The SANITATION OF CITIES

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by

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AND STAFF
OF

THE SANITATION CORPORATION
NEW YORK CITY

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CONTENTS

WHICH·WILL·HE·BUY?

ON·THE·SANITY·OF·HIS·CHOICE·THE HEALTH·OF·HIS·CITY·WILL·DEPEND.

THE SANITATION OF CITIES

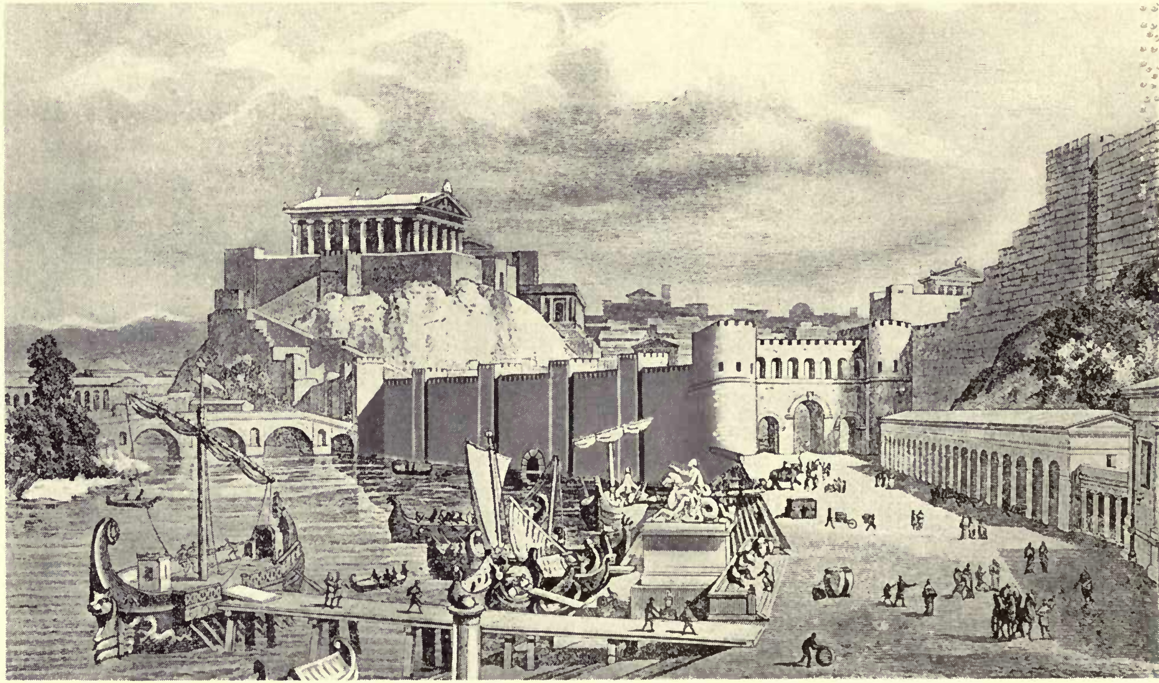
CHAPTER I

GENERAL CONSIDERATIONS

BENJAMIN FRANKLIN in one of his wise sayings reminds us that the choice of a good wholesome situation to fix a dwelling in is a very serious affair, especially as not only the comfort of living but even the necessaries of life depend in great measure upon it; since a family frequently sick can rarely, if ever, thrive.

The truth of this and the wisdom of his advice are obvious. Sanitation is a broad subject, and in the present age is especially the problem of the city.

Civilization is the child of the city, and the true measure of social advancement is made manifest particularly in the comfort, health and prosperity of the inhabitants of cities. The ancient municipality encircled by its strong walls reveals civil and social conditions controlled by power and served by slavery. Many cities are written large on the pages of history which are illumed thus with deathless glory. Babylon, Nineveh, Memphis, Jerusalem, Troy, Athens,



ANCIENT ROME

TEMPLE OF JUPITER OPTIMUS MAXIMUS

Showing the temple, the Cloaca Maxima, or great sewer of Rome, and the Emporium and Rome are names each of which is invested with an infinite charm, both of grandeur and pathos. But we of this utilitarian age are usually forced to turn from their story, notwithstanding its enchantment, with the feeling that it offers little to guide us, beyond affording lessons of what to avoid.

History and archæology reveal abundant data concerning cities, their growth and problems, and present the drama of their civil and political experience, but teach very little that is helpful about their sanitation which, since it is related directly to human life, must have been always of primary importance. We are told of wars, of victories and disasters; of arts triumphant over social degradation; and of slavery. Ancient literature, immortal, or as nearly so as anything human can be, reveals the men of bygone ages who seem still to live and speak. But of sanitation there is little to be learned from ancient history and literature, save only the lesson taught by its absence. The strength of cities and of nations was sapped and undermined, often when facing relentless enemies without the walls, by the diseases within resulting from ignorance and incapacity to provide for sanitary needs.

In these ancient cities war carried off its thousands, and pestilence its tens of thousands. The manifold diseases described under the names of plague, black death, cholera, typhoid, typhus, etc., were due to insanitary conditions; *uncleanliness* was the predisposing and most powerful cause—meaning by this the accumulations of

ANCIENT EUROPEAN CITY
Showing the method of sewage disposal obtaining in this city at that time. Waste matter pouring from the buildings into a canal

decaying animal and vegetable matters around human habitations, and the saturation of the soil with filth. Nor were the cities of antiquity the only sufferers from these visitations. Athens had reached her meridian and her sun had set; Rome had passed into ruin, and yet the progress of pestilence advanced even into our own age.

The millions of deaths that history ascribes to diseases and epidemics, due principally if not altogether to the lack of sanitation, far exceed all the losses of life through the ages caused by wars. It has taken centuries for our race to learn that our greatest enemy bears no sword or stave, but enters our camp unobserved, like a spy—a relentless foe, hidden within and fostered by the neglected rubbish and offal—that comes forth from his lurking place without warning, to strike the human body itself, which cannot be defended effectively against the onslaught of epidemic pestilence when thus attacked.

The sanitary modern city has been well described by an ingenious writer as the result of a number of contributing developments which have created a unit that may reasonably be compared with the human organism; with its skeleton, the city streets; the water distributing pipes and sewers, its arteries and veins. Through the arteries, so called, courses the water which is the life-blood of the community; and through the so-called veins, the sewers, pass off the liquid matters contaminated in the processes of the bodily functions. To carry the simile further, the heart might be compared to the waterworks pumping plant, and the kidneys to the sewage disposal system.

Thus the city may be looked upon as an organism, as well as a social unit, having its organic life and requiring for its normal existence the healthful performance of its various functions.

The present century is especially the age of

CROSSNESS, LONDON, ENGLAND
Sewage pumping station

cities. The urban population of the United States in the thirty years from 1880 to 1910 increased from 29.5 to 46.3 per cent, and in the last decade alone there has been an increase of more than 35 per cent. People prefer to live in cities primarily because of better facilities for earning a living from trade and industry, and because of better opportunities for social enjoyment and recreation. Secondarily, because the conveniences of life are afforded in greater measure than in rural communities.

The industries and commerce that are the physical support and wealth of a city are largely dependent upon means of communication and transportation by rail and by water, and upon

NEW YORK CITY, BOROUGH OF MANHATTAN
River view of Washington Market section with New York City's famous sky-line in the background, showing Woolworth Building, tallest office building in the world

the existence of extensive tributary areas from which raw materials are obtainable, as well as abundant supplies of food; and further, upon sanitation and a naturally healthful location.

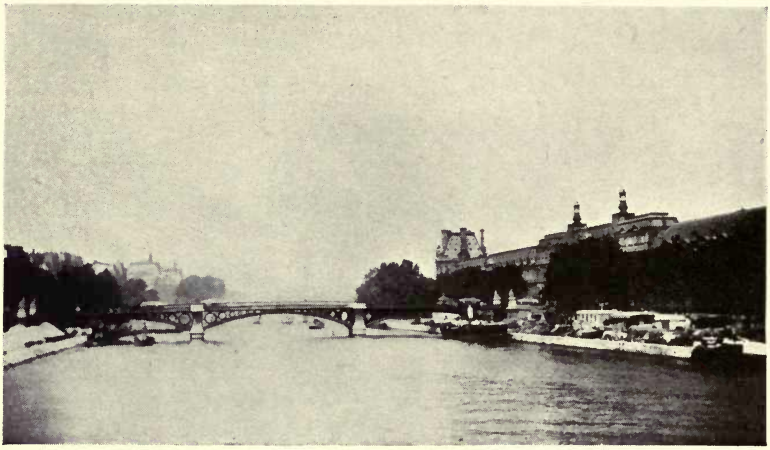
Before the introduction of railways the great cities of the world depended in almost every case on water transportation for their prosperity; nor has the railway greatly altered this. Access to the ocean-borne commerce of the world and to river transportation is the greatest possession of a city. With the growth of cities there has come a great increase in the mutual interdependence of their inhabitants and a more general recognition of the value of organized activity in municipal life. In modern times an essential por-

MIAMI, FLORIDA
View of a southern park

tion of the city's care is preservation of law and order, safety from fire, provision for public works and their upkeep—such as water supply, pavements, sewerage, sewage disposal, wastes disposal, parks, public baths, and various other social conveniences.

But it is only in recent years that serious efforts have been made toward correlating these activities, thereby obtaining not only a more economical plan in the outlay of public funds, but also a much higher efficiency. It is self-evident that street layouts should be related not only to the needs of traffic and the marketing of real property, but also with regard to the most efficient and economical design for the public utilities, such as water supply, surface drainage and sewers. It is no less evident that the needs of water purification and methods to be employed should be considered in relation to sewage treatment and disposal—and that garbage disposal and sewage disposal should be considered together. There are many other questions that are related and should be given consideration at the same time, even if not intended to be provided for together, so that when provided for they may fit in as harmonious parts of a well-planned municipal unit; and the construction of the parts may be carried on progressively, always aiming at a future result by practical means, within the reasonable capacity and resources of the city.

The "reform of the city plan" would be a better term perhaps than "city planning," which has of late gained such currency as to become fashionable. It is seldom that new cities are built from the ground up. Occasionally there is an op-



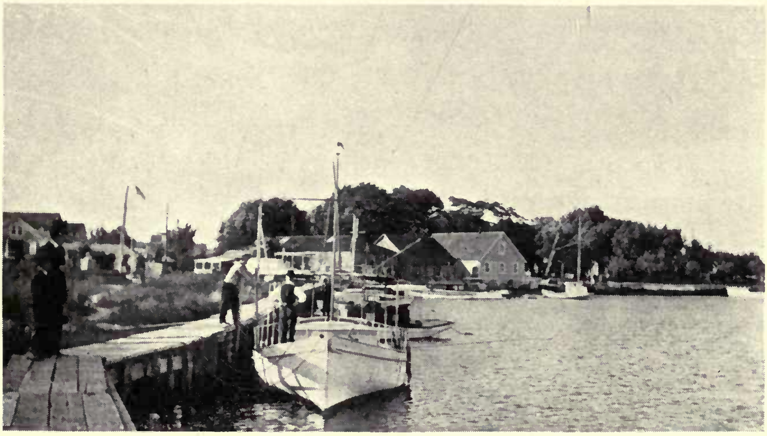
PARIS, FRANCE
River Seine, near the Louvre

portunity for a L'Enfant to lay out a great capital, but this is seldom. The work of the city planner is chiefly the work of the reformer—and his work in these days is very necessary.

Existing cities require replanning in many ways in order that they may be made sanitary, convenient, efficient and beautiful. The sites of many cities owe their selection to the avenues of trade and commerce, and their street design principally to the land speculator. A veritable wilderness may in a few years become the center of a vast population, a metropolis, with its people gathered from every quarter of the earth.

Sanitation is seldom considered at the beginning of such a city and, as its need becomes imperative, makeshift design is resorted to, usually offered by unskillful or unqualified persons. Of the American cities it may too often be said that they "just grew," were not founded by any one in particular, and had no city plan. Hence it is that existing streets do not properly provide for existing—not to mention future—traffic, and that in the layout of these streets insufficient consideration was given to the requirements of sewerage and drainage.

In some cities, where much money has been expended on streets and architectural embellish-



A TIDAL STREAM ON LONG ISLAND
Undeveloped and insanitary but not unhappy looking. Oyster beds nearby caused typhoid fever on several occasions

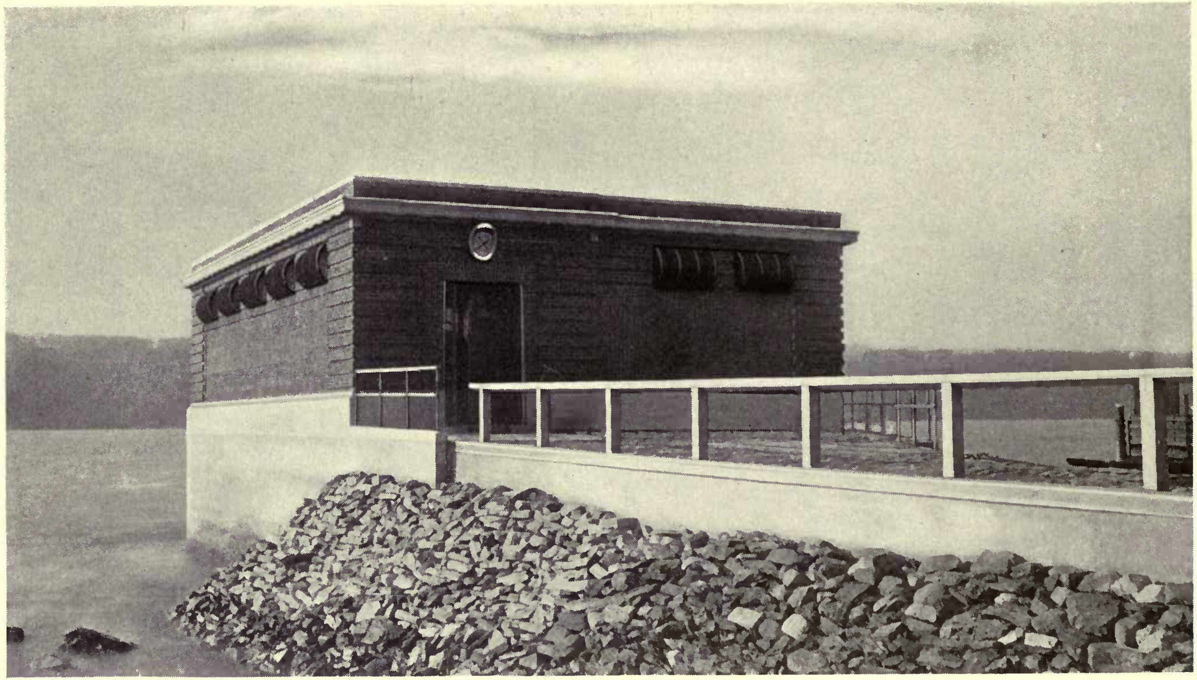
ments, the sanitary condition of the river or harbor, upon which the wealth of the community primarily depends, has been neglected and the water has already become, or is rapidly becoming, grossly polluted. Plants for high grade sewage treatment have been introduced at great expense by some cities which do not even purify their drinking water—a far greater necessity—since no possible grade of sewage treatment can render river water, mixed with sewage plant effluent, desirable or really safe for human consumption. There frequently is a general absence of scale, or perspective, in these improvements, and with the best intentions in the world the result is much wasteful expenditure.

The principles that should control in the "reform of a city plan," particularly those relating to sanitary requirements, are of interest to everyone. Much has been written by experts on this subject, especially by English and European engineers and architects, and even by some of our own countrymen. Unfortunately these writings are scattered through many pages of the technical magazines, sometimes in a foreign language or in expensive text books not readily available to the lay reader for whom this paper is primarily intended.

CHAPTER II

THE CITY PLAN AND THE SANITARY UTILITIES

It is obvious that the street plan of a city should not only provide for traffic, and the various other more apparent purposes for which streets and highways are provided, but also for economy and efficiency in the installation and operation of the important sanitary utilities—water supply and sewerage—in order that the water may travel the shortest distance practicable from the main supply to the consumer, and the sewage the shortest practicable distance to the point of disposal without such loss in velocity as would cause deposits in the sewers. But the city planner, whose mind is usually occupied with city beautification, and the needs of street traffic, often overlooks these sanitary improvements; and, in reforming or improving the street plan, often neglects the opportunity to design the new streets with the view of more efficient sewers, that would afford a much more rapid concentra-

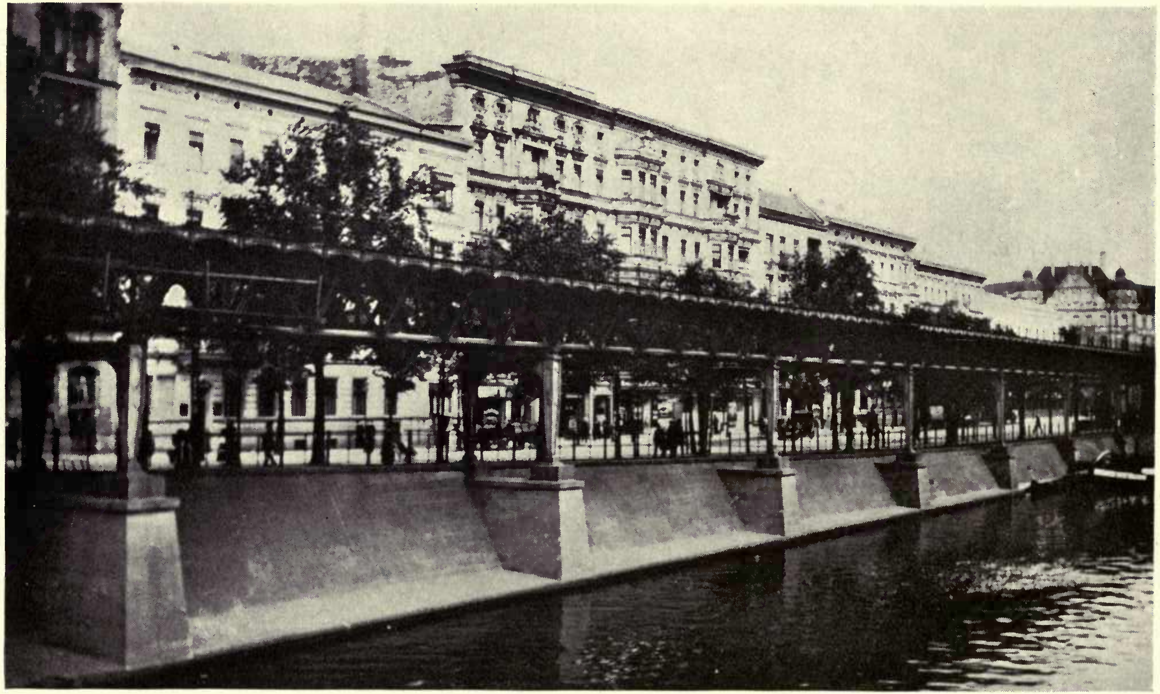


NEW YORK CITY, BOROUGH OF MANHATTAN
Dyckman Street and Hudson River
Superstructure of R-W screen sewage treatment plant

tion of the flow, and lead the sewage to the main outfall before the suspended solids had time to pass into solution.

