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# THE DISPOSAL

OF

# HOUSEHOLD WASTES.

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A Discussion of the best Methods of Treatment of the Sewage of Farm-houses, Isolated Country Houses, Suburban Dwellings, Houses in Villages and Smaller Towns, and of Larger Institutions, such as Hospitals, Asylums, Hotels, Prisons, Colleges, etc., and of the Modes of Removal and Disposal of Garbage, Ashes, and other Solid House Refuse.

BY

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NEW YORK CITY.

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# PREFACE.

The author's book on "*House Drainage and Sanitary Plumbing*," published in 1882, in this *Science Series*, did not include a discussion of the all-important question of how to *dispose* of the waste matters of the household in the safest, least disagreeable, most efficient and most economical manner, but it was promised by him that a future volume would be devoted to the "*Disposal of Household Wastes*."

The manuscript for this volume was prepared in the spring of 1886. Portions of it appeared, as a series of articles, in the Chicago *Inland Architect*, and were reprinted in the twelfth annual Report of the State Board of Health of Rhode Island. Some circumstances over which the author had no control, and the various duties of a busy professional life prevented the completion of the manuscript for publication in book form.

While the book as now offered to the public is not as complete as the author would wish to make it, particularly as regards illustrations, it is published in its present form at the urgent request of friends.

It discusses, in language as free as possible from technical terms, the disposal of the sewage, and of garbage and ashes, chiefly from the householder's point of view.

It has been the author's endeavor to give perfectly unbiased descriptions and unprejudiced comparisons of the various systems which, at the present day, seem to offer a possible solution of the problem, supplementing the same with a few examples from his own practice.

For any omissions, the author asks the kind indulgence of his readers, promising that these will be rectified in future editions of the book, if such should be called for.

THE AUTHOR.

NEW YORK, *May* 1, 1890.
39 UNION SQUARE.

# CONTENTS.

# THE DISPOSAL OF

# HOUSEHOLD WASTES.

## INTRODUCTORY REMARKS.

It will be admitted by those who have given thoughtful consideration to the subject that, in the present state of sanitary science, it is one of the duties—and a most responsible duty—of those professional men who are devoted to the practice of sanitary engineering to *create* and keep up a general interest in the subject of household sanitation, to stir up an indifferent public to action, to impress it with the necessity of sanitary improvements, to educate it to appreciate sanitary preventive measures and to lead the way towards the undertaking of active and radical measures tending to the knowledge and skill of civil engineers to grapple with it. Yet, upon looking more closely into the question at issue, various difficulties will at once confront us. While the problem of how to dispose of refuse matters is still comparatively simple in the case of small, isolated cottages and single farm-houses, it often becomes a troublesome puzzle in the case of large country houses, especially where they have an ample supply of water and where buildings are located closely together, as is the case in many suburban places. These difficulties increase in the case of large institutions or groups of buildings where a great number of persons are crowded together, and, finally, in large cities and towns the sewage question assumes such enormous proportions as often to require the combined knowledge, experience, judgment and skill of the engineer, the chemist and the agriculturist to deal successfully with the problem.

If the definition formulated many years ago by Mr. Tredgold, and adopted by the Institution of Civil Engineers, is true, that "*the profession of civil engineering is the art of directing the great sources of power in nature for the use and convenience of man*," then the question which I propose to discuss is an eminently practical one, which to solve successfully is worthy of the best efforts of the civil engineer or of the specialist devoted to domestic and municipal sanitary engineering.

The forces made use of by the engineer in dealing with the sewage and garbage disposal question are principally the so called "elements" of the ancients, namely, water, air, earth and fire, to which should be added plant life and certain forms of minute organisms or bacteria, to which, according to recent investigations, certain changes of organic matters are largely due, and finally electricity, which quite recently has been called into service in experiments relating to the purification of sewage.

The principle, "Whatever is worth doing is worth doing well," is one peculiarly applicable to the whole question of the disposal of household wastes. It is the custom of some people to consider the whole subject nasty and offensive; hence it is often evaded and neglected by those who ought to know better. But to leave it in the state of neglect and indifference in which we often find it, is to my mind vastly more nasty and disgusting, and, as every householder, in city and country, in the mansion and in the cottage, is confronted by it, it would seem advisable to face the problem squarely, and study carefully its various possible solutions.

### Definition of the Term "Domestic Refuse."

I shall, first, consider the meaning of the terms domestic refuse or household wastes. Taken in its broadest sense, domestic refuse consists of *solid garbage*, of the liquid and semi-fluid wastes or *sewage* and of *gaseous impurities.*

Solid garbage comprises three kinds of waste material, namely, first, animal and vegetable matters; second, mineral matters; and third, miscellaneous coarse rubbish.

Organic refuse or kitchen offal is largely composed of those animal or vegetable parts of food which are removed in preparing it for eating, such as potato parings, husks of certain vegetables, cabbage leaves, fruit peelings, intestines of birds, etc., of portions of food left after cooking and food remnants removed from the table, such as meat and fish bones, waste bits of birds, meat offal, kitchen grease, bones, fat, etc.

The mineral matters consist of the incombustible remains of fuel, such as coal and wood ashes, cinders, clinkers, of house dirt, yard sweepings, small rubbish, and of miscellaneous dry refuse matter.

The coarser miscellaneous rubbish consists of a heterogeneous mixture of every imaginable thing, such as dust, floor sweepings, litter, mud, broken bottles, oyster cans, tin cans, worn out kitchen utensils, preserve jars, medicine bottles, broken toys, old mattresses, straw, hay, old boots, baskets, pieces of matting, oil cloth, carpet, wall paper, leather, rubber, paper, pieces of cloth, bits of wearing apparel, hoop skirts, towels, napkins, shirts, sheets, stockings, rags, stones, clinkers, brick-bats, plaster, flower-pots, old crockery, broken glass, old iron, scrap tin, bones, hair, sticks, shavings, oyster and clam shells, etc.

House sewage consists of water fouled by use in the household, such as soapy and fatty slop-water, kitchen and laundry wastes, chamber slops, to which are often added solid excreta, urine, the flushing water used in the removal of liquid and solid excrements through a system of plumbing fixtures, etc., stable drainage and manufacturing wastes.

The gaseous impurities comprise air, fouled by the process of respiration, by emanations and exudations from the skin and body, by perspiration, by the combustion of fuel, by noxious products incident to most forms of artificial illumination, by the processes of cooking and washing, by exhalations from soiled linen, cast-off clothing, etc., accumulations of decomposing matters of all kinds, and occasionally bad gases originating in the drains, waste pipes, traps and plumbing fixtures of a house.

The removal of gaseous impurities is accomplished first, by removing all direct sources of bad air, and second, by ventilation, and since this may properly be considered a separate and distinct subject, although of equal importance in domestic sanitation, I shall not in the following pages touch upon it.

Generally speaking, the solid refuse, the garbage and ashes are either properly disposed of on the premises adjoining habitations, or else they are removed by *scavenging.* Liquid refuse or slop-water is disposed of on the premises where sufficient space is available, or else it is removed by *sewerage.* Human excreta are sometimes disposed of on the premises by admixture with garden earth or ashes or else removed in pails or tubs, all comprising the so-called *dry methods of re-*

*moval.* As a rule, however, excreta are admitted into the house sewer and removed from the building by the *water-carriage system.* In this case they are either disposed of on the premises, generally by intermittent application to land, whereby they are rendered innocuous, and at the same time utilized in the cultivation of crops, or else removed and delivered into the sewer.

From this it follows that it is obviously not sufficient merely to collect and remove household refuse, be it solid or liquid. It is necessary, in order that no nuisance and no danger to health may arise, to dispose of all waste matters in the most economical, least disagreeable and safest manner possible. This *ultimate disposal of waste matters* is precisely what constitutes at times the difficult and vexed part of the problem referred to in the beginning.

Additional questions arise wherever houses are located close together, as in villages, towns or cities. Such problems are the proper removal of trade refuse or manufacturing wastes; the purification of liquid wastes from industrial establishments; the disposal of garden refuse and of building rubbish from structures in course of erection; the cleaning and sweeping of streets and alleys, the flushing and cleaning of gutters and catch basins, the removal of storm-water from roofs, yards, courts and areas, and from streets, the removal of snow from crowded thoroughfares, etc. All these are highly important branches of municipal sanitation, but they obviously exceed the limits of this little book, and I must content myself with merely mentioning them.

In cities, as we shall see further on, the question at issue practically resolves itself into that of providing a systematic and regular garbage removal and of arranging a perfect system of house drainage and street sewerage. As a rule, both present, so far as the householder is concerned, fewer difficulties in closely built up towns and cities, than where houses are scattered and located widely apart. In the former instance the municipality undertakes the removal and disposal of sewage and of garbage from the street, and the householder's duty is simply to deliver the garbage regularly to the street curb, and for the sewage removal to provide and build a well-arranged and properly laid house-drain

In the case of isolated houses in the suburbs or in the country, each individual owner is obliged to act independently, and he will often encounter considerable difficulties in the disposal of the waste matters from his house. I shall, therefore, begin with the consideration of isolated habitations, and of these I shall consider first, small cottages and farm-houses, second, larger cottages and suburban and country residences, and, finally, larger buildings and institutions. If the needs of small as well as large isolated buildings are thoroughly understood it will obviously be easy to follow the same general rules, or, if necessary, to modify them, so as to make them applicable to dwellings built closer together, as in villages and small towns.

# I.

# ISOLATED COUNTRY HABITATIONS.

## 1. Small Cottages and Farm-houses.

Let us consider, first, the treatment of the solid and coarser refuse of small dwellings standing scattered and isolated in the country. Household refuse is always generated in the process of housekeeping; in fact, it is an unavoidable incident of human life. Therefore we must be prepared to find such refuse present, in moderate quantities, in even the smallest inhabited cottage. The majority of human beings, fortunately, feel instinctively, as it were, the necessity of removing all cast-off matter from their premises. The oftener and the more regularly this removal is accomplished, the nearer do we succeed in maintaining in our homes that cleanliness which is one of the first virtues of the householder. A great statesman has once truly remarked that all dirt and dust in our homes is merely "Matter in the wrong place." Accordingly, it becomes an imperative duty to accomplish its removal as thoroughly and as promptly as the means at our disposal will permit. The contents of swill barrels are always more or less subject to rapid fermentation and decomposition, and soon become not only highly offensive, but dangerous to health. This is particularly the case during hot weather. Hence, in summer time a *daily* removal is especially important.

Garbage and Ashes.—With small cottages, farm-houses, mechanics' and laborers' dwellings, the management of both garbage and sewage is not a difficult matter. Instances are extremely rare where such scattered habitations are not provided with sufficient garden space to enable the farmer or laborer to return to the soil as manure the wastes from the household. It matters little whether the plot of ground attached to the house is arable or pasture land, a vegetable or flower or fruit garden. Each of these may advantageously be cultivated by their owner. Moreover a good and thrifty housewife will soon learn the habit of saving the fat, lard, tallow or grease, either to sell it to the soap manufacturer, or else to use it on her own premises in making soap. Much of the meat refuse and other swill can be disposed of as food for household animals, such as dogs or cats. Some of the refuse is taken up with avidity by chickens; finally, one or more swine, kept in cleanly surroundings—for it is a mistake to suppose that a pig is by nature not a clean animal—will dispose regularly of much of the remaining swill or kitchen refuse; other parts may, without difficulty, be dried and *burnt in the kitchen range*. Coarser refuse and many of the matters contained in the above enumeration may be picked out and kept in a dry condition, in an out-house, until some peddling junk-dealer arrives, who will always be glad to remove them. It appears, therefore, that the garbage question is not at all a troublesome one, requiring only a little intelligence and common sense management.

Excreta of domestic animals and various other refuse, whatever this may be, may be dug into the ground, and thus every cause of a nuisance can be effectually removed.

By a little considerate management of the range and fuel, securing a better combustion, the quantity of ashes and cinders can be kept down to a minimum, and if kept dry and absolutely free from admixture with organic refuse, ashes and cinders may be utilized to improve garden walks, or country roads, or to fill up low spots.

Liquid Wastes, or Slop-water.—The disposal of the liquid sewage in small isolated houses can be equally easily accomplished, wherever a small vegetable garden, a lawn, a grape vine trellis or an apple orchard adjoin the house. The sewage may, with advantage, be used to feed the plants and fruit trees and to irrigate the soil. The ruling principle should be to keep solid and liquid waste matters as much as possible apart, as this will facilitate the disposal of both. The kitchen water, the soapsuds from washing, chamber slops, urine and other foul water, are easily disposed of, by daily distribution in the garden, either by surface irrigation or by sub-surface irrigation. Both methods are far preferable to the crude methods usually adopted, of discharging such liquids into an open ditch, or into some neighboring water-course, brook or pond, or of retaining them on the premises by pouring them onto the surface of the ground, in front of the kitchen window, keeping the soil continually moist, and saturating it quickly with putrefying filth. or else by storing the slop water in leaching or tight cesspools or pouring it into disused wells. The disposal of liquids by application to the garden, where they may be used to feed and nourish plants, is so easily managed in the case of small cottages or farmhouses, that it is a matter of wonder to find this method adopted in as yet comparatively few instances.

The slops may be collected every day in a tight tank and carried by hand or carted in a wheelbarrow to the garden, and there used to water plants, shrubbery, or fruit trees, or to cultivate other garden plants. Instead of by surface irrigation, the slop-water may be discharged into one or more lines of absorption drains, consisting of common agricultural tiles, laid with open joints at a depth of from 8 to 10 inches below the surface. For the smallest cottage fifty feet of absorption tiles are sufficient, laid either in one or several lines, and the amount of tiles should be increased in proportion to the quantity of waste water from the household.

The principal points of importance are that the sewage be applied to the soil while *fresh*, and before it begins to decompose; that it should be applied in moderate quantities only, to prevent an over-saturation of the soil; that the sewage be applied on or near the surface of the soil, within reach of the oxidizing influence of the air; and finally, that the application be made intermittent, so as to give the soil after each discharge a chance to breathe, as it were, and to allow the finer solid particles to be oxidized and destroyed. An easy method of accomplishing the disposal of slop-water where the house contains no plumbing fixtures, is to have near the house a hopper or receiver made of wood, of rustless iron, or better, of earthenware, and provided with a strainer and a proper cover. From this a pipe may be carried under ground to the absorption tiles, and the sewage from the house may be carried to this hopper in a pail and discharged into it, thus sending a considerable volume at one time into the absorption tiles.

SOLID EXCRETA.—The solid excrements are taken care of quite as readily and inoffensively by adopting an earth or ash-closet, in place of the usual privy, still so much *en vogue*, although long ago universally condemned by sanitarians.

In the dry-earth system sufficient dried earth or garden loam, and sometimes coal ashes, are mixed with the excreta to absorb all foulness, to keep down all odor, and to prevent putrefaction. Such earth-closets have been found to answer satisfactorily and form a simple and cleanly substitute for the common privy. Many kinds of earth-closets, from the plainest and most inexpensive to the most elaborate and complicated apparatus are manufactured. As a rule, the simpler the arrangement, the better.

An earth-closet, if out-of-doors, should not be placed too far away from the house. The structure should be strong, substantial, with a good roof to protect it against rain or dampness, well lighted, well ventilated, preferably plastered on the inside, so as to prevent exposure in cold weather, and not too much exposed to the rays of the sun. A carefully made and dry walk should lead to it from the house, and it is better to have the walk screened from view and from the prevailing winds. If the earth-closet is placed inside of the dwelling the same precautions must be observed, which are taken in the case of water-closets.

The ventilation of the apartment is an important matter, and should receive careful attention. As a rule it is better to locate the earth-closet in an isolated or detached part of a building. While an earth-closet is inferior to the best water-closet, I have no hesitation in pronouncing it, if well taken care of, superior to many water-closets as usually arranged and kept. The excreta should be received in a movable wooden box, well tarred, or else in a galvanized iron pail, which must not be too large, and of such shape and construction that it can be easily carried. All parts of the earth-closet should be above ground and no vault or pit of any kind should be permitted. The receiving vessel should fit close up under the seat, and each time the closet is used, ashes or dry earth should be added as deodorizers. There can be scarcely any doubt about the economy, efficiency and convenience of such apparatus for small houses.

The property of dry earth, of not only deodorizing, but also absorbing and rendering harmless excreta of animals, has long been well known. Some difficulty has been experienced in cases where the earth was kept too damp by the urine. According to recent observations, a much smaller quantity of earth is required for earth-closets if the separation of the liquids and solids is at once effected, which may be accomplished by intercepting the urine under the seat, and removing it by a separate waste pipe.

The earth-closet is thereby more easily kept free from smell, and if properly used and well taken care of it can be located in an extension of a dwelling without becoming a nuisance. The dry earth manure ought to be removed at frequent intervals, and in summer time used in the garden attached to the country house. In winter time it may be dried in an out-house, and can then be applied over and over again. Ashes are sometimes used in place of earth, or else finely powdered charcoal, which latter is a well-known deodorizer. The charcoal may be applied by means of a mechanism similar to the one used in the earth-closet, and it is claimed that only about one-fourth the quantity will be needed. As charcoal is rather expensive, this is an important consideration. Some claim that removal need not be so frequent in the case of charcoal closets, but this is, at best, a doubtful advantage.

In houses of some more pretensions, where the earth-closets are located in an extension of the cottage, it may also become desirable to have a somewhat more convenient method of disposal of the liquids. A properly ventilated and trapped waste pipe may carry the waste from the kitchen sink, the laundry-tub, and, where the latter is provided, from the bath-tub, into a small receiving tank, located outside of the house, and placed below the depth to which frost usually penetrates. This tank may be a plain wooden box, or an iron or earthen tank, or else a tank built of brick-work. It may be emptied in the plainest kind of an arrangement by hand, or else it may be discharged by an automatic device, such as a siphon, a tumbler tank or other mechanical appliance. It may be useful even in the case of small houses, to build some sort of a grease trap to prevent the grease from being discharged, and finally clogging the small absorption pipes. It is, of course, assumed that the general topography of the lot is favorable to such an arrangement; in other words, that there is not a slope from the garden, or absorption field, toward the house, in which case disposal by gravity becomes impossible.

The question whether a small farmhouse or laborers' cottage should be provided at all with plumbing work, and above all whether it is wise to have an in-door water-closet, which in turn requires a system of service pipes and a service cistern, is largely one of convenience and comfort. The annoyance and cost of frequent repairs, and the difficulty in country districts of getting a mechanic to fix such apparatus when out of order, the danger of exposed pipes and traps freezing in mid-winter, or sometimes the lack of an abundance of water for flushing, or the necessity of raising it by pumping, all these are considerations which may deter many from putting any plumbing work into their homes. It is undoubtedly much easier and simpler to deal with the sewage problem of cottages, if the strict separation of solids and liquids is adhered to. A water-closet in a house not only requires a larger discharge pipe than the usual waste pipe, but complicates at once the whole arrangement. That it can be made quite safe, perfectly inodorous and inoffensive, it is not necessary for me here to assert. Those who have followed the recent improvements in house drainage and plumbing work will know that it is possible to select and fit up a water-closet in such a way as to make it in all respects satisfactory.* In point of cleanliness I

* The reader is referred for further information to the author's two previous volumes in

think it certainly stands ahead of any other device. Its advantages are many, but its disadvantages under certain conditions ought not to be overlooked. If a water-closet is used in the house the solids should not enter the flush tank, for they would soon clog the siphon, or further on, the absorption tiles, but should be intercepted in a settling chamber and frequently removed. How this may be done will be explained later on in speaking of larger country houses.

PRIVY VAULTS, MANURE PITS, ASH-HEAPS, STABLES, BARN-YARDS, ETC.—I do not feel called upon to refer at length to the disadvantages and dangers, from a sanitary point of view, of privies and vaults. The objections against them have been pointed out time and again, and are now so well recognized that I think it is suffi-

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the *Science Series:* No. 63—House Drainage and Sanitary Plumbing. No. 93—Recent Practice in the Sanitary Drainage of Buildings.

cient to utterly condemn such devices as relics of primitive stages of civilization.

