SEWERAGE.

CHAPTER I.

THE SYSTEM.

ART. 1. REQUIREMENTS OF A SYSTEM.

A system for the removal of sewage is demanded by a populous community on two grounds: the higher one of the public health, and the more popular one of convenience; and in designing a system each of these purposes must be kept constantly in mind, the first being ever given predominance over the second if they conflict in any way. The proper meeting of these demands determines the principles of designing.

There are two imperative essentials to sanitary sewerage:

I. That the sewage, and all the sewage, be removed without any delay to a point where it may be properly disposed of.

II. That it be so disposed of as to lose permanently its power for evil.

Convenience requires that the sewage be collected and disposed of with the least trouble to the householder and in the least obtrusive and offensive way.

In taking up the study of sewerage for any particular place or community the first question arising is that of the general
system to be adopted. In many cases financial limitations will be forced upon the engineer as an unfortunate but imperative argument in the choice not only of the details of the system but even of the system itself. He must perforce recognize these limitations in addition to the requirements of sanitation and convenience, but should not carelessly assume that since there is but little money to spend upon the work the care given to the design will need to be only proportionately great. He should realize that the highest talent is needed to obtain the best results with limited resources.

The solution of the difficulty, when a complete water-carriage system is rendered out of the question by reason of its cost, may lie in the construction of only the most necessary portion of the system or in the adoption of one of the dry-sewage systems.

ART. 2. DRY SEWAGE METHODS.

The methods in common use for removing excrement and liquid house wastes may be divided conveniently into three general classes: (1) Dry Sewage, (2) Pneumatic, and (3) Water-carriage systems.

The most primitive method of application of excrements to the soil—if it can be called a method—would be embraced under the first head. The old-fashioned privy was a step forward, and in a large part of this country is as yet the only one which has been taken, privacy being the main argument for its adoption. But, while contributing somewhat to this and to comfort, it cannot be considered as a sanitary appliance. "Constructed for the avowed purpose of retaining the solid matters as long as possible upon the premises, they become centres of pollution and infection. The liquid portions, escaping, pollute the soil and neighboring wells; the noxious exhalations arising from their putrefying contents contaminate the air." (Samuel M. Gray's Report on Proposed Sewerage System for Providence, R. I.).
Regular movement of the bowels is essential to health and to bodily and mental vigor. Yet a rainy day, a deep snow, or publicity of location has kept many a person from the daily attention to nature's demands when this requires a visit to the outdoor privy.

This last objection is met by the indoor closet connected with a cesspool. This is an improvement on any method of exposed deposits, as it prevents the transportation of noxious substances therefrom by flies. But cesspools should be made tight and be cleaned at intervals.

A cesspool 8 1/2 feet in diameter and 10 feet deep to which a family of five contribute a daily average of 25 gallons of sewage (a low estimate) would, if tight, require to be cleaned twice each year. Very few, it is believed, are cleaned this often; many are never cleaned, but the contained liquid leaches out into and through the adjacent soil, which soon loses its power to purify it. This soil pollution is the most serious objection to the cesspool, and has rendered unsafe the waters of many private wells and even public ones.

Fresh sewage is not injurious to health unless taken into the stomach, nor is it very offensive to the smell; but from putrescent excreta and kitchen slops come those noisome gases which, although probably not themselves bearers of malefic germs, at least lower the vitality and render the body more vulnerable to disease, and may constitute a serious nuisance. Retained for weeks and months in a liquid or semi-liquid state in a cesspool, sewage is then under the conditions best adapted to putrefaction in its foulest form. Especial pains should be taken, therefore, to see that a sufficient outlet be always open for the escape of these gases, such as by the continuation of the soil pipe above the roof, or by a special vent carried above the reach of snow.

