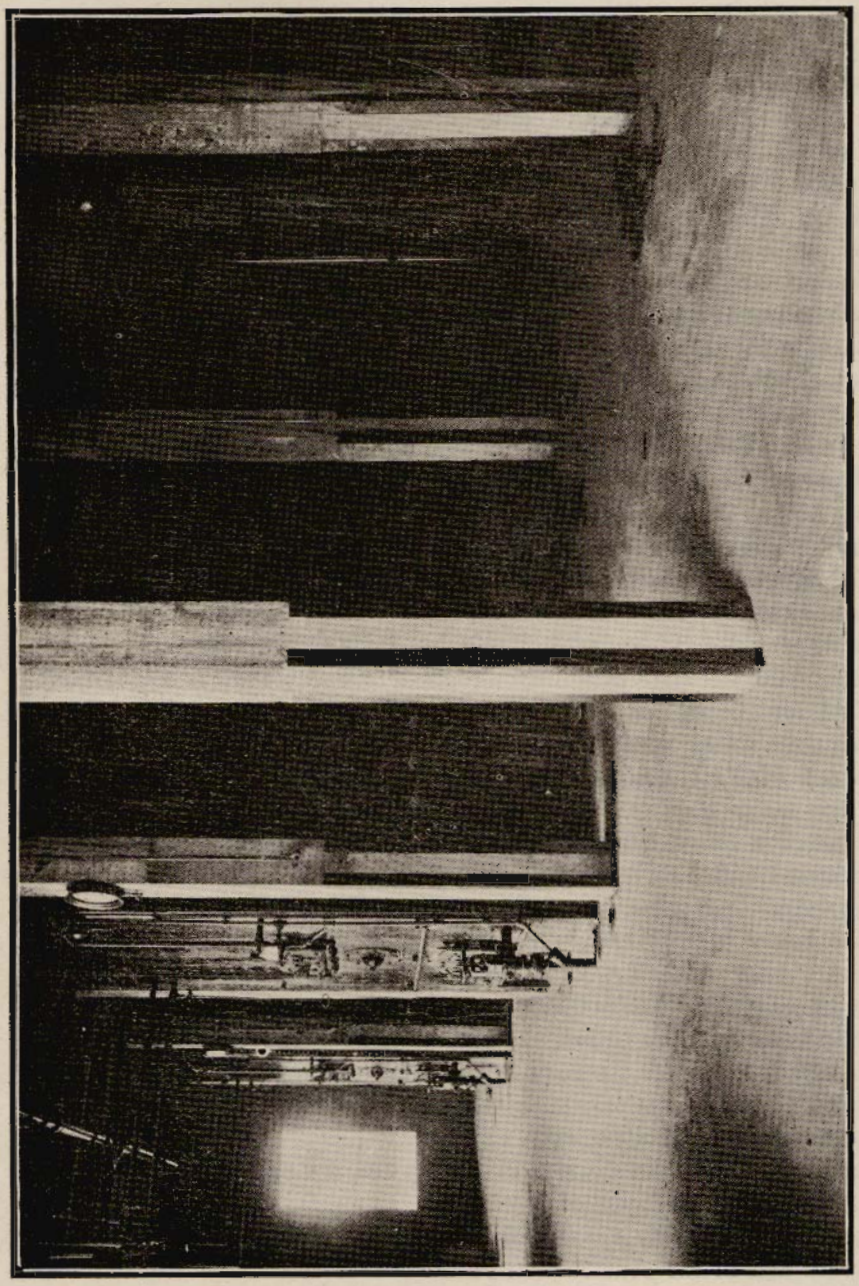
value, but an approximate average may be determined sufficiently to fix a standard by which to arrive at the number of thermal units available in the total amount of garbage and refuse collected during a day. This calorific value is, of course, variable according to the season of the year, and from the records obtained from several cities, the number of thermal units contained in the mixed refuse varies from 3,200 to 4,800 B. T. U. per pound. Due to this variation some incinerators are found to evaporate three-fourths of a pound of water at 212° F. per pound of mixed refuse, and in others the evaporation has reached as high as two and a half pounds of water at 212° F. per pound of refuse. Upon analyzing the tests carried out in several incinerators it may be stated in general that the incineration of mixed refuse will produce, on an average, the evaporation at 212° F. of not less than one pound of water per pound of mixed refuse in well-designed and constructed furnaces. According to Mr. W. Goodrich, in the test conducted at the plants in Bradford, Hackney and Greenock, they generated sixty, fifty and eighty kilowatts-hour, respectively, per ton of refuse incinerated there, thus giving an average of 63.3 kilowatts-hour per ton. In the plants at Stoke-upon-Trent, Woolwich, Preston and St. Albans, tests were conducted during which 97, 90 and 92 kilowatts-hour per ton, respectively, were generated with a total average of about 92 kilowatts-hour per ton of refuse incinerated.