The first principles of street design require the proper accommodation of these utilities. This indeed, should be considered as one of the main objects, if not the most important object, to be obtained by the redesign and improvement of the street system. It is not necessary in this connection to go into detail concerning the architectural and engineering features, as to width, etc., of streets. The city planner will not neglect to take proper care of this feature of his work.

The street plan should be economical, and conform to the topography, with the lines made as simple as possible. Various forms of plans are recognized—as the radial and circumferential, the rectangular or "gridiron plan," and a combination of these plans. In some instances, plans are used greatly resembling those of European cities of the Middle Ages, which have in recent years been replanned with circumferential streets, replacing old lines of city walls now removed. In others, new streets are controlled mainly by property lines. But whatever the scheme or form, the effect on sanitary utilities should be given primary consideration; and before the improved street plan is fixed upon, the design of the sanitary system should be completely worked out by experts, and the proposed plan amended, if neces-



BERLIN, GERMANY
View showing the method of treating the side of a canal with elevated railway following the line of the canal

sary, to conform to the requirements of these utilities.

The sanitary requirements having been provided for, the architectural judgment of the city planner can be trusted to produce fine effects—by a proper treatment of existing streets, with parks introduced where possible, or with fine buildings at focal points. This is that portion of the designer's work which is appealing to the layman. It is the finished side of the embroidered fabric, showing the beauty of the design, while the under side—or seamy side—remains hidden, and the hard work expended on planning to meet the requirements of traffic and commerce, as well as sanitary and other utilities, is seldom seen or appreciated by the pleased beholder.

The appearance of the streets of a city is best shown by pictures. This is also true of parks, water fronts and seaside resorts, which may constitute some of the very important parts of a city design.

American city designers have been especially successful in preserving and accentuating the intimate character of the city intrusted to their professional care. It is of interest to compare the street views of various cities and observe their individual characteristics.

In the old world this quality has grown through ages of history, and gives to each city an air of personal distinction; especially is this the case

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NEW YORK CITY, BOROUGH OF MANHATTAN
Hudson River and famous Riverside Drive, showing Grant's Tomb with the New Jersey Palisades in the distance

with European cities which have not suffered or benefited by extensive replanning. In Europe, for instance, much that has been done in the line of very necessary civic rebuilding has involved extensive destruction of old buildings, and reconstruction on lines, not unlike our rapidly advancing western cities, which, while partaking of the general character of newness belonging to our country, are not quite in harmony with the distinction and personality of the ancient European city. Moreover, the new structures and plans have a remarkable sameness, which to a great extent deprives each newly planned and reconstructed city of its individuality. On the other hand, it must be admitted that in a material sense, the replanned cities are unrivaled. The provisions made for health, prosperity, and efficiency, are of the very best, and these include the sanitary systems provided, as well as the more apparent features of the plan.

DRESDEN, SAXONY
Panoramic view of the city and River Elbe

CHAPTER III

WATER SUPPLY AND REMOVAL OF SEWAGE

THE sanitary utilities which are especially necessary in a city are water supply and sewage collection and disposal. There are other sanitary utilities, such as those for the removal and treatment of waste materials—from kitchens, etc., and the sweepings from streets; but these do not require the installation of special structures underground in every street, and are seldom considered in connection with the city plan.

The supply of water, and its removal and disposition when it has become polluted by human use, constitute a problem that cannot fairly be divided. The structures required form one vast machine, consisting of two principal parts—the one carrying in the pure water, and the other carrying out the polluted water, or sewage, and providing for its disposal.

The water supply and sewage removal structures may be described as a single system, since neither water supply, nor sewerage, constitutes by itself a complete sanitary utility without the other—which system may be considered as properly consisting of the following parts:

Source of supply		Plumbing fixtures
Collection		Sewerage system
Preparation	Service to Consumer	Sewage treatment
Storage		Effluent discharge
Distribution		Final disposal

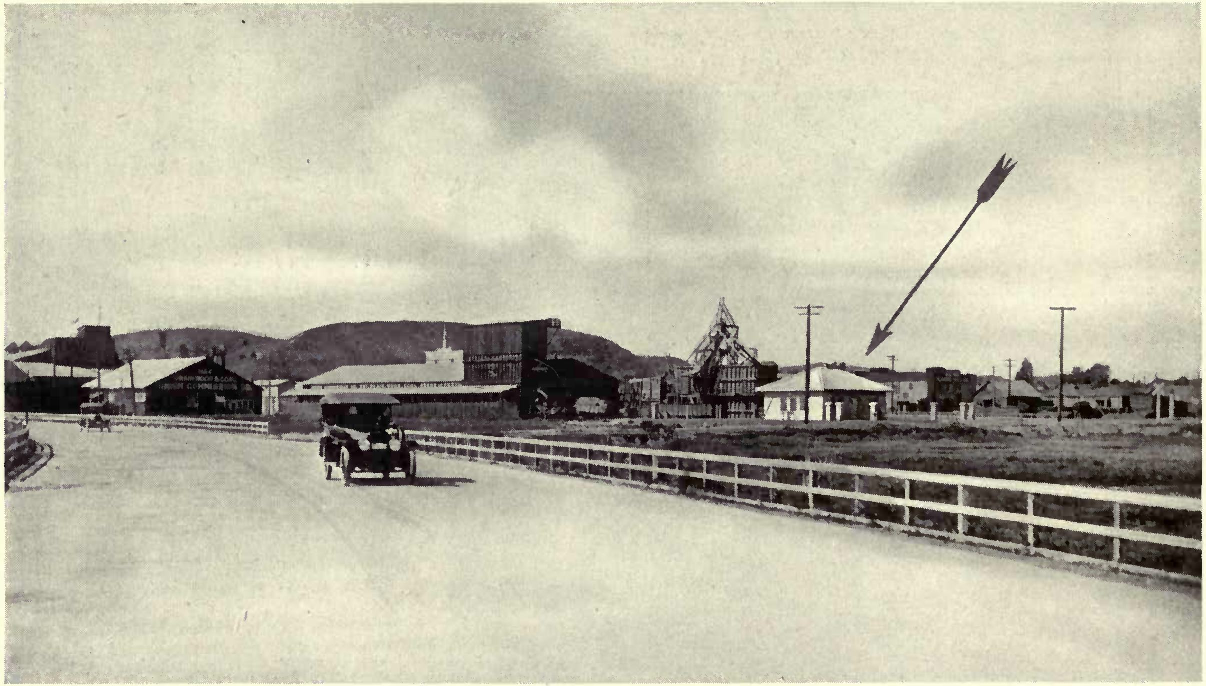
Thus it will be observed that the operation of this great sanitary system is continuous from the source of the water supply to final discharge; and a further consideration will reveal the interdependence of every part above indicated, on every other part in the system. In fact, the relation of part to part is self-evident; but there are many qualifying circumstances that enter into the problem, when it is examined in detail. Local conditions, a term so often used by sanitary engineers, supply most of the qualifying factors, and are of great importance in every instance of actual design; but in a broad generalization such as this study intends, average conditions only can be considered. The portrayal of general truth is intended, rather than the delineation of specific instances.

The sources of water supply have a direct relation to, and bearing upon, the last step in the chain: namely, sewage treatment and disposal. If it is asked to what extent water should be treated, or purified, in preparation for human consumption, the answer involves the further question—"How impure, or polluted, is the source of

BIRMINGHAM, ENGLAND
Outfall of treated sewage from treatment plant. The treated sewage from this plant is greater in volume than the ordinary flow in the river into which it is discharged and is much purer

supply?" If on the other hand, it is asked to what extent sewage should be treated, the answer involves a reply to the question—"Will the effluent by any means find its way into the source of a water supply?"

Obviously, if a source of supply is free from all danger of sewage pollution, it need not be treated to remove the danger of causing diseases which commonly arise from this pollution.



SANTA BARBARA, CALIFORNIA
Ocean Boulevard adjacent to R-W sewage treatment plant, the building of which is indicated by arrow

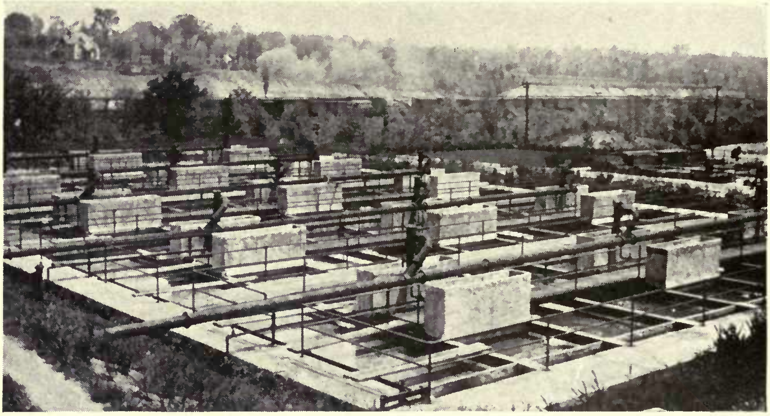
There are other reasons, however, on account of which treatment may still be required—such as hardness, discoloration, etc. It is no less evi-

DAYTONA, FLORIDA
Foot bridge across the Halifax River, immediately below R-W sewage treatment plant into which the treated sewage is discharged

dent that sewage treatment will need only to be provided for the purpose of keeping a waterway in a sanitary condition, if the water therefrom is to be used for, or find its way into, a source of water supply.

The treatment of water, for water supply purposes, is one thing, and the treatment of sewage quite another. On this subject there is much misunderstanding in the public mind. Many people, not accurately informed, appear to think that the treatment of water for drinking, and the "purification" of sewage to secure practically the same grade of purity, are equally feasible and quite simple. There could be no greater mistake.

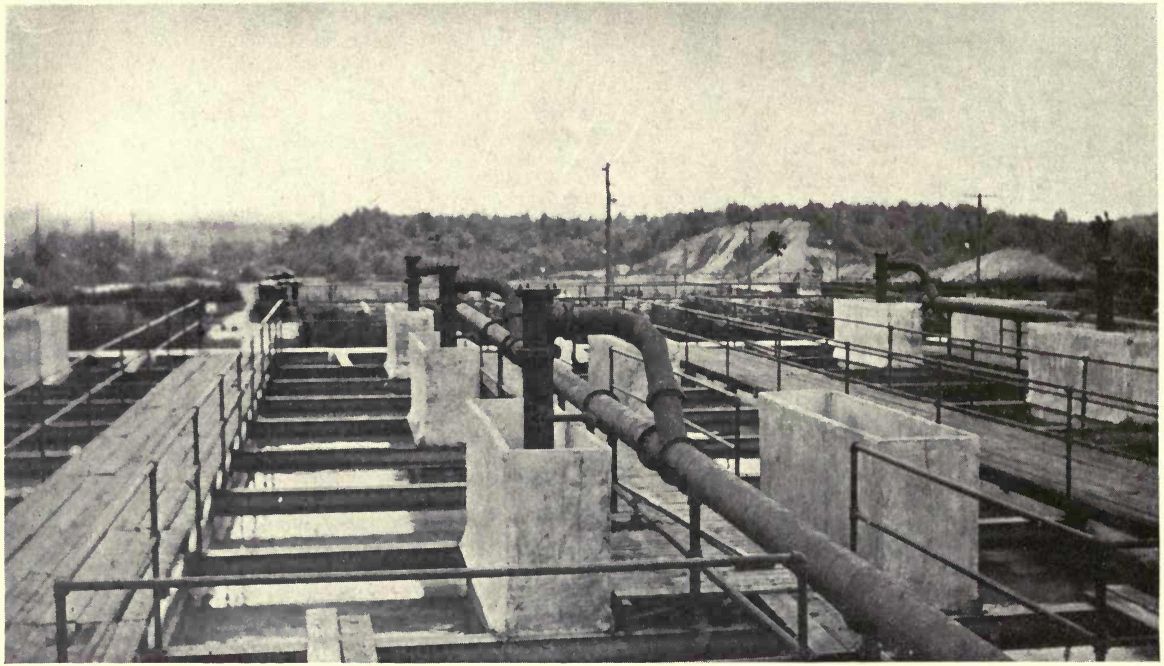
Water for drinking purposes usually carries but little organic impurity, in comparison with sewage, and is very readily purified, and the plants



FITCHBURG, MASSACHUSETTS
A large Imhoff tank sewage treatment plant

provided for the purpose are reliable and efficient. Sewage practically cannot be purified by any known process that is reliable. Beyond a reduction in suspended matters, and a partial oxidation of dissolved solids, the treatment of sewage produces negative results. When there is danger of sewage pollution, and no other source of water supply is available, water purification affords about the only solution of the problem.

It should be understood that sewage treatment can not replace water purification; but water purification will give reasonable protection from water-borne disease-germs, whether we have sewage treatment or not. Therefore, the real purpose of sewage treatment should usually be



FITCHBURG, MASSACHUSETTS
Close-up view of Imhoff tank sewage treatment plant

limited to the prevention of a nuisance in the vicinity of the discharging sewage effluent, in the waterway which it enters. It is seldom proper or advisable to use water that contains sewage as drinking water, even if treated by a purification plant. It is unwise to treat sewage with a view to turning it into drinking water.

Water purification should be as perfect as possible, as this is the only real protection against water-borne diseases which may lurk in any natural surface water. Sewage treatment should be as simple as possible, and the extent of treatment no greater than sufficient to maintain satisfactory sanitary and æsthetic conditions in the

MIAMI, FLORIDA
Royal Palm Park, Biscayne Bay

local waterway receiving the sewage. Much money has been wasted on elaborate sewage treatment plants, designed to attempt the "puri-

SANTA BARBARA, CALIFORNIA
Exterior view of R-W fine screen sewage treatment plant

fication" of sewage, or protect water supplies "lower down" on a river, to an extent uncalled for by local requirements.

Sewers must of necessity discharge into rivers —they will always do so—and rivers should be avoided if possible as sources of water supply, but kept in such sanitary condition that fish life will be protected; and there should be no visible nuisance. Further protection than this is seldom called for, or justifiable.

A simple and reliable, positively operating sewage disposal plant, designed to meet the actual sanitary needs, is always better than a complicated plant designed to give a greater degree of treatment than is necessary, that within a year or two may be abandoned because of operating difficulties, or a higher degree of skill required in management than is ordinarily available.

In the selection of water supplies, quality and quantity of water must be considered first,—then the expense of development, etc. The sources of the water supplies used by most of the larger American cities are shown by the following statement:

Wells of various kinds	40	per cent
Ponds, lakes and springs	25	" "
Rivers and streams	24	" "
Mountain streams	11	" "
	100	" "

It has been estimated that about 4000 American cities and towns are provided with public water supplies. Most of these are relatively small installations, and the majority obtain their supplies from wells. The amount of well water obtained in some places is remarkably large—one supply from the sands of Long Island yielding daily up to 100,000,000 gallons, with a supply per square mile of 750,000 gallons.

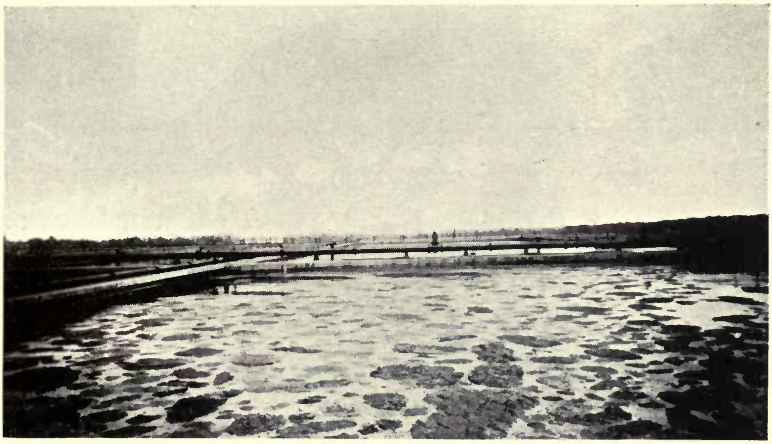
Water taken from wells is usually excellent, clear, pure and colorless, requiring no purification; but it may be hard, and some well waters contain various inorganic matters in solution which cause a slight trace of color. This, as well as excessive hardness, can be removed by appropriate treatment. Water supplies obtained from deep wells seldom, if ever, are in danger of

ORMOND, FLORIDA
View of a park

sewage pollution, even where the water-bearing sands are located within fairly populous districts; as is the case with the Long Island supply before mentioned, on the drainage area of which dwells a large population, in several towns of considerable size.

Lake supplies are much more subject to pollution than well supplies—and in almost every case sanitary safety demands water purification where water from these sources is used for human consumption. Buffalo, Cleveland, Chicago, Detroit, Duluth, Erie, and Milwaukee, as well as many other cities and towns, use lake water. Long intakes in many instances are provided at great cost, to obtain supplies far enough from the shore to avoid local pollution.

The Great Lakes receive the sewage and storm washings from many urban surfaces, and millions of people depend upon the lake water for drinking and other purposes. To improve waterfront property, and prevent local nuisance, sewer outlets are also extended outward from the shores; so that a race seems to be on between the extending water intakes and the sewer outfalls. Experts are employed to select locations for water intakes, at points where prevailing winds and currents will not carry the polluted water from the city streets and sewers. In some places, the cry goes up that the sewage should be so completely treated as to prevent all danger of pollution entering the water supply, and methods of treatment are recommended which, notwithstanding their great cost, when installed, fail to accomplish this purpose. For, as has been often pointed out, no method of sewage treatment affords a means capable of turning sewage into an acceptable drinking water.