Ash-heaps and manure pits, both common adjuncts of most farm-houses, may be maintained in a tolerably good condition and free from offense by keeping them as dry as possible. Slops from the household should never be poured upon them. Ash-heaps should be frequently screened and all coarse cinders removed, which latter can be used to advantage in covering roads or walks, while the fine ashes can be used instead of dry earth in the dry closet.

Much might also be said here about the proper cleanliness of barns and barn-yards, horse and cattle stables, dog kennels, poultry yards and similar out-houses of residences in the country and of farm-houses, but the few hints thrown out may be considered sufficient.

### 2. Larger Cottages, Suburban and Country Residences.

We will now pass on to the consideration of the disposal of garbage and sewage of larger cottages, suburban and country residences, seaside villas, mountain cottages and log cabins, etc.

GARBAGE DISPOSAL.—Concerning the garbage, much the same course may be pursued as in the case of smaller houses, the difference being only one of degree, for the quantity of refuse to be removed obviously increases with the size of the house. Even here, in the majority of cases, a removal to distant points is not required.

A large part of the kitchen refuse may be disposed of by burning in the range, which satisfactory method can be employed to greater advantage in larger residences, owing to the better opportunity afforded of an almost constant fire in the kitchen range. Of course the burning of kitchen refuse should not be understood as meaning that the refuse should be thrown directly into the range. It must first be dried, which can be done conveniently by means of domestic garbage burners, without creating annoying odors in the house. After it has been thoroughly desiccated, the refuse is dumped into the fire and rapidly and completely consumed.

Some of the swill may be used as food for domestic animals, other parts may be dug into the ground. In short, as long as there is sufficient garden space around the house, the need of removal from the premises rarely exists. All that is required is to keep separate the liquid and the solid, the organic and the mineral refuse. Ashes and cinders, after being freed from coarser impurities, may be passed through a sieve and the cinders used to fill up low spots, or to improve walks, while the ashes may be utilized in an out-door earth or ash-closet. Wood ashes are sometimes sold to manufacturers of soap. Paper, litter, rags, etc., may be burnt up, and miscellaneous house refuse, such as old tin, iron, leather, etc., disposed of to junk dealers.

Sewage Disposal.—The sewage disposal, however, is often—indeed in most cases, and particularly when a house is occupied during all seasons of the year—

a much more puzzling problem. What shall be done with the more or less large daily volume of sewage, of a detached and isolated suburban or country house, not in reach of sewers, so as to avoid creating a nuisance either on one's own premises or on those of the neighbors? This is a question of much interest to thousands of householders living in the better class of country or suburban homes, who are often compelled to meet the difficulties as best they can. The problem has long engaged the attention of engineers. While it may be possible that the best solution has not yet been found, several methods are in more or less successful use.

Generally speaking, a detached country house, not in reach of sewers, can dispose of its sewage by one or the other of the following methods:

1. It may discharge its sewage into an open surface ditch or gutter, removing everything from the house, and carrying it into a distant sink hole or to some low spot where the sewage is

allowed to soak away and to evaporate slowly. This method, based on the principle of "out of sight, out of mind," is a very primitive one, and one that has not a single feature of merit. As a rule, such a system becomes highly offensive to the immediate vicinity of the house.

2. The house drain may empty the sewage into a large open or leaching cesspool, which allows the liquids to ooze away through underground porous strata or through fissures and cracks in rocks. We shall see further on that this, although a very common method of disposal, is in reality one very dangerous to health, particularly so where the water supply is local, being derived from wells, cisterns or springs on the premises. It is a method utterly to be condemned as both unsafe and nasty.

3. The drain may deliver the sewage from the house into a tightly-built cesspool, provided with an overflow pipe carried into some ditch or water-course. This is a makeshift arrangement, which cannot ordinarily be endorsed.

4. The sewage may be emptied into an absolutely tight cesspool, without any overflow. This, as we shall see, is an arrangement permissible under certain circumstances, or rather it may become a necessary evil, for it should be borne in mind that it involves a system of long temporary storage, and does not provide for immediate or nearly immediate disposal, hence cannot be approved from a sanitary point of view.

5. The sewage may be discharged into some adjacent water-course, such as a brook, river, canal, or tidal estuary. This in many cases must be regarded as a very crude method; for, by pouring the filth into the nearest water-course, we simply remove the evil from one place to another, while we do not attempt to abate the nuisance. It is a method which, especially if the current is not rapid, and the volume of water in the river or stream is not large, may cause serious annoyance, particularly if adopted by a number of adjoining dwellings.

6. The only available outlet is some-

times the ocean. The method of discharging sewage directly into the sea is limited to houses at or near the seashore; but it is seldom practicable or applicable even to these, as we shall see later.

7. The sewage may be disposed of on the premises or on some adjoining land, generally the former, either by application to land if the lay-out of the land and the soil are favorable, and if the area available for purifying the sewage is sufficient, or else by some process of mechanical straining and filtering.

8. The sewage may be purified by chemical treatment—a method rarely adopted in case of isolated houses, owing to its comparatively high expense.

Whatever method of disposal may be adopted, it becomes necessary to decide about it before arranging the house drainage system inside of a house, as the best arrangement of the main drain and its branches in the cellar or basement of a house will depend upon the direction in which the sewage tank will be constructured, or upon the location of the final outlet.

The several methods enumerated above will be considered in the following somewhat more in detail.

*a.* LEACHING CESSPOOLS.—The most primitive form of cesspool is a hole dug more or less deep in the ground, into which sewage is continually poured. the expected result being that at least the liquids soak away into unknown underground recesses and disappear from sight. A cardinal principle, always to be observed, is to avoid stagnation of sewage as much as possible. In the leaching cesspool we have the worst possible example of stagnation and of accumulation of putrefying filth on or near our premises. The great objections to a leaching cesspool are not only that it constitutes in itself an abominable nuisance, but that it unavoidably and invariably pollutes the sub soil in the neighborhood of dwellings, contaminates the water supply, and renders the air which we breathe obnoxious by its exhalations.

If we consider for a moment that such isolated country dwellings and farm-houses, which are not in reach of sewers, also usually do not enjoy the benefit of a public water supply, but must derive their potable water from wells, cisterns, or springs on the premises, the full extent of the evil and the force of our objections become more apparent. It is, indeed, of the utmost importance that the local water supply of isolated dwellings be kept as pure and free from contamination as possible; but even supposing that water is introduced from the street supply, as is sometimes the case with suburban residences, the enormous evils of soil pollution and air contamination remain. Where a public water supply is provided it is the universal experience that water will be used more lavishly in the household. The daily quantity of water thus befouled will become much larger, and the question of sewage disposal becomes more troublesome on this account.

Two thousand years ago, an old philosopher, Hippocrates, preached a sanitary formula which has not been improved up to the present day. Recognizing the dangers to health resulting from neglect of sanitary precautions, he expressed his advice in the words "pure air, pure water and a pure soil." What, then, shall we say if some of our best architects at the present day persist in suggesting, as the most convenient and ready means of getting rid of the sewage of a country house, the adoption of a leaching cesspool ?

I admit that in sparsely populated country districts, and for summer cottages occupied only during a few months, a leaching cesspool, located at a great distance from, and at a lower level than the house, may sometimes be used without causing any harm to the occupants of the house. As a matter of principle, however, sanitary science must condemn such devices in every case. If the principle is true, that we should speedily return all organic dirt and filth to the earth, it should be carried out in such a manner that the soil may accomplish the complete destruction of organic filth. We shall see, later on, that this can be done only near the surface of the soil, and by application of the sewage before it becomes putrid. In pouring our sewage into leaching cesspools we, on the contrary, bury all matter deep in the ground, remote from the cleansing and oxidizing effect of the atmosphere, of the purifying action of plant life, and of the help which is rendered by the low organisms, called bacteria, in the process of nitrification and destruction of organic matter. Then, again, we lose sight entirely of the fact that often where a leaching cesspool cannot work any danger to our own house, our own well, or spring, it may pollute shallow or deep wells belonging to our neighbor's property or to adjoining estates. It is therefore evident that, as habitations are built closer together, leaching cesspools become more and more inadmissible. If we are selfish enough to locate such a cesspool in the remotest and lowest corner of our own garden, entirely forgetful of its immediate proximity to our neighbor's drinking water well, it is but perfectly proper that our health authorities should remind us that we have some obligations to fulfill against our neighbors.

Occasionally such cesspools are built with the sides solid, leaving only the bottom loose for the escape of sewage, or in cases where they are originally open on the sides the pores soon clog, and the removal of the liquids takes place in a very imperfect manner, either at the bottom or by means of an overflow.

*b*. TIGHT CESSPOOLS.—Passing over now to the consideration of tight cesspools, we find that they are built both with and without overflows. The former arrangement may be considered a direct outcome of the leaching cesspool. While such a tight cesspool, with overflow located far away from the house, and with its overflow carried perhaps to some rapid stream, may be unobjectionable where but little water is used in the house, it constitutes in the case of larger houses a fearful nuisance, as the sewage, when removed, is already putrid. The alternative is a cesspool built absolutely tight and without overflow. Such a one avoids the pollution of the water supply, and also the contamination of the surrounding soil; it is, therefore, an arrangement much to be preferred to a leaching cesspool. Yet, its objections are many and serious ones.

The object of all good drainage being to get rid of filth from the premises at once or else to dispose of it on the premises while *fresh*, so as to be completely taken up by vegetation and purified by the soil, it is evident that a vast receptacle of accumulated filth cannot be considered a good device, from a sanitary point of view. The stagnating sewage within the walls of the cesspool undergoes a process of decomposition, and the gases generated are extremely unwholesome, and often cause, by improper escape or by entrance into houses through the sewer pipes, a nuisance. To ventilate such a cesspool successfully is rather a difficult and often an impossible matter.

To overcome some of these objections, it is the habit of some architects and builders of country houses to use two cesspools, delivering into the one all water-closet wastes, while the other one is intended for the reception of kitchen, bath, basin and laundry water, and is usually constructed with open sides and bottom. I do not approve of such an arrangement. The wastes from bath-tubs, wash-basins and laundry-tubs, if oozing from a leaching cesspool, pollute the soil, although perhaps not so quickly and to such an extent as an open cess-pool receiving water-closet drainage. Practically, it is found that, after awhile, the foul contents of both cesspools do not differ much as regards the degree of putrefaction and offensiveness of their contents; nor can I see any sense in duplicating or multiplying the dangers which adhere to all cesspool arrange-ments.

There are some cases where no good feasible way of dealing with sewage may be found, other than to run it into a tight cesspool. In that case the following precautions are to be observed: It should be located as far away from the house as possible, and there should be a proper disconnection between the house drain and the cesspool. The latter should be built in two compartments, the first of which constitutes an intercepting chamber for the solids, while the second and larger chamber will receive the liquids. Both chambers should be built thoroughly tight, of hard burned brick, laid in hydraulic cement, preferably of a circular shape, and the walls should be well rendered inside and outside with Portland cement. Each chamber should be arched over and topped with a manhole covered with a tight iron cover.* The cesspool should at all times be well ventilated, and must be emptied, cleaned and disinfected at frequent intervals. The separation of the liquid from the solid matter facilitates much the disposal of both. The liquids may be baled, or,

* See Appendix.

better, pumped out, and used to sprinkle and irrigate the lawn, or a kitchen garden, shrubbery or vine trellis. The solids may be removed and dug as fertilizers under the soil. The oftener this is done the better, and the less offense will be caused by the application of sewage to land.

Some objections to a cesspool always remain. If it is built, as it should be, absolutely tight, and of moderate size only, to avoid the retention of too large a volume of sewage, then the necessity of frequent pumping arises, and with it the annoyance of constant attention, expense, and of manual labor. If, on the other hand, we enlarge the dimensions of the cesspool, to avoid the frequency of pumping out, we increase the dangers always resulting from stagnant sewage, and create, as it were, a large gasometer for noxious gases.

*c.* Discharge into Water-courses, Rivers and Tidal Basins.—Where a stream of running water of large volume is available, a single house may discharge its sewage directly into it, trusting to the dilution of sewage and to the self-purification of the stream to render the sewage innocuous. What is feasible for a single house is not, however, practicable for a number of adjoining isolated country houses. The pollution of creeks, rivers and streams must be avoided, especially so in those water-courses serving as a source of supply for potable water of villages and towns located along the banks of these streams, and from which canal boats or river craft draw their drinking water. The riparian dwellers must always suffer by direct discharge of sewage. The watering of cattle, the washing and bathing in the river, are thereby often rendered impossible, and a more or less great damage is done to fish culture, particularly when the sewage is discharged in a putrid condition. While it is a well-known fact that some kinds of fish feed on *fresh* sewage matter, others, particularly salmon and trout, are very delicate and suffer much from the pollution of streams.

Channels with tidal flow should never receive sewage, for much of the solid matter will float up and down with the ebb and flow of the tide, instead of being removed. Offensive odors pervade the air, the banks will become defiled, the river beds will silt up, and the channels will be obstructed.

*d.* Discharge into the Sea.—Although apparently a ready means of getting rid of sewage, this method is not always practicable; for experience has demonstrated the unpleasant fact that floating sewage matter discharged into the sea may return to the shore with the tide, or by the action of eddies, currents, winds and waves. The sandy beaches become polluted, and the damage inflicted will interfere seriously with the use of the beach for bathing or recreation purposes. This method is only practicable where the sewage outfall from houses on the cliffs is carried far out into deep water, and all sewage matter carried away by some strong currents setting in at right angles to the sewage outfall.

*e.* Purification of Sewage.—It is obvious, therefore, that in the majority of instances, house sewage cannot be directly admitted into water-courses or streams of any kind, without creating a nuisance to sight, smell, or a danger to health. Sewage must, therefore, be purified by removing the suspended impurities, and at least a part of the matters in solution.

The purification may be effected either by artificial filtration, or by a chemical treatment, or by application of sewage to land.

While it is only rarely possible to derive profit from the utilization of sewage, it is always possible to effect a purification to such an extent as to avoid the usual fouling of surface or subterranean water-courses. Wherever land can be obtained, the purification of sewage is best accomplished by applying it to the soil, and here I must call attention to the truly wonderful forethought of nature in providing the means for this purpose.

We see in nature a constant round of

circulation going on. Take, as an example, water. Arising as a vapor from the ocean, and from large exposed surfaces of flowing water, it is carried along in the upper strata of the atmosphere by air currents forming clouds, from which it is again precipitated upon the surface in the form of rain, snow, hail, or dew. A part of the storm-water, falling upon the surface of the earth, is immediately evaporated and returns to the clouds, another part flows off on the surface forming successively springs, brooks, rivers, streams —all flowing toward the great ocean, while a third part soaks into the ground and is partly absorbed by vegetation and partly forms underground streams of water with an incline towards some river, or else forms springs, which come out at the surface.

A similar round is constantly going on between the animal and vegetable life. Plants are nourished and grow upon decomposed animal matter, and effect a change of those substances which might be dangerous to animal life into harmless food substances for the roots of plants. The same plants, perhaps, form the nourishment for man and animal, and are again discarded, to feed vegetation. The whole process of circulation has never been better described than in the words of Mr. F. O. Ward at the General Congress of Hygiene at Brussels in 1856. These words, quoted by Mr. Edwin Chadwick, the Nestor of Sanitary Science in England, in an address on "Circulation or Stagnation," are as follows: "The water which falls on the hills in a state of purity, undergoes a natural process of filtration through sand, enters the rural collecting pipes, and passing through the aqueduct to the metropolitan distribution pipes, finds its way to every story of every house in the town; whence again, after having supplied the wants of the inhabitants, it runs off, enriched with fertilizing matter, which it carries away before allowing it time to ferment. This manure, driven along irrigation pipes, is deposited in the soil, leaving the water to pass into drainage pipes, and flow on to the rivers. The rivers conduct it to the ocean, where it rises as vapor under the heat of the sun, to re-descend as rain on the hills, enter again the collection pipes, and re-commence its vast and useful course of circulation."

*f.* Chemical Treatment.—A partial purification of sewage may be accomplished by precipitating the suspended and a part of the dissolved impurities by means of chemical precipitants. Quite a large number of chemical processes have been invented, but none of them have attained any very extensive use. One of the most common processes consists in the addition of milk of lime to sewage. Much more effective than lime is the solution of sulphate of alumina, or a solution of perchloride of iron. Such chemical treatment, while not accomplishing a very thorough purification, removes the impurities to such an extent as to permit a discharge into a tidal river or a large stream.

In selecting a precipitant, preference should be given to one which accomplishes the process of subsidence with rapidity, also to one which produces a sludge of minimum bulk with maximum amount of solid impurities. In both respects, milk of lime is inferior to the other named chemicals.

A difficulty adhering to all chemical precipitation processes is the disposal of the sewage sludge. It usually contains, after precipitation, from 90 to 95 per cent. of water, and unless the latter is removed it soon decomposes and becomes offensive. It has been suggested to evaporate this water by artificial heat, but the process is expensive. Others have suggested the separation of the liquid matter from the solid by centrifugal machines. In some cases sludge is pumped directly from the precipitation tanks to land, where it is left exposed to the air, and when dry is dug into the ground. In some patented processes such chemicals are added which enable the manufacture of bricks or of cement from the sludge. More recently, powerful filter presses have been used, which offer very great advantages. By means of these the sludge is pressed into cakes, which may be sold as manure to farmers.

Chemical treatment must at times be adopted where land is not available for purification purposes, or where its high price precludes any efforts to obtain an area sufficient for irrigation. It may be necessary, also, to resort to it if the soil is underlaid with rocks. Chemical precipitation may be combined with the application of sewage to land, in which case a much smaller irrigation or filtration area is sufficient.

Chemical treatment, however, is not a method readily adaptable to single isolated dwellings. The process implies the construction and careful manipulation of tanks, the provision of suitable chemicals, the thorough mixing of the sewage with the chemicals and other items, all of which call for considerable expense. In the case of large institutions and hotels such a system may at times be contemplated, where other methods of purification cannot be adopted. Whatever the chemical treatment may be, it will be wise not to have too much faith in the realization of a large commercial profit from the sewage treatment. Far better to make the ultimate purification of the sewage the chief end in view. It is also well to remember that, in certain chemical processes, the effluent water is of such a character that, if discharged into brooks or rivers, it may kill fish and injure fish-culture. Chloride of lime is particularly objectionable. Sulphurous and hydrochloric acids are also said to be very hurtful.

*g*. Artificial Filtration.—I shall not consider here the question of artificial filter beds, for, to my knowledge, such a system has never been used in the United States in connection with the sewage from houses. I desire simply to refer to a very ingenious mechanical filter invented in England, and known as the Farquhar-Oldham filter. The chief characteristic of this machine is the revolving cutter, which is so arranged that, whenever the surface of the filtering medium clogs up with the sewage sludge, it can be removed by said cutter in a few moments, and practically a new filter established. This may be repeated as often as desirable. I have not personally used this filter for the purification of sewage, but I understand it is in use at a country house at Seabright, New Jersey, and elsewhere. I have considerable faith in the working of this apparatus, and where I would not be debarred from using it on account of expense, I should think it would form a successful solution of the problem of sewage purification for larger country houses, wherever no system of application to land is possible. The best filtering material for such a filter is sawdust, which, when removed, can be readily utilized to fire up the boilers needed for the pumping apparatus.

*h*. SUBSIDENCE.—All attempts at sewage purification by simple subsidence have proved a failure. By collecting house sewage in subsidence tanks, which are usually nothing but cesspools, we effect merely a partial and very imperfect clarification, consisting in the settlement to the bottom, of the heavier particles of sewage. The resulting effluent is of a very foul character, and the difficulty of disposing of the same remains.

*i.* Application to Land.—Wherever suitable land is available, the application of the sewage to the soil forms the best solution of the problem of sewage disposal. The conditions of successful application are a sufficiently large area of suitable, absorbent, well-aërated, properly prepared and thoroughly under-drained soil.

I may add to these conditions another one, namely, the proper and judicious management, careful and equal distribution, and before all the *intermittent* application of the sewage to the soil, which latter is absolutely required to insure its thorough aëration.