This vilest of liquids is dangerous in two ways: it may reach and taint wells for hundreds of feet around, and it may pollute the air existing in the soil under cellars, which air will
exhale and permeate the houses above. In excavating for sewers in gravelly soil in a city street the author has found the gravel colored black by the liquid from a cesspool located 75 feet distant in the rear of the house opposite; which liquid must consequently have passed under or around the cellar of this house.

The general adoption of the septic tank, which has been called the "glorified cesspool," cannot properly be urged as an excuse for the cesspool. In reality the two differ in every essential. In no satisfactory septic tank does the sewage remain longer than twenty-four or at the most forty-eight hours. Even then there are given off large quantities of gases which no one would think of piping into his house, as is practically done from most cesspools. Moreover the use of cesspools scatters a large number of centres of soil-pollution throughout a closely populated area.

ART. 3. DRY SEWAGE SYSTEMS.

The methods already referred to can hardly be called systems, but are rather make-shifts. The simplest systems which can be at all commended are the Pail system and the Earth-closet. These are used but little in this country, but would be for many small villages a vast improvement over the privy or cesspool.

The Pail system consists essentially of the placing under the privy-seats of pails, which are to be removed, emptied in some spot where a nuisance will not thereby be created, cleaned, and returned. Duplicate pails must be provided to be used in place of these during their absence.

This method has been used at Marseilles, Havre, and other French cities; at Rochdale, Birmingham, Manchester, and other places in England; but only in certain districts of these cities, which are introducing water carriage and are yearly increasing the territory thus sewered. It has been used by a few communities in this country also, among them Vineyard, N. J., Memphis, Tenn., Atlanta, Ga., and Warren, O.,
but has been replaced in most of these with water-carriage systems.

A modification of and improvement upon the Pail system is the Earth-closet system, in which pulverized dry earth, charcoal, or ashes are used as a deodorizer and are applied to the excreta while fresh, the mixture being subsequently removed, preferably as in the Pail system. Brick-clay and loam rank high as deodorizers when applied in a perfectly dry and powdered state. Ashes are not so effective. In Bremen powdered turf is used. There is not evident a sufficient superiority in charcoal to compensate for its cost and other disadvantages.

The deodorizing-powder should be applied each time the closet is used. An excellent arrangement is that of a large box or barrel resting upon an extension of the seat and with an aperture and slide so contrived that any desired amount of the powder may be deposited upon the excrement by a slight motion of a convenient handle. The simplest method of applying the deodorizer is by a small scoop or shovel, the earth being kept in a box placed in a convenient position in the closet.

For either the Pail or Earth-closet system the receptacle should be round, as this form is more easily cleaned than a

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![Diagram of a modified Birmingham Pail](image-url)
square one; and preferably of metal, as a wooden pail soon becomes saturated with foul liquors. A good form is that of the modified Birmingham pail. The pails should be thoroughly cleaned after each emptying, and a thin layer of earth should be spread over the bottom of the pail when it is replaced under the seat.

The mixture of earth and excreta may be dried and used again; but there is a possible danger in this, since bacteria are not often destroyed by moderate heat; it will probably be found more convenient also to deposit it immediately upon the garden or field as a fertilizer. If the Pail or Dry-earth system is adopted for a village or city an arrangement may be made by contract for removing the buckets or tubs at intervals of not more than a week, the material to be disposed of by the contractor. Such disposition of it should be made—either by placing it directly upon the fields; or by drying and pulverizing it, in which form (poudrette) it is more convenient for use as a fertilizer; or by burning it (see Chapter II)—as will avoid the creating of a nuisance (see Art. 10).

There are several methods, some patented, for disposing of excreta and garbage on the premises by means of heat, by either drying or cremating. The heat for these is obtained either from a furnace constantly burning, in which case its use in summer is exceedingly inconvenient and is usually dispensed with; or by occasional fires lighted at long intervals, during which the waste matter undergoes dangerous putrefaction. On account of these and other equally serious objections these methods are not to be commended, particularly since the cost, were every house to adopt them, would in most locations suffice to construct an excellent water-carriage system.