BALTIMORE, MARYLAND
Settling or septic tanks in operation

Impounding reservoirs are usually necessary with any system of water supply other than a source derived from driven wells, or from large lakes. Storage greatly decreases the danger of bacterial pollution, especially from pathogenic germs; affords opportunity for suspended matters to settle; and enlists the bleaching effects of sun and air in the removal of any undesirable color. Its main purpose, however, is to provide an adequate reserve supply; especially where the spring and fall rains are heavy and the rainfalls of the other seasons are insufficient for the periods in which they fall.

NEW YORK CITY, BOROUGH OF MANHATTAN
Hudson River, Fort Washington Point, and Fort Washington Park, a popular bathing beach

According to most authorities, it is a well established fact that sewage bacteria, especially of the *B. coli* group, die off rapidly in clear cold water, while the aerobic bacteria, natural to water, are not so adversely affected, and remove any trace of organic pollution which may chance to be present. The number of bacteria present is evidence, or even a direct index, of the amount of bacterial food supply existing in the water and, if the storage is properly regulated by successive basins, a natural purification takes place, which often renders further treatment unnecessary. For example, at Lawrence, Mass., the bacterial reduction in a two weeks' passage through the city reservoirs exceeds 93 per cent on the average. At Washington, D. C., in one week's passage through, the reduction exceeds 90 per cent, and at the Boonton reservoir, a part of the supply of Jersey City, N. J., a six months' storage, or passage through, effects a removal of 99 per cent of the bacterial pollution.

There is, however, a limit to the time during which storage is advisable. If it is too long, stagnation occurs, especially in the bottom layers of the reservoir, accompanied by various growths common to stagnant ponds—organic matter is deposited and dissolves, bacteria increase, as well as other low forms of life which give a bad taste to the water, and deprive it of dissolved oxygen. Aeration and filtration are

NEW YORK CITY, BOROUGH OF MANHATTAN
Hudson River foot of 86th Street, showing a popular yacht club and the high class residences and apartment houses in the rear

both used singly or combined to correct the difficulty referred to. The odor and bad tastes due to stagnant water are not as troublesome as those from certain forms of animal and vegetable life, commonly known as algæ. The tastes and odors referred to are caused by the essential oils which these organisms secrete during their growth. They fortunately exist only during the summer months, and can be controlled by minute amounts of certain chemicals, and by a proper regulation of the reservoirs.

Rivers, next to the Great Lakes, afford the largest supplies of fresh water available, and are more subject to pollution than the other sources of water supply. River water usually requires purification in order that its use may be free from danger.

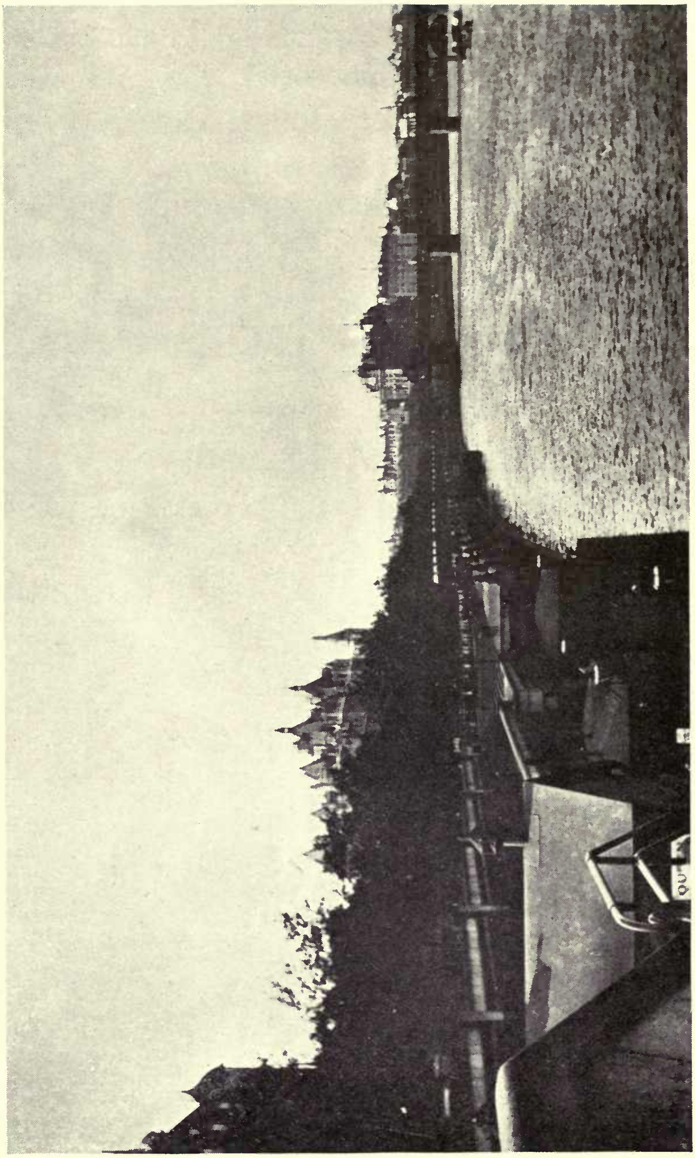
As has often been pointed out by sanitarians, one of the first facts to be recognized in connection with the discharge of sewage into a river, and the use of the water for a public supply, is that no practical method of sewage purification will remove absolutely all danger of pathogenic germs. It is therefore better to obtain other supplies if possible.

The primary object of a sewage disposal plant is to remove the offensive matters and treat the sewage to the highest degree commensurate with requirements of the local conditions. Public waterways will always continue to receive the

PLAINFIELD, NEW JERSEY

General exterior of R-W fine screen treatment plant. This plant was installed to screen sewage before it entered the tanks to prevent foaming and frothing sewage of cities, and the one thing which remains to be done is to see that sewage wastes are made unobjectionable before their discharge. This is practically all that any community should be required to do.

The ideal state of affairs toward which American sanitarians are working, is to permit all cities to discharge their sewage into the nearest stream, but require them first to treat it to a degree which will preclude the establishment or maintenance of obnoxious conditions in the stream. Rarely are two problems of this kind found to be alike. The sewage of some cities should be treated to a far greater degree than that of others, dependent on the initial pollution of the stream, its minimum volume and velocity of discharge, and the distance to the next city or, more exactly, to the intake of the next water supply.



LONDON, ENGLAND
Thames River and Embankment

CHAPTER IV

THE PURIFICATION OF WATER SUPPLIES

THE treatment of water to improve its appearance and quality has been undertaken in various ways for many years. In ancient times, the most important method seems to have been storage; and from observing the effect of natural filtration through sands, along the shores of streams, it is not improbable that some form of filtration was employed at a very early date. The Chinese, from very ancient times, have used sulphate of alumina for the purpose of improving the appearance of water. In modern days, the first large filter appears to have been placed in service on the water supply of London, England, in 1829. After the cholera epidemic of 1849, the filtration of the entire supply of that city was made compulsory. But the existence of disease-bearing bacteria, or "germs," was unknown, and the most important office of filtration was not appreciated until long after this date.

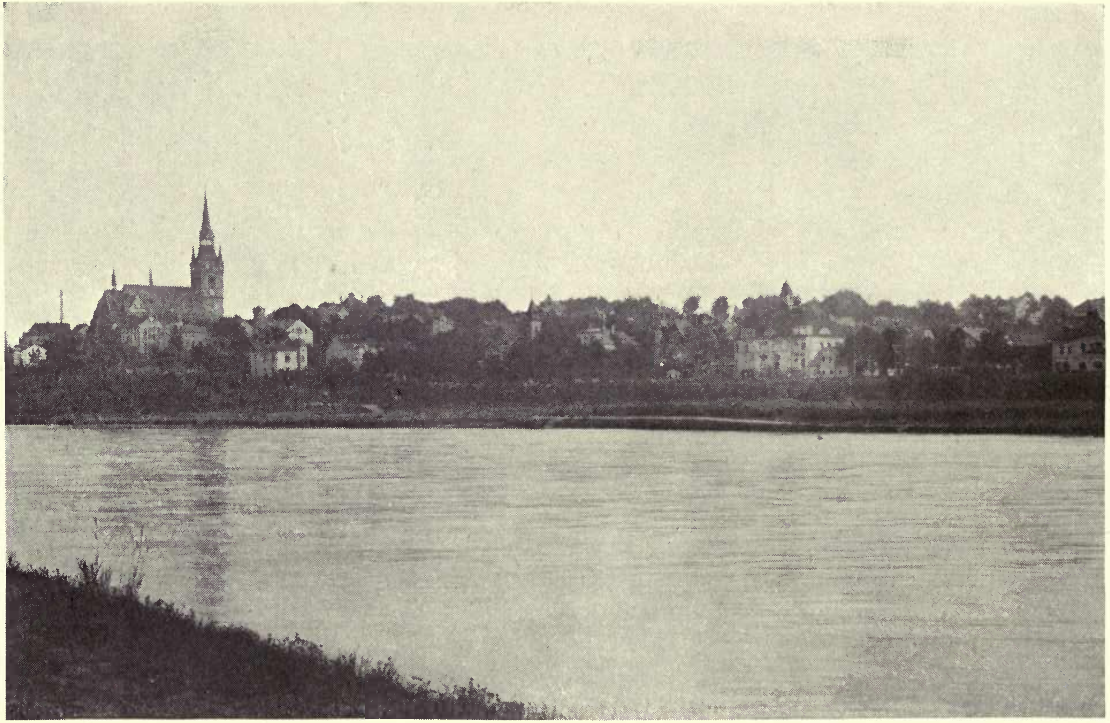
HAMBURG, GERMANY
City Hall and improved waterway "Kleine Alster"

The life-work of the immortal Pasteur demonstrated the germ theory of disease, and gave a new meaning to water purification, as well as to all branches of sanitary science derived from biology.

The work of Koch on the causes of cholera, which created the technique of bacteriological study, and included the discovery of the cholera germ, or bacillus; that of Eberth and Gaffky on typhoid fever, with the discovery of its specific bacillus; and that of the *Bacillus coli* by Escherich, gave a new purpose to water purification, and sewage treatment. These discoveries late in the last century led to the widespread adoption of water filtration, with the result that typhoid deaths were reduced by this means in many of the great European cities, to a very small fraction of their former number. This work also led sanitarians to conclude that, with a universal adoption of this means of protection, typhoid, cholera, and other water-borne diseases would in time entirely disappear from the death statistics of nations.

Water purification was an English invention. The first filters, as mentioned before, were placed in 1829 and the whole supply of London was ordered filtered in 1849—following which the introduction of filters in other cities made rapid progress.

In 1860, English engineers installed the first



DRESDEN, SAXONY

View of the River Elbe and environs at the point of discharge of effluent from the sewage treatment plant; although a comparatively small river, no evidence of the sewage discharge is shown upon the surface of the water, nor is any nuisance suffered by the community filters on the Continent at Altona, Germany, later at Berlin, and at several other German cities. The Altona filters are famous as having prevented the cholera epidemic from spreading to that city in 1892, although it raged in Hamburg, an adjoining city which was not served with filtered water. Both of these cities at that time took their water supply from the Elbe River into which also they discharged their sewage, without treatment. Altona filtered its water but Hamburg did not. At present, both cities filter their water supplies but neither of them finds it necessary to go further with sewage treatment than medium fine screening. The Hamburg sewage screen plant has screens with $\frac{6}{10}$ inch clear openings. Altona uses coarse screens for part of its sewage discharge, but for the major part provides no treatment whatever, depending entirely on water purification for the safety of its water supply.

Out of the English practice two types of filters have been developed for water treatment. These are usually named from their most salient features, slow sand filters, and rapid sand filters. The earlier installations were all slow sand filters.

A slow sand water filter consists of a watertight basin, the floor of which is provided with underdrains, with a covering of about one foot of coarse gravel, over which are placed several feet of clean sand. To prevent freezing, a roof usually carried on groined arches is placed over the basin.

The drains referred to, consist of a main collector with lateral branches at regular intervals —graded stone or coarse gravel is usually placed

PARIS, FRANCE
A park-like development of the irrigated field from the sewage treatment plant by broad irrigation

on the bottom, sufficiently deep to cover the lateral drains. Over this, the sand, which is the filtering material, is placed to a depth of three or four feet.

When ready for service, water is permitted to enter the filter to a depth over the sand of about three feet, and percolates through the sand at a daily rate of about ten cubic feet per square foot of bed, affording a daily flow of about 3,000,000 gallons per acre of surface. But it is not until after several weeks of operation that the filter does its best work. By this time, a gelatinous film has formed on the surface of the sand, derived from the organic matter and sediment present in the unfiltered water, which gives it its highest efficiency. This film, however, becomes in time so thick that it clogs the filter, and the operation must be interrupted for its removal, and for the cleansing and restoration of the surface. There are various ways of effecting this, some of them very ingenious. The result is that the capacity of the bed is renewed and operation again proceeds. Where the untreated, or raw, water carries large contents of suspended matter, settling tanks are used as a preliminary treatment before filtration.

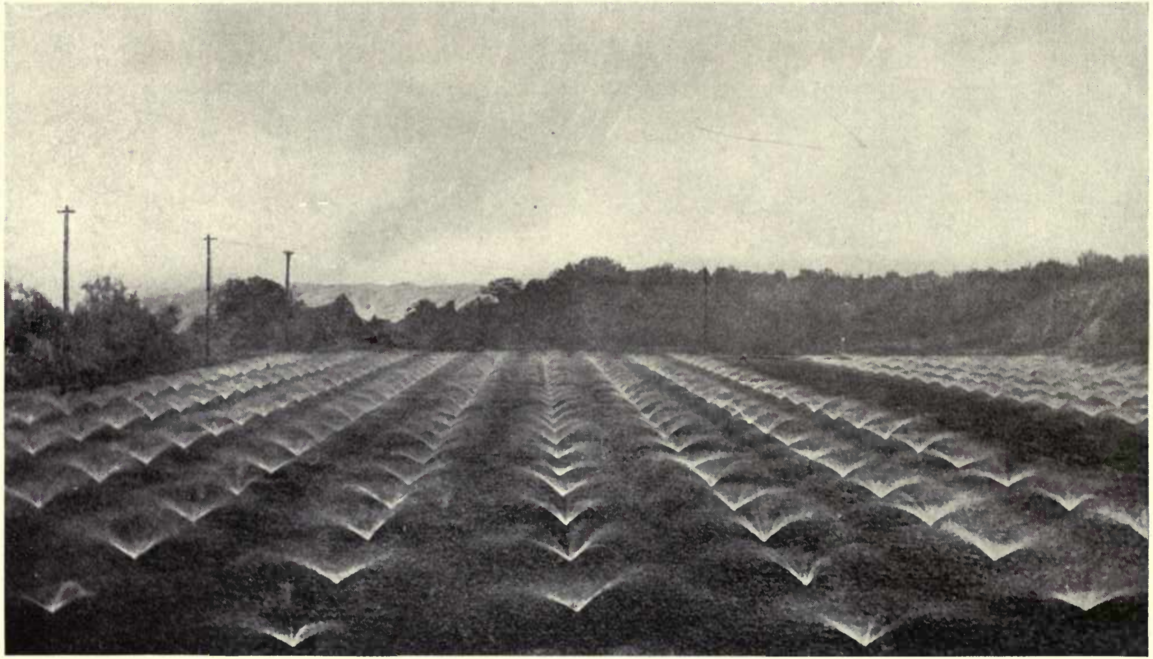
Filters of this type with variations have been installed in many cities here and abroad, the

ORMOND, FLORIDA
View along the shore of the Halifax River

plants in England being particularly well known. Those at Altona and Hamburg in Germany have been mentioned. There are many others in that country. In Japan, a number of such filters have been built, those at Yokohama and Osaka being noteworthy. The largest filter plant of this type is at Philadelphia, Pa., and treats water from the Delaware River.

Rapid sand filters, as well as slow sand filters, were originally invented in England. A chemical coagulant is always added to the water to be filtered by rapid sand filters, and preliminary sedimentation is usual. The sand grains are coarser, and the bed of sand is cleaned in place, by reversing the direction of flow—so that filtered water is forced back through the filter bed. The raw water is first clarified by the addition of the coagulants, and after sedimentation in a tank, is passed to the surface of the bed, over which the coagulant causes the rapid formation of a gelatinous film, and is allowed to pass downward through this and the sand at a rate about forty times greater than the slow sand filter would permit. Rates of 100,000,000 to 125,000,000 gallons a day to the acre of surface are usual.

The filters are usually built of concrete, each consisting of a rather small unit; embedded in the floor of each is the underdrainage system, consisting of perforated pipes or strainer cups, designed to allow the filtered water to flow out, but to retain all the sand and effect an even distribution of the wash water, when the direction of flow is reversed for cleaning, by which means the layer



FITCHBURG, MASSACHUSETTS
Trickling filter plant in operation

PARIS, FRANCE
View shows the purified stream of sewage which discharges into the river nearby. The water is as clear and sparkling as spring water

of dirty material is broken up and removed from the upper surface of the sand, and led away through waste gutters to the sewer. Washing takes only from ten to fifteen minutes and, due to the coagulant, a new film forms quickly. The coagulants commonly used are compounds of alumina and iron.

Rapid sand filtration has come into extensive application since 1885, when such a plant was installed at Somerville, N. J., attracting much attention. Since then, nearly 400 cities in various parts of the world have adopted this method of water filtration.

The largest plant of this kind is probably that of Cincinnati, Ohio, with a daily capacity of 112,000,000 gallons. Some of the noted plants are at New Orleans, La.; Hackensack, N. J.; Little Falls, N. J.; St. Louis, Mo.; Louisville, Ky.; Toledo, O.; Minneapolis, Minn.; Grand Rapids, Mich.; Alexandria, Egypt; Kyoto, Japan; etc.

Among the cities in America provided with slow sand filters may be mentioned Washington, D. C.; Albany, N. Y.; Poughkeepsie, N. Y.; Philadelphia, Pa.; Superior, Wis.; and other places.