The land selected for the purification of the sewage should not be located too near to the dwelling. In particular, if wells are used for domestic water supply, it should be kept at a safe distance from these, the exact measure depending not so much on the configuration or slope of the surface, as upon the inclination of the underground geological formations and strata.

We may distinguish several systems, namely, broad sewage irrigation, sub-surface irrigation, and intermittent downward filtration. The Report of the Royal Commission on Metropolitan Sewage Discharge defines "broad irrigation as the distribution of sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation, consistent with due purification for the amount of sewage supplied." The same report speaks of intermittent downward filtration as "the concentration of sewage at short intervals on an area of specially chosen porous ground as small as will absorb and retain it, not excluding vegetation, but making the produce of secondary importance."

In the system of broad irrigation the sewage flows principally *over* the land, in the system of intermittent downward filtration it passes *through* the land. Sub-surface irrigation is a modification of the filtration system, which I shall describe further on.

Broad irrigation requires very large areas of land, and the land must not be continuously flooded, so that, in order to manage an irrigation farm successfully, it is at least advisable to have a piece of fallow land, and to distribute the sewage on different portions on alternating days. By passing sewage through a properly prepared filtration area, we may effect the purification of a much larger volume, provided we maintain an intermittent discharge, so as to secure thorough aëration.

In all methods of application of sewage to land it is advisable to intercept at least the coarser suspended organic matters contained in sewage.

The irrigation field must in all cases be properly and thoroughly under-drained. The preparation of the surface of the land should be simple and inexpensive, and will depend somewhat upon the general topography of the field, as well as upon the vegetation which it is intended to raise from sewage. It is always important that the sewage be distributed evenly, and in as fresh condition as possible. We may distinguish various systems, such as the catch-water system, the pane and gutter system, and the ridge and furrow system ; the latter is used principally where vegetables are grown, such as mangles, cabbages, or in the case of osiers. Where grass is grown on irrigated land the latter should be treated in the same manner as where meadows and pasture land are laid out for irrigation. Much the best plan to secure an intermittent discharge, and to avoid an irregular and trickling flow, is to collect the sewage first in a *self-acting flush tank*.

Wherever possible, the sewage should be conveyed to the latter by gravitation, and the land for sewage irrigation should be selected accordingly. Occasionally, however, pumping becomes necessary, and this may be accomplished either by a turbine, a wind-mill, a gas engine, hot air engine, or a steam pump.

*k*. SEWAGE DISPOSAL BY SUB-SURFACE IRRIGATION.—If I dwell in the following more at length upon the details of the system of sewage disposal by sub-surface irrigation, it is because I regard it as the system *par excellence* for the disposal of liquid and semi-liquid wastes of isolated country houses. It has long ago attracted public attention, and has in recent years been taken up by the best sanitary engineers; for more than any other method it promises the entirely successful solution of the problem of sewage disposal for isolated houses. It certainly recommends itself, owing to the peculiar facilities for disposing of sewage without creating an offense to sight or smell, while it is well known that open irrigation becomes in many cases exceedingly objectionable in close contiguity to mansions or dwellings. The origin of the system is usually attributed to the Rev. Henry Moule, Vicar of Fordington, the inventor of the earth-closet. He looked upon it as the best solution of the slop-water disposal question for cottages where the earth-closet system has been introduced. According to Mr. Edwin Chadwick, sub-surface irrigation had previously been tried independently and systematically on a large scale by Mr. Charpentier, a French vine grower, near Bordeaux. He states that the results which the latter obtained with vines and fruits, as well as with market garden produce, were most satisfactory.

The system would probably never have grown to its present popularity had not Mr. Rogers Field, Mem. Inst. C. E., recognizing the desirability of intermittent action, invented his automatic flush-tank, and applied the same successfully to the disposal of liquid household wastes. His first experiments were made at some laborers' cottages, belonging to his own estate at Shenfield, in Essex, England. Since then, sub-surface irrigation has been adapted to all possible conditions and has given such satisfaction that it is now considered admirably adapted to isolated houses not in reach of a sewer, but having sufficient ground about them with favorable lay of the land.

It is well known that Col. Geo. E. Waring, Jr., was the first to try this system in this country, about 15 years ago. Finding that it worked satisfactorily in the case of his own residence in Newport, R. I., then not in reach of a sewer, he adopted it afterwards with success for the disposal of sewage of suburban residences, and on a larger scale for the purification of sewage at the Women's Reformatory Prison, at Sherburne, Mass., the Keystone Hotel at Bryn Mawr, Pa., and at Lenox, for the sewage of the whole village. Since a number of years the system has been extensively applied by the writer and other sanitary and landscape engineers, and by a few progressive architects, for the disposal of sewage of isolated country houses or institutions liberally supplied with water and plumbing appliances, but not within reach of sewers.

The system is based upon the well known fact that the well aërated layers of soil *next to the surface*—the sub-surface—possess in a high degree the power of destroying organic substances buried in them, by nitrification and oxidation, aided during a part of the year by vegetation, and assisted at all times by minute organisms or bacteria. The latter play an important part in the round of changes in nature. They are, says Tyndall, "by no means purely useless or purely mischievous in the economy of nature. They are only noxious when out of their proper place. *They exercise a useful and valuable function as the burners and consumers of dead matter, animal and vegetable,* reducing such matter with a rapidity otherwise unattainable to innocent carbonic acid and water. Furthermore, they are not all alike, and it is only restricted classes of them that are really dangerous to man. One difference in their habits is worthy of special reference here. Air, or rather the oxygen of the air, which is absolutely necessary to the support of the bacteria of putrefaction, is, according to Pasteur, absolutely deadly to the vibrios which provoke butyric acid fermentation."

I lay particular stress upon the importance of distributing the sewage close to the surface of the soil at a depth not exceeding ten or twelve inches. Aëration is a *conditio sine qua non* of the whole system. At greater depths oxidation and purification become very much slower, until they finally cease altogether. The *subsoil* is not able to effect a complete purification of sewage, as the oxidizing influence of the atmosphere does not so freely reach it. It is the layer of earth next to the surface, the *sub-surface*, which acts on the sewage. Hence the name of the system is derived, and it is an error, committed quite frequently, and to which I have more than once called attention, to call the system "subsoil" irrigation.

Only when sewage is distributed close to the surface are the organic matters in it partly taken up as nourishment by the roots of plants, and partly reduced and destroyed by the bacteria in the soil, wherever sufficient oxygen attaches to the particles of the soil near the surface. The liquid sewage, freed of its coarser impurities, soaks away into the porous ground, and thus becomes still more clarified by filtration, so that, when removed by deep under-drains, it is generally found to be quite clear, colorless, free from taste or smell. By arranging an *intermittent* discharge, the upper layers of the soil are enabled to take up, during intervals between discharges, oxygen, and prepare for the next discharge, while the ground is prevented from becoming saturated, wet and swampy.

There is a radical difference between such a system and a loose or leaching cesspool. With the latter the amount of soil used for purification is quite small as compared with the former, where the surface can be adapted in proportion to the amount of sewage to be disposed of which is not feasible with a cesspool.

We all know that even a leaching cesspool, when newly built and first used, accomplishes some purification of the sewage which oozes out at its pores. After some use, however, its pores clog up, and the soil around the cesspool becomes saturated with sewage matter undergoing, in the absence of oxygen, a very slow process of decomposition. Sewage soaks away unpurified, polluting our springs and wells, and the unwholesome gases generated taint the ground-air, are given off at the surface, and enter our houses, and thus a leaching cesspool soon becomes a nuisance and a standing danger to health.

*l.* Details of the Sub-surface Irrigation System.—The sub-surface irrigation system consists essentially of two parts: *first*, an absolutely tight receptacle, or sewage tank for liquid household wastes, including the contents of water-closets; *second*, a network of common two-inch distribution drain tiles, laid a few inches below the surface of the ground with open joints, so as to permit the liquid to ooze out at numerous points. This network of pipes buried in the ground constitutes the irrigation field.

As stated heretofore, it is an important condition to insure the successful working of the system, that the discharge of the sewage from the sewage tank to the irrigation field be *intermittent*, and that, instead of a constant dribbling stream from the tank, there be a powerful rush of sewage in a big volume, so as to secure an even distribution and the filling up of all pipes. It is, to say the least, desirable that the discharge does not occur more frequently than *once a day*. The soil of the field should, preferably, be gravelly and porous. All tight clay soils and ground liable to dampness should be properly underdrained by deep land drains. The subirrigation field should not be located too near a house, where there is abundance of land favorably located to permit the sewage to flow away by gravity. As a precaution, some attention should be paid, in locating the irrigation field, to the direction of the prevailing winds, although, as a matter of fact, a properly working irrigation field is quite inodorous. The tiles may be, and in practice often are, laid under the well-kept lawns, adjoining summer residences. Where the water supply is derived from wells or springs, the field should not be located near these.

In discussing the disposal of slop-water of farm-houses and cottages provided with earth-closets I have already referred to this system, and described it in its simplest application for the purification of slops, and I shall consider it here mainly in its application to larger country houses, provided with water-closets and with a full system of plumbing fixtures.

As regards, first, the preparation of the sub surface of the field, this is accomplished as follows: Common two-inch, porous agricultural tiles, one foot long, are laid about eight or ten inches below the surface on continuous boards, or, better, in gutters of earthenware, laid accurately in the trenches at the required grade. Should the tiles ever clog up, it is easy to take them up, to clean them, and to re-lay them in the gutters—an operation easily performed by a common laborer. It is important that the tiles should have at each joint a space of about one-quarter inch to facilitate the oozing out of the sewage. Small earthen caps are placed over each joint to protect it from dirt or earth falling from above. It is not necessary to give to the absorption tiles a greater fall than about two or three inches per hundred feet; for, if laid at too steep a grade, the sewage will rush to the lowest level and saturate that part of the irrigation field. It should be noted that much of the success of the system depends upon the accuracy with which the distribution tiles are laid. If practicable, the tiles should be laid in parallel lines about five feet apart. They should branch out from the bottom of the main carrying conduit, and special T or Y branches are manufactured for this purpose. The main drain should be laid at least two feet deep, and the two-inch branches should be cemented until they strike the proper depth of eight or ten inches. The main drain conducting the sewage from the flush tank to the irrigation field should be four inches in diameter, and can be laid with as much fall as the lay out of the land will require, but where it approaches the absorption field its fall should be limited to four or six inches in one hundred feet, to prevent the sewage from running to the lower part of the field, overcharging the lower line of drains.

The number of feet of tiles which it is necessary to lay will depend upon the quantity of sewage delivered each day from the house, and also upon the porosity and general character of the soil of the absorption field. Wherever the soil consists of a heavy clay or is liable to be wet or swampy it is absolutely necessary to thoroughly under-drain it by a complete system of agricultural tiles laid at a depth of four or five feet, removing and discharging the purified sewage, as well as any excess of moisture.*

It was my original intention to illustrate the system quite fully, and to submit various designs of flush tanks, but to do so would require much more space than is at my disposal, and a few hints regarding the construction of the flush tank must suffice.

Flush tanks for sewage disposal are best built of brick, laid in hydraulic cement mortar, and made perfectly watertight. An important and most necessary precaution to prevent the clogging of the siphon or the equally annoying frequent stoppage of distribution tiles is to build in connection with the flush tank, and between the house and the latter, an intercepting chamber or grease trap, intended to intercept all solids, undissolved paper and fatty waste matters of the kitchen. Such a chamber is, in a certain sense, a cesspool, although differing from the ordinary objectionable device of this kind, in having its liquid contents fre-

*See Appendix.

quently changed, and in being built of small size. The emptying and cleaning of this chamber must, of course, not be neglected. Much of the solid matter and paper, etc., is reduced by maceration and decomposition, and flows dissolved by water into the liquid sewage chamber. The overflow pipe connecting both must dip well below the surface of the water level in the first chamber, in order to prevent scum or grease from overflowing into the flush tank.

The flush tank proper should be built generally circular in shape, and of a size to hold one day's volume of sewage.*

The liquid wastes from the household are retained in this tank until it is filled, when its whole contents are suddenly delivered into the main drain, and thence into the irrigation pipes, whereby all the rows of tiles are *uniformly* charged, and the whole of the absorption field is brought into use each time the tank is emptied. It is notable that, if the sewage is discharged in a large volume

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*See Appendix.

quite suddenly, it will ooze out not only at the bottom, but at the sides and top of each joint. The purification begins at once. The clarified liquid soaks away into the ground, the impurities being retained by the earth, where they are quickly destroyed. Air enters the pores of the soil and prepares it for future use, while the tank is gradually filling for the next discharge.

The interval required between two consecutive discharges, the exact proportion between capacity of tank and size of house, between size of tank and number of feet of drain tiles, etc., are details requiring some judgment, skill and experience.

To discharge the flush-tank recourse may be had to various appliances. The simplest arrangement, but one which requires daily attendance, is to place a gate-valve at the outlet of the tank, which can be opened or closed by hand. An *automatic* device is preferable in many respects. This may be either a tumbler or tilting tank, or one of several siphon devices now in the market. One of the simplest constructions of siphons is the annular siphon, as arranged by Rogers Field, C. E.

Another automatic siphon of English make is the Adams siphon, which seems to operate satisfactorily. Other automatic siphon tanks are those of Rhoads and of Williams.

*m.* Objections against Sub-surface Sewage Disposal.—And now, having spoken so much in its favor, it is but proper that I should notice, and make mention of, the objections which have been raised, and which are at times brought forward both by professional men and by laymen against the system.

1. It is sometimes feared that the land into which the sewage is continually poured will become saturated with sewage, its surface rendered wet or swampy, and the whole irrigation field converted into a large cesspool, spread out laterally instead of downward. There is, however, absolutely no reason

to apprehend such trouble. Wherever the soil is not porous, *underdrainage* is essential and must be provided for. If properly carried out, all superfluous moisture in the ground will be removed. *Aeration* is another essential condition, and wherever it is neglected the soil may become saturated with sewage matters. By arranging for an *intermittent* discharge, with intervals of at least twenty-four hours between consecutive emptyings of the flush-tank, the soil is given ample opportunity for aëration. This secured, oxidation and nitrification, and the destruction of the organic particles attaching to the earth will follow with regularity.

2. Much apprehension is often felt lest such a system will not work properly in winter time, and fear is expressed that the ground about the absorption tiles may freeze. Experience with the system in the coldest parts of the New England States, where the system has been in continuous use for many years, has fully removed any doubts on this point.

It is found by practical experience that the warmth of the sewage is sufficient to keep the ground at the disposal field from freezing.

3. It is often objected that the intercepting chamber is in reality a cesspool. This is to a slight extent true, but nevertheless I always advise building it, using due precaution in its construction to make it perfectly tight. It should be remembered that the liquid sewage in the intercepting chamber is constantly changed, a large volume of water passing through it every day. Although it retains organic waste matter partially putrefied, the amount is not to be compared with that in a cesspool. Some of the solid matter is reduced by maceration, and being dissolved passes into the liquid chamber, and is discharged by the siphon into the absorption drains. By cleaning the intercepting chamber once a month, the amount of solid putrid matter may be kept down to a minimum, consequently there will be little exhalation of gases, and as the water level

remains constant, the gases are not forced out as in the case of ordinary cesspools. By proper ventilation the intercepting chamber can be kept quite free from offense.

I should mention here that, owing to these objections, attempts have several times been made to do away with the intercepting chamber. But in all cases where water-closets are used and their contents discharged into the tanks, it becomes imperative to prevent the solid portions of the sewage from clogging the siphon or the tiles.

I well remember an attempt made several years ago to do entirely without intercepting chamber by simply surrounding the siphon with a double wire screen of coarse and fine mesh. The result was that in less than four months the tiles were entirely choked. The only alternative is to strain the solids. English engineers, among them Mr. Rogers Field and Mr. Wm. Eassie, prefer a straining chamber. To quote Mr. Field: "The distinguishing feature of this arrangement is that there is no tank or depression for the sewage to collect in, but that the bottom of the chamber is on the same level as the bottom of the drain, so that the liquid sewage passes through the chamber without any obstruction. The interception of the solids is effected by two strainers, which consist of small upright iron rods fixed in an iron frame and so arranged as to be movable. The bottom of the chamber is constructed of concrete smoothly cemented and rounded, so as to form a sort of channel for the passage of the liquid, and to enable the solids to be more readily cleaned out. This bottom also has a rapid fall from the inlet to the outlet, which still further facilitates the rapid passage of the liquid. The sides are usually formed of brick-work and the whole is covered by a light wooden lid, opening on a hinge." In such an arrangement a man can easily remove the solids by scraping them up by means of a hoe over the edge and mixing them with dry earth. To prevent such a chamber from becoming offensive, the solids should be daily removed.*

Another arrangement suggested is that of having in a straining chamber a perforated pail or movable iron basket which intercepts all the solids, and which must be emptied daily. Of the two devices, the plain strainer appears to me far preferable.

I have not yet tried the perforated pail device, but where in the case of larger institutions I have made use of the straining chamber in addition to the intercepting chamber, for the removal of coarser substances, I have found it to work well where I can rely implicitly upon *daily* removal. While the trouble involved in keeping the straining chamber clear and inoffensive is not large, it should be remembered that servants are proverbially neglectful, and the arrangement suggested, while applicable to larger sizes of flush tanks, such as are

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* The writer has used such a straining chamber with success in connection with the sewage disposal works at the Middletown (N. Y.) Insane Asylum.
W. P. G.

constructed for hospitals, asylums or institutions, is not one that I should recommend for single country houses, for it undoubtedly robs the system of one of its best features, namely, that of being automatic. If daily attendance is required, it might be just as well to require the help to empty the sewage tank daily by opening a stop-gate, and thus do away with every kind of automatic siphon or other device, while retaining the features of intermittent discharge of a large, suddenly sent off volume.

4. Owners of country residences find an objection to the system in the necessity of emptying the intercepting chamber, claiming that this causes a nuisance. An answer to this objection might be that of the two evils of cleaning out a large ordinary open cesspool and the little intercepting chamber, the latter is far preferable. But then we forget that the same people who raise this objection would probably never see to it that their large cesspool is cleaned, paying no attention to it as long as the sewage runs off and out of sight.

5. It is objected that sometimes the tiles choke and must be taken up and re-laid. I never deny the possibility of such an occurrence, although this may only become necessary about every three years on the average. Supposing even for a moment that the tiles must be cleaned and re-laid each year, what little amount of labor, trouble and expense is involved in doing so, owing to their being laid in permanent gutters, and close to the surface. Compare this with the trouble and annoyance of having to empty and clean a disgusting overflowing cesspool at frequent intervals.

6. The ground where the tiles are buried cannot be plowed, nor can heavy wagons drive over it without the risk of breaking or displacing the pipes. This objection cannot be denied, but it is at best a slight objection only.

7. Many people object to the cost of the automatic siphon. However expensive such a siphon may be, this cannot be considered a valid and sound objection against the system. As a matter of

fact, the annular siphon, at least in the case of isolated country houses does not cost very much. But, where this expense is objected to, the mistake should not be made of providing only one large overflow pipe from the liquid sewage tank, from which a constant small stream dribbles toward the irrigation field. This is a very imperfect and faulty arrangement. Only a short length of the tiles would receive an almost constant trickling flow of sewage, saturating the ground around it to the surface, and keeping it in an unwholesome condition. Aëration, intermittent action, oxidation, powerful flushing, filling tiles uniformly and wholly, all these essential conditions would be absent.

The only admissible arrangement, and one which I have adopted for smaller country houses, where the owners objected to the expense of a flush tank, and which may be considered often unobjectionable, is a sewage tank, provided with a large number of overflow pipes, all placed exactly *at the same level* in the tank—

not a very easy thing to do, by the way—and discharging simultaneously equal or nearly equal portions of the sewage into the various lines of absorption drains, thus securing a better distribution of the sewage. The tiles are likely to choke sooner than in the system with intermittent flush tank, since they lack the cleansing effect of a sudden rush of water from the tank.