These dry-sewage systems, though improvements on the privy and cesspool, are imperfect from a sanitary point of view in that they require the excreta to be stored about the premises for a certain period, and because they fail to pro-
vide for the removal of slops and sink-water and dispose of urine to a limited extent only. Neither do they provide for the drainage of the soil nor for the removal of surface-water. Convenience also is not fully served by their use.

ART. 4. PNEUMATIC SYSTEMS.

In the pneumatic systems the fæces only are removed, the house drainage, surface and sub-soil water requiring a separate system of sewers or utilizing the gutters. The most widely known of these is the Liernur, which is used in Amsterdam, Rotterdam and one or two smaller Holland cities. This system is practicable under certain conditions only and will not be described at length. Its object is to remove the sewage at frequent intervals through pipes, by means of a vacuum, to a central station, there to be disposed of in some way, usually by being manufactured into a fertilizer. The great cost of this system is prohibitive to its introduction into small cities and towns, and on account of its limited applicability, as well as for practical and sanitary reasons, its adoption in future designs is improbable.

The Shone system, which is used to some extent in England and her colonies and in this country, although classed among the Pneumatic systems, is really not in itself a system, but an application to the water-carriage system of a method of pumping sewage by the direct action of compressed air. It will therefore be considered under the head of the Water-carriage System.

ART. 5. WATER-CARRIAGE SYSTEM.

The Water-carriage system has now been so almost universally adopted where any improvement upon the primitive privy has been attempted that the term "Sewerage System"
is ordinarily used without further qualification to refer to it. When properly constructed and managed it is certainly deserving of its popularity, being the best and cheapest method yet contrived for the removal of sewage.

As its name implies, its distinctive characteristic is the removal through conduits, by gravitation, of sewage which has been greatly diluted with water. It meets the first principal requirement of a sanitary system (Art. 1)—it removes all house-wastes and removes them immediately. It also serves the secondary but by no means unimportant purpose of removing the surface-water and draining the ground. Its convenience also is excelled by no other system. Moreover, where the territory is quite thickly populated—as in the average town—it is in the end cheaper than any other system. The two most weighty arguments against it are the large amount of water needed for its efficient working, and the pollution of streams and waste of the valuable manurial properties in the sewage when this is emptied into river or sea, as is frequently done. Victor Hugo in his "Les Misérables" devotes a long chapter to the "Crime of the Century" involved in this waste. But whether this matter is ultimately wasted or its use by man only deferred it is not necessary to discuss. The all-convincing argument with any but the sentimentalist is that, while there may be manurial value in sewage, no commercially profitable method of utilizing it has yet been found. The best disposition to be made of it is therefore that which is least harmful, unpleasant, and expensive, and in most cases water carriage enables us to provide such disposition.

The argument that its proper working involves the use of large quantities of water is undoubtedly true. But where water-works already exist this objection has little force—less in this country than abroad, where 20 to 40 gallons per capita is considered a liberal allowance for water-consumption.
while in this country our small cities must provide two or three and the large ones five or six times this amount, which, with in many cases a small percentage additional for flushing, is usually sufficient and no difficulty is found in providing it. Some expense, however, is frequently incurred for flushing-water and to this extent is there force to the objection.

Places which are without a general water-supply or the general use of individual supplies are barred from the adoption of the Water-carriage system. For such, the best plan is to adopt the Earth-closet system until such time as water has been introduced into most of the dwellings, when a Water-carriage system may be initiated, the Earth-closet pails being continually relegated, as the conduit system is extended, to the outskirts of the town, where the growth will probably keep a year or two ahead of the water-supply and sewer-construction.

Other objections are sometimes raised to the Water-carriage system which are either equally applicable to all systems or which are the result of prejudice. The possibility of the introduction into dwellings, through the house-connections, of sewer-air (which is not a "gas") is one of these, and is certainly a real one. But the resulting danger is not so great as that connected with similar evils of other systems, and it is preventable by careful designing and construction of the sewers and house-plumbing.