To form an idea of the importance of the value of calorific potence of refuse and garbage it is only necessary to make a comparison between these substances and sugar-cane bagasse which is also a combustible matter of low calorific degree, and without which our sugar industry would never have reached its actual development. It is well known that the bagasse contains approximately from 30 to 50 per cent of fibrous matter, up to 10 per cent of sucrose and from 40 to 60 per cent humidity, which composition varies according to the extraction efficiency of the grinding mills. The calorific potence of the bagasse, when this is entirely dry, averages 8,300 B. T. U.; but inasmuch as a part of this heat is used to evaporate the humidity contained in the bagasse, in the average condition this calorific potence is reduced to about 3,300 B. T. U. per pound. One pound of bagasse can evaporate from two to three pounds of water at 212° F. which in general may be equivalent to from 1.25 to 1.40 horsepower por ton bagasse in twenty-four hours. If the thermal potence of mixed refuse is accepted as the same average of 3,300 B. T. U. per pound as in the

bagasse, it will be found by theoretic calculation that with 100 tons of mixed refuse delivered at the incineration plant every twelve hours it is possible to generate about 250 horsepower in an equal length of time.

The amount of mixed refuse collected in the city of San Juan, Porto Rico, was approximately 65 tons daily in 1918. With the increase of population since that date we figure that the average daily collection of refuse is now over 85 tons. The mixed refuse in our capital is high in combustible matter due to the extensive section of Santurce and its surroundings. Some parts of this suburb are small forests in which residences have been built, thus causing the refuse to contain great quantities of wood which increases its thermal potence. In view of the above-mentioned facts it is easy to realize the importance of these figures in connection with the installation of a refuse-incineration plant in the city of San Juan in the future.

Among the principal types of furnaces constructed for the incineration of refuse, the following classification has been made: (*a*) English type furnaces (English Destructors) of high combustion temperature of about 2,000° F., constructed with fire bricks and provided with forced draft by means of mechanical blowers. These furnaces are generally designed to operate without additional fuel for the incineration of garbage and mixed refuse. A number of them have been constructed in the United States under the name of "Hennan & Froude Destructors." (*b*) American type furnaces to operate at low temperature, designed ordinarily for the cremation of garbage, requiring as a rule additional fuel and constructed with fire bricks, a type which may be called "Crematory". (*c*) American type furnaces that work at medium temperature of the boiler type "Decarie", water jacketed, with mechanical forced draft and preheater. This last type of furnaces can operate in most cases without additional fuel, have given highly satisfactory results and may be called "Incinerators". This type would seem the most adaptable for the communities of Porto Rico because of its simplicity of construction and operation and because it *is* a combination of furnace and boiler. The thermal potence of the mixed refuse is utilized to generate steam. There is also an English type of furnace developed under the name of "Balmer Refuse Destructor", said system being employed by the English Engineer' Mr. Robert Balmer some years ago in the construction of the plants at Montevideo and Buenos Aires, S. A. This system was first used in the United States