8. Another objection made refers to the cost of the work. The first expense is, of course, more than that for a cesspool, but the frequently recurring expense of cleaning and emptying the latter soon make the sub-surface irrigation cheaper than the ordinary cesspool. For a small country house the whole expense should not exceed $250, and for a larger country residence it averages about $500.

9. It is objected that the system is impracticable in the case of *very level* ground, or where the lawn rises in the rear of the house, or where the soil pipe leaves a house at a depth below the cellar floor. Some concessions must, at times, be made,

of course, and in places where the available fall is slight, no plumbing fixtures should be placed in the basement or cellar, and the soil pipe must leave the house as near the surface as practicable. In some cases it may even become necessary to build the flush tank in an embankment or an artificial terrace at the side of the house. By keeping the depth of water shallow, it may be possible to effect a suitable arrangement. In extreme cases it may become necessary to lift the sewage, and this can be done by a variety of mechanical devices. Where a small air compressor may be operated in the cellar of the house, Shone's sewage ejector would appear to offer a simple solution of the problem. But whatever the difficulties may be, they can usually be overcome at a slight sacrifice, and need not be considered objections to the system as such.

10. The objection that the sub-surface irrigation system poisons the wells may be removed by simply locating the field away from wells, or, where it must be

close to a house, to abolish wells and depend on rain water collected in tight cisterns.

11. Some think that it is impossible to purify sewage by turning it into agricultural drains below the roots of the plants. It is hardly worth while to consider such objection, as many years' experience contradict it.

12. The system has received condemnation because "sub irrigation is a process faulty in principle as it feeds vegetation by the upward rising of moisture, accompanied by evaporation with all the chilling influences which are so injurious to vegetation as well as to human beings." I can only answer that, so far as my observation goes, practically no harm has ever been done to vegetation; on the contrary, sub-surface irrigation stimulates the growth of grass, of shrubbery, or of fruit trees.

13. Where the irrigation field is underdrained, it frequently happens that at first the sewage leaks away too quickly, without being purified, at the points

where the distribution tiles cross the lines of the agricultural tiles. This can be remedied after a while when the trenches for the land tiles have settled down and become solidified.

I believe I have mentioned all the criticisms raised against the system. I leave it to any intelligent observer to weigh their importance. While I do not wish to be understood as claiming this method of disposal as a panacea for all the evils attaching to country house drainage, I hold that the system is an excellent one wherever suitable land, of suitable character and size, and in proper location, may be obtained.

*n.* Summary.—To review briefly what I have said about the methods of disposing of the sewage of isolated country houses not in reach of sewers:

Such country houses can dispose of their liquid sewage in some cases by direct discharge into a stream, taking this word in its widest significance, or into the sea. As a rule, it is vastly better and in many cases absolutely necessary, to subject the sewage to a system of purification on the premises. Of systems of sewage purification, the one by application to land is preferable to mechanical filtration, or to chemical precipitation, which latter should only be resorted to where no land suitable for disposal is available. Of the methods of applying sewage to land, broad irrigation is the least favorable, as it requires a large area of land, and in cases where the field is located close to the house it becomes objectionable on account of possible noxious odors. Intermittent downward filtration, while requiring a much smaller surface, is yet open to the second objection made to broad irrigation. Far preferable to both methods is the sub-surface irrigation system, described at length above. In a few cases it may be necessary to adopt a tight cesspool, and to pump the liquid manure out for distribution upon land. This alternative should be resorted to only where all other methods prove objectionable.

### 3. Large Buildings and Institutions.

In the case of isolated large buildings, such as asylums, hospitals, prisons, hotels, college buildings and educational institutions, both sewage and garbage disposal become more difficult problems.

*Garbage Disposal.*—Owing to the large quantities of garbage and refuse, it generally becomes necessary to have the same removed with regularity from the premises. Pending this removal they should be stored in well-closed, tight, metallic vessels. In some cases, for instance, where the scavenger does not make a daily visit, fixed receptacles are used. They are always inconvenient, and should be avoided when possible. A separation of the different kinds of waste matters is always desirable; thus, bones and meat are often sold to manufacturers of fertilizers, swill is removed by market gardeners, fat is disposed of to manufacturers of soap. The chief point is to always insist upon frequency and promptness of removal. It may, in some instances, where removal cannot be satisfactorily and regularly accomplished, be desirable to erect for an institution a separate garbage cremator. In such cremators all kinds of refuse may be successfully destroyed and quickly consumed. The residue consists of hard burned clinker, which may be used as packing for roads and walks, or else may be ground into powder for use as mortar. Such garbage destructors may be erected in a convenient position near the institution, and since the gases are all made to pass over a fire, no nuisance need be feared.

*Sewage Disposal.*—Regarding the disposal of sewage, various modes are of course available. The closets may be earth-closets, or else the removal of excreta may be accomplished by a pail system. The slop-water may, wherever land is obtainable, be applied to it by irrigation, sub-surface irrigation, or intermittent downward filtration. Wherever the cost of the land precludes the possibility of obtaining an area sufficient for purification, sewage may be filtered through an artificial filter. Wherever an extensive system of plumbing, including water-closets, is arranged in large institutions, the whole of the sewage should be purified by irrigation or by sub-surface irrigation. The former method may be adopted if the irrigation field can be located at a distance from the buildings, and as it requires no underground distribution tiles, to be laid with great care, it is somewhat less expensive than sub-surface irrigation. If the field must be in the vicinity of buildings it is better to avoid any nuisance to sight or smell by adopting a sub-surface irrigation system. In both cases the sewage should be collected in flush-tanks and discharged intermittently. In the case of large flush-tanks and intercepting chambers it may become advisable to deodorize and disinfect the sewage by an addition to the intercepting chamber of some chemical substance such as perchloride of iron or sulphate of alumina, to hasten the precipitation of the solid matters. Where liquid sewage can be discharged without nuisance into a large body of water, this method of removal is to be preferred to any local treatment.

Many interesting descriptions of instances of the successful disposal of sewage for institutions may be found in sanitary books, journals and health reports. My first intention was to give to the reader brief illustrated abstracts, but to do this would unduly increase the bulk of the volume, and I must content myself with a brief reference to the publication containing same.

The sewage disposal system by subsurface irrigation at the Keystone Hotel at Bryn Mawr, Pa., and at the Women's Prison at Sherburn, Mass., have been described by Col. George E. Waring, Jr., in his book, "Sewerage and Land Drainage."*

The same book gives a complete illustrated account of the surface irrigation system carried out by Col. Waring at the Norristown (Pa.) Asylum for Insane.

Mr. F. S. Odell, C. E., describes the

* Published in 1889 by D. Van Nostrand Co.

sewerage and the sub-surface irrigation sewage disposal works at the Lawrenceville (N. J.) School in No. 352 (Feb., 1887), Transactions of the American Society of Civil Engineers.

In the eleventh annual Report of the New Jersey State Board of Health its efficient Secretary, Dr. Ezra M. Hunt, published an account of the sewage disposal at the Morris Plains Asylum for Insane.

In the seventh annual Report of the Massachusetts State Board of Health may be found a description of the sewage disposal works by irrigation at the Augusta (Me.) State Insane Asylum.

The sewage disposal by surface irrigation at the State Lunatic Hospital at Worcester (Mass.) is described in the annual Report of that institution for the year 1879.

The sub-surface irrigation system at one of the buildings of the Woodstock College, Canada, is described by Mr. Edm. Burke, architect, of Toronto, in the January, 1889, number of the *Canadian Architect and Builder.*

In the January, 1889, issue of the *Philadelphia Builder* Mr. George N. Bell, C. E., describes and illustrates the sub surface irrigation system built by him at the Methodist Episcopal Orphanage near Philadelphia.

The disposal of sewage at the Massachusetts Reformatory, formerly the State Prison, at Concord, Mass., is described by William Wheeler, C. E., in a paper published in the seventh annual Report of the Massachusetts State Board of Health, Lunacy and Charity (1886).

A few instances from the writer's own professional practice may prove interesting. The following are extracts from my Preliminary Report on Sewage Disposal for the Middletown (N. Y.) Homœopathic State Insane Asylum, the system outlined being adopted and carried out in 1887 under the writer's immediate superintendence.

SEWAGE DISPOSAL AT THE NEW YORK STATE HOMŒOPATHIC ASYLUM AT MIDDLETOWN, N. Y.—The important problem of how to dispose of the sewage and semi-liquid wastes in the most economical, safest and least disagreeable manner, is one which always presents itself wherever a large number of persons are congregated together in one or more buildings located closely together.

It is not necessary for me to dwell upon the relations existing between foul and decomposing waste matters from households, and certain diseases of a zymotic character, or upon the dangers to health, resulting from imperfect removal or faulty disposal of such organic waste matters. I shall, therefore, at once take up the practical discussion of the question. It is also hardly necessary for me to point out that, whatever method of the disposal of the sewage be adopted, it should be one free from annoyance to sight or smell or otherwise, both to the institution and to the adjoining neighbors. Investigation shows that there are two ways in which the problem may be solved. One of these is to get rid of all the sewage from the buildings by removal through a main sewer, discharging into, and connecting with, one of the sewers in the village of Middletown; the other is to dispose of the sewage on the premises. The first method would require the laying of a pipe sewer, probably twelve inches in diameter, if all the storm-water were included, and over one and one-fourth miles long, the acquisition of the right of way, the right to empty into the village sewer, etc. All this would involve a very large expense and there seems to be no reasonable doubt that, if some method were available of disposing of the large amount of sewage on the grounds belonging to the asylum, the latter method would be far simpler and less costly.

Fortunately, the asylum buildings are so favorably situated on the crest of a hill as to allow of perfect drainage, and large areas of ground are available about the asylum, the location, topography and character of soil of which render them well adapted for use in connection with the purification of the sewage.

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It is obvious that, considering the small volume of water in the creek at the rear of the asylum grounds, the sewage should not be admitted into it without previous purification.

For the purposes of this report it seems unnecessary to describe at length all the various purification processes which are in more or less successful application. Broadly speaking, we may distinguish *natural* and *artificial* purification processes. The former methods consist in the application of sewage to land as liquid manure, while in the latter sewage is purified either by artificial (mechanical) filtration, or by subsidence, or finally by chemical precipitation. The experience which we have derived so far from sewage purification works in this country and in Europe warrants the statement that *natural* processes are superior to *artificial*, first in being simpler and cheaper, and second in being more effective in removing impurities from sewage, and yielding an effluent of such purity that it may at once be emptied into a water-course. Wherever, therefore, suitable and sufficient land can be obtained, the application of sewage to the soil is vastly preferable. There are, occasionally, conditions which render this impossible, and in such a case either artificial filtration or chemical precipitation in tanks, by the addition of milk of lime, or sulphate of alumina, or perchloride of iron, must be resorted to, but the processes are expensive, the effluent is not of such purity as to allow of immediate discharge into a water-course, and a new and often formidable difficulty arises in the disposal of the precipitated matters or "sludge," which must be artificially dried, or pressed by means of powerful filter presses into cakes, which do not possess a great value as manure. Both methods are sometimes combined, using purification by chemical treatment first, and afterwards application to land, and in such a case a much smaller irrigation area will be sufficient, but the process is proportionately more expensive. In your case application to the soil is decidedly the best method.

*What are the conditions essential to a successful* *application of sewage to land?* These conditions are, so far as the soil is concerned, a sufficiently large area of suitable, absorbent, and well aërated soil, which has been thoroughly under-drained and properly prepared. Much of the success of the system will depend upon proper arrangement of the work, judicious management and careful distribution of the sewage, and, above all, upon the *intermittent* application of sewage to the soil. The land selected for sewage purification should not be located too near to the buildings, and no wells used for water supply should be near the irrigation field.

In the application of sewage to land several systems may be distinguished, namely, broad sewage irrigation, sub-surface irrigation and intermittent downward filtration. To a certain extent *filtration* through the soil forms an important element of all three systems. Broad irrigation may be defined as the distribution of sewage over a large surface of ordinary agricultural soil, having in view a maximum growth of vegetation, consistent with due purification for the amount of sewage supplied. Intermittent downward filtration, and to some extent sub-surface irrigation, consist in the concentration of a large volume of sewage at intervals on as small an area of porous ground as will absorb it. Here the cultivation of crops and the production of marketable vegetables are but a secondary consideration. In broad irrigation sewage is made to flow *over* the land, although even here a part filters through the soil, while in intermittent downward filtration the sewage passes principally *through* the land. Sub-surface irrigation is merely a modification of the filtration system.

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The process of purification which takes place in the soil may be explained as follows: When sewage is distributed on or close to the surface, its organic impurities are retained in the soil, and are, to some extent, and when vegetation is active, taken up as nourishment by the roots of plants, while the water, thus partly purified, soaks away into the soil, becoming still more clarified by filtration, until it reaches the under-drains or some other lower outlet, where it escapes, generally clear, colorless and free from taste or smell. While vegetation assists in the purification of sewage, it should be understood that the soil itself possesses great purifying power, and this explains to a large extent why the system continues to work in winter time. By making the discharge intermittent, the upper layers of the soil are enabled to take up, during intervals between discharges, oxygen from the atmosphere, without which the bacterial growth would soon cease. The complete reduction of the organic impurities is then effected by the bacteria, aided by the oxygen in the air.

Broad surface irrigation requires very large areas of land, the usual allowance being one acre to every one hundred persons in the case of favorable soil, and it is an essential condition that the latter should not be continuously flooded. Hence, to manage an irrigation farm successfully, it is advisable to have pieces of fallow land and to alternate in the distribution of sewage. In intermittent downward filtration through properly under-drained land, a much smaller area of land is required. In both systems the sewage is delivered at the field on the surface, and this may, at times, become highly objectionable, and cause offense to sight or smell, if the irrigation field is located close to the buildings. In the modified system of *sub-surface irrigation* this objection is entirely overcome, as the sewage is distributed under the surface at a depth of from eight to ten inches, through a net-work of irrigation tiles. The preparation of the sub surface is, of course, somewhat expensive, but it secures the advantage that, once properly arranged, it does not require constant attendance, as with surface irrigation or filtration. Such a field, however, cannot be deeply plowed, and it is, therefore, best to arrange it as grass or meadow land.

I am informed that the land which is suitably located for the disposal of sewage from the asylum has been thoroughly under drained many years ago, so that it would appear to be well aërated and in a fit condition for purifying sewage by one or other of the above methods.*

The land should be well cleared of all stones which would interfere with the cultivation of the soil.

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The preparation of the land is accomplished as follows: Supposing the land to be thoroughly under-drained, all stones and stumps of trees should be removed, as well as the roots of shrubbery and trees. The land should be suitably and evenly graded, and then trenches are dug, wherever possible, in parallel lines. Into these trenches and at a depth, not exceeding eight or ten inches, are laid common two-inch porous agricultural tiles, one foot long. They should rest on continuous boards, or, better, in gutters of earthenware, laid in the bottom of the trench after the latter is evenly and accurately graded.

It is important that the tiles should have at each joint a space of about one-fourth inch to facilitate the oozing out of the sewage. Small earthen caps are placed over each joint to

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* This subsequently turned out not to be the case and explains the partial failure of one part of the system as carried out.—W. P. G.

protect it from dirt or earth falling from above. The line of absorption tiles should have a fall of only about two or three inches per one hundred feet, just sufficient to keep the sewage flowing through them. If laid with greater fall the sewage would rush to the lowest points and over-saturate that part of the field. The success of the whole system will depend largely upon the accuracy with which these tiles are laid, hence it is very important to have this part of the work done by experienced drain layers only.

For the disposal of 20,000 gallons (400 persons at fifty gallons) for the two buildings and laundry, at least 20,000 feet of absorption tiles would be required. The distance between the lines should be about five feet, though this will depend upon the configuration of the surface, the lines following very closely the contour levels. The system at the barn would require at least 10,000 feet of tiles, suitably laid and arranged.*

The first system would require the building of a new tank, in brick-work, laid in Portland cement mortar, and made perfectly water-tight, and holding not less than 20,000 gallons. It should be built in three chambers, two of these being intercepting chambers for retain-

* This estimate of the amount of sewage, based upon data given by the engineer of the institution, subsequently turned out to be too small.—W. P. G.

ing. the solid impurities and into which the sewage flow may be turned alternately, thus enabling the cleaning and disinfecting of one chamber while the other is in use. From each chamber an overflow into the liquid tank, dipping well below the surface of the liquid, so as to prevent any floating scum from overflowing into the liquid chamber, should be arranged. In the liquid tank is placed the Field siphon. For the third building, part of the present large cesspool may probably be retained, after being suitably reconstructed and remodeled for the siphon. The liquid wastes are retained in each tank until it is filled, when the siphon is brought into action and automatically discharges the whole of the contents into the main conduit, leading to the irrigation field. Thus all the rows of tiles will be uniformly charged and the whole of the absorption field is brought into use each time the tank is discharged. The sewage oozes out at all open joints at the irrigation field, purification begins at once, and while the tank is again filling for the next discharge, the soil is aërated and prepares itself for further sewage purification. It may become advisable to prepare a reserve field for each flush tank, in order to send the sewage onto it during some period of time, to prevent a possible over-saturation of the soil of the main field.

I should, perhaps, mention that wherever in this report the word *sewage* occurs, it should be understood to mean the household wastes proper, *excluding* any storm-water. Fortunately there is now, at all three buildings, a double system of pipes, one of which removes rain-water only, while the other receives the foul liquid wastes. The storm-water should be removed separately into the creek, or elsewhere, but should not be delivered into the flush tanks. Wherever sewage must be purified it is always best to exclude the rainfall from it, for in rainy weather the purification area would be least capable of receiving the sewage, then largely increased by the bulk of storm-water.

In the spring of 1888 the author was called upon to make an examination and report on a method of sewage disposal at the Louisiana State Insane Asylum, at Jackson, La., portions from which report are herewith reproduced.

Sewage Disposal at the Louisiana State Insane Asylum, at Jackson, La.—The present system of sewerage at the asylum is defective and gives undoubtedly cause for complaint, principally on account of the method adopted of discharging the sewage unpurified into the creek flowing through a part of the town of Jackson, La. The sewer system of any institution should remove instantly and efficiently all the sewage to a point of outfall located where it may not cause a nuisance to sight or smell In your case the natural configuration of the surface is quite unfavorable, and is the chief cause of the difficult problem arising. It is necessary to run the sewers from the buildings towards the creek in the rear of the asylum, beyond which rises a steep hill. It is, in my judgment, quite improper to discharge the crude sewage any longer into this creek. Several plans suggest themselves for remedying the present defective disposal of the asylum sewage.

The first plan is to collect all the sewage in the rear of the asylum in a number of settling tanks of large capacity, and to treat the sewage in the latter by chemical precipitation by adding to it chemicals in solution, such as salts or alumina, whereby a speedy precipitation of the suspended and at least a part of the dissolved impurities is effected. The effluent, while not of great purity, would be sufficiently clarified to permit its discharge into the creek. Such a method of treatment would not, however, in your case be economical, as it would require, first, the construction of several large tanks, built in masonry, provided with screening arrangements for intercepting foreign matters and larger floating impurities, furthermore devices for dissolving and mixing the chemicals, sheds for the storage of chemicals, employment of manual labor the year round, to perform the necessary manipulations of the sewage, and, above all, it would necessitate the purchase and freight expenses on the latter, which, in your case, might become very large. Finally such a system involves the manipulation of the resulting large quantities of sewage sludge, which would have to be pumped out of the tanks and dried either in the air or by artificial heat or by means of filter presses. The latter, although efficient, are expensive, and the money realized from the sale of the manure cakes would not compensate for the running expenses incident to such a system. Hence, the whole plan may be dismissed as complicated and uneconomical.