The question as to which method, whether the slow filtration or the rapid, is better for any place, depends much on local conditions. Both give good results, and each has its advocates. With either, the water consumer is reasonably insured against water-borne disease, and is certain of an excellent water for all purposes.

It should be noted that none of the cities, mentioned above, undertake to purify their sewage beyond the sanitary requirements, nor beyond what is necessary to maintain a satisfactory oxygen content in the rivers and to prevent the formation of sludge banks and visible pollution.

The disinfection of water to remove disease germs is frequently resorted to where the water is taken directly from sources of supply without filtration.

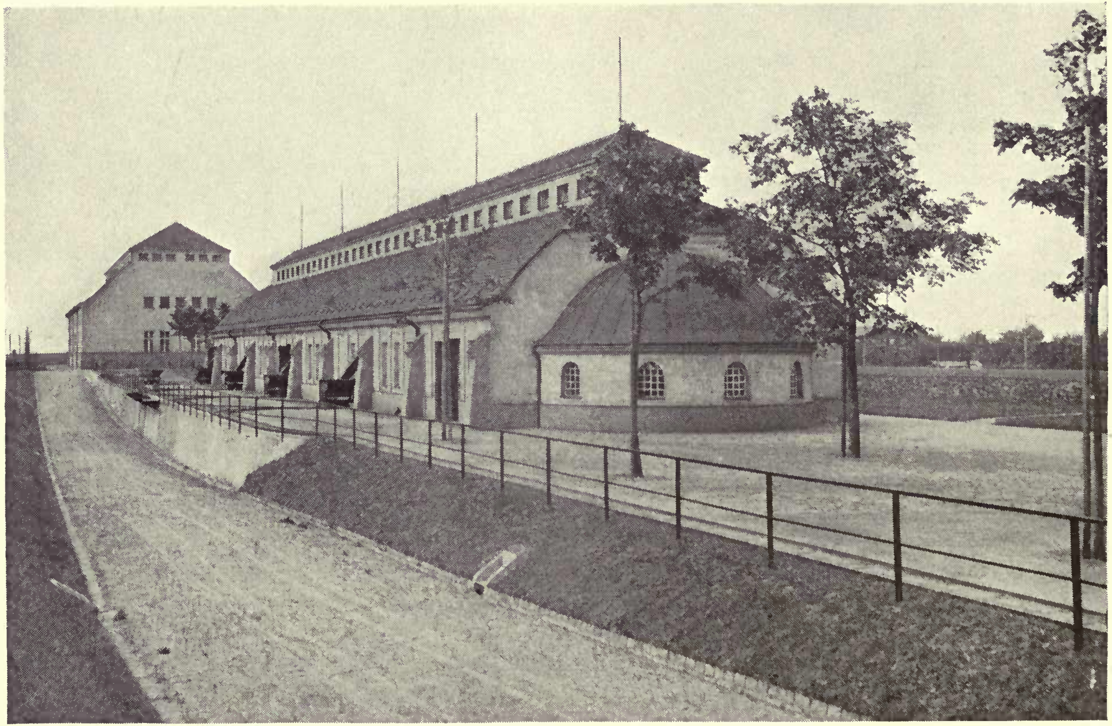
The chemicals ordinarily used are hypochlorites of lime or soda, or liquid chlorine gas. These

LONG BEACH, CALIFORNIA
Bathing beach adjacent to sewage treatment plant

chemicals are applied in very minute quantities with entire success. The majority of American cities have at times used them with good results, under special conditions, and sometimes following filtration.

These chemicals are also used to disinfect treated sewage, when it is necessary to render effluents harmless, in the protection of oyster beds, or to kill disease germs that might find their way into the intake of a water supply plant farther down-stream.

THE BEACH AT DAYTONA, FLORIDA
A popular winter resort having a modern sewage treatment plant



DRESDEN, SAXONY

Exterior view of the Riensch-Wurl screen house, showing elevator discharge chutes, industrial cars for screenings, trackage, and loading platform for direct delivery to carts of the screenings sold to agriculturists as fertilizer

CHAPTER V

THE SEWERAGE SYSTEM

THREE different plans or classes of sewerage systems are in general use. Of late the newly designed intercepting sewers which carry the outfall to a new point of final discharge have come to be called the main drainage. The method of sewage treatment required by a city depends very largely on the design, extent, and class of sewerage systems installed. Each of these systems may be briefly considered, as follows:

THE COMBINED SYSTEM

In this system all kinds of sewage and drainage are carried in the same sewers. There is ordinarily but one sewer in each street, and to this the street inlets or basins are connected to admit the storm waters, as well as the house sewer connections, which admit all domestic wastes, roof water, yard water, etc.

In this system the outfall mains are of sufficient size to take care of the vast quantity of storm water when it rains; consequently they are

BROOKLYN, N. Y.
View in a northern park

so large that in dry weather they act as settling tanks, and delay the velocity of the domestic or dry weather flow sewage—which causes deposition of solids in the sewer inverts. The solids thus deposited remain, and decompose until a storm flow flushes them out. With this system, the sewage in dry weather loosens much suspended matter during its passage through the sewers, and the storm flow is rendered exceedingly heavy with decomposing sewage solids which are gathered up from the inverts during the first part of a storm.

Combined and Intercepting System

This system is similar to the foregoing system; in that all of the smaller sewers are combined sewers; but to obviate the trouble caused by the dry weather, or domestic flow, in the large mains, and prevent the deposits therein of sewage solids, intercepting sewers are provided to collect the dry weather sewage from the smaller sewers, and act to some extent as separate sewers, paralleling the lines of the large mains. These interceptors take off the dry weather flow at certain places called diversion points, by gravity, as they are usually placed at a lower elevation.

Separate System

In this, a double system is provided; one system for the storm water, usually called drainage,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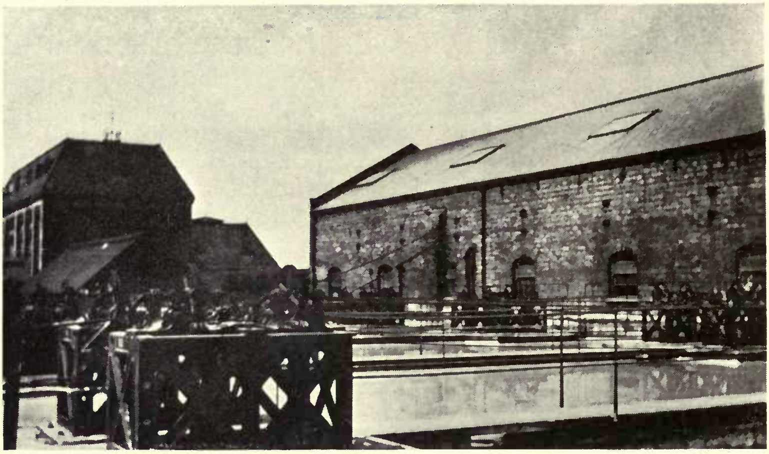
NEW YORK CITY, BOROUGH OF MANHATTAN

Hudson River, with adjacent high class apartment houses and residences on the famous Riverside Drive and one for the sewage, usually called sanitary sewers.

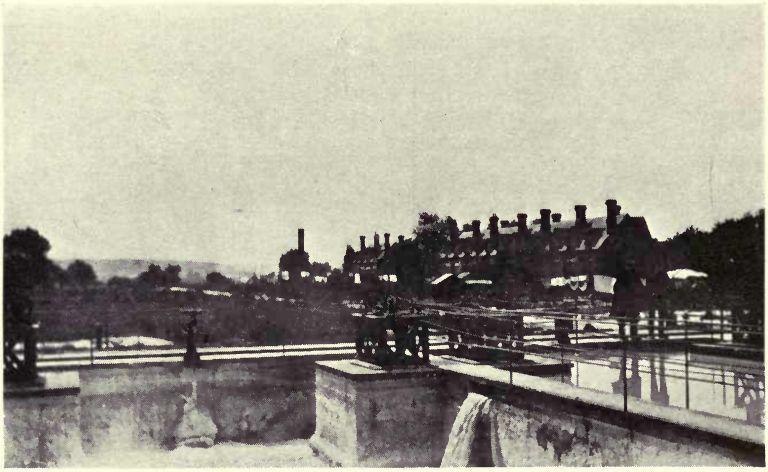
The cost is much greater than the others, but the system is more efficient and, if possible, should be used rather than either of the others; especially, if the sewage or the storm water, or both, are to be treated; as their treatment involves very different problems, and is much more economical if each is kept separate.

The installation of the sewerage system, for a given city, has usually been completed to a great extent before the city planner, or replanner, has been consulted. In most of our cities the sewerage system, like the street system, "just grew" without design and is especially in need of expert study, and complete redesign.

The progress that modern cities have made in population, commerce and material prosperity, was not and indeed could not have been foreseen, even a few years ago. In sewer design, the most that was usually attempted was the removal of polluted waters from the houses and streets, and the discharge thereof into the nearest waterway deemed of sufficient size to carry off the discharge without causing a local nuisance. Where sewage treatment was adopted, the method was usually but little better than an experimental application of some laboratory results, that seemed sufficiently promising to justify a more extensive trial.



CROSSNESS, LONDON, ENGLAND
Chemical precipitation sewage treatment plant



CROSSNESS, LONDON, ENGLAND
Sewage treatment plant chemical precipitation

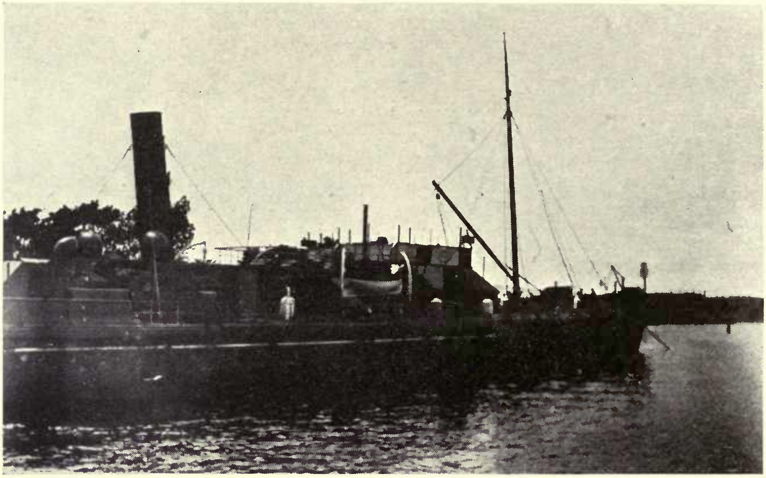
CHAPTER VI

THE SEWAGE TREATMENT PROBLEM

Disposal of the wastes of human life has, from the earliest times, been one of the problems of civilization. As early as the ninth century before Christ, the Assyrians constructed a sewer to drain one of the palaces of Nimrod.

The Romans, the great engineers of antiquity, devoted much attention to sanitation, in which they made steady progress up to the fall of the empire. The Cloaca Maxima, or Great Sewer, of Rome, constructed about the seventh century before Christ, is still in use.

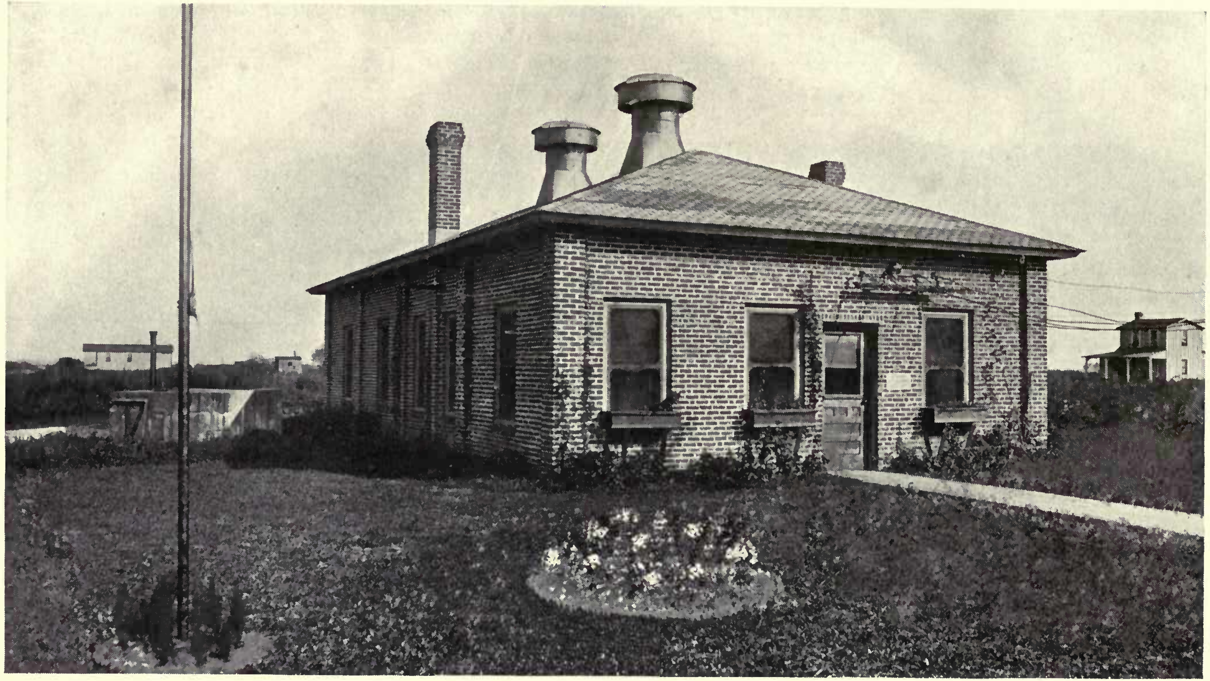
With the advent of the dark ages, sanitary engineering went the way of learning in general, and all that the Romans had learned seems to have been forgotten. Great cities grew up in Europe, entirely without provision for the disposal of waste matter, and in time inevitably became literally buried in filth. Great plagues broke out again and again, and swept like devastating fires over mediæval Europe; cities became vast charnel houses, and the accumulation of filth almost surpasses human belief—yet it was not until the



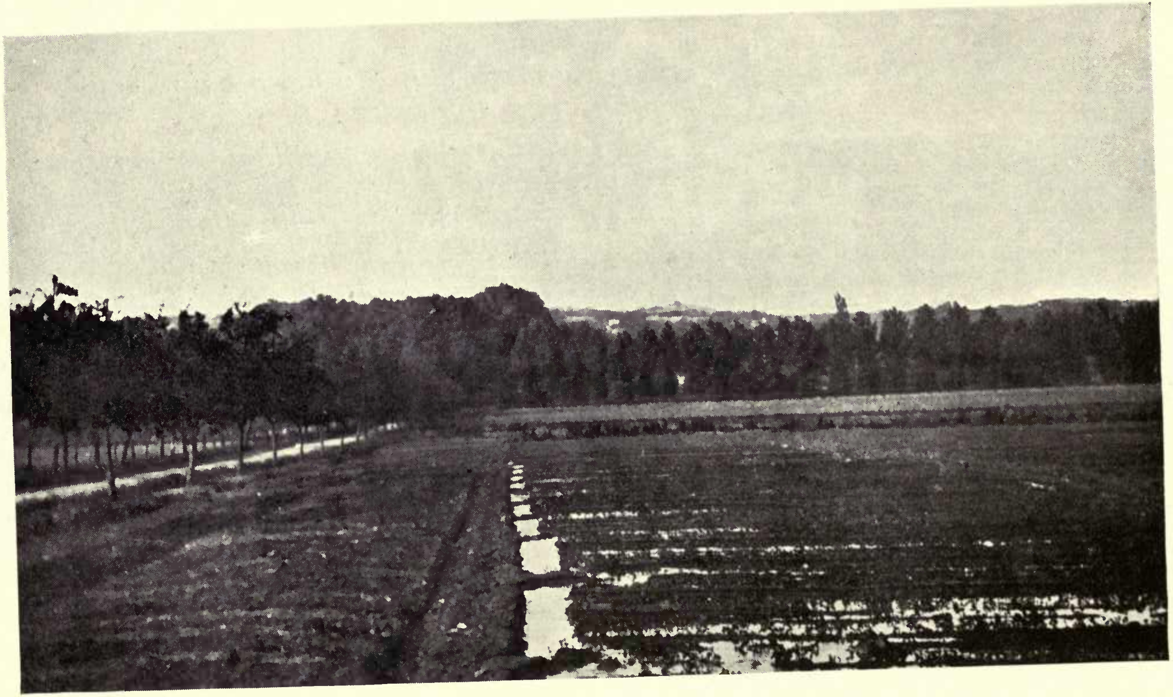
LONDON, ENGLAND
Showing boat for conveying sewage sludge to the North Sea whence it is discharged

fifteenth century that faint interest began to be manifested in the study of sanitation and not until well into the nineteenth that the subject began to be understood. As late as 1847 John Phillips, one of the first engineers to make an official report on sanitary conditions in London, stated that conditions as he found them were so bad as to defy description.

In 1848, 1849, and from 1852 to 1854, London was devastated by cholera. In 1849, 14,600 deaths were recorded; and in the latter half of 1854, 10,675 deaths. The connection between the rapid spread of the disease, and a contami-



WILDWOOD, NEW JERSEY
General view of R-W sewage treatment plant. Process consists of mechanical fine screens with direct discharge of the effluent into the bay



PARIS, FRANCE

Sewage treatment by broad irrigation. View of cultivated field, sewage being applied to a growing crop. The entire field is underdrained, underdrains discharging to open ditches which flow into the outfall brook nated water supply, was readily shown, and the result was an Act of Parliament, which laid the foundation for the prosecution of plans for an adequate sewerage system.

It may be said that modern sanitary engineering dates from the construction of the Hamburg sewers by William Lindley in 1842. Since that time, rapid progress has been made and, particularly in late years, many millions of dollars have been spent in this country and abroad, in the construction of systems of sewerage and sewage treatment plants.

The serious consideration of sewage purification in this country may be said to have begun with the construction of the chemical treatment sewage disposal plant at Worcester, Mass., in 1889, and the establishment of the Massachusetts State Experiment Station at Lawrence at about the same time.