Interior of the Incinerator at Balboa, Panama, having 180 tons capacity

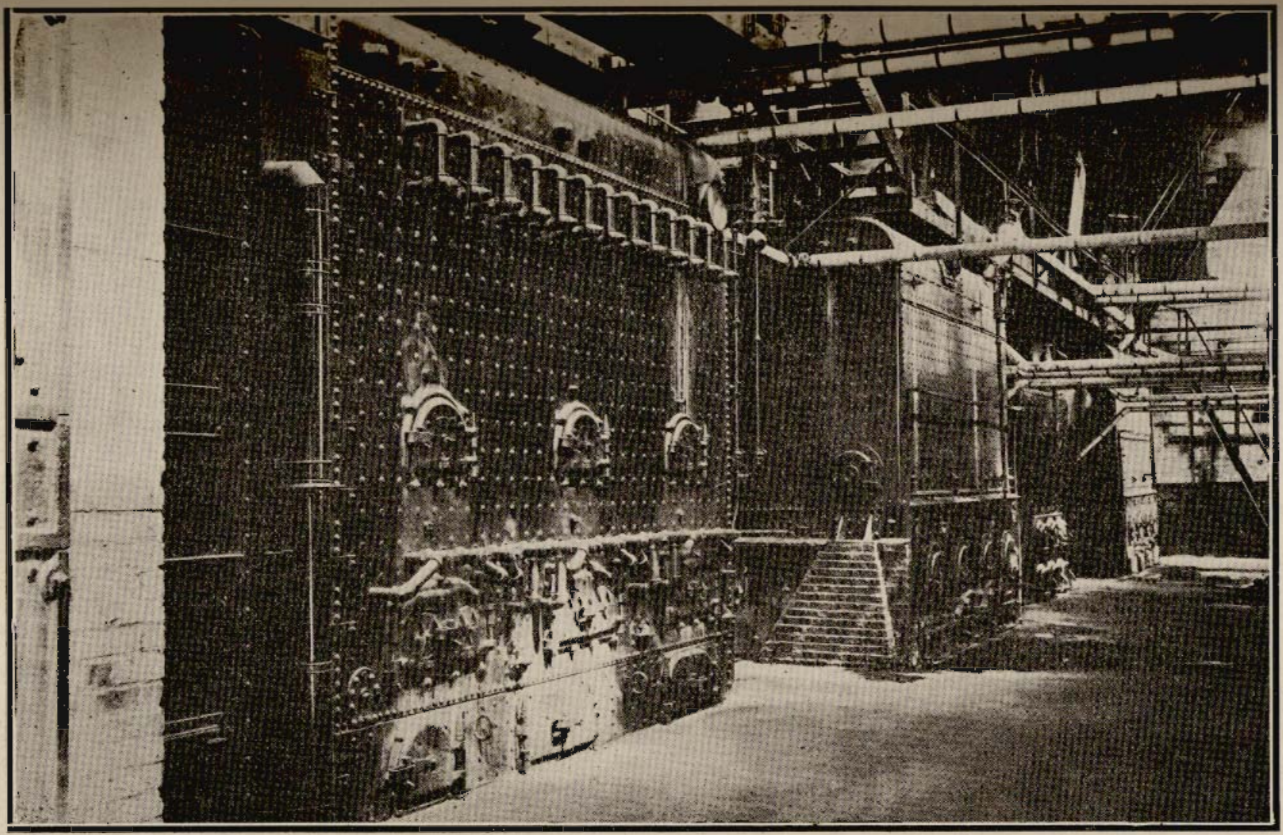
in the construction at Charleston, West Virginia, of the first "Balmer Refuse Destructor" in 1923. The inventor Mr. Balmer who visited us at our office in New York, explains in detail the principal points of his incinerating furnace system and shows how he takes advantage of the development of the hydro-carbides in the fermentation of the garbage and refuse stored alongside the furnace on concrete bins, the bottom of which forms the upper part of the hot-air chamber, thus receiving by radiation the heat from the combustion in the furnace with the view to activating the formation of hydrocarbides that increases the thermal potence of the mixed refuse and waste. The vapors and gases produced by the heating of the mixed refuse stored on the concrete bins are used to intensify the combustion at the grates. As is plainly seen, the system is based on the storage of the refuse and garbage during a certain length of time, and due to this circumstance the adoption of this system would not seem feasible in tropical countries as the storage of the garbage would, no doubt, occasion bad odors in the plant and its vicinity.