A second plan, which suggested itself to me as a possible solution, would be the purification of the sewage by means of mechanical filtration —filtration through land and surface irrigation being both impracticable, no land being available between the asylum and the first creek, to which the sewage could be carried by gravity. Sewage is not a liquid which renders filtration easy, on account of its slimy nature, which causes the pores of the filter to clog gradually, when the filtering operation comes to an end until the impervious deposit has been removed. There is, to my knowledge, but one kind of filter which is arranged so as to overcome this difficulty successfully. This is the Farquhar-Oldham sewage filter, an English apparatus, the peculiarity of which consists in having a revolving "cutter" or scraper which continually removes the upper layers of the filtering material, which have become clogged, and hence have ceased to work effectually, and thereby frees the surface of the filter from the slimy impurities which stop filtration. Thus, to all practical purposes, a new filter is created. The filter bed of the apparatus is composed of ordinary sawdust or powdered cinders, which are cheap and easily obtainable in any quantity, and the sawdust, when filled with the absorbed impurities, may be dried and serve as fuel under the boilers.

If such an apparatus were used the sewage should be collected in a storage reservoir, located to the south of the asylum, on the slope of the hill bordering the first creek, and from it the sewage would have to be pumped and forced under pressure through the filter, the effluent being thereby clarified to such an extent as to permit its discharge into the creek. Such a filter would probably answer your purpose perfectly, but I have no knowledge as to its exact cost, and I am informed that it can no longer be obtained in the United States

The only two possible plans of local purification, either by chemical precipitation or by mechanical filtration, being impracticable, it thus becomes necessary to remove the sewage to a greater distance from the asylum, in other words, to carry it to the second and larger creek tributary to the Feliciana River. Its discharge into the latter would be, in my judgment, perfectly unobjectionable for a great many years to come, and it remains to discuss the best method of carrying the sewage across the first creek, and across the hill beyond the latter.

One plan would consist in bridging the first creek, or throwing an embankment across the same with large culvert, and in carrying the sewage across the bridge in a pipe sewer, and tunneling through the hill at such a depth as to permit the sewage to flow by gravity to the larger creek beyond the hill. Such a plan is, no doubt, feasible, but it is necessarily expensive, owing to the great depth at which the sewer would have to be built.

I come now to the fourth plan, which is a modification of the one named last, and consists in lifting the sewage to the top of the hill by a system of pumping by means of compressed air, and allowing it to flow thence by gravity to the outlet at the larger creek. The apparatus by which this can be accomplished is called a Shone hydro-pneumatic ejector, and it is described at length in a pamphlet which accompanies this report. It is not a new experimental apparatus, having been successfully used in the sewerage of a number of English cities, also in the remodeling of the houses of Parliament, Westminster, London, and other places. The apparatus may now be obtained in this country.* Briefly described, a "Shone" ejector is an apparatus for automatically raising liquids by means of compressed air, and its chief advantage over an ordinary sewage pumping apparatus consists in the fact that it does not require any storage tanks of large capacity into which the sewage must flow before it can be lifted, these tanks becoming necessary with ordinary pumping apparatus, owing to the variable rate of flow of sewage during the day. By adopting the "Shone" ejector, on the contrary, no collecting tanks are required, as the rate of discharge of an ejector corresponds to and varies with the quantity of sewage flowing into it.

The construction of the ejector is clearly shown in the accompanying pamphlet. It is, practically, a cast-iron artificial receiver, having an inlet and an outlet pipe, and on each of these there is a wooden ball valve. As the sewage flows into the ejector it lifts the inlet valve off its seat and gradually fills the ejector, whose capacity is about 200 gallons. As soon as the ejector is full, compressed air of a pressure depending upon the total lift of the

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* It has quite recently been used in connection with the drainage of the Auditorium building, in Chicago.

sewage—about 45 lbs. pressure per square inch in your case—is automatically admitted, a float operating an automatic valve apparatus at the top of the apparatus in connection with the compressed air supply main. The inlet ball valve now closes, and the whole contents of the ejector are forced through the outlet pipe towards the outlet. When the ejector becomes empty, the float drops and closes the air supply valve and the ejector again fills up, the same operation repeating itself as soon as the ejector again becomes full. The apparatus, of course, requires an air-compressing station, with boiler and engine of about 2½ horse-power, an air compressor and an air reservoir. These could, in your case, be placed in the present boiler house and would require a line of small iron air pipes connecting the air compressor and reservoir with the ejector. In order to avoid trouble in case of accident or temporary repairs to the apparatus, it is recommended to provide the air compressors in duplicate.

The ejector could be located on the slope at the rear of the buildings, and the discharge pipe could be carried, either under the bed of the creek or else across a bridge, to the top of the hill beyond, from which point the sewage would flow by gravity to the outfall. The system just outlined appears to me, on the whole, to solve your sewage difficulty in the best and most economical manner.

Its operation would be as follows : The sewage, as produced, flows down the properly graded house drains to the ejectors. The moment the ejector is full, compressed air is automatically admitted and the sewage forced into the discharge pipe. The ejector is self-cleansing and self-ventilating and forms an absolute barrier against the passage of sewer air back into the drains. The compressed air is not admitted to the ejector until it is full, and the air is not allowed to exhaust until the ejector is emptied down to the discharge level. In consequence of these actions the sewage is dealt with just as it flows from the house drains, whether it be at the maximum or minimum rate, and by a simple automatic arrangement the production of air is regulated to the demand.

In case you should decide to adopt and carry out the system recommended by me, it would, of course, become necessary to reconstruct the system of sewers outside of the buildings, and to collect all of these into one main six-inch sewer, leading to the ejector, of a capacity sufficient to carry the whole sewage.

According to measurements taken by me, the water pumped from the well into the tanks of the various buildings varies from 35,000 to 45,000 U. S. gallons per 24 hours. This amount represents, practically, the quantity of sewage proper of the asylum, because no rainfall is admitted into the present sewers, being at the rate of from 70 to 90 gallons per head per diem. In reconstructing the system of sewers, I strongly advise dealing with the rain-water from the roofs separately, as heretofore. There is no good reason why the rain-water should not be made, in your case, to flow off on the surface, where necessary in surface gutters. The drain from each of the buildings should be a six inch glazed earthenware sewer pipe, laid with a fall of at least 1-8 inch to the foot, and with joints properly made with Portland cement. Should any of the lines pass near the asylum well, it would be better to substitute cast-iron pipes with leaded and caulked joints, to insure that your drinking water remains uncontaminated. A thorough examination of the apparatus recommended for lifting your sewage across the first creek and the hill beyond, will convince you that its construction is simple and that hence its cost of maintenance, repairs, etc., would be small. The annual expense of operating the same would not form a serious item, as the engineer who runs the dynamo and engine of your electric light plant could simultaneously look after the air compressor and its engine, and very little extra fuel would be required for the boiler. The ejector is self-acting, and would not require any daily attendance.

As to the plumbing work inside of the buildings, my examination leads me to believe that much of it is unsafe and not in accordance with modern rules and requirements. As the sanitary condition of the asylum and the good health of the inmates depend, to some extent, upon the proper arrangement, trapping and ventilation of the plumbing fixtures and house pipes, I recommend that the whole work be reconstructed at an early date. In consideration of the fact that your asylum is located away from the centers of population, and hence that plumbing repairs are difficult and costly, I should advise having as little plumbing work in the buildings as possible and avoiding the use of lead waste pipes, by adopting a system of heavy screw-jointed wrought-iron soil pipes, with iron branches to water-closets, slop-hoppers and bath-tubs, and wrought-iron, well-ventilated siphon traps under fixtures. New bath-tubs of cast iron, painted, or, better, enameled, should be fitted up without any surrounding wood work. Likewise should modern flushing-rim enameled iron slop-hoppers be fitted up. Finally, I would advise putting up for each ward at least one good water-closet for patients' use at night. The slop-hoppers should not be used for this purpose, and their outlets should have well-fastened strainers. to prevent obstructions in the pipes and traps. Some of the wash-bowls at present in the building might with advantage be dispensed with, as being a source of constant annoyance and repairs. I fully approve of your present system of out-door closets for the patients who are able to be out and work on the farm or in the garden. As an improvement upon the present system of pails, which, however, is vastly better than the ordinary privy vault, I would recommend the use of improved forms of earth-closets.

## II.

## HABITATIONS IN VILLAGES.

I shall not here consider such villages where the houses are scattered about and have each a large amount of garden space. Such houses can always dispose of all of their filth products on their own premises, by one of the methods described for isolated country houses and neither a system of scavenging nor a sewerage system are required. There may, and probably always will be, in every village a few houses without any garden space attached, but these are usually able to make a separate arrangement either with a neighbor or with some farmer. The whole solution of the question may be characterized by, and embodied in, the following rules: *Cesspools and privies must be utterly abolished; wells, cisterns and springs must be protected from pollution; slop-water should be disposed of in the garden, or under the lawn by means of a flush-tank; and dry earth or ash-closets,* *or else the pail or tub systems should be adopted for the excrement disposal.* The earth-closet system is particularly adapted to villages, as there can seldom be a difficulty in procuring sufficient loamy soil or garden mould, and in subsequently utilizing the earth manure in gardens or on adjoining farms.

In proportion as dwellings become aggregated and crowded closer together and the gardens attached to them reduced in size correspondingly, and as the population increases, it becomes more and more difficult for the individual householder in villages to dispose of his refuse separately. It is obvious that, in the case of densely populated and closely built up villages, united action of the residents becomes a necessity to effect any reform in the much prevailing cesspool nuisance. In other words, the community as a whole must carry out proper measures for sewage removal and disposal.

It may, in some instances, be feasible to retain the earth-closet near the farmhouse. But, wherever the resulting earth manure cannot be made use of on the ground, it may become preferable to arrange, under supervision of the village authorities, a system of dry removal by tubs or pails. Much of the success of such systems will depend upon the care and regularity with which the deodorizing material is supplied, and upon the frequency of the removal of the dry manure and of the pails.

Surface or sub-surface irrigation in the garden being impracticable where no space is available, and both open and tight cesspools being objectionable, the one because it will contaminate the soil and the other because it will require frequent pumping out, while both will become foul, owing to decomposition of their contents, the only remedy for the slop-water nuisance is to build a main sewer pipe—a six-inch pipe will answer for a whole village of one thousand or even more inhabitants —with branch pipes to each dwelling, for the removal of the slop-water proper. From this sewer all surface and sub-soil water should be rigidly excluded; in other words, the *separate system of sewerage* should be adopted.

A cardinal rule is that the sewage be delivered at its ultimate point of discharge before it can begin to putrefy. Whether its immediate discharge into a water-course is practicable, or whether a previous purification by chemical precipitation, filtration or by irrigation is necessary, must be made the subject of a particular investigation in each case. Wherever a village adopts a sewerage system, the houses may and usually will sooner or later be provided with "modern conveniences," in other words, with a more or less elaborate system of plumbing fixtures, including water-closets for the removal of human excreta in place of earth-closets or pails.

Wherever the majority of the village houses are without sufficient garden space, a system of public scavenging may be required. But, as a rule, most of the dry refuse matter can be disposed of on the premises of village houses, in much the same manner as indicated for farm-houses and isolated country residences. As a rule, the disposal of garbage is more readily accomplished in villages located in agricultural districts than in mining or manufacturing villages, or in towns.

Interesting accounts of the sewerage and sewage disposal of the villages of Lenox, Mass., and of Cumberland Mills, Me., are given by Col. Waring in his recent book, quoted heretofore. The sewerage and sewage disposal of the model town of Pullman, Ill., afford another interesting example (see description by Mr. Benezette Williams, C. E., in the Journal of the Association of Engineering Societies).

In this connection I may be permitted to quote from my report, prepared in 1889 for the Westinghouse Air-Brake Co., on the Sewerage and Sewage Disposal of Wilmerding, Pa., a model manufacturing village near Pittsburgh, Pa., similar in character to the town of Pullman, Ill.

Sewage Disposal at Wilmerding, Pa.— I come now to the discussion of what is probably the most important, and at the same time most difficult part of the whole problem, *i. e.*, to the question: How and to what extent shall the sewage be purified before it is discharged into Turtle Creek?

Bearing in mind the instructions given me to propose and devise as simple and inexpensive a plan of purification as possible, and the fact that a high standard of purification is not essential, I would suggest that, for the present, a system of purely mechanical clarification by simple subsidence in duplicate settling tanks be tried, wherein strainers intercept the coarse floating substances, while the finer solids and a portion of the flocculent, suspended impurities be allowed to settle by gravity to the bottom of large tanks through which the sewage should pass with a very much reduced velocity.

The coarse substances intercepted by means of suitable upright bar screens and floating skimming boards should be removed daily and dealt with in the same manner as the solid garbage of the village and of the works. As the best method, I would recommend the burning of such material in a suitably constructed garbage destructor, to be erected in the vicinity of the settling tanks.

The resulting liquid effluent from the subsidence tanks would necessarily still contain all the dissolved impurities and some of the lighter suspended particles. The accumulations of semi-solid sewage sludge deposited in the bottom of the tanks are more difficult to deal with. I would suggest that the sludge might be retained in the tanks until such times when, owing to floods, the creek carries sufficient volume of water to render the discharge of the sludge into it unobjectionable. The discharge itself may be effected by gravity if the tank bottoms can be located at a sufficient elevation above the ordinary water level in the creek, or else—and this is more likely—it will be necessary to provide pumps to lift the sludge from the tank bottom.

I am not at all certain that the method of purification by mere subsidence will be practicable and satisfactory, and I will say frankly that the whole method of purification outlined so far should be considered as experimental; for it is to me doubtful whether the suspended sewage impurities will, even if the sewage be brought to nearly absolute rest in the settling tanks, drop to the bottom to such an extent as to give an effluent from the settling tanks, which could be considered sufficiently clarified. According to experience gained elsewhere it is highly probable that the effluent would remain putrescible and liable to cause a nuisance in the creek.

It will therefore be advisable to construct the subsidence tanks at the outset, in such a manner that, if found necessary, chemical treatment may be applied.

I am not in favor of a system of mechanical filtration of the sewage, and to my knowledge experiments in this direction have not proved a success, owing probably to the slimy nature of sewage which causes every filter-bed, of whatever material and construction, to gradually clog up, requiring a frequent renewal.

I am loth to recommend a system of chemical precipitation at the purification works for I am aware that it complicates the whole arrangement and increases the cost of purification. Such chemical precipitation consists in the addition of certain chemicals to the sewage, whereby the solid, suspended matters, and at least some of the dissolved impurities, are precipitated, while at the same time a partial deodorization is effected. The sewage to which the chemicals are added in solution flows into tanks and is passed continuously, and at a very slow rate of velocity, through a series of basins, allowing the impurities to settle to the bottom while the clarified effluent is discharged into the creek. The precipitated sludge is periodically removed from the tanks. Many different processes exist, varying chiefly in the chemicals employed. Experience gained in such works abroad tends to indicate that the lime process and the process using sulphate of alumina and lime combined as chemica precipitants, promise the best result. The lime process is cheaper, but the combined alumina and lime process is more effective. The lime process is also objectionable because it creates a much larger amount of sludge, and the effluent is apt to become offensive.

The arrangements for separating the grosser solids from the sewage would remain substantially the same in chemical precipitation, as for the subsidence tanks, but, in addition, machinery would be required for mixing the precipitants, and it would also involve the buying of large quantities of chemicals, either sulphate of alumina or protosulphate of iron, and lime, which must be stored in suitable buildings, prepared in suitable receivers, and added to, and mixed in suitable proportions with, the sewage flowing into the tanks.

Still, there cannot be the slightest doubt that chemical precipitation would effect a quicker and more complete clarification of the sewage than mere mechanical straining and subsidence. On the other hand, the disposal of the sludge will be rendered more difficult, owing to the fact that its quantity will be increased by the addition of the chemicals, particularly if lime should be used, and hence that the tank bottoms will fill up quicker and will require more frequent emptying and cleaning. If chemical treatment be adopted it will probably be advisable not to attempt to discharge the sludge into Turtle Creek, but to establish suitable sludge compressors, by which the black fluid or sludge, which in the bottom of the tanks contains about 90 per cent. of water, will be deprived of at least 50 per cent. of this water, and be consolidated into pressed manure cakes, which can be further dried in the air, which are more readily handled, and which possibly could be disposed of to farmers in the neighborhood, although its sale may be uncertain, and a large profit cannot thereby be realized. As stated above, the effluent from such a process would still contain dissolved impurities, but it could be discharged with impunity into the creek.

In my judgment such a system of purification by chemical precipitation, together with sludge compression, will be the proper one ultimately to adopt, although necessarily more costly than a system of mere subsidence. A system substantially as described has been in successful use for the purification of the sewage of Frankfort-on-Main, Germany, and in some places in England. A similar system is in operation at the large works of Herr Krupp, at Essen.

I would, accordingly, propose to build at the point located on the map, precipitation works, consisting of two large settling basins, into which the sewage would be delivered by means of sluice gates. These basins would be used alternately, in order that the one may be thoroughly cleaned while the other receives the sewage. The basins should be built in brick masonry or of concrete, and faced inside and outside with pure Portland cement. Each basin should be 60 feet in length, 30 feet in width, and from 5 to 6 feet deep, giving a capacity of 60,000 gallons or one-tenth of the expected total daily volume of sewage. Each basin would be again subdivided by cross walls into three tanks. The sewage, after receiving the chemicals, would flow into the first tank; when this is filled it overflows over the bridge wall into the second, thence into the third, and at the lower end of this it would overflow into an outflow channel, leading to the creek.

This same arrangement of basins would, of course, answer in case it should be decided to adopt a system of simple subsidence. The details of the arrangement of the basins and channels could be determined later on.

It may seem advisable not to decide at once upon the system finally to be adopted for purification. Each year brings new systems, and we likewise gain more experience and obtain scientific data from systems in actual use. In Germany, in particular, some new methods of purification have been lately devised, which promise good results and are highly spoken of by sanitary engineers in good standing.*

Unfortunately, I am not familiar with them from a personal inspection and observation and only know them from descriptions; hence I do not feel prepared to suggest them without having personally looked into them.

The following abstracts are taken from my report on the Sanitary Condition of Watch Hill, R. I., made in September, 1889, at the suggestion of the State Board of Health of Rhode Island. A few unavoidable repetitions of former statements will, I trust, be excused by the important relation which they have to public health.

SEWERAGE AND SEWAGE DISPOSAL AT WATCH HILL, R. I.—Situated at the extreme southwestern point of the State of Rhode Island, on a narrow peninsula, surrounded almost entirely by water, Watch Hill would seem to offer, by its select position, peculiar advantages as a watering-place and seaside health resort. Bounded on the east by the open Atlantic ocean, and by the waters of the quiet Little

* The writer refers particularly to the Müller-Nahnsen and the Rothe-Röckner systems of sewage purification.

Narragansett Bay on the opposite side, exposed to invigorating sea breezes, from whatever direction the wind may blow, this beautiful spot appears to be particularly favored by nature to be a fit resting place for tired brain-workers, and for all persons in search of health and healthful surroundings.

The place at present consists of a few village dwellings and stores, a number of large summer hotels, some of which are situated on the bluffs from which magnificent ocean views may be obtained, and of a large and rapidly increasing number of isolated summer cottages.

There is no system of sewerage at present at Watch Hill, nor is there a public water supply. Each individual cottage and each hotel has its own supply of water, derived from storage of rain-water in cisterns or else from wells and springs. Each building takes care, in a more or less perfect manner, of its liquid and semi-liquid refuse. All cottages and hotels have more or less of the usual inside house plumbing. As a rule, each cottage has its own water-tight and cemented cesspool, but to avoid the annoyance of frequent emptying or pumping out, I am informed that many cesspools are provided with overflows, allowing the surplus liquid waters to soak away into the ground, while the solids and grease are retained in the cesspool, which is emptied each fall at or after the close of the season.

It is a well-established axiom of sanitary science that storage of putrefiable or putrefying filth of whatever character in the immediate neighborhood of human habitations should be avoided; and while this applies even to the smallest single habitations or isolated cottages, it is particularly applicable to summer hotels, where a large number of people congregate annually for pleasure or health. With only very few exceptions I find that this law is violated at Watch Hill, and the fact that this resort has so far enjoyed an immunity from infectious disease must be explained to a large extent by the above mentioned exceptional natural advantages of the place. It should be remembered, however, that more people will be attracted to the place from year to year, owing to the salubriousness of its climate, and as rapidly as the place is destined to grow, the unsanitary conditions created or maintained by mankind will multiply and become more and more a source of possible danger to health to the increasing number of permanent summer residents. Therefore, bearing in mind the old proverb that "an ounce of prevention is better than a pound of cure," it is none too soon to begin to think seriously of sanitary improvements. Hotel owners in particular, whose success depends almost entirely upon the good sanitary reputation which a place bears, as well as upon the healthfulness of their buildings, should ever remember that every dollar judiciously expended in the interest of the healthfulness of a resort, will soon be returned to them ten or twenty fold.