Although sewage irrigation was practised in ancient Athens, and in the Far East for about 2000 years, and sewage farming was introduced at Bunzlau, Germany, 300 years ago, it was not until 1850 that the purification of sewage began to attract attention in England. During the period between 1850 and 1875, the impetus given to sanitary work by the cholera in London resulted in the sewering of many towns, with consequent pollution of streams, and it became necessary to develop some method of purifying sewage.

Sewage may be treated on agricultural land to secure a more or less complete purification, if sufficient land is available for this purpose; or on intermittently dosed sand filters, with the same end in view. Here also the purification secured is biological, and there is a fairly well marked limit beyond which land or filters will not afford purification. This limit can be much enlarged by preliminary treatment. Without preliminary treatment, land used by the method known as broad irrigation, as practised in France for the sewage of Paris, and in Germany for the sewage of Berlin, is capable only of receiving the sewage of from 50 to 200 persons per acre, depending upon the character of the soil. Intermittent sand filters, under similar conditions, will only provide for from 250 to 1000 persons per acre.

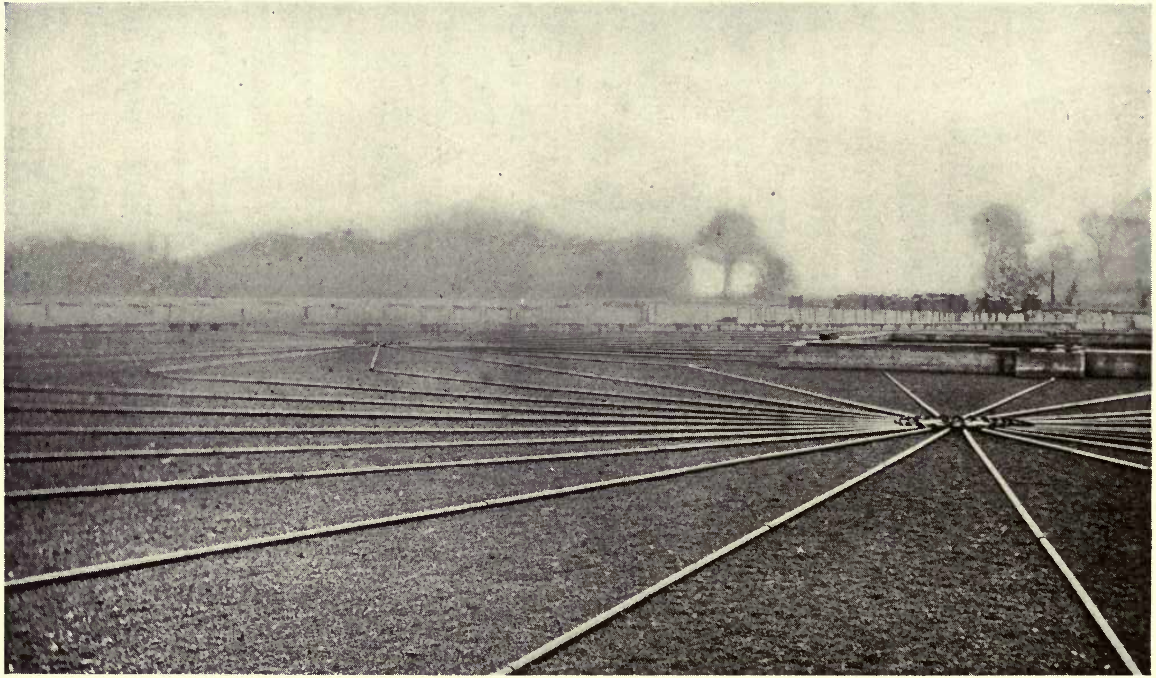
Broad irrigation and sewage farming soon proved unsatisfactory and sanitary development leaned in the direction of septic tanks and trickling filters as more intensive methods.

From earliest times household wastes have been carried in one way or another to the nearest water course or river capable of receiving them without causing a nuisance. Primitive as this method is, it is still one of the most practical methods of sewage disposal, and is generally known as "Disposal by Dilution."

This method answers the requirements as long as the proper conditions are maintained—that is, as long as the volume of water is sufficiently great in proportion to the amount of waste allowed to pass into it. But with the rapid growth of cities, the pollution of waterways and harbors becomes a serious problem, and the development of methods of sewage treatment has been mainly with the object of preparing sewage for dilution, so that the streams receiving the effluent can safely take care of the burden of self-purification.

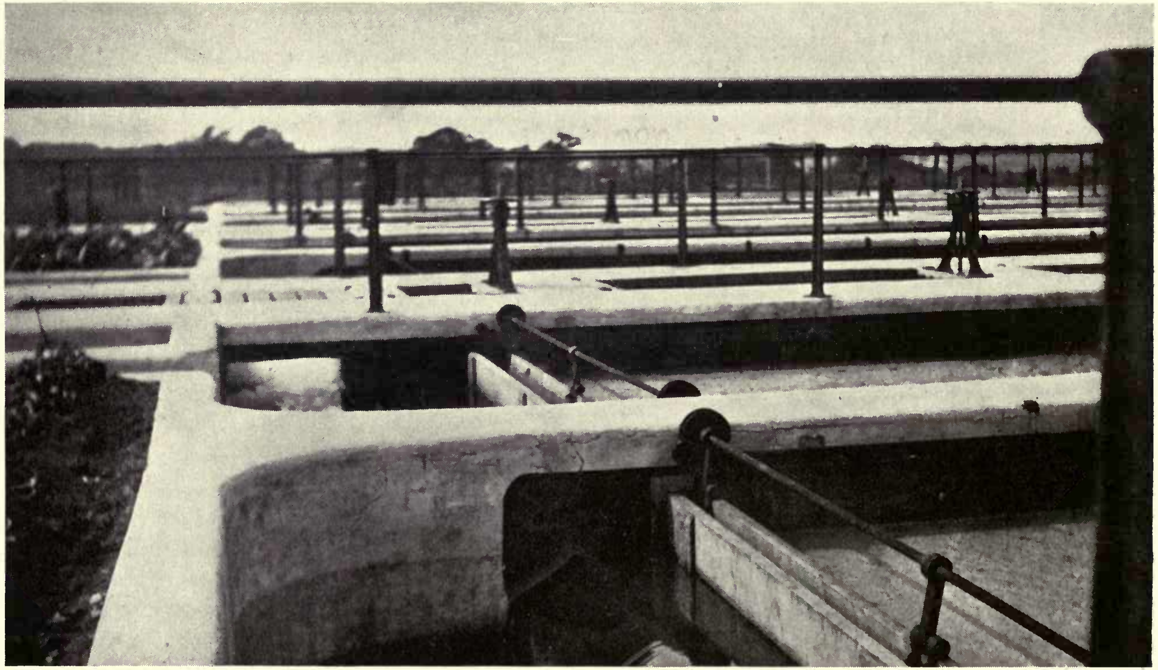
If the sewage is discharged into a sufficiently great volume of water, say 3⅓ to 4 cubic feet per second of flow per 1000 persons contributing sewage, as provided for by the Chicago Drainage Canal, no treatment is considered necessary, as the water will in time effect complete purification by biological agencies, in the presence of the dissolved oxygen content of the stream. But even in this case, sanitary standards require the removal of floating and suspended matter from the sewage. Where the volume of flow per second in the waterway falls below the above requirements per capita, some other form of sewage treatment is usually resorted to, and the extent of treatment required will differ in each case with the volume of water available for dilution of the effluent, with the local conditions, as well as with other factors which enter into the problem.

Obviously where streams or other waterways will not afford sufficient dilution to effect biological purification, without causing exhaustion of



MANCHESTER, ENGLAND
View of filter bed

dissolved oxygen from the water, or where the formation of banks of deposited sewage solids might cause a nuisance, even if the water for dilution were sufficient, preliminary or preparatory sewage treatment is necessary. Also, where the disposal is on land, or by means of sand filters, in order that the polluting effect of the sewage may be so far diminished that a much greater quantity can be disposed of per acre by these methods, preparatory treatment is required for the same reason.



NORWICH, ENGLAND
Travis tank sewage treatment plant

CHAPTER VII

THE BIOLOGICAL TREATMENT OF SEWAGE

Sewage treatment is seldom undertaken at a sewage disposal plant, regardless of the method employed, with the object of producing actual sewage purification. This would indeed be a very costly matter, and fortunately is required only under exceptional conditions, and is practically restricted to the method known as sand filtration. Purification is, however, the end or result which every method has in view. As this may seem a paradoxical statement unless further explained, it should be pointed out that the purification of polluted waters observed in nature is strictly a biological process; and that considerable time is required for its complete action, whether by filters, on land, or by dilution.

The object sought by sewage treatment is the removal to a greater or lesser extent, as conditions require, of the floating matters, settling matters, non-settling putrescible matters, and objectionable bacteria. Trade wastes, which are

LEEDS, ENGLAND
Chemical precipitation sewage treatment plant

the spent liquors and waste material resulting from the operations of various industries, must also be considered in the treatment.

Floating matters may be broken up and settled, and partially removed by baffles placed in grit catches, etc. Various methods, such as tanks and fine screens, have been devised for the removal of floating and settling matters, which tend to dissolve, or break up into finely divided suspended solids, usually called "colloids," if not promptly taken from the liquid part of the sewage; and thus give rise to the presence of non-settling putrescible matters, which are very difficult to remove. These cause the most costly part of sewage treatment, if their removal must be effected. But they are the part of the sewage matters that are most rapidly disposed of by biological oxidation in rivers, and on land, if they are not present in quantities great enough to produce oxygen exhaustion. Objectionable bacteria are such as may cause human disease; their removal is effected usually by some form of chemical disinfectant applied to the treatment plant effluent.

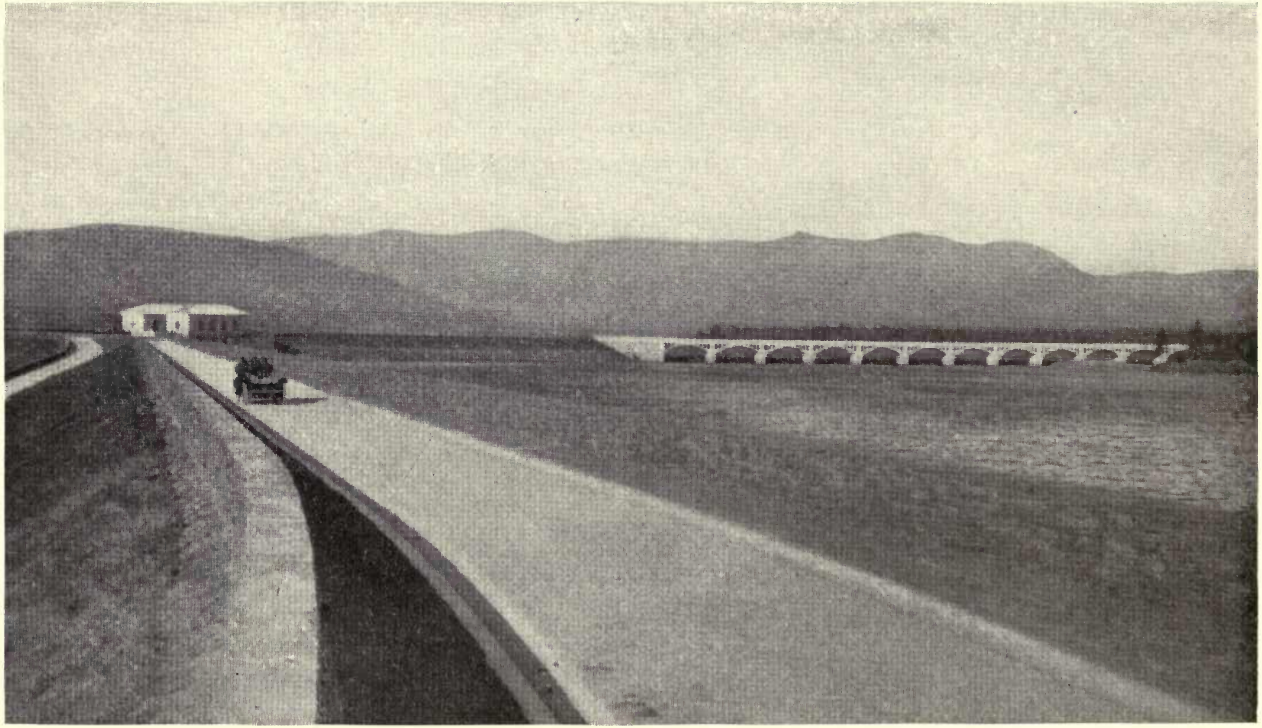
The removal of settling matters from polluted waters and sewage has for ages been accomplished by means of tanks. Of these, two general classes should be mentioned: tanks which depend merely on detention of the sewage, and sedimentation, which are the oldest form used; and tanks

NEW YORK STATE BARGE CANAL
Entrance to land line at Fort Miller, Champlain Branch
Courtesy of State Engineer and Surveyor's Dept.

in which sewage is treated with a precipitant such as lime, or other chemicals.

Chemical precipitation as a means of sewage treatment was widely introduced during the period from 1885 to 1895, and was thought to promise a complete solution of all sewage disposal problems. In Great Britain several of the large cities adopted this method, among which were London, Birmingham and Glasgow; in America the cities of Providence, Worcester, and some smaller places constructed such plants. At present the method is unpopular. It is costly to operate, produces great quantities of sludge and does not give an effluent free from causing a nuisance. The State of Massachusetts has ordered Worcester to discontinue the stream pollution caused by such a plant, and the method has been abandoned both here and abroad, by most of the cities that once were enthusiastic about such plants.

Plain sedimentation without the use of chemicals, in tanks of the ordinary type, involves the filling of a tank with sewage, which is then allowed to stand long enough for deposition of the heavier solids. Then the sewage is discharged and the settled matters removed, usually by hand. The settled matters are very foul and offensive and require special treatment and disposal. A more advanced design of these tanks is provided with a bottom consisting of one or more inverted



NEW YORK CATSKILL AQUEDUCT
Ashokan Reservoir looking west from middle dike

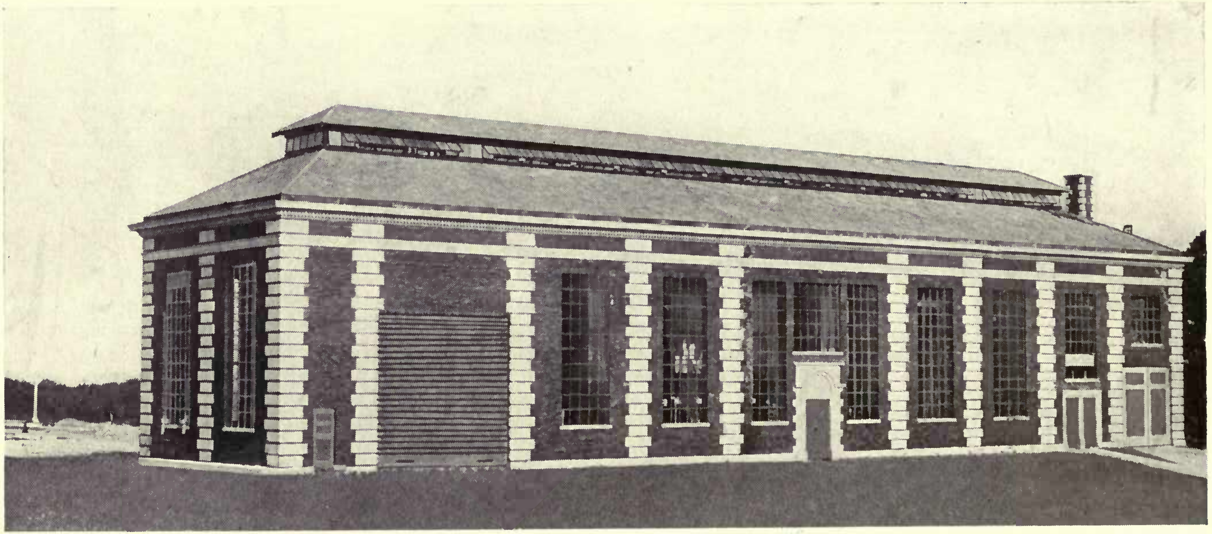
pyramids or hoppers, each hopper having a sludge pipe outlet, through which the settled matters may be removed by gravity.

This form of tank often creates bad odors, especially if the settled matters are not removed frequently. Such tanks also cause much of the suspended matter to dissolve, or to break up into colloidal matter, and as oxygen exhaustion usually intervenes in this operation, and a vast increase of bacteria, the sewage effluent is worse, and more foul than it was before entering the tank, and more likely to cause a nuisance near the outlet of the sewer.

The solution of suspended matters and their apparent disappearance in tanks from the sewage several years ago, misled many engineers to the conclusion that a complete biological method of sewage treatment had been discovered, which was effected by anaerobic bacteria. Further studies resulted in the so-called septic tank. Much was claimed for this tank, but it actually accomplished very little. The tanks at Columbus, Ohio, and at Baltimore, were among the largest of this type. The latter continue in service, the sludge being taken from them before the septic process is complete, and carried to completion in separate digestion tanks. The septic tank generally caused bad smells. Sewage ran through it continuously with a detention due to the size of the tank, varying from 8 to 24 hours. Some tanks were covered, and some opened at the top; a heavy scum of floating matter and grease covered the surface of the sewage, and helped to prevent the escape of foul smells; but much of the hydrogen sulphide and other gases was carried out of the tank with the effluent, which was foul, black and highly putrescible.

NEW YORK CITY, N. Y.

Chart showing proposed number and location of district or divisional sewage treatment plants (indicated by black symbols) suggested by the Metropolitan Sewerage Commission



ROCHESTER, N. Y.