During the winter of 1922 investigations were practiced on a large number of incinerators constructed in the United States and at the same time correspondence was carried on with the municipal authorities of the leading cities of the country that had already installed plants for the destruction of refuse and garbage. The result of these investigations was classified into two groups, as follows:

Group No. 1.—Incineration plants operating successfully without additional fuel, some of them generating steam or electrical current.

Group No. 2.—Incineration plants operating successfully but requiring additional fuel.

The investigations were concentrated on the plants described in group No. 1, and a thorough study of these, from the standpoint of their mechanical installation and economical operation was made, inasmuch as the plants that are operated without additional fuel are the only ones, that should be used in Porto Rico. In almost all the incinerators constructed on the mainland up to 1910 the operation of charging or feeding the furnace with mixed refuse was done by hand, but since that time a number of incinerators have been installed in which the handling of the refuse from the time it is delivered at the plant until it is reduced to ashes is done mechanically. The plants at Paterson, N. J.; Clifton, N. Y. and Savannah, Ga. are examples of incinerators for mixed refuse where all the handling



Incinerator at Minneapolis, Minn.; model of 1916 in the foreground and model of 1901 in the background

of refuse, charging of furnaces and extracting of ashes is done mechanically. The plant at Paterson, N. J., is of the English type "Heenan & Froude Destructor" with furnaces constructed of fire bricks and forced draft by means of mechanical blowers. This plant, designed for the admission of sixty tons of mixed refuse is prepared to incinerate dead animals and is located in a central part of the town. On visiting this plant it was noticed that no bad odors or signs of contamination were perceptible. The wagons that deliver the refuse dump their contents into a storage pit constructed of concrete below the level of the floor, the capacity of this pit allowing for approximately one and a half day's work. From this storage pit the refuse is hoisted up by means of an electric crane which runs over the furnace up to the hopper which is located over each compartment constituting the furnace. The bucket has a capacity of one cubic yard and is of the "clam shell" type, similar to those used in harbor dredging. The furnace is charged by means of four gates hydraulically operated, requiring complicated machinery. The combustion of the refuse is utilized to generate steam by means of a 200 horsepower boiler. Part of this steam is used to operate a mechanical blower for the furnace and the balance is used to operate two turbo-generators. The electrical current generated is used for charging the batteries of the electric trucks which haul the refuse. The chimney, of solid brick construction, is six feet in diameter by 150 feet high. This incinerator is operating successfully, but on account of the excessive amount of machinery required, it would not seem expedient to use it in the cities of Porto Rico.

The plant at Savannah, Ga., is also built of the English type "Heenan & Froude Destructor" constructed in 1914 with a daily capacity of 130 tons of garbage and street and stable refuse. The plant contains two 65-ton capacity furnaces each having four compartments. Two boilers of 200 horsepower capacity generate steam to operate one 75-kilowatt turbo-generator. The steam is also used to directly operate the waterworks pumps. The arrangement of this plant is similar to the one at Paterson, N. J., so far as the handling of the refuse and ashes is concerned. The capacity of the receiving pit located at the level of the floor is 260 cubic yards. According to the data available, the plant evaporates an average of 1.3 pounds of water per pound of mixed refuse incinerated. This plant, like the one at Paterson, N. J., contains a good deal of costly and complicated machinery, and is another type that does not seem adaptable to the municipalities of Porto Rico.