Privy vaults, as well as leaching cesspools, are abominations which should no longer be tolerated in any civilized community. All collection and storage of putrefying organic matter, on or under the surface of the ground, should be avoided as constituting an ever present menace to health. Such accumulations of putrefying filth, undergoing constant decomposition and creating poisonous gases, have been well compared to a powder magazine, lacking only a single spark to become the center of vast destruction through the rapidly multiplying germs of disease when introduced by a single case of illness. With privy vaults and cesspools abounding, the surrounding earth becomes saturated, the air tainted, the general health of persons living in the immediate vicinity, and compelled to breathe such air, becomes affected, and the power of resisting infectious disease will be lessened. Again, the drinking water derived from wells or springs will gradually be poisoned, and thus may arise a second and equally potent cause of illness.

Cesspools and vaults are retained in communities only through ignorance or indifference. It is a fundamental principle that all filth incident to human life should be removed thoroughly and immediately, or at least before putrefactive decomposition begins. Likewise should all liquid or solid offal, garbage, or manure from stables, cow-barns, hog-pens, henneries, or places where animals are slaughtered, be collected and removed by scavengers, and as much of it as possible used by farmers to enrich the land.

No doubt there will be some who will argue in defense of the "leaching cesspool" for seaside resorts, that it is used only during three or four months of the year, and that it consequently has ample time during the remaining period to purify itself. To this it must be replied that even during the short period of four months a leaching cesspool may become highly dangerous by reason of soil pollution and air contamination, particularly in the case of larger hotels. Besides, it is tolerably safe to assert that proper oxidation does not take place except near the surface, and that even where the foul liquids leach away in the sand the solid foul matters and grease will remain in the cesspools and in the pores of the ground, accumulating from year to year.

Until a pure and abundant general system of water supply is introduced, all wells and cisterns should be diligently watched and kept free from all possible surface defilement and underground pollution. Water stored in cisterns is frequently polluted through the overflow pipe connecting the cistern with a cesspool or some drain carrying foul sewage. It is obvious that such a connection is absolutely inadmissible. Rain-water collected in cisterns may be contaminated through various other causes. Much care should be exercised to see that the roofs and gutters are always kept in a clean condition, and that no slops are thrown out from windows onto low roofs, draining into cisterns, that no leaky drain passes near the cistern walls, that the latter are carefully built of sound brick laid in cement, and with the inside rendered with Portland cement and preferably provided with a filtering compartment.

Vigilant care should be exercised with regard to the storage of focd, particularly of meat and milk, and the wastes from ice boxes or storage boxes should under no condition whatever be joined directly to any sewer or drain leading to a cesspool.

As to the disposal of human excreta, one of two rules well established by experience may be followed, namely, either to adopt some so-called dry method of disposal, by which the excreta are kept perfectly and absolutely dry, and by admixture of loam, rich garden earth or ashes, converted into manure to be used on the land, or else to remove the same rapidly by means of plenty of water through a system of water-closets and tight sewers, discharging either into some large body of water, or else delivering the sewage in a diluted condition onto the land to be used as a fertilizer.

After these general considerations, it is proper to give somewhat more specific advice relating to the problem on hand There is very little doubt in my mind that, with the growth of Watch Hill, nothing short of a complete and comprehensive sewerage system will satisfy the sanitary needs of the place. Other watering-places, for instance Nahant, Mass.; Bar Harbor, Maine; Long Branch and Atlantic City on the Jersey coast, have adopted and carried out complete sewerage systems. The system most fully adapted to the needs of the place would, in my judgment, be the separate system, dealing only with the sewage proper, while excluding all rainfall, and therefore requiring comparatively small sizes of sewers. Neither the Pawcatuck Bay nor the water in front of the principal bathing beach would be suitable places for the main sewer outlet. It seems, therefore, probable that in the future a main sewer would have to be carried along the narrow edge of land stretching out to Napatree Point, where the sewage delivered either by gravity or by a system of pumping could be discharged into the sea, and probably would be carried away forever by the tides, winds, and strong currents. But the construction of such a comprehensive system would require a comparatively large outlay of money, which for many years to come would be unnecessary.

I shall, in the following, avoid suggesting any too extremely radical method of improvement. The key-note of my advice may be expressed in very few words; for the privy vault and manure pit substitute some dry conservancy system, such as the earth or ash-closet, or else some movable pail system, with frequent removal; for the leaching cesspool substitute either a tight cesspool, to be frequently emptied, or better, a water-tight sewer, removing all liquid waste organic matter, and discharging it in a fresh, unputrefied condition into the deep water of the ocean or bay, or else use—in the case of the isolated summer cottages and residences—flush-tanks with sub-surface sewage irrigation, leaving to the bacteria, which have aptly been designated as nature's scavengers, and to the roots of plants, the task of the complete destruction of the hurtful elements of sewage, and their conversion into useful elements suitable for nourishment of growing crops, or grass, or shrubs.

Leaving aside, for the present, the question whether the hotels should have dry-earth or ash-closets, or else a system of well-arranged, well-flushed, and well taken care of water-closets, it is obvious that each hotel will require a sewer for the removal of the slop-water, of kitchen and laundry wastes, wastes from bath-tubs, etc. The topography of the place being such as to admit in nearly every case of good falls being obtainable, no large sewers are necessary. A six-inch sewer, laid in a well-graded trench, with well-made joints, perfect alignment, and a bore as smooth and true as that of a gun-barrel, will be amply sufficient for the largest size hotel, even where water-closets are used. The best material for such sewers would be salt-glazed, hard-burnt, vitrified pipe, the joints being made with Portland cement mortar. The outlet pipe, leading into the water, should be constructed of heavy cast-iron pipe, well protected against corrosion, by tarring.

One of the hotels is now *removing* all of its sewage by means of such a pipe sewer, discharging into Pawcatuck Bay. I have closely watched the water near this sewer outlet, and have been unable to find any floating sewage matter, nor was there apparent any defilement of the shore from stranded sewage particles or paper, and although the bay is extensively used during the summer season as an anchoring ground for all kinds of pleasure boats, I am told that no complaint has ever been made of any nuisance created by this sewage discharge. This may partly be explained by the well-known fact that sewage discharged in a *fresh* condition is quickly consumed by fishes, animalculæ, and forms of aquatic life, and partly by the fact that, where sewage mixes with salt water, heavy matters are precipitated to the bottom. Putrid sewage, on the contrary, when discharged into water-courses, will drive fish away; hence it is apparent that one of the cardinal principles to be observed should be the quick removal of all sewage, before decomposition sets in.

While I believe that it would be injudicious in case Watch Hill should be completely sewered, to locate the sewer outlet into Pawcatuck Bay, I can see, for the present, no serious objection to the discharge of the sewage for single hotels or cottages into the large volume of water in this bay. Under no circumstances whatever should any drain or sewer be carried to the bathing beach, which should be kept scrupulously clean and unpolluted. For this reason, I should consider it unsafe to carry any sewage to the head of the great ocean pier near the promontory on which stand the Life-saving Station and the Watch Hill Light House.

As an alternative method, applicable to the hotels overlooking the ocean, I would suggest the discharge of their sewage directly into the Atlantic Ocean. There is some doubt in my mind as to the possibility of the sewer outlets becoming choked by sand and gravel, washed into the pipes by the force of the breakers; but this could probably be overcome by carrying the mouth far out into deep water, and by the use of a flush-tank, discharged at high tide only. The iron pipe itself should be well laid and strongly and suitably protected, by stone-work, against the strong blows of the waves. It may become advisable to construct the iron outlet sewer in sections, bolted together by flanges, and to remove the pipe at the end of each season.

Each hotel should construct a large flush-tank, built of hard-burnt brick, with cement mortar, and made absolutely water-tight. Between the house and the flush tank, I advise arranging a well-covered intercepting or straining chamber, with brick side walls and rounded concrete bottom, and with inlet and outlet pipes level with the bottom of the chamber, so as to avoid absolutely any stagnation of sewage in the straining chamber. This chamber to be provided with one or two rows of upright iron bar strainers, put closely together (one wide and one narrow strainer), for the interception of all coarse, solid substances, such as paper, napkins, rags, corks, soap, etc., which should be scooped out and removed daily, and either dried and destroyed by fire, or else composted with garden earth, charcoal and ashes, and carted away onto the land, to be used as a fertilizer. The amoünt of such intercepted matter, if removed daily, would be comparatively small, and, with a little care in management, it could readily be dealt with without creating any nuisance. By arranging such a straining chamber, the possibility of a defilement of the beautiful beach, by solid sewage matters returned to the shore, would be entirely avoided. This beach,. although not much used for bathing, being composed of fine sand, is a favorite place for pleasure strolls, and, being one of the attractions of Watch Hill, every effort should be made to keep it unpolluted.

For this reason, too, I suggest the use of a flush-tank, in which the hotel sewage may be retained daily until the commencement of the outgoing tide. Once, or, if necessary, twice a day, at this time, the flush-tank should be emptied, and thus its contents discharged with great velocity into the ocean. The rush of water will tend to keep the sewer outlet free and unobstructed, and the outgoing ebb tide will carry all liquid sewage far away to sea. Flush-tanks are often provided with automatic appliances, called siphons, to empty the tanks as soon as they become full. In this case, I advise the much simpler plan of placing on the discharge-pipe, where it leaves the flush-tank, a shut-off gate-valve, accessible through a manhole, and to be operated by hand. The hotel manager should make it the duty of some trusted employe to empty this tank twice a day at regular intervals, corresponding to the hours of the beginning ebb tide. The flush-tank should receive not only the waste flow from urinals and water-closets, but also all chamber-slops, bath-wastes, and all fouled water from the kitchen and laundry. It should be provided with an overflow pipe, to prevent the tank from overflowing in case the opening of the gate-valve should, through negligence, be forgotten. The tank should be arched over, covered, and provided with inspection man-holes, carried to the surface. Inasmuch as the sewage is stored in it for no great length of time, I do not consider it necessary, nor even desirable, to ventilate the flush-tank, but, at the end of each season, it should be thoroughly cleaned, the walls washed and disinfected, and the pipes leading to and from it thoroughly cleaned, and all obstructions removed.

A few cottages adjoining the hotels could do away entirely with the present cesspools, by joining the hotel sewer and bearing a part of the expense of its construction. A few others, located on the shore of the bay, can easily drain directly into the same, and thus dispose of all their water-borne filth in an efficient and innocuous manner.

By far the greater number of cottages,

however, are isolated and scattered about, and for the present, at least, a common sewer would seem to be out of the question. A local treatment of the house sewage becomes, in such cases, a necessity.

The present method of tight cesspools with overflows, allowing the sewage to soak into the ground, is, to say the least, crude and imperfect, and is accompanied with some danger wherever the domestic water supply is derived from a well. Although the wells are lined with cement pipes, to keep out any surface water or soakage from the strata which the well pierces. yet none of them are very deep—water said to be of good quality being generally obtained at a depth varying from fifteen to twenty-five feet. There is, however, absolutely no security against the soakage of sewage into the ground, and it would be obviously dangerous to trust to the filtering power of the deeper strata of earth to purify the sewage before it reaches the underground sheet of water from which the well draws its supply. It is well known and a well established fact that the upper layers of earth, the *sub-surface* to a depth of one or two feet, are pre-eminently fit, owing to the oxygen contained in the pores of the soil, to oxygenize and render innocuous sewage matters delivered into the same. In this purifying process the ground is assisted during the summer season by the action of vegetation, and furthermore by the action of the bacteria contained in the upper layers of the soil. Hence it is much preferable to keep all sewage on the surface or just under the surface, and this can be done with success in several ways.

In the case of small cottage lots the only safe method is to build absolutely tight cesspools. I should construct these cesspools not in the usual way, but with two chambers, the first and smaller one to act as a retaining chamber for solids and grease, while the second and larger one is to receive by means of an overflow, dipping well down below the water level of the first chamber, only the liquid sewage. Much of the latter can be pumped out at intervals and used to water the lawn or flower beds, and the first chamber should be frequently emptied, at night, and the contents mixed with charcoal, gypsum, and ashes, and dug into the ground. All flow of rain or surface water into the cesspool should be avoided. Another scheme, applicable to larger lots, would be to carry from the liquid chamber a number of outlet pipes all placed on the same level, distributing the sewage close under the surface of the ground, but under no circumstances should an overflow be taken from any sewage cesspool to the beach.

Where plenty of land is available around a cottage, and where the soil is of a suitable character, excellent results may be obtained by using the sub-surface sewage irrigation system, which consists essentially of a small flush-tank, having a capacity equal to the daily sewage of the house and a net work of open jointed, small agricultural drain tiles, laid only a few inches below the surface of the ground, preferably under grass land or a lawn. The flush-tank discharges as soon as it is full automatically and intermittently—usually by means of some form of automatic siphon—and sufficient time is thus given between consecutive discharges for the soaking away of the liquid sewage, the ground acting as strainer, and the oxygen contained in the pores of the soil acting as a destroyer of all organic matter attaching to the particles of the soil. A quick, intermittent discharge from such a flush-tank is obviously much to be preferred to the slow and irregular oozing out through a number of overflow pipes.

It seems to me that many of the present cottages have sufficient ground about them to adopt the system of sub-surface irrigation recommended, and a trial of this method, which, in many country places without sewers, has given good results, would seem to me to be worth while.

In all such cases I should advise the discontinuance of the use of well-water for drinking purposes, except where the well can be put at least one hundred feet away from the sewage field. Rain-water, stored in perfectly tight and well-kept cisterns, can be made very palatable by filtration, or by boiling and subsequent aëration and cooling with ice. I would strongly urge the consideration of introducing and distributing water to all hotels and cottages, under pressure, at an early day. As the place grows, the need of such a public water supply will become more apparent from season to season.

Apart from the liquid refuse or slop-water, which are most easily disposed of by sewers, two methods may be adopted in dealing with the excreta from the houses and the hotels. One system applies the deodorizing and absorbent power of dry earth or of ashes, while the other uses water as the vehicle for the removal of fecal matter. In one case, the receptacles for removing filth are earth or ash-closets, or tubs or pails; in the other case, the receptacle used is the water-closet. The first method necessitates a temporary retention and storage of fecal matters on the premises, while in the second these latter are immediately and completely removed through well-constructed, well-flushed, and amply-ventilated underground pipe channels. Of the two methods, the removal by water carriage is certainly the better, cleaner, and more efficient.

The advantages of the earth-closet are, briefly, that its first cost is less; that the quantity of water used in the house is much reduced; that the closet itself is not so liable to get out of order as many forms of water-closets; that stoppages, from improperly introduced substances, will cause less damage, and that there is less danger of injury to the apparatus by frost. Finally, the manurial value of the excreta and urine are saved, and the dry-earth manure may readily be stored (at some distance from habitations) until needed on the land. On the other hand, the earth-closet is undoubtedly inferior in point of cleanliness and appearance to a well-kept and well-flushed water-closet. It is also less free from objectionable odors. The use of the dry-earth system on a large scale, especially in two-story closet structures, as required by the hotels, is attended with some difficulty. A large quantity of suitable dry earth or loam is required. The method of throwing earth by a scoop to cover the deposits is hardly sufficient and reliable in the case of hotels, and more or less complicated mechanical arrangements for distributing the earth, to enable each user of the closet to cover the excreta at once, must be provided; and these, although obtainable in the market, may prove, in the end, almost as difficult and troublesome to take care of as a simple flushing rim hopper water-closet. The collection and removal of the earth boxes or pails must be attended to with regularity and frequency; and thus the management of such dry systems may also prove an obstacle in the case of the larger hotels.

Taken as a whole, I believe that ultimately all hotels should be fitted up with a system of interior plumbing and water-closets. While it would be unreasonable to expect to find at summer hotels, where the season is only short, all the refinements of plumbing work, such as are becoming more usual in the larger cities, the leading principles of safe sanitary house drainage should be observed in the construction and arrangement of the water-closets, sinks, bath-tubs, and wash-basins.

The amount of plumbing work in the hotels should, preferably, be as small as possible, and all the sanitary arrangements should be of the most simple yet efficient character. Plumbing fixtures should be confined to the water-closets and urinals, the slop sinks, possibly a few bathrooms, the kitchen, scullery, pantry and laundry. No plumbing fixtures should be put in bedrooms under any consideration. But wherever sinks or basins are placed, with waste-pipes and traps, the pipes should have the fullest possible ventilation up through the main roof, and the traps should be rendered safe against siphonage or back pressure, and this applies particularly to the kitchen and laundry department of hotels, where, as a rule, the plumbing work is found to be in a more neglected state than in the apartments accessible to the hotel guests.

It is safe to assume that, at least in some cases, defective sanitary conditions may be attributed not to indifference or carelessness of owners, but to the existing doubts as to which course to pursue or what remedy to adopt. It is a frequent experience elsewhere, that where a feasible, practical, inexpensive, and not too radical remedy is suggested, hotel keepers, as a rule, are quite ready and even anxious to adopt the suggestions and to introduce sanitary improvements.

Each succeeding year will undoubtedly bring more attention to the details of sanitary construction. Meanwhile, let hotel keepers bear in mind that it is their sacred duty to provide for their guests a pure and wholesome water supply, good food, pure air, thorough drainage and neat surroundings, free from all soil pollution. Let them spare neither pains nor expense to realize this; let them secure the best expert talent to have their places annually re-inspected, and when the more palpable defects are pointed out, let them engage good mechanics to obtain the best possible workmanship in the putting in order of their sanitary arrangements.

Finally, I quote from a report which I prepared in the year 1885 on the sewerage and sewage disposal of Coney Island, a small watering place near New York City:

*Disposal of Sewage at Coney Island.*

Having explained how the sewage of Coney Island can be removed from the buildings in a rapid and thorough, yet economical manner, the next question requiring consideration is what to do with the sewage accumulating in the collecting reservoir at the pumping station. Unless float experiments demonstrate conclusively that the existing lateral current in front of the beach is sufficiently strong and of such a direction as to prevent the ultimate return to the beach of any sewage or floating bodies discharged at a considerable distance from the shore into the sea, this method of getting rid of the sewage should evidently not be adopted. It would, also, obviously be wrong to deliver the crude sewage into Coney Island Creek, without any attempt at purification by removing the suspended as well as part of the dissolved organic impurities.

Assuming that a purification is necessary, the first thing to be done is to remove the foreign solid and coarse floating matters, which can be readily accomplished by suitable mechanical separation by means of straining arrangements.

This should be done before the sewage is lifted from the collecting reservoir. The strained sewage contains much dissolved matter as well as finer flocculent or suspended particles, which, while fresh, form fertilizing substances of some value to the farmer. Hence, the idea at once suggests itself of utilizing the sewage on the land. While we do not entertain any hopes that the disposal of the sewage by irrigation over, or by filtration through, land will prove in the end very remunerative, yet we are convinced that it would not be difficult to obtain in the town of Gravesend sufficient grounds on the mainland between the ridge and the creek where broad sewage irrigation, or else intermittent downward filtration, might be practiced, in such a manner as to at least pay expenses. The disposal of sewage by irrigation over, or by filtration through, land is based upon the purifying qualities of the upper strata of the soil, assisted by the absorption of the nutritive elements of sewage by vegetation. To be managed successfully it requires that the sewage be delivered in the irrigation field in a fresh condition. It also demands a thorough under-drainage of the irrigation field. The land should always be subdivided, and use made at the time of only one section, while the others are being purified by oxidation. Thus it will be possible to avoid the saturation of the soil with sewage and moisture. If this plan of sewage purification is adopted at

Coney Island the pumping station should be located near the Coney Island Creek, and from it the sewage should be delivered in a pressure conduit to the irrigation farm. If the price of the land should prevent the purchase of a sufficiently large area to practice broad irrigation, it may be advisable to purify the sewage, first by chemical treatment, and subsequently by filtration through the soil. Since it costs more or less to adapt a tract of land to sewage farming, it may be advisable to reduce the area required, by removing first some of the impurities of sewage by a system of precipitation. This is a question which can be decided only by detailed estimates. It should be remembered, however, that Coney Island seems to offer special facilities for irrigation, as the amount of sewage is large only during the summer months, at a time when the desired purification by land is much assisted by vegetation, while during the winter season the amount is so small as to give the land ample time for self-purification.