Superstructure of R-W screen sewage treatment plant. Two screens operating before Imhoff tanks and two screens operating independently, both effluents discharging into Lake Ontario

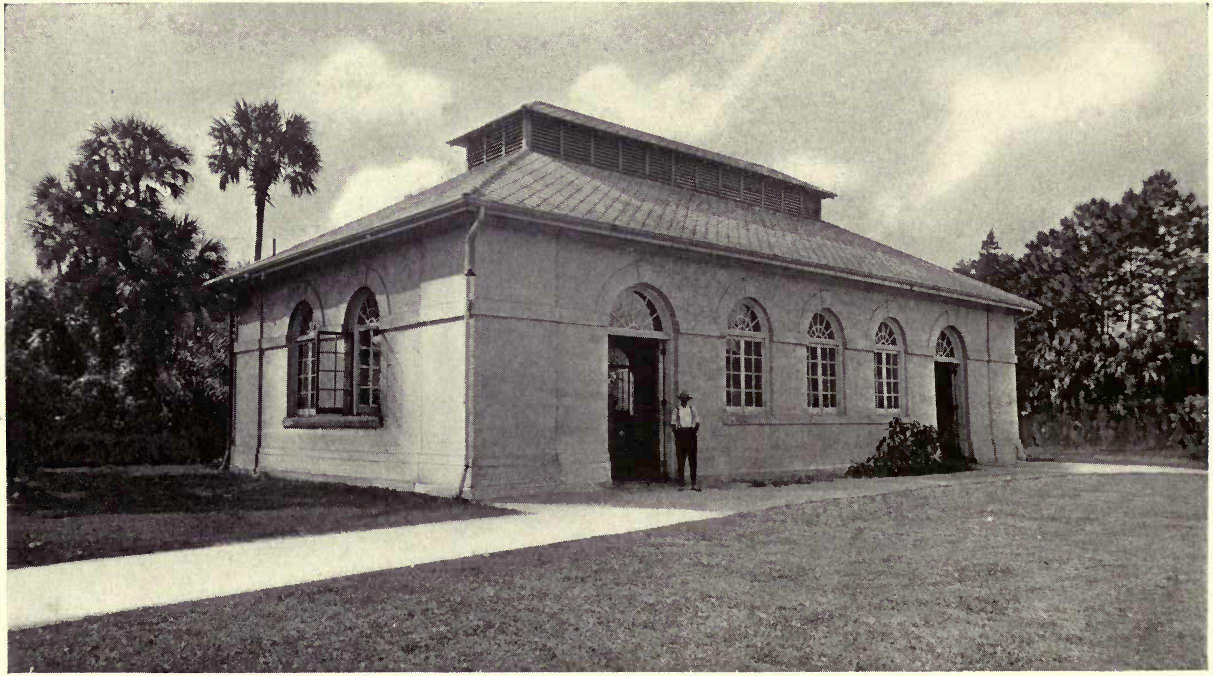
CHAPTER VIII

DIFFICULT PROBLEMS FOUND IN TREATING SEWAGE

ONE of the greatest difficulties connected with sewage treatment is the disposal of sludge from septic tanks and settling tanks, as the sludge from these tanks is highly putrescible. This has led to the invention of two forms of tanks, each of which attempts to carry the septic treatment of the sludge to such a point that when discharged it will not cause a nuisance.

These tanks depend upon the assumption that when the so-called septic action has been carried to its extreme, the unstable organic matters which are attacked by anaerobic bacteria, become incapable of further putrescence and dissolve, or split up; part going into solution, part into inert matters, and part remaining as organics, that do not readily putrefy, which are deposited with the mineral materials present on the bottom of the tank.

The greatest problem met by designers of tanks has been to design a tank in which the reten-



DAYTONA, FLORIDA
R-W sewage treatment plant in an Atlantic Coast winter resort

tion of these putrefying matters would not cause them to mix with the incoming sewage, and render it highly "septic," or putrescent, as it left the tank. This was the great difficulty with the original septic tank.

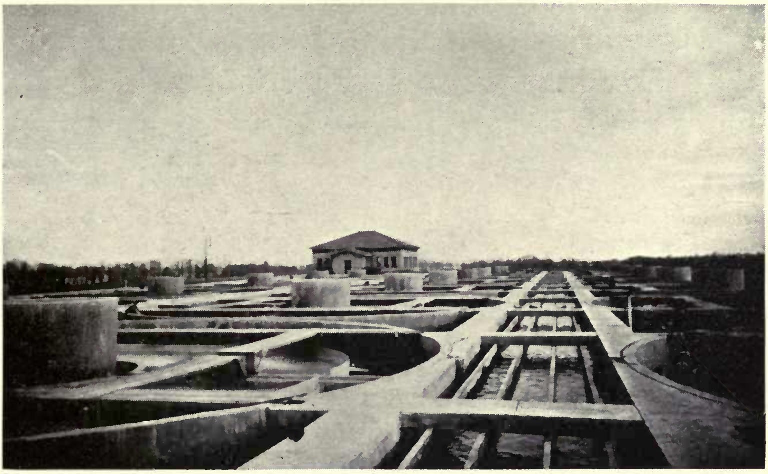
The first two-stage, or two-story, tank was invented in England about fifteen years ago and was known as the Travis tank. It is provided with two upper, or flowing-through chambers, the bottoms of which are inclined at an angle of about 45 degrees and are provided at the lowest point with ports, or openings, into the lower chamber which was placed between the two upper chambers, through which the settlings and sludge pass by gravity. The lower, or digesting, chamber has its bottom, which is the deepest part of the tank, formed in one or more hoppers, or inverted pyramids, provided with sludge outlet pipes. The upper part of this chamber is at the same elevation as the upper part of the flowing-through chambers, and a portion of the sewage is permitted to pass through it. The flowing-through chambers have a network of slats formed into trellises which are placed across the direction of the flow, the purpose of which is to act as a remover of colloids by "adsorption," it being claimed that fine particles of organic matter in a colloidal state tend to adhere to surfaces where they are readily attacked and liquefied by bacteria.

But few plants with tanks of this type have been built. The effluent was little if any better than from a septic tank. The sludge was not suf-

ESSEN, GERMANY
Imhoff tank sewage treatment plant

ficiently digested to dry on a bed without causing odors. At Norwich, England, using this system it was necessary to dispose of the sludge in trenches.

The Imhoff tank is a more successful effort to solve this very difficult problem. Invented at Essen in Germany, it is a further development of the Travis principle. It discards the "colloiders," and provides two chambers, an upper or flowing-through chamber for the sewage, intended for plain sedimentation, and a lower or digestion chamber, for the settling matter or sludge. The upper chamber is designed with sharply sloping bottom surfaces, provided with slots at the lowest point, through which the settlings enter the lower, or digesting chamber; a baffle or fender is arranged under the slots to pre-

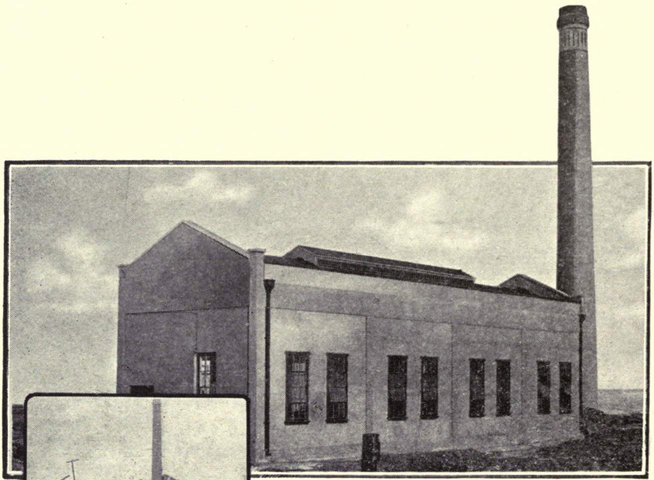


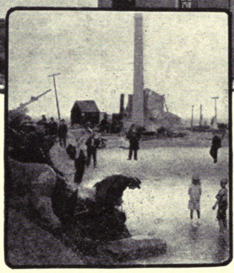
BALTIMORE, MARYLAND
Imhoff tank sewage treatment plant

vent the gases arising from the digesting matters from entering the upper chamber. The lower chamber is provided with vents or chimneys which reach the surface to permit the escape of gases into the air.

Many tanks of this form have been built, especially in Germany, and when properly designed and operated with a very short detention period this has proved to be the best type of tank.

The septic process is essentially a fermentation and rotting out process. It is an attempt to let nature take her course, in carrying out the various changes that are required, for the partial or complete decay of organic solids; but confining the nuisance, and odorous process, within the limit of a tank. It now is well understood that this process requires a long time to accomplish much of value in the reduction of organic solids; and that the danger of a nuisance is present, in the tanks so far designed.





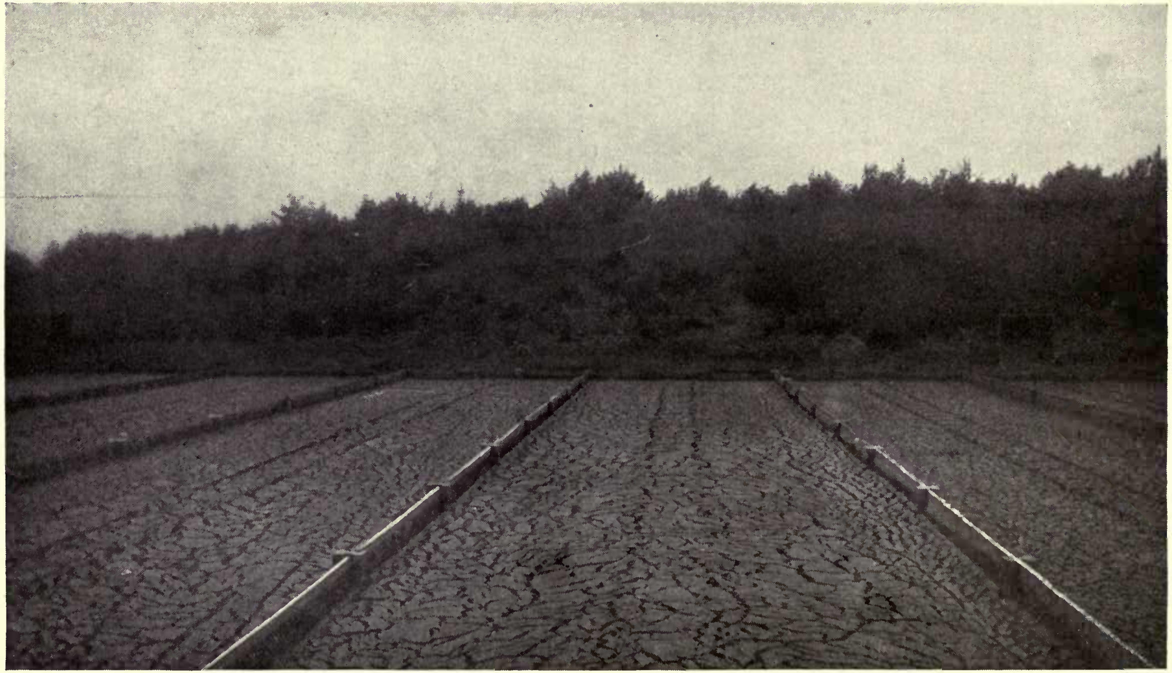
LONG BEACH, CALIFORNIA
R-W screen sewage treatment plant adjacent to bathing beach shown in small insert

CHAPTER IX

THE MECHANICAL TREATMENT OF SEWAGE

THE natural agencies employed under operating conditions sometimes escape from the control under which the septic type of plant attempts to place them, and cause odors and a more or less active nuisance. Since the first tank was used, objections have been made on the part of the public, and sanitary engineers have sought for other methods of freeing sewage from matters in suspension. It was noted soon after tanks began to be used that they did not give a very high removal of total solids from the sewage, and that much suspended matter passed from suspension into solution, making the liquid part more foul than before, especially if subjected to long periods of detention.

An obvious principle of sewage treatment is, that the quicker the polluting organic solid matters are removed from the liquid part the better, as this prevents solution of the solids; it also



FITCHBURG, MASSACHUSETTS
Sludge drying beds, Imhoff tank plant

keeps the sewage from becoming septic, and prevents the vast increase of bacteria that a long period of treatment invites.

As sedimentation was at best a slow process, and could seldom escape causing septic conditions, it was asked, "Can we not find a mechanical method of treatment which will remove the suspended solids at once?" On this problem engineers and scientists have been engaged many years. Much of this work was done in Germany where, as in America, with large rivers, conditions were favorable to the discharge of fresh liquid sewage if freed from suspended matters above a certain size, without further treatment. In England the streams as a rule are so very small that the mere removal of fresh suspended solids was not usually sufficient, and filtration was required in any case; and having started by using tanks before filtration, the conservative English engineer has been slow to take advantage of progress made elsewhere.

Much has been published about the success of the mechanical treatment of sewage in Germany. For the present purpose it need only be stated that the quick removal effected by fine screens of the suspended matters above a certain predetermined size—to be decided upon to meet the local needs—has been very successful.

The evidence of this success has appealed so strongly to American engineers familiar with Ger-

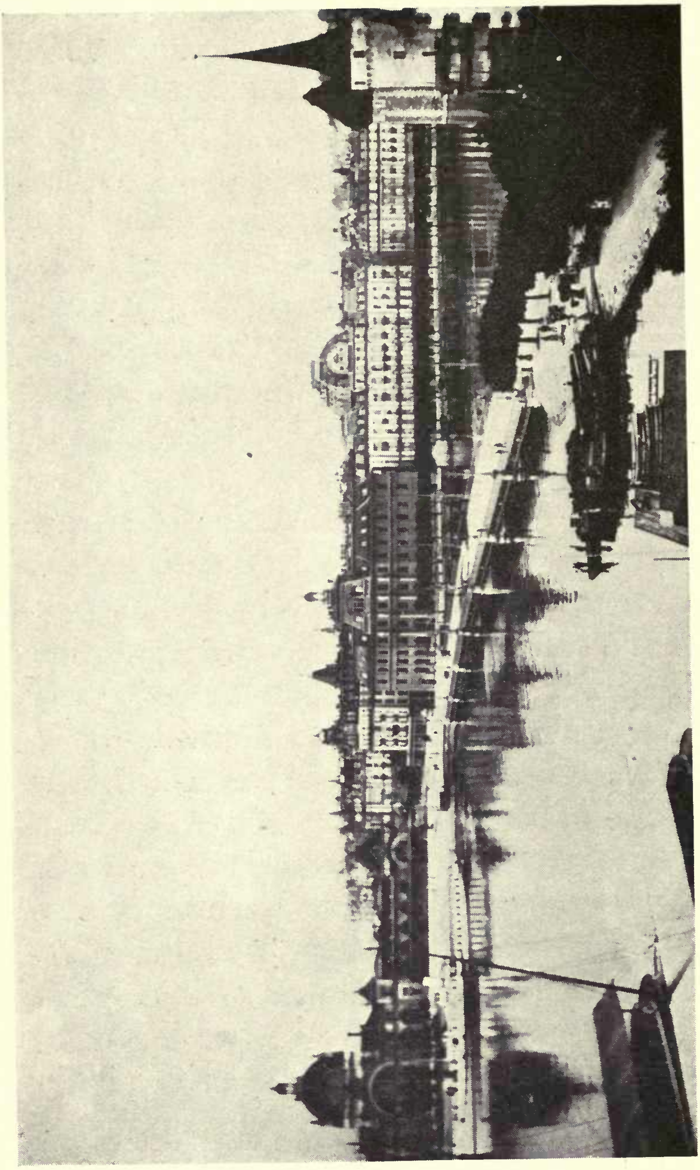
BIRMINGHAM, ENGLAND
View showing the largest trickling filter plant in the world

man fine screen plants that the introduction of fine screens for treating sewage in the United States has made rapid progress, and is giving general satisfaction.

There are a great many such plants abroad, some of notable interest; of which Dresden may be mentioned as a type and as the largest installation, where the sewage of an entire city, having a population of about 600,000, is fine screened as its only preparation for discharge into the Elbe River, a small stream at this place, and more than 400 miles from the sea.

A principle followed in the design of sewage treatment plants in Germany has been, first, to improve the river that is to receive the effluent, so as to improve its capacity to afford dilution, and at the same time render it better able to carry river transportation. Thus a commercial waterway of great economic value can be created, with part of the funds, and the cost of sewage treatment greatly reduced. To prevent nuisance in the unimproved stream would have required a much higher grade of treatment, and greater investment of money in plant, as well as more costly operation.

Having regulated and dredged the river, it has usually been found that the needed expenditure for sewage treatment has been reduced more than half, and a prosperity producing improvement obtained, for money that would otherwise have



LUCERNE, SWITZERLAND
View showing improved waterway

been locked up in a costly sewage treatment plant.

It may confidently be stated that in America with its large rivers, more than half of the money used in sewage disposal plants, and expensive main drainage systems, would far better have been expended on the improvement of the rivers; with the two objects in view of making them valuable commercial assets, and of reducing the need of sewage treatment expense to a minimum. Dredging commercial waterways and deep channels, not only provides for water-borne freight, but also greatly increases the quantity of water present available for sewage dilution, and provides favorable conditions for the mechanical treatment of sewage. The danger from floods is also greatly reduced, and the natural drainage of extensive tracts of country much improved; swamps and marsh lands are dried, directly preventing malarious conditions, and destroying the breeding places of mosquitos. The commercial and sanitary conditions are all benefited by such use of money—and the saving in cost of sewage treatment is large. Money used in waterway improvements gives immense returns on the investment, while that used on sewage treatment plants—notwithstanding their sanitary importance—is locked up forever.