The Ridgewood plant at Borough of Queens, N. Y., is of the "Decarie" incinerator type, does not require the installation of boilers because the furnace is a boiler in itself, it contains two furnaces of fifty tons capacity each, both being designed to receive at one time a whole charge of sixteen cubic yards of mixed refuse. Each furnace contains a separate combustion chamber, preheater and forced draft blower; the combustion gases are carried out through one tube which connects with the brick chimney six feet in diameter by 150 feet high. Part of the steam generated in the plant is utilized for the operation of the machinery and for heating adjoining buildings, the balance is wasted because due to previous contracts they are not authorized to generate electrical current. This incinerator is operating successfully and does not require so much machinery as the other types described above. It is believed that this type would be an ideal one for Porto Rico.

In order to give an idea of the cost of incinerators, an analysis of the cost of a limited number of plants has been made.

	Capacity per ton	Cost of plant	Cost of operating per ton
Milwaukee, Wis.	165–300	$208,000	$1.59
Paterson, N. J.	50– 60	79,000	.85
Portland, Oreg.	146–150	99,000	.43
Berkeley, Cal.	40– 75	65,000	1.28
Savannah, Ga.	80–125	125,000	1.00
Atlanta, Ga.	250–250	260,000	.56
Ridgewood, N. Y.	50–100	97,000	.42
Jamaica, N. Y.	53–100	202,000	.55
Ravenwood, N. Y.	50–100	186,000	.53

As some of these plants generate steam and electricity, any income derived from same must be deducted from the cost per ton of refuse incinerated given above. The cost of operation covers wages and maintenance and the cost of the plant includes the amount paid for the land where the incinerator is installed. The cost can not, of course, be accepted as a fixed basis because there are local conditions that may affect the initial cost of the plant as well as its maintenance.

SUMMARY

After a careful study and investigation it is believed that the boiler type incinerators, with water jacket, like those installed at Ridgewood, N. Y., and other cities, have a great advantage over the furnaces constructed with fire bricks and these advantages make

them more adaptable to the special conditions of Porto Rico for the following reasons:

1. The furnace itself is a boiler prepared to generate steam, and on this account the installation of additional boilers to utilize the heat from the combustion of refuse is not required.

2. The furnace, being constructed with steel plates, does not require the protection of fire bricks, and on account of this the cost of maintenance is much less.

3. The arrangement of this furnace does not require the construction of receiving pits or bins for refuse which are always a source of bad odors, especially in warm countries.

4. This furnace does not require the use of additional fuel and is designed to have an evaporating capacity of not less than one pound of water per pound of mixed refuse, provided the proportion is 75 per cent garbage and 25 per cent rubbish, which is more or less the composition of the mixed refuse in San Juan.

5. These furnaces, built of steel plates and with water jackets may operate economically during a period of eight to sixteen hours while on the other hand, the English type of furnaces require constant operation of twenty-four hours a day in order to give satisfactory results.