If, for any reasons which it is impossible to foresee, it should be difficult to obtain farm lands for sewage irrigation, the sewage should, after straining, be clarified and purified by chemical precipitation, in large and suitably constructed settling tanks. While it is not, at present, feasible, by any of the known chemical processes, to restore sewage to the purity of ordinary water, it is at least possible to reduce the amount of impurities in solution to such an extent as to render the resulting effluent fit to be admitted into a water-course. In the particular case of Coney Island all that can reasonably be demanded is that the effluent may be delivered into Coney Island Creek or into the sea without in either case creating a nuisance dangerous to health, or even causing offense to sight or smell. Without entering into a detailed consideration of the many processes of chemical precipitation, the choice would seem to be restricted to the lime process, the A–B–C process, the sulphate of alumina and lime process, and the process using perchloride of iron as a precipitant. It is not necessary to enter at present into a consideration of the construction of the settling tanks, the mixing apparatus, and the various details required for the successful operation of a chemical precipitation process. The processes named, none of which have been put to a practical test on a large scale in this country, have all given more or less good results in England. All of these processes arrest, to a certain extent, decomposition, and cause the products to be comparatively inodorous and inoffensive. Preference should, obviously, be given to a process which effects a rapid, and at the same time maximum, amount of precipitation of sewage impurities with the minimum amount of resulting sludge; for the disposition to be made of the latter presents some difficulty.

The lime process is in this respect said to be inferior to the other processes named, besides giving an effluent which is injurious to fish. The resultant sewage sludge, usually consisting of ninety per cent. of water, must be dried artificially and thus be reduced in volume, in order to be in a removable and transportable shape. It does not constitute a manure of high value, yet it is believed that farmers could make use of it, and would gladly take it at the actual cost of manufacture. Attempts have at various times been made to manufacture the sewage sludge into cement, or bricks, by the addition of suitable ingredients. The best method of treating sewage sludge at present known appears to be to reduce it in volume in large filter presses the resulting product being a circular cake which can be readily handled. But, whatever the process of manufacture be, care should be taken to prevent its creating a nui sance.

It should be borne in mind that the laws of health should be primarily considered, and that the aim should be not so much the creation of a marketable article, as the purification of sewage and the rendering it innocuous. If this can be done in a manner so as to cover actual running expenses, including the interest on first cost of the purification apparatus, all that is necessary and desirable would seem to be accomplished. In the present state of the sewage question it is not considered feasible to manufacture from town sewage an artificial manure which will realize large and handsome profits.

If chemical purification only is adopted, without subsequent further purification of the effluent by irrigation or land filtration, the pumping station may be located either near the Coney Island Creek, at the rear of the district to be sewered, or else at the western extremity of the island, if discharge into the sea when the ebb tide sets in, is preferred. This plan would, of course, require the laying of a much longer suction main, and may prove objectionable on that account.

Should it be considered inadvisable to discharge the effluent into the sea after purification by straining and chemical precipitation, it may be further treated by filtration through a large Farquhar-Oldham sewage filter, the chief characteristic of which consists in the revolving cutter which removes the surface of the filtering material, usually sawdust, as soon as it becomes clogged, thus practically establishing, at intervals as often as may be desired, a new filter. This additional mechanical filtration would without doubt render the sewage sufficiently pure to allow of its being discharged into the Coney Island Creek.

## III.

## HABITATIONS IN CITIES AND TOWNS.

In cities and towns, it is most essential that all foul water from the household be removed as rapidly as possible. Moreover, it is imperative from a sanitary point of view that all semi-liquid and solid excreta be removed with promptness and regularity. It is finally absolutely necessary that all such liquid filth as constitutes town sewage be disposed of in a manner so as not to cause a nuisance. If we consider that the quantities to be removed and disposed from a densely populated town are enormous, the magnitude and difficulty of the problem become at once apparent.

Garbage Removal and Disposal.—The prompt and thorough collection, removal and disposal of garbage from city and town houses is only second in importance to a proper system of sewerage, and the efficiency with which the collection and removal are accomplished has, without doubt, a very great influence upon the health and comfort of the community. The laws of health require that, in order that no nuisance may be caused, offal and dry house refuse should be removed from habitations and their immediate surroundings and from streets, alleys and public squares with the greatest regularity, and before decomposition sets in.

The removal of garbage should be effected promptly and quickly, in well-covered, water-tight wagons, by a house-to-house call, preferably in the early morning hours. It may be done either by a scavenging contractor or else directly under the superintendence of the municipality. The latter system, wherein the city authorities own suitable scavenging apparatus and the necessary wagons and horses and employ their own drivers and scavengers, has much to recommend it. All owners or tenants are required to place, at or shortly before the time fixed for removal, the kitchen refuse accumulated during the previous day, at or near the street curb. Dust bins or fixed receptacles for house refuse are not common in American cities, although in some cases they are used for large tenement houses. They are on many accounts objectionable, and being located near the house they often cause a serious nuisance. If adopted for tenement houses, they should be well protected against wetting, should be kept small in size, thoroughly cleaned, and frequently disinfected

Movable receptacles are far better. Such receptacles for kitchen refuse should not be of wood (barrels or boxes) but of metal, preferably circular in shape, and of a strong and easily portable construction. The iron should be galvanized, or otherwise efficiently protected against corrosion. The vessel should have suitable handles, as well as tight-closing lids or covers: first, to prevent the offensive contents from being exposed to the sun and to the eyes of the passers-by; second, to avoid as much as possible the annoyance caused by their emitting noxious odors; lastly to prevent their contents from being scattered about in the streets, either by the force of the wind, or else by being accidentally or purposely upset. The covering up of swill barrels is also of importance in order to prevent the contents from being wetted during a rain storm,or from moisture in the atmosphere. *Immediately after being emptied, theswill receptacles should be removed from the streets.* This rule should be enforced in every city and town by proper ordinances.

For large city houses or buildings, such as hotels or restaurants, it may be better to provide a double set of receptacles; one to be taken and placed on the wagon, removed and returned the next morning, the other meanwhile being gradually filled. This would avoid altogether the objectionable disturbance caused by emptying the contents of the barrel into the garbage wagon in front of the building.

The details of the construction of garbage carts are matters not properly belonging to the subject of this book. Suffice it to mention that such carts should be absolutely water-tight and impervious, to prevent the possibility of filth absorption. The covers of the carts should fit tightly, so as to avoid the spread of objectionable odors while the wagons are passing through the streets. The carts must, of course, be frequently and thoroughly scrubbed, washed, cleaned, aired, and kept in good repair.

Mineral refuse, ashes, cinders, sweepings, rubbish, etc., should not be mixed with any organic refuse from the household. In fact, the aim should always be to keep the ashes as free as possible from admixture with filth of any kind. Then, and only then, they may be used with advantage to fill in low spots, building lots, or for the grading of streets and sidewalks. If ashes, as is unfortunately so often the case, become mixed with refuse, street sweepings, foul liquids, and decomposing animal or vegetable matter, the disgusting practice of dumping the obnoxious mixture upon future building sites should not be permitted by health boards, as it is obvious that habitations erected upon such sites must be very unhealthy.

While it is possible to keep the. ashes free from moisture, and from animal or vegetable matter, it is next to impossible in city houses to keep the coarser miscellaneous house refuse separate. Where large quantities of litter accumulate, as in workshops, stores and office buildings, tenants should provide separate vessels, which should not be too heavy, so as to facilitate the work of the scavengers. Litter and waste paper should not be thrown into the ash barrel, but must be either burned up or else disposed of to rag sellers. Everything harboring dust, such as old clothing, etc., should be gotten rid of from habitations quickly. I consider a fixed ash-pit as much objectionable as the dirt or dust bin. For ordinary cases ashes and rubbish may be collected together in special portable ash barrels, fitted with well-closing lids, to prevent the scattering about of ashes and dirt, and the admixture of rain-water. They are then removed in separate ash-carts, covered with canvas or tightly-fitting lids. Where both ashes and organic solid refuse are thus promptly collected and removed from habitations, cleanliness is readily maintained. But great difficulties are experienced in cities in keeping the kitchen (or organic) refuse and the ashes (or mineral refuse) separate, particularly in tenement districts.

A good method of disposal of the ashes and coarse house refuse is to have them carted and dumped upon a lot outside of the city limits, specially provided for this purpose, where they may be screened, sifted, picked and sorted. Many hard refuse substances, for instance, old iron, tin, glass, bottles, lead, are sold by the scavengers to junk dealers, or given away to those who are willing to remove them promptly for the sake of the value of the material. Whatever rags, paper, litter, have not been picked out by the industrious rag-picker in the city streets, may be sold to rag dealers; straw, matting, shavings, pieces of baskets, etc., may be burnt up.

Kitchen refuse or swill may be disposed of in many cases to farmers or market gardeners, who use it to feed swine or to convert it into compost or manure for their land. Kitchen grease is sold to soap-makers, bones to bone factories who grind them and manufacture bone powder and fertilizing manure, meat offal may be sold to, and removed by, rendering establishments.

In the case of seaboard cities, the refuse material is often dumped upon hopper barges, and carried out to sea, into deep water, to a sufficient distance to make sure against deposits being washed back to the shore. In cases where towns are not so situated as to be able to sell the refuse to farmers, it may be mixed with sewage sludge and pressed into cakes or ground to powder.

Where all of these methods are unavailable the best thing to do is to burn and destroy the refuse by subjecting it to the all-purifying action of fire, in a garbage cremator. Whatever the construction of this may be, it should not be located too close to habitations, and the gases should be made to pass under the grate of the flame, so as to be purified before passing out of the chimney and perhaps causing defilement of the atmosphere in the neighborhood. For a detailed description of garbage cremators, I must refer the reader to valuable articles by Dr. S. S. Kilvington, Health Commissioner of Minneapolis, published in the Transactions of the American Public Health Association.

SEWAGE DISPOSAL. — As regards the removal of house sewage, it is of the utmost importance to keep it as an entirely separate matter from the garbage removal. By the careless admixture of both kinds of household wastes, the greatest nuisances are often created. That a pail of slops or of kitchen water should not be disposed of by being thrown into the garbage pail or ash barrel, is not a difficult matter to teach the domestics. It is much more troublesome to avoid the improper disposal of garbage or of coarse house refuse, such as enumerated in the beginning of this volume, by attempting to pass it through the plumbing fixtures, their traps and waste pipes, into the main soil pipe. That old rags, napkins, towels, brushes, orange peels, and occasionally bottles are thrown into water-closets is a constant complaint of plumbers, and a source of trouble and expense to landlords, particularly of tenement houses. It is just here where an intelligent use and management of plumbing work is required. It should be understood that all plumbing in houses is intended only for the removal of liquid household wastes and of excreta, and that all other refuse matter, of whatever kind, size or character, must be disposed of by a dry system of removal.

As to the sewage proper, the points to be observed by the householder to secure its efficient removal and disposal from city houses are that the sewage must be removed from the premises instantly, quickly and thoroughly. Cesspools under houses, with overflows into the street sewer, brick sewers large enough to form elongated cesspools, and vaults outside of the house, such as may be found in Philadelphia by the hundred, are an abomination, and should not be tolerated. Of course I assume that every built-up lot has a sewer in the street, or in the alley in the rear of the house. The house owner should ascertain whether this sewer, to which he wishes to connect, is intended for the removal of house sewage only, or whether it is also to remove the storm-water from roofs, yards and streets, as the arrangement of his house pipes will, to some extent, depend upon this. He must also look into the question of sewer ventilation, for this is at times intended to be accomplished by a direct and uninterrupted connection of all houses with the sewers, in which case each house soil pipe, properly tightened and extended above the roof, helps to ventilate the sewer. In case this system is adopted by a city—and it is a good one for a well-built, well-arranged, well-flushed and well-ventilated system of sewerage—the householder must leave out the trap on the main drain. He must under all circumstances see to it that the connection with the main street sewer is well made, according to the best engineering practice. He should see to it that his house drain does not run into an outside cesspool nor into a filth-reeking vault with overflow to the sewer.

Inside of the dwelling he has, of course, many other things connected with the drainage of his house to look after, but they are foreign to the subject of this paper, and have been exhaustively described and discussed by the author in his other books.

If a house drain is well laid, well flushed and well ventilated, the immediate removal of all sewage is secured, and any stagnation whatever on the premises avoided. All sewage is delivered to the sewer in a fresh condition, and thus each house will help in accomplishing its removal to the outlet in the shortest possible time, whereby its disposal without nuisance is much facilitated.

What this disposal of the sewage of a city shall be, whether the sewage may be directly emptied into a river or tidal estuary, or discharged into the sea, or whether the sewage must be clarified and purified, before being admitted to any water-course; and again, whether such purification shall be accomplished by application to land, or by chemical treatment, by intermittent downward filtration, or by irrigation, by precipitation, or subsidence, or else by a combination of some of these processes, is a broad subject, in which municipal authorities are more directly concerned than the individual householder. The work of the latter may be defined as commencing at the junction between the house and the street sewer.

The questions just referred to, as well as those relating to the choice of the best system, specially adapted in cities to the removal of excreta, whether by ordinary water carriage system (separate or combined), by pneumatic system (Liernur, Shone or Berlier), or by some pail or tub system, or earth or ash-closet system, exceed the limits of this volume. These questions are so broad in character as to require a thorough and separate treatment.

But, whatever system may be adopted in cities and towns, it is established beyond question that all kinds of cess-pools must be prohibited; that in particular the use of abandoned wells, as cess-pools, must be regarded as a relic of barbarism, and that privy-vaults, with or without sewer connections, ought to be done away with. In other words, *all stagnation of sewage matters, with its unavoidable putrefaction, must be avoided.*

# APPENDIX.

# I.

## SPECIFICATION FOR LAYING HOUSE DRAINS AND PIPE SEWERS.

### I.—MATERIALS.

No materials of any kind to be used until they have been inspected and accepted by the engineer in charge. All rejected materials to be plainly marked and removed.

(*a*) *Vitrified Earthen Sewer Pipe.*—All vitrified pipe to be first quality salt-glazed sewer pipe, perfectly straight, circular and true in section, two and three feet long, of a uniform thickness of not less than ¾ inch, free from cracks, flaws, blisters, fire-checks or other defects or irregularities; to be sound and hard-burnt throughout, and not brittle, to be smooth and impervious on the inside, and highly glazed on the inside and outside, except at the pipe ends. All pipe to be socket pipe, with hubs not less than three inches deep, true and circular, and concentric with the bore of the pipe.

(*b*) *Fittings or "Specials."*—All fittings, such as Y branches, Ts, elbows, handholes, reducers, etc., to be of same quality, character and strength as specified for pipes.

(*c*) *Iron Pipes and Fittings.*—Iron pipes shall be used only wherever specially directed by the superintending engineer. Iron pipe shall be cast in a vertical position, and shall be truly cylindrical, of length, weight and thickness specified, with strong hubs, and joints shall be properly leaded and calked. [Here insert detailed requirements for iron pipes and fittings.]

(*d*) *Cement.*—Hydraulic cement for making pipe joints to be a good, pure, quick-setting brand of Rosendale or Portland cement, as may be selected, to be fine and freshly ground. Cement to be subject to inspection and proper tests by the superintending engineer, who may reject all cement of improper quality. All cement not immediately used, to be kept well protected from the weather.

(*e*) *Sand.*—To be clean, sharp, silicious sand, free from all dirt, dust, loam or other foreign matter.

(*f*) *Mortar.*—Hydraulic cement mortar to be made up as follows: to consist of one part hydraulic cement and two parts of sand, measured quantities. Cement and sand to be mixed dry, and to be wetted up only in small quantities as used, and with just enough water added to make a paste of proper consistency. No lime to be used in the mixture. No mortar to be used that has begun to set.

(*g*) *Concrete.*—Concrete to be composed of one part cement mortar, made up as specified, and of five parts broken stone. The broken stones to be wetted up and mixed with the mortar paste in a thorough manner by several turnings of the shovel. All mixing to be done in boxes or on a tight board floor. The concrete, after being thrown in place, in layers not over nine inches thick, to be tamped with wooden rammers. No concrete left over at the close of the day, to be used afterwards on the work.

(*h*) *Brick.*—Use only best quality whole bricks, hard-burnt and regular and uniform in shape and size; all bricks to be free from deep fire-cracks, and to ring sharply when struck together. All bricks to be inspected upon delivery, when all of an improper quality will be rejected, and all so condemned to be at once removed.

II.—WORKMANSHIP.

(*a*) *Excavation and Trenching.*—All excavation shall be done in open cuts from the surface to the necessary depth. and no tunneling will be allowed, except by special direction of the superintending engineer. Trench for drain pipes to be carefully excavated, to have perfect alignment, to be opened only as wide as necessary, to have sloping or vertical sides, as may be directed, to have sides suitably braced and supported by plank shoring, wherever required, to prevent any caving in of the sides; to have the bottom trimmed perfectly to the exact grade, and shaped as nearly as possible to fit the lower half of the pipe, and to have at each pipe socket special grooves cut, in order to give the pipes a firm bearing throughout their whole length. The excavation at each joint to be at least six inches wider than the pipe, to enable the workmen to make the pipe joints properly. The trench shall be dug to within six inches of grade by measurement from the grade stakes on the street. The last six inches shall be taken out after grade pegs have been set in the bottom of the trench by the engineer. Grade and alignment will be given by the engineer every 25 feet on stakes set in the trench bottom. Not more than 150 feet of trench shall be opened in advance of the completed sewer. Trenches to be kept free from water during pipe laying.

(*b*) *Pipe Laying.*—Vitrified pipes to commence at a distance of five feet beyond the foundation walls of the building. Before lowering pipes into the trench, the pipe sockets to be examined with special care for cracks or flaws, and pipes to be matched and fitted, so as to form a true line when laid. Pipes with permissible defects are to be so laid as to have the defects on top of the pipe. Pipes to be laid to the exact grade staked out, and in perfectly straight alignment. Deviations from straight line must not be made with straight pipes, but with special curved pipes of large radius. Pipes to be laid with the socket up grade, and at a depth of not less than three feet, in the case of house drains, as a protection against frost. Pipes to be joined in such a manner that the flow line will be true and even, in order to prevent stoppages. All branches to join the main line by Y branches, pointing in the direction of the flow. No T branches to be used, except for cleaning handholes and lampholes. Inspection and cleaning handholes to be located on the line of the main drain, at distances of fifty feet, or wherever directed. No pipes shall be laid and jointed during freezing weather.

(*c*) *Pipe Jointing.*—The joint between the end of the iron house drain and the earthen pipe sewer to be made perfectly tight by means of pure hydraulic cement.

Joints of vitrified earthen pipe to be made as follows: The space between spigot and hub, if the hub is sufficiently deep, to be filled first with a small gasket of oakum, to prevent any cement mortar from entering at the joints. The remaining space to be entirely filled with mortar, which must be applied with particular care at the bottom of the joint, where the mortar should be firmly pressed in with the fingers. Water accumulating in the hollowed grooves must be removed before applying mortar to the joint. Some cement should be wiped smoothly to the face of each pipe socket, and cut in a bevel, and, as soon as the joint is finished, the grooves shall be filled with earth in order to support the cement at the joint until the cement has had time to harden. The utmost care to be observed, after a joint is made, to prevent any disturbance of the pipes by stepping on them or otherwise. The inside of each pipe joint to be thoroughly cleaned from any projecting oakum or cement. Each length of pipe to be covered in the center with a few inches of earth, in order to steady it and to prevent any pipes from moving. Wherever vitrified pipe drains or sewers pass close by trees, the joints shall be surrounded with concrete, so as to protect the pipes from the roots of trees.