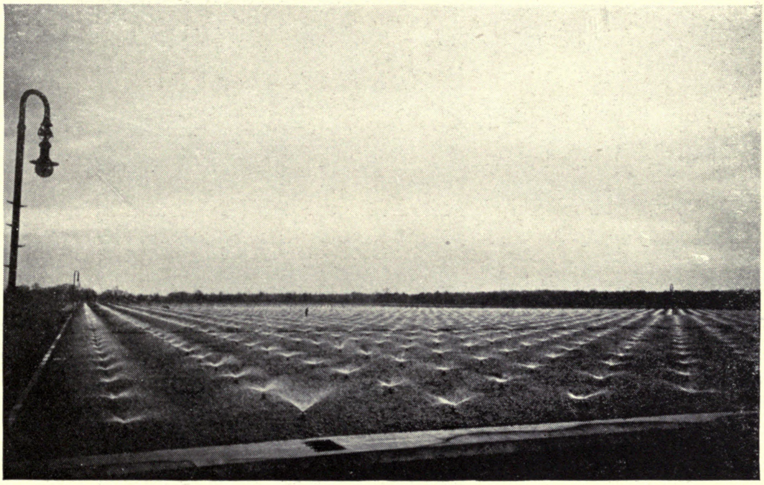
DRESDEN, SAXONY

Interior view of the screen house, showing general arrangement of the Riensch-Wurl screens (each twenty-six feet three inches diameter), screen bridges, motors and driving mechanism, with elevators for screenings, effluent discharge channel at left

CHAPTER X

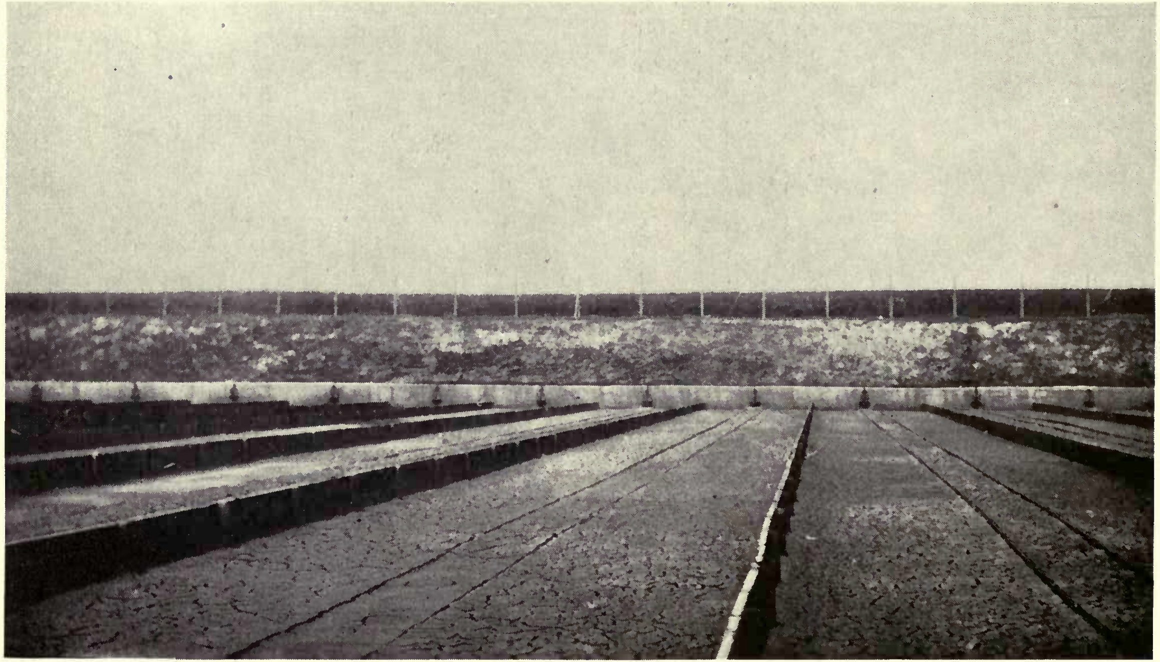
THE PURIFICATION OF SEWAGE

FROM the foregoing considerations we now turn to the need of a more complete treatment of sewage than the removal of suspended matter will give. Such treatment may be required if the efflu-



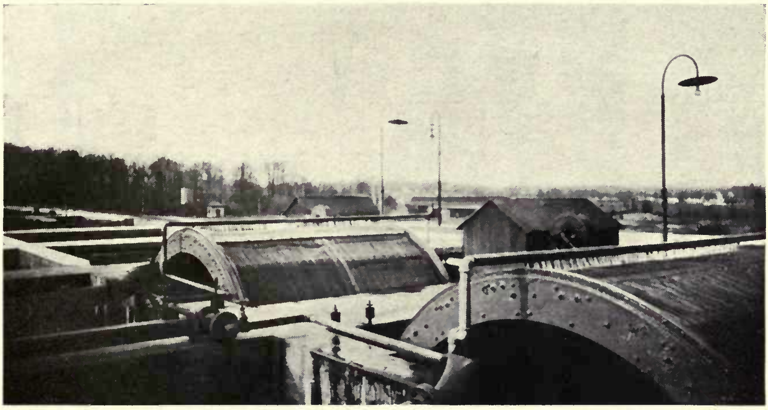
BALTIMORE, MARYLAND
Trickling filter bed, the largest plant of this type in the United States

ent is to be discharged into a stream so small that the diluting water will not provide biological purification without putrescence. The means of giv-



ESSEN, GERMANY
View of a sludge drying bed

ing this higher grade of purity to the sewage is strictly biological, and the designs used in such plants have for their object the cultivation of

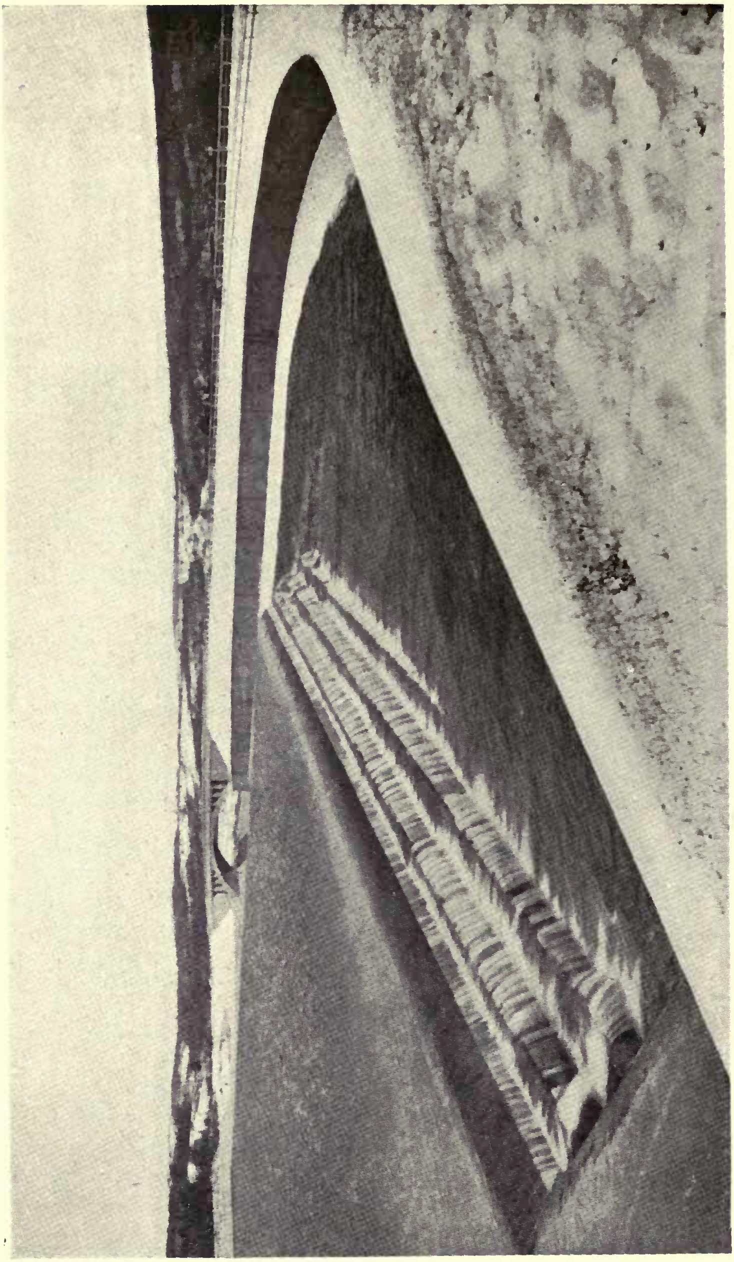


BALTIMORE, MARYLAND
Sewage treatment plant, showing two cylindrical screens for treating the sewage after passing through tanks prior to entering filter beds

aerobic bacteria under control, and in the presence of a plentiful supply of oxygen.

The standard methods now used are all secondary forms of treatment; that is, the sewage has already passed through a stage of preparation by which suspended solids have been removed to a greater or lesser extent. Examples are shown in the accompanying illustrations of the various forms of plants used for the purpose.

It would be useless to attempt a detailed comparison of the methods of secondary or oxidation treatment. The installation of such plants is seldom really necessary, and much public money has been uselessly expended in the futile attempt to



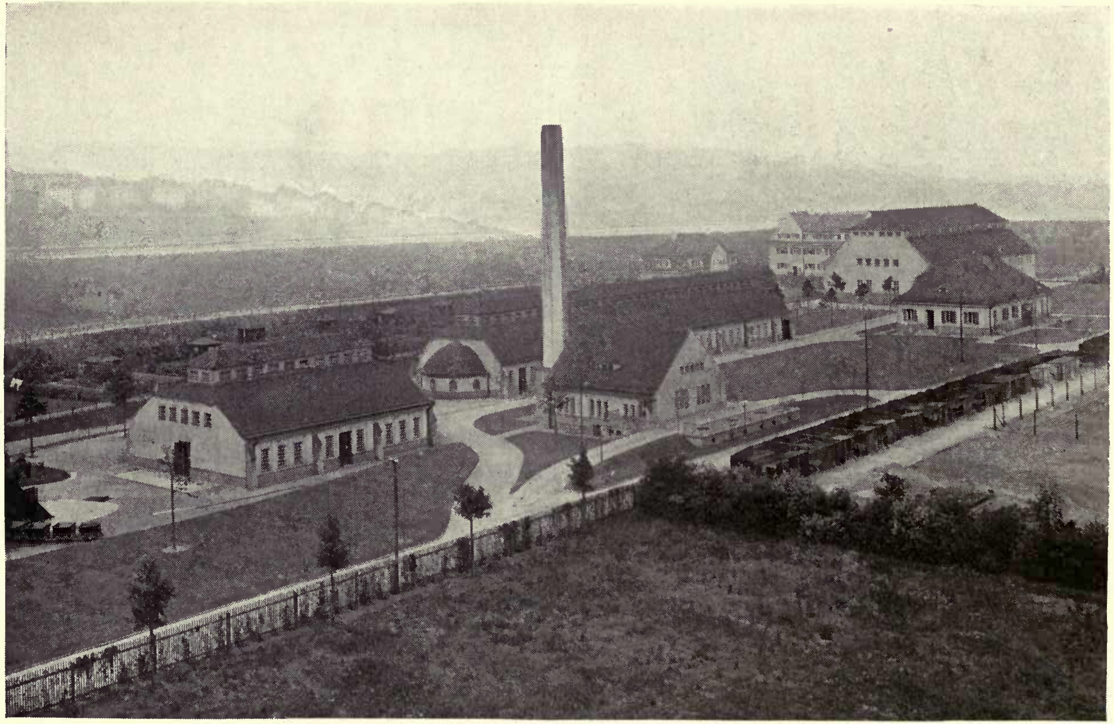
NEW YORK CATSKILL AQUEDUCT
Ashokan reservoir, waste weir, spillway channel and bridge

make drinking water out of sewage. The real and usually the only requirement is to prevent a nuisance in a stream or waterway the use of which is unavoidable for sewage discharge.

In Chicago a few years ago, a board of consulting engineers considered various plans for the sewage disposal of that city. One of these plans consisted of primary and secondary treatment by means of tanks, followed by sprinkling filters of immense size and capacity; the other was for a canal connecting the waters of Lake Michigan with the Illinois River, thereby creating a great commercial waterway, into which the entire sewage of the city could be discharged, and completely treated by the mere dilution thereof, with the waters of the canal.

CITY OF CHRISTIANIA, NORWAY
View of waterfront and Riensch-Wurl treatment plant (indicated by arrow). Note class of residential buildings in immediate vicinity of the plant and pleasure craft in the harbor into which the screened effluent is directly discharged

The result to be obtained by the first method at best was uncertain, and the period of time during which it would be sufficient was doubtful.



DRESDEN, SAXONY

General view of the sewage treatment plant, showing the detritus, bar screen and sludge by-product treatment house, the Riensch-Wurl screen house, the pump house, the boiler house and the workmen's cottages

The success of such a plant depended principally on perfect care and first-class ability being applied to its operation and maintenance. At best,

VIEW OF CITY OF CHRISTIANIA, NORWAY
Showing location of screening plant, indicated by arrow

the very large cost would give nothing of commercial value. Its condition would rapidly depreciate in service, and in a few years call for extensive repairs, and finally for reconstruction. It would require many acres of valuable land which besides first cost, would be removed permanently from industrial or home development; and large surrounding areas would probably be rendered undesirable by the presence of the plant, which would cause local nuisance and depreciate property values.

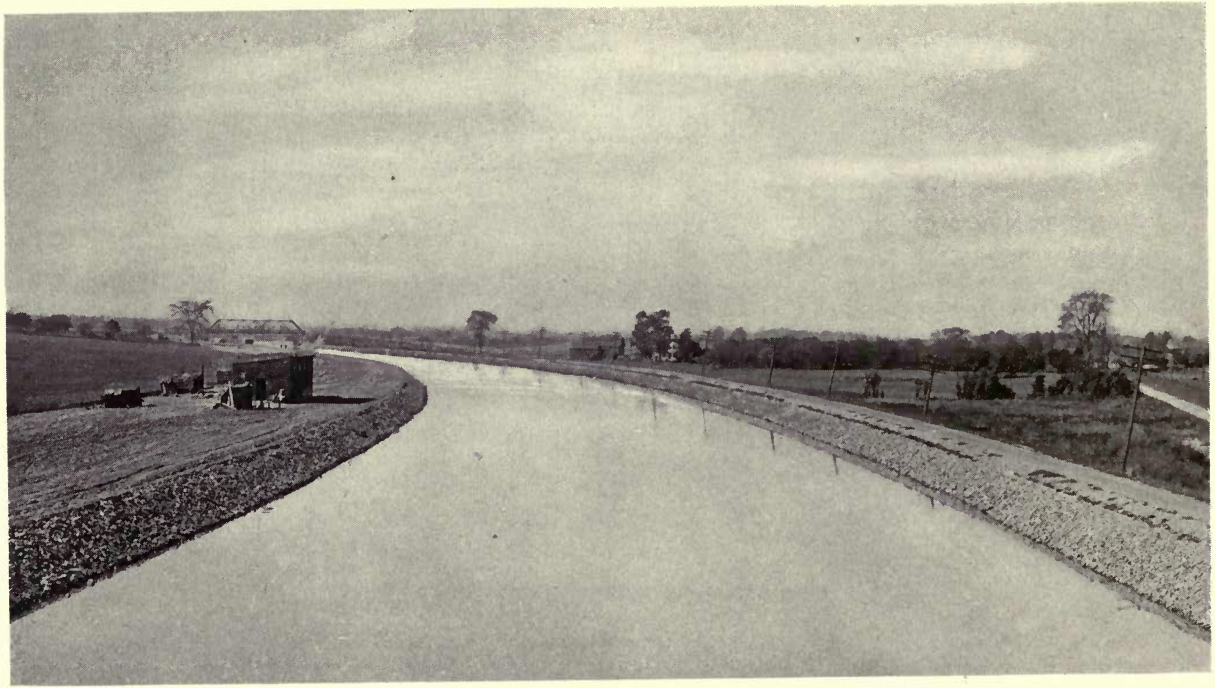
The canal avoided these objections. The water available for dilution afforded a satisfactory treatment, and insured the inoffensive oxidation of sewage pollution within a few miles of the entrance of the sewage. No valuable land was to be taken from its natural development and taxable value; and taxable values would be increased, instead of diminished, by the presence of the canal, as its commercial possibilities became evident.

The commission wisely decided upon the canal, which is now completed, and gives Chicago a commanding commercial situation, since through it can come to its gates the commerce of the Mississippi and its tributaries which, when fully developed as they are almost certain to be, will lead a flood of gold into her commercial channels.

CHAPTER XI

DEVELOPMENT OF COMMERCIAL WATERWAYS AS A SANITARY MEASURE

THE development of the internal commerce of the United States is one of the most important interests of our nation. With the great increase in cost of railroad operation, resulting from a diminishing coal supply and lack of labor, the return of river and canal transportation for freight is to be expected. Our country is far behind the old world in this respect; there, a large portion of freight, especially in heavy bulk, is carried by steamboats and barges, and the regulation of rivers and waterways and canal developments have been brought to a high point of efficiency. We are just about making a start in this line, and the prosperity of many cities is deeply concerned in the progress of this means of transportation. Cities served by railroads only may within a few years find themselves outclassed by more fortunate rivals possessing river and canal facilities.



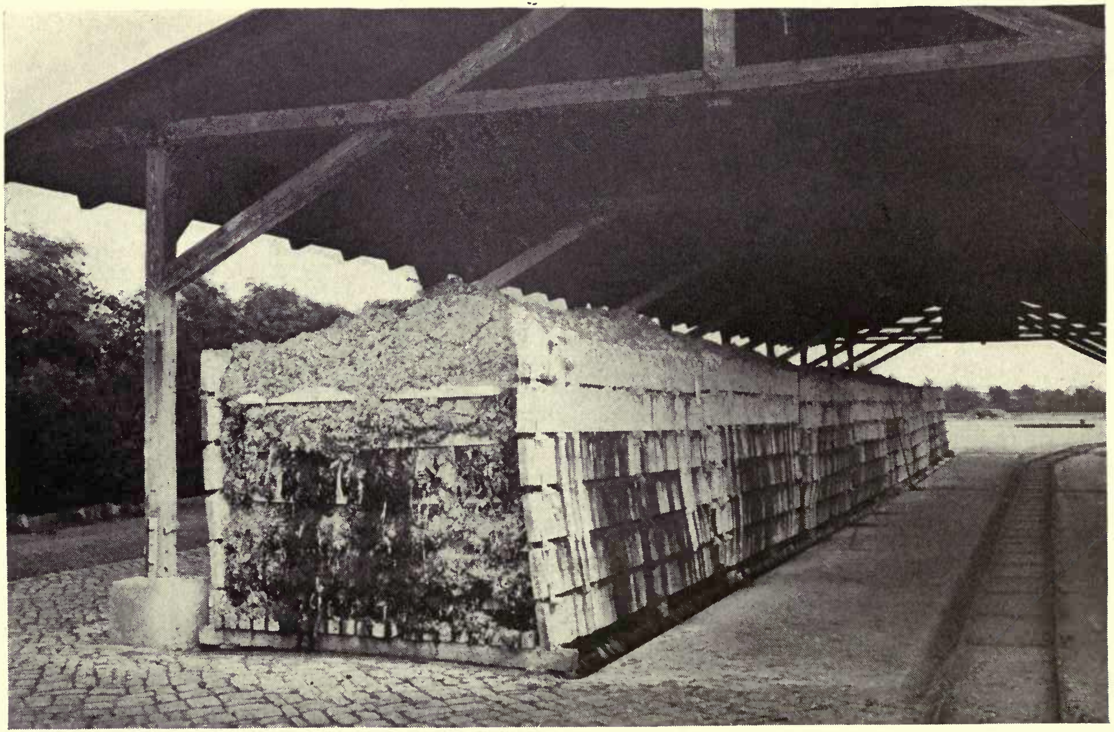
NEW YORK STATE BARGE CANAL
Land line in western section of the State
Courtesy of State Engineer and Surveyor's Dept.