**ART. 6. COMBINED AND SEPARATE SYSTEMS.**

The Water Carriage system has been adopted generally in all civilized countries as preferable to any other yet devised. This system has been subdivided according to construction and use into the Combined and the Separate systems; the terms "Combined" and "Separate" referring to the two classes of waters which it is desirable to remove—rain water
and house sewage. In the former, both classes of water are carried in a common conduit; in the latter the house sewage is removed through small sewers, and the storm water through other larger ones or in the gutters, or partly in one and partly in the other.

A few years ago there was a rivalry between these systems, but it is now generally realized that there are conditions under which each of them is most desirable, and in many instances a judicious combination of the two will work to better advantage than either alone. Such combination is referred to in this work as a Compound system.

The relative advantages of the two classes of sewers will be treated of more at length in Chapters II and VI. They may be stated briefly as follows: The small house sewers of the separate system give a greater velocity to ordinary amounts of sewage, and consequently cleaner sewers, than do the larger combined sewers. This smallness of size, however, has the objection that it renders more difficult the removal of any obstructions or sediment which may collect.

Where a complete system of both storm and house sewers is provided in the separate system the total cost is greater than that of a system of combined sewers of equal capacity. This additional cost, however, is, to a certain extent, offset by the fact that the storm sewers can frequently be placed at less depth than could combined sewers which must carry house sewage, which will effect some reduction in cost. The fact that towns which do not require complete storm sewerage or which are too poor to afford a complete system of separate sewers can obtain the more necessary removal of house wastes at much less expense, is of great advantage in permitting an earlier installation of the latter than can otherwise be possible.

Objection is made that large quantities of water are used for flushing the pipes of the separate system. But if the sewers of a combined system are kept equally as clean, much larger
quantities of water would be required for the same purpose except during the occasional seasons when rain storms are frequent.

The occasional claim that large sewers possess the advantage that they can be laid at flatter grades than small ones is incorrectly advanced, since, as a matter of fact, the larger sewers must be given steeper grades to secure equal velocity in the ordinary dry weather flow.

It is true that, where the separate system is used, surface water is frequently allowed to run for long distances in the gutters. But this is not a fault of the system, and merely indicates that those in authority consider the funds available to be more wisely spent in providing house sewerage than complete surface drainage, the latter of which can be arranged for whenever desired, if the designer of the system has not been remiss.

The danger of house traps being forced if adequate ventilation is not provided is less when large sewers are used than where the sewers are small. But such ventilation is an essential part of each system, which there is no excuse for omitting. The removal of foul air can be effected more completely in the smaller sewer, but is somewhat less necessary in the large one of equal cleanliness. Much more important is the fact that deposits, which are the cause of foul sewer air, are more likely to form in the large sewer than in the small ones.

A very important argument in favor of the separate system and one which the action of many State Health Boards is making almost imperative in their respective states, is the practical necessity for its use where a treatment of the house sewage is either immediately necessary or required by the authorities, or may in the future become so. It is true that street washings are often as foul as house sewage and that purification of them is desirable; but there are few, if any, combined systems where storm water is purified, and the
present tendency is away from rather than toward any consideration of such purification.

**Art. 7. Summary.**

The proper conclusion in reference to the system to be adopted would seem to be—the water-carriage, where its expense is not prohibitive and the dwellings are abundantly supplied with water. If the cost of the water supply is peremptorily limited, a dry-sewage system—preferably the dry earth—would be a great improvement on the privy or other primitive methods. The dry-sewage system is described at sufficient length in this chapter, as the proper conduct of it requires little else than cleanliness and faithful attention. The disposal of sewage thus collected will, however, be referred to in Part IV.

The water-carriage system is more complicated in design, in construction, and in operation; and to the consideration of this system the remainder of this work will be devoted.