(*d*) *Pipe Foundations.*—All earthen pipes to be laid on a firm bed. In the case of a loose soil, a bed of gravel or sand, or else a concrete foundation, as the superintending engineer may direct, shall be prepared so as to properly support the pipes.

(*e*) *Testing Earthen Drains.*—Before refilling the trenches for outside drains, the earthen pipes and pipe joints are to be tested by closing the main outlet and filling the pipes with water, so as to have a pressure at the lower end of drain, corresponding to at least 12 inches head of water. If the total vertical fall is such as to bring a too heavy pressure (exceeding 5 lbs.

per square inch) on the pipes, the drain must be tested in sections. All joints to be proven tight to the satisfaction of the superintending engineer. The contractor is to furnish the plugs to close pipe outlets, and is to fill the pipes with water, and to do all work required in connection with this test.

(*f*) *Refilling Trenches.*—After inspection of the sewer and testing the pipe joints with water, the back-filling shall be done with great care, in order not to disturb the pipes. The earth used for filling must be free from stone, and is to be thrown in layers of not more than twelve inches in depth, and the back-filling must be well tamped, rammed or puddled to make the trench compact, and to prevent the slightest settling.

(*g*) *Branches, Handholes, Lampholes, Manholes, Flushtanks.*—Y branches for connections, lampholes, handholes and manholes, to be placed wherever directed. Openings of Y branches to be closed by earthen caps, cemented into the socket, to prevent obstructions.

Handholes or special sewer pipes with detachable cover, giving access to the pipe interior, shall be placed at equal intervals, as may be directed.

Lampholes shall consist of T branches placed in an upright position on the sewer line. The vertical pipe to be 6 inches in diameter, to be carried within a foot of the street level, and top opening to be closed by suitable cover.

Flushtanks shall be built in brick masonry, laid in hydraulic cement mortar, and made perfectly water-tight, so as to hold the water for flushing. The capacity, size, form and details of siphon and supply to be as per detail drawings furnished by the engineer in charge.

Manholes to be constructed of hard-burnt bricks laid in cement mortar on concrete foundations. Thickness of all walls to be eight inches. The manholes to be four feet long by three feet wide at the bottom, and two feet diameter at the top. Manholes to be topped out with heavy cast-iron frames and covers as per detail designs. Wrought-iron steps to be built into walls of manholes as will be directed. Steps to be made of $\frac{3}{4}$ inch round iron, to project three inches, to be twelve inches long, and about fifteen inches apart. Inside and outside of manholes to be rendered with pure cement mortar.

All bricks to be thoroughly immersed in water just before being laid.

No masonry to be laid during freezing weather, and all unfinished work to be duly protected.

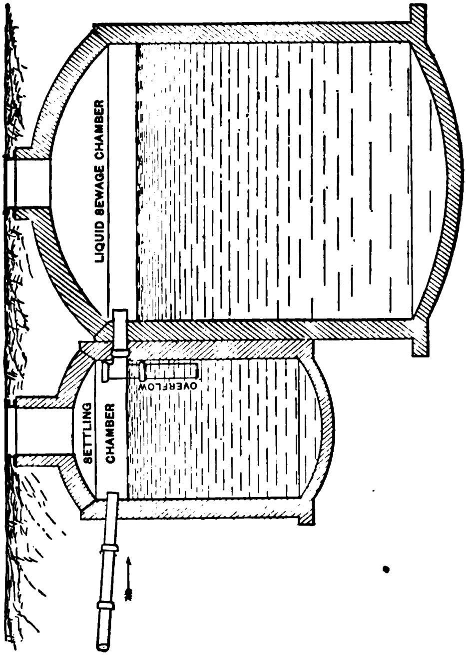
## II.

## SPECIFICATION FOR BUILDING A TIGHT CESSPOOL.

The cesspool for sewage is to consist, as shown in drawing, of two compartments, an intercepting chamber or catch-basin for solids and grease, and a larger chamber for liquid sewage. Cesspool is to be built complete and ready for use by the mason in accordance with the drawings accompanying the specifications.

Both compartments are to be built circular in shape, the intercepting chamber to have five feet inside diameter and six feet in depth from water-line; the liquid sewage chamber to have ten feet inside diameter and a depth from water-line to bottom of chamber of ten feet. [The dimensions here given must be altered to suit each special case. They depend on the size of the house, the number of its occupants, the number of plumbing fixtures, and the amount of water used daily in the household.]

Walls of each chamber to be eight inches thick; to be built of best quality hard burned bricks, laid in hydraulic cement mortar. The mortar to be mixed dry according to the following proportion, viz.: 1 part cement to 2 parts sand, measured quantities. This mixture to be wetted up only as fast as needed for use, and no mortar that has partly set to be re-tempered. The cement to be best quality Portland cement. The sand to be clean, sharp,




TIGHT CESSPOOL

silicious sand, free from clay, loam or dirt. No lime should be used at all.

Bottom of both tanks to be slightly rounded and pitching to the center. Bottom to consist of concrete, six inches thick, well rammed. The concrete to be composed by measure of 1 part of mortar, mixed as above, and 5 parts broken stones. The stones to be of a size to pass readily through a 2-inch ring ; to be previously cleaned from all dirt, to be wetted up and then mixed with the paste, by frequent turnings of the shovel.

If preferred, the mason may lay the bottom with bricks set on edge and bedded in hydraulic cement mortar.

Each tank is to be arched over, and, when finished, the floor, the walls and the dome are to be well rendered with a neat coating of cement. Both chambers are to be built absolutely and perfectly water-tight. Each chamber to be topped with a manhole, twenty inches in diameter, carried to the surface of the ground and covered with a cast iron tight-closing manhole cover, set in an iron frame bedded in the masonry.

Provide between the first and the second chambers, as shown, a 4-inch overflow pipe, made of extra-heavy cast-iron plumber's pipe, with a Tee and a long dip in the first chamber, reaching to two feet below the surface of the water, to prevent the scum from being drawn into the overflow pipe. Provide and set also two ventilating pipes, as directed by the superintendent. The iron piping required to be furnished by the mason, who is also to set pipes in place and to fill up all holes with brick and cement, so as to make the whole perfectly tight.

The back-filling around both chambers to be applied with great care, to be thoroughly rammed, and, if found necessary, to be puddled with water to the satisfaction of the superintendent.

The mason is to provide all materials and labor necessary for the complete and substantial execution of the cesspool, including all excavation, transportation, apparatus, centers, scaffolds, etc., that may be required, and inclusive of the iron piping, as set forth above.

All materials to be the best of their respective kinds, and all workmanship to be of the best quality, and the whole to be completed to the satisfaction of the engineer in charge of the work.

Should any rock excavation be required in making the excavation for the cesspool, this is to be paid for at a rate previously agreed upon between the owner, or his representative, and the mason.

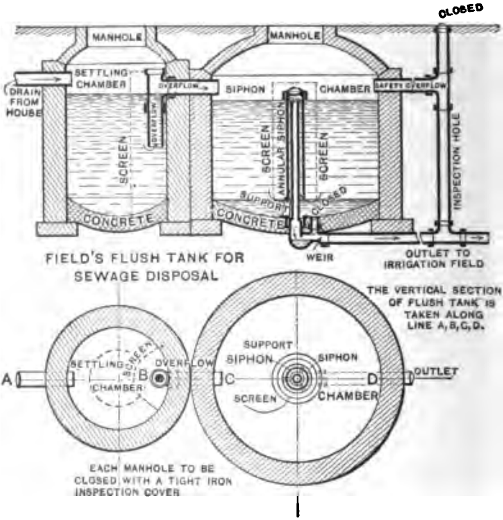
If any grading should be required around cesspool, this is to be considered extra work.

## III.

## SPECIFICATION FOR SUB-SURFACE IRRIGATION SYSTEM FOR A COUNTRY HOUSE.

(*a*) *Flush Tank.*—The flush tank for sewage disposal is to consist, as shown on drawings, of two chambers, an intercepting or settling chamber and a receiving or siphon chamber. Each chamber shall be circular in shape, of dimensions as stated in drawings. The settling chamber is to be the one nearest to the house, and the main house drain is to deliver into it near the top, as shown in drawings. On the line of the house drain between the house and the flush tank, and near to the latter, place a 5-inch earthenware main trap, with a 4-inch opening on the house side of said trap, from which a 4-inch pipe is to be carried above the level of the ground, to act as a fresh air inlet pipe. The opening of this pipe is to be suitably protected by a screen or vent cap against accidental obstructions.

All walls are to be 8 inches thick and built according to plans, of best quality hard burnt bricks, laid in hydraulic cement mortar. The bottom of all chambers is to consist of bricks, set on edges and bedded in mortar, or else of best Portland cement concrete, six inches thick. All corners shall be properly rounded as shown. Each chamber is to be arched over with a brick arch, four inches thick, and to be topped with a 20-inch manhole, for inspection and cleaning purposes. The manholes are to




be closed with heavy, tight, round iron covers, set in cast-iron frames.

When built, the floor, the walls and the dome are to be well rendered with a neat coating of cement. Each chamber shall be built absolutely water-tight.

Between the settling and the receiving chamber of the flush tank provide and set a 4-inch overflow, made of cast-iron plumber's pipe, with T branches and a long dip into the settling chamber as shown, to prevent any scum from being drawn into the overflow pipe. All holes around pipes are to be properly filled with brick and cement, so as to be thoroughly tight.

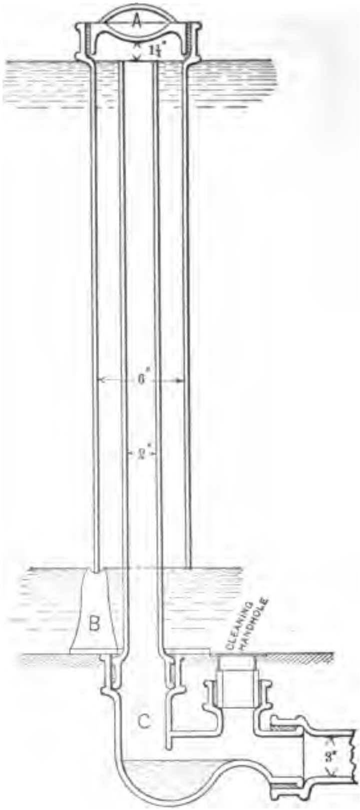
Provide and set in siphon or discharging chamber a cast-iron automatic siphon such as may be selected by the owner.

The back filling around both chambers must be done with great care, to be thoroughly rammed, and, where necessary, to be puddled with water.

All the mortar used in the work to be mixed dry according to the following proportions, viz.: 1 part cement to 2 parts fine sand, measured quantities. This mixture to be wetted up only as fast as needed for use, and no mortar that has partly set to be re-tempered. The sand to be clean, sharp, silicious sand, free from clay, loam or dirt. No lime to be used at all.

(*b*) *Siphon.*—If the owner selects the Field annular automatic siphon, it shall be made and set up as follows :

The Field annular siphon is constructed of plumber's heavy cast-iron pipe and of the special pieces *A*, *B* and *C*. The piece *A* or cap with

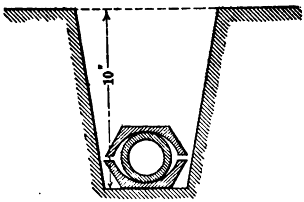



FIELD'S ANNULAR SIPHON

handle is calked tightly in the usual manner into the hub of the 6-inch pipe. The piece *B* has three standards which act as support for the 6-inch pipe. Piece *C* is the weir, a single casting of peculiar construction, by means of which the siphon is brought into operation. Into the 3-inch hub of this weir is calked a 2-inch iron pipe set with its hub downward. This 2-inch pipe forms the discharging limb of the siphon, while the receiving limb is formed by the annular space between the 6-inch and the 2-inch pipe. The outlet of the weir is calked into the hub of a horizontal 3-inch pipe which in turn is calked into a 4-inch T branch receiving the safety overflow. The weir *C* and the 2-inch pipe *must be set perfectly plumb*, and the 2-inch pipe should be cut off at the top at the height to which the tank is to be filled. The 6-inch pipe is cut of such a length that its lower end will be at the proper height above the tank bottom, governed by the height of the standards, while, at the same time, the inside of the cap *A* is kept at 1¼ inches distance from the top of the 2-inch pipe.

The siphon should be set in the center of the tank, so that it may be readily got at through the manhole. The receiving (6-inch) limb can be lifted for inspection and cleansing.

(*c*) *Absorption Tiles.*—Beyond the 3-inch length of soil pipe and the 4-inch overflow connection, shown in the drawing, the outlet of the tank leading to the irrigation field may be of 4-inch vitrified pipe with cemented joints. This pipe should be laid two feet below the surface, as a protection against frost, and it should be laid with regular, although but slight, fall. Six inches in 100 feet is all that is necessary.




The arrangement of the 2-inch tiles, at the irrigation field, depends, of course, mainly upon the surface or contour of the ground. Speaking generally, the lines should follow the contour levels. They should not have a greater fall than 2 or 3 inches per 100 feet. They should be laid, as nearly as the contour of the ground will permit, parallel to each other, and at distances of from 4 to 5 feet between the lines.

The absorption tiles should not be laid at a greater depth than *twelve inches below the surface;* a depth of ten inches is preferable. The tiles are laid in permanent earthen gutters, as shown, and should have open joints—with at least one-fourth inch space. These joints are covered with caps, as shown, as a protection against earth falling in from above.

The two-inch lines should branch from the main four-inch conduit by means of special 4x2 **T** or **Y** branches, opening out from the bottom. All the joints in the main conduit pipe should be cemented; those in the two-inch branches should be cemented only where they are more than twelve inches deep; all joints at less depth should remain open.

## IV.

## SUGGESTIONS FOR A SANITARY CODE.

### *A.*—REGULATIONS REFERRING TO PRIVY-VAULTS, CESSPOOLS, AND EARTH-CLOSETS.

1. Leaching cesspools shall be prohibited everywhere.

2. Privy-vaults and cesspools shall not be permitted for any building in reach of and accessible to a street sewer.

3. It shall be considered unlawful to connect any vault or cesspool of a building with a private sewer.

4. No privy-vault or cesspools shall hereafter be built, except in accordance with the subjoined regulations, and pursuant to a permit first obtained from the village or town authorities; nor shall any shed or cover be made or put upon or over the same, until it has been inspected by the proper inspector, and found to correspond to the regulations.

(*a*) No privy-vault or cesspool shall be placed nearer than ten feet from a building, unless special permission is first obtained to do so.

(*b*) Every privy-vault or cesspool located within a distance of 25 feet from any building shall be suitably ventilated by means of two 4-inch pipes, the one kept at a height of about

7 feet from the ground, and the other carried to the nearest wall of the building, and from there upward to such a height that its upper terminus will be at least 10 feet above any window.

(*c*) Every vault or cesspool to be constructed of suitable bricks, approved by the inspector, and with joints laid in best hydraulic cement mortar.

The walls to be not less than 8 inches thick, and to be made perfectly water-tight, and rendered, inside and outside, with a neat coat of pure Portland cement, or else to be cemented on the inside, and to have on the outside a backing of at least 9 inches of well-puddled clay around and beneath such brick-work.

(*d*) Each cesspool to be well and securely covered or arched over, and to be fitted with a well closing iron manhole cover for inspection, and to be rendered accessible for the purpose of removing its contents and cleansing the cesspool.

(*e*) No surface water or rain-water from leaders shall be discharged into any vault or cesspool.

(*f*) No cesspool or vault to have any connection by a drain pipe or otherwise with a street sewer.

(*g*) Vaults and cesspools shall be cleaned out as often as necessary to prevent their overflowing on to the surface of the ground.

(*h*) No person shall empty or cause to be emptied any vault or cesspool unless a permit is first obtained to do so. The emptying shall be done in a manner so as not to cause any offense.

(*i*) No contents of any vault or cesspool shall be transported through any street unless it be removed by means of an air-tight apparatus, which shall prevent entirely the escape of any noxious or offensive odors.

5. Every person who shall construct an earth-closet in connection with a building shall furnish such earth-closet with a receptacle of suitable construction and of adequate capacity, for dry earth or other deodorizing substance, and said receptacle shall be constructed in such a manner and so placed as to admit of ready access to said receptacle for cleaning purposes. Suitable means or apparatus shall be provided in connection with said receptacle for the effectual application of a sufficient quantity of dry earth or other deodorizing substance.

Said receptacle shall be constructed of a capacity not exceeding 10 cubic feet. Said receptacle to be constructed of such materials and in such manner as to prevent any absorption of filth deposited therein, or any leakage of any part of the contents of said receptacle. Said receptacle to be constructed in such a manner that it may not be exposed at any time to rainfall or to the drainage or waste liquid from the premises.

### *B.*—RULES AS TO DISPOSAL OF SLOPS AND POLLUTION OF STREAMS.

1. It shall be considered unlawful to throw or cause to be thrown any chamber-slops or slop-water or sewage of any kind from habitations, or wastes from manufacturing establishments, into the ground about buildings, nor into any creek, pond, or open water-course.

2. It shall be considered unlawful to allow any soakage into the ground from stables, barns, pigsties, cattle-yards, fowl-houses, or any soakage of slop-water, liquid manure, or waste-water of any kind.

3. A proper disposal of the slops shall be accomplished by one of the following methods:

(*a*) By connection with a street sewer.

(*b*) Wherever no street sewer is accessible the waste-water to be run either into a tight cesspool, built according to regulations, properly ventilated, cleaned and disinfected, or into a flush tank in connection with a system of surface or sub-surface irrigation, where ample grounds are available about a building for such purpose.

### *C.*—RULES AS TO REMOVAL OF GARBAGE AND ASHES, SNOW, ETC.

1. It shall be considered unlawful to throw or allow to be thrown, any garbage or solid manure, swill or offal of any kind, on to the ground about buildings.

2. It shall be considered unlawful to allow the accumulation of garbage or offal, or any manner of refuse in or near habitations.

3. Whatever garbage or refuse cannot be burned up in the range, and all that is not fed to fowls, pigs or other animals on the place, shall be kept in water-tight, well-covered receptacles, that can be easily lifted, handled and emptied by one man, and these vessels shall be kept readily accessible to the garbage collector, and the offal shall be frequently collected and removed by water-tight carts, wagons or other vehicles, securely covered, but must not be kept exposed to view.

4. Ashes shall not be mixed with garbage, but must be kept in separate, well-constructed iron vessels.

5. It shall be considered unlawful to deposit or cause to be deposited any solid house refuse, garbage, or any kind of vegetable or animal matter on any empty building lot to fill the same up to grade. Screened ashes, entirely free from organic impurities, may, however, be used for such purpose.

6. It shall be considered unlawful to throw or place any coal or wood ashes into or upon any paved street or sidewalk, except in suitable boxes or vessels on the sidewalk, near the curbstone.

7. It shall be considered unlawful to suffer or permit snow to remain more than six hours

after the same has ceased to fall upon any paved footway or gutter in front of any building or vacant lot, and the occupier, or, if unoccupied, the owner of the lot, shall be held liable.

8. It shall be considered unlawful to cast or throw down out of any cart, wagon, or other vehicle, rubbish, offal, filth, dirt, earth, animal or vegetable refuse of any kind, swill, the carcass of any dead animal, or any manure, urine, excrement or filth from vaults, cesspools or privies, in any highway or into any vacant lot.

9. It shall be considered unlawful to place, deposit or throw, or cause to be thrown, any broken glass, china, crockery ware, cuttings of tin, sheet-iron, nails, hoop-skirts, or any other articles calculated to wound or bruise man or animal, on any public street or highway.

10. It shall be considered unlawful to cast or throw, or cause to be thrown, on the sidewalks of public highways, any fruit or the peeling thereof.

11. It shall be considered unlawful to throw, or cause to be thrown, on the sidewalks of public highways, any straw, hay, hoops, staves, shavings, sweepings, or rubbish of any kind, from stores, manufactories, shops or dwellings.