RECOMMENDATIONS

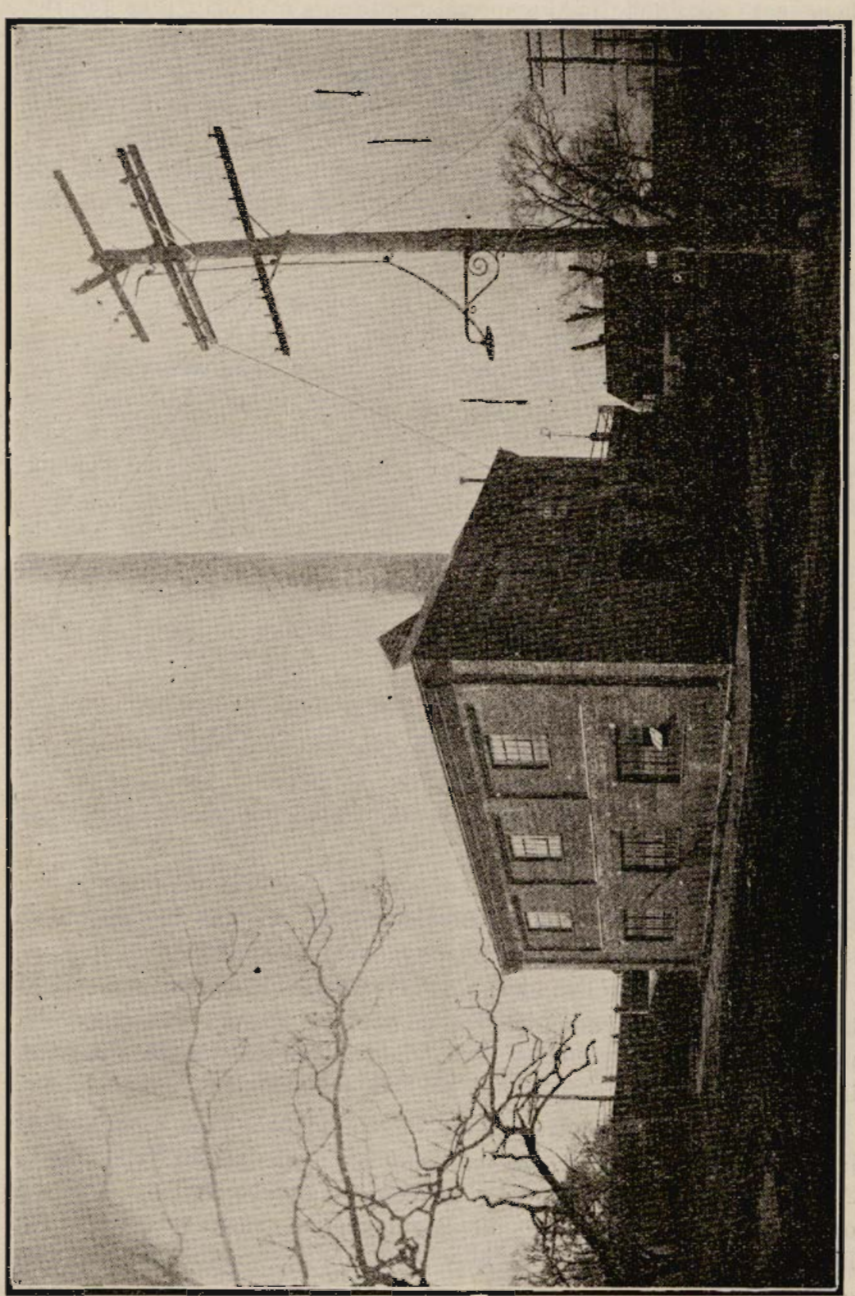
In view of the foregoing observations which should be carefully borne in mind when undertaking the solution of the problem of refuse destruction in Porto Rico, the following recommendations are made:

1. That the plants constructed must be preferably of the boiler type, similar to the plant at Ridgewood, N. Y., for the operation of which only five men and one mechanic is required.

2. That when the installation of a refuse-incineration plant is to be effected, the manufacturer or constructor should guarantee the plant to operate without the use of additional fuel, evaporating not less than one pound of water at 212° F. per pound of mixed refuse.

3. That the incineration plant for the city of San Juan should be prepared to generate by the combustion of refuse from 150 to 200 horsepower. This electric current might be utilized for the operation of machinery in the municipality, such as pumps for lifting sewage water and machinery for the new municipal abattoir, etc.

4. Should any of these plants be constructed, the work should



Incinerator at Jamaica, Borough of Queens, New York City; constructed in 1912; 100 tons capacity

be divided into two parts to be carried out at different periods. The first part should comprise the construction of the incinerator proper, with all its equipment and machinery necessary for operation, like the plants, at Ridgewood, N. Y., Jamaica, N. Y., etc. The second part should comprise the installation of a complete electrical equipment so as to utilize all the energy or steam that may be generated in the boilers. This second part of the work should be performed after the incinerator has been in operation for a period of about three months and, once complete tests have been carried out, an estimate should be made to accurately ascertain the amount of steam available so that the exact capacity of the electrical equipment may be determined.

REFERENCE: "Collection and Disposal of Municipal Refuse", by Hering & Greely. 1921.