The Great Lakes form a chain of inland seas which are paralleled by many of the great rivers at approachable distances for connection by canals. The development and regulation of these rivers, with canals passing from them to the lakes, will afford the most splendid internal commercial waterways in the world, and one of the greatest projects ever proposed by the civil engineering profession.

Of such canals, the New York Barge Canal is the most important that has been realized in completed form. That it is to be only the first among others as important is confidently anticipated. Now that New York has opened this immense opportunity for reducing the cost of traffic, others will soon follow.

The sanitation of cities situated on rivers that can be improved to afford much larger volumes of water than at present, and on canals comparable in size to the Chicago drainage canal can, by developing their waterways and making existing channels deeper and wider, save much of the cost required for sewage treatment plants. The money saved by thus avoiding the necessity for constructing vast sprinkling filter beds, etc., can be applied to improvements of a more desirable and profitable kind.

The New York State Barge Canal, beginning at Buffalo, will carry an ever increasing stream of commerce to New York and Brooklyn, and this



DRESDEN, SAXONY

View showing sale shed and bins for storage of screenings. Note the character and consistency of the screenings, which are fresh and contain their manurial values, finding ready sale in the raw state as fertilizer will have an important effect on many local sanitary problems. Jamaica Bay, a large but shallow body of water within the area of the city of New York, and adjoining the harbor, was becoming polluted with sewage, and was negligible in commercial value because of the high cost of dredging, until the prospect of the traffic to be anticipated from the new barge canal made its value apparent, and plans were prepared for its extensive improvement. It was then found that with the newly dredged channels, required for commerce, the sanitary problem had been much simplified; that biological sewage treatment plants consisting of sprinkling filters for the treatment of sewage entering the new channels, would not be necessary; and that money thus saved might be used on other improvements.

There are doubtless many other places where dredging adequate channels in a stream or harbor for the benefit of commerce would also solve the problem of sewage treatment to such an extent that the cost of treatment plants would be reduced more than half, and risks of nuisance entirely disappear. Such problems invite the serious study of municipal officials before they authorize the expenditure of large sums of money on disposal plants that would become needless, should the river or harbor be properly dredged for shipping.

NEW YORK CITY, BOROUGH OF BROOKLYN
Superstructure of High Pressure Fire Station

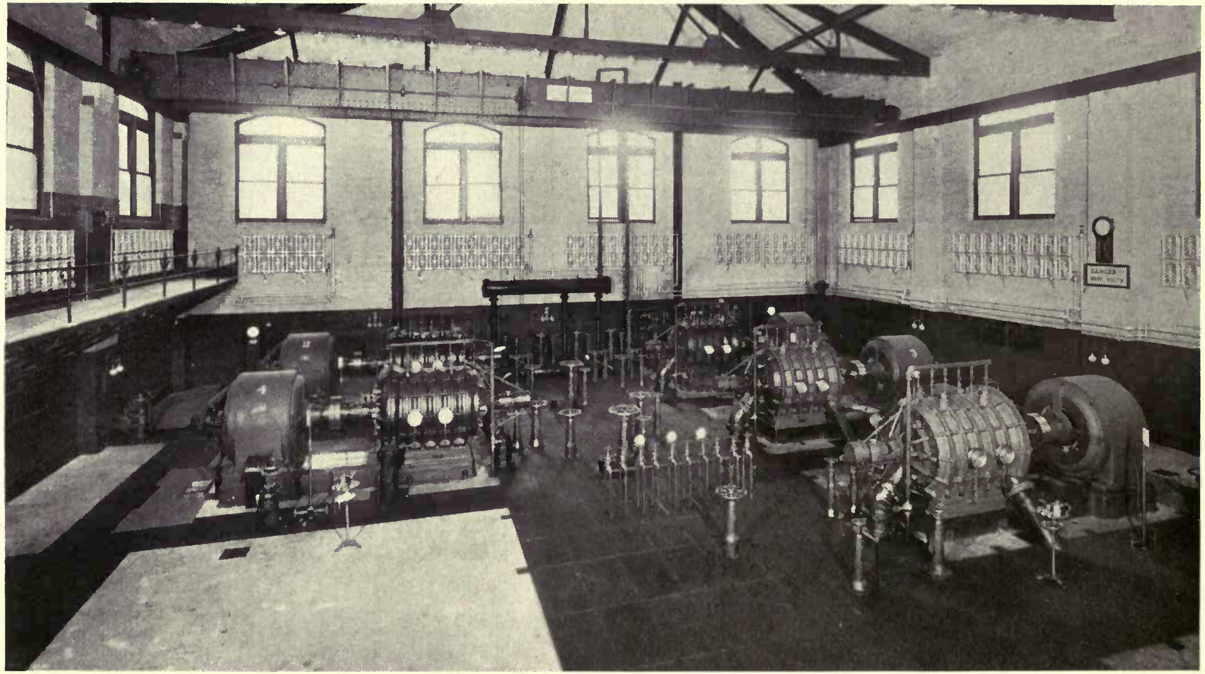
CHAPTER XII

HIGH PRESSURE FIRE SERVICE

THE health and prosperity of the community depend upon pure water, sanitary conditions, successful industry, and facilities for ready transportation of freight and persons. The public does not fully or properly comprehend the benefits to be derived from a general and thorough study of municipal problems in the supply of pure water and the treatment and disposal of sewage, rubbish, and garbage, as parts of a common municipal development.

The reasonable procedure to follow would be to have trade wastes treated prior to discharge into the municipal sewers, so that such wastes would be at least in a condition comparable with the domestic sewage of the city. Moreover, the value of by-products to be derived from this treatment of trade wastes should be of special interest to the manufacturer.

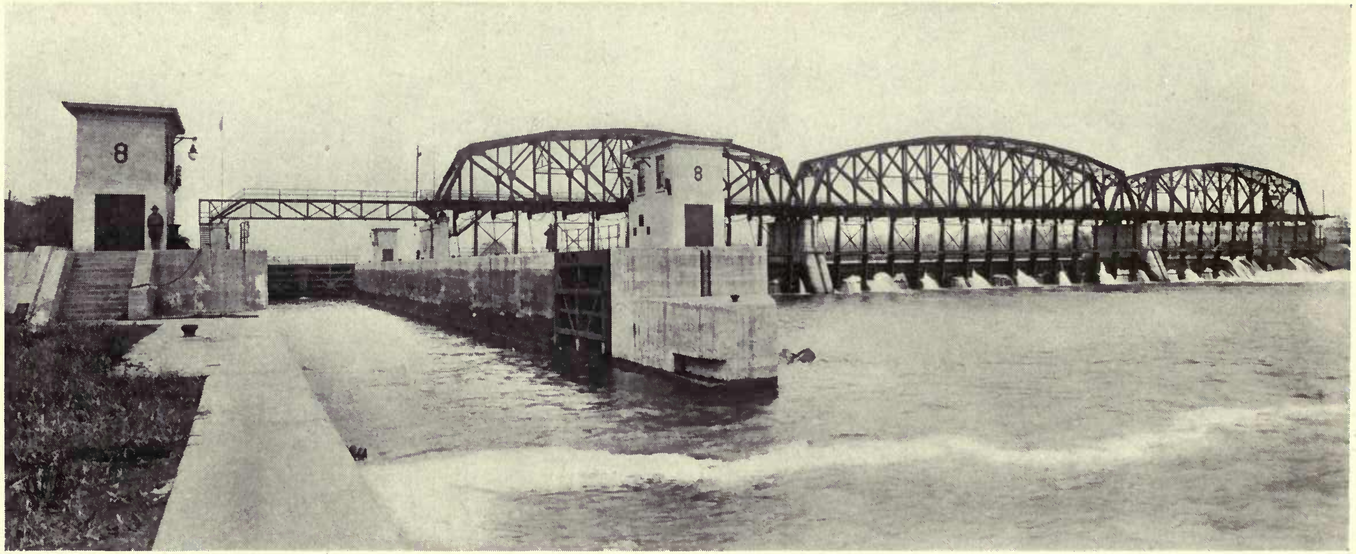
The problems of city sanitation include and merge into the more general problems of the public welfare. The agencies of municipal govern-



NEW YORK CITY, BOROUGH OF BROOKLYN
High Pressure Fire Service Station

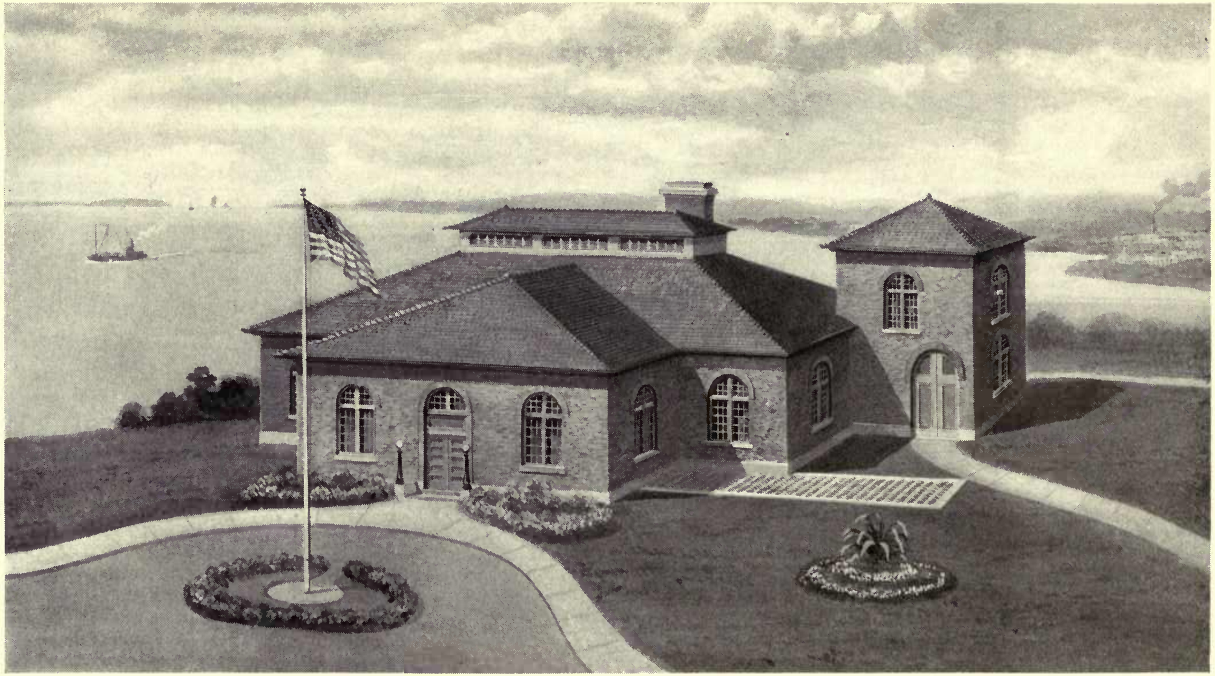
ment are all provided for that one end and purpose—city sanitation and municipal welfare go hand in hand. The administration with its executive, police, health, street-cleaning, engineering, and fire protection departments, etc., all should be considered in connection with the public welfare and city sanitation. It is not possible in such a brief survey as this study intends to go further into detail as to the influence of all these and other municipal departments on the sanitation of cities; but the effect of each is obvious—a full accounting of the progress made in the development of all of the various agencies of city welfare would be most interesting. For illustration on this point we may take the single feature of fire protection—a most important and interesting subject in itself—affording a rather striking picture of municipal progress. Not many years ago our fathers were satisfied with bucket brigade fire protection, and each solid citizen of the last century had his half-dozen leathern buckets, marked with his initials and the words "For fire only," hanging in his hall at a convenient place, ready for the emergency when the fire bell should call out all of the volunteer fire laddies. Next came the well-known fire engine, still with us; and in the fullness of time came the high pressure service, with its powerful pumps, typifying modern progress.

The practice of protecting the congested busi-



NEW YORK STATE BARGE CANAL
Movable dam and lock in Erie Branch
View showing gates down, and the structure fulfilling its purpose as a dam
Courtesy of State Engineer and Surveyor's Dept.

ness districts of our greater cities by means of high pressure fire service is now so well established that we can scarcely realize the feelings of business men in the past, before the adoption of this system, who, on leaving their offices and warehouses at night, were always haunted by the danger of destructive conflagration before morning. The experiences of Chicago, Boston, and Baltimore are still fresh in the public memory; but with the new high pressure protection the danger has largely vanished. A few pictures of some of these stations are included as an indispensable feature of this study. Greater New York was the first city to install such a fire protection service. The first high pressure stations were constructed in the Borough of Brooklyn, followed soon by stations in the Boroughs of Manhattan and of Richmond. Not only cities of the first class, such as New York, Philadelphia, San Francisco, etc., have installed high pressure fire service, but many smaller and no less progressive cities—such as Miami, Florida, for instance—have also established this protective method of fire protection; and almost every American city not yet so protected now has the project under advisement, and it is generally admitted by all authorities that no subject can be of more urgent importance.



BRIDGEPORT, CONNECTICUT

Largest fine screen sewage treatment plant in America, sanitary in every respect. View shows exterior of building which houses the complete process for the treatment of sewage

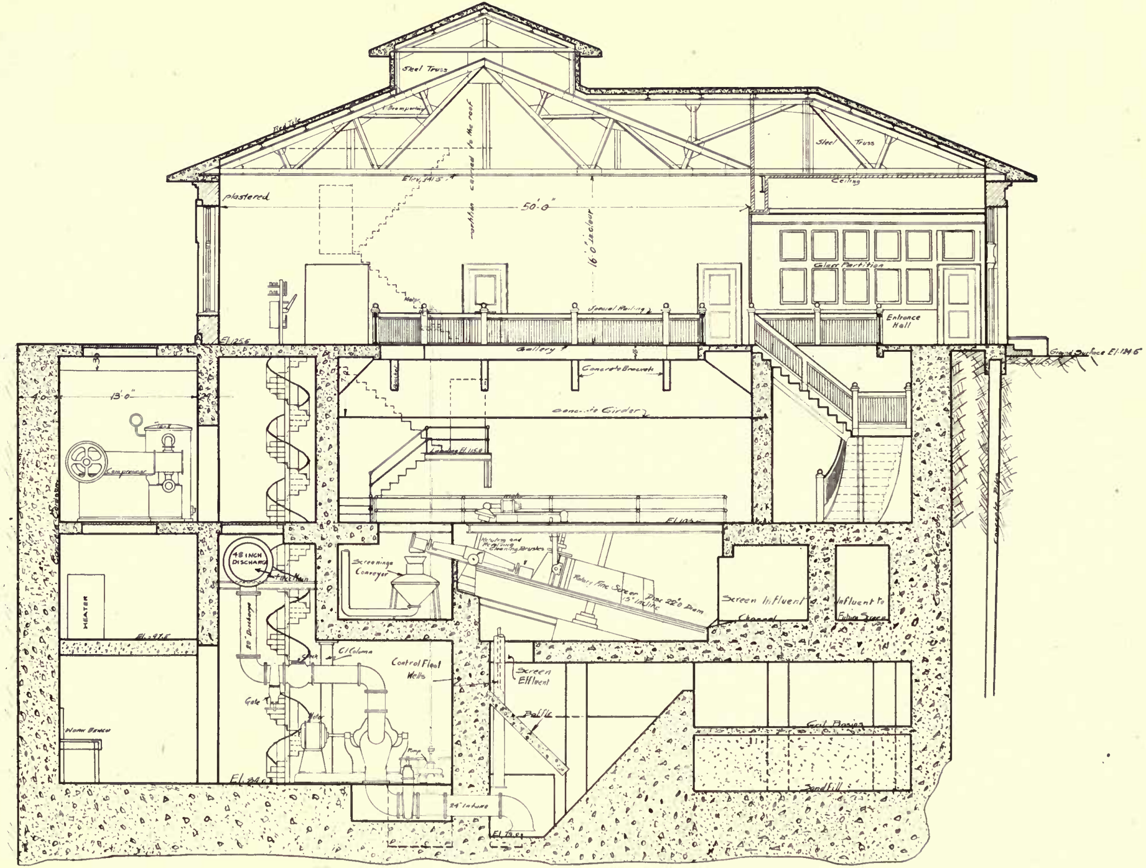
CHAPTER XIII

CONCLUDING REMARKS

CONSIDERING the vastness of the subject, we have presented a very brief review of the Sanitation of Cities. With our rapidly increasing population, and the almost magical growth of cities; with problems of housing, providing markets, means of industry, and of recreation, etc., into all of which sanitary questions enter, the immensity of the sanitation of cities problems is apparent. Of necessity, we have been forced to limit the various questions discussed to broad principles.

A thought that we wish to convey in conclusion is the unity of municipal problems, and particularly the problems relating to Sanitation. It may be said that these problems are really one, which might be generalized as the "Human Problem."

Wastes of all kinds are the result of human life; whether derived from the home or the factory, they must be disposed of. Pure water must be obtained and supplied in an unfailing



BRIDGEPORT, CONNECTICUT

Sewage treatment plant, fine screens. Sectional elevation of what is reported to be the most modern and sanitary sewage treatment plant yet constructed stream, regardless of cost, but funds must be expended with a wise economy. To these matters we have given our principal attention in this study.

It is evident that we have been discussing but one problem of many parts, and that it is of such extent that even if presented in many more pages than we have used, the subject would be far from exhausted. The most we can hope for is that in a brief space we have given the reader a picture of some of the larger problems involved, at least, with well defined outlines of the Sanitation of Cities.

Designed and Illustrated by
FRANKLIN V. SIKES, *Inc., New York*

Printed by
THE DE VINNE PRESS, *New York*