CHAPTER IV

SEWERAGE AND DRAINAGE

Cleanliness is the chief aim of sanitation, not only in the personal sense of keeping the body, food and clothing clean, but also in the wider sense of cleanliness of surroundings. Man, in the course of his life is constantly polluting his environment by discarding waste materials which, if not rapidly removed, will certainly set up conditions inimical to his life. The removal of these waste materials from the neighbourhood of his home is carried out by a drainage system in the case of materials themselves liquid or able to be borne by liquid, and by a system of refuse collection and disposal in the case of solid materials. Sewage is the name given to the liquid waste, the great bulk of which is water polluted by grease, soap, foul matters from the surface of the body and from clothes and general house washing, waste materials from the body itself, urine and excreta, some rainwater which has fallen on houses, gardens and roads, and in many cases, trade effluents from manufacturing processes. Sewage from different communities varies a great deal in composition, the main reasons for this being (1) the character of the water supply, harder water involving the use of more soap, (2) the amount of rainfall admitted to the sewers, (3) the presence or absence of trade effluents, and (4) the manner in which human excreta are dealt with. There are still many houses in this country where human excreta are not carried in the sewage, but dealt with along dry or conservancy methods (p. 108) and there are other houses in which the flushing of the closets is done with household waste water (p. 79), while in some parts of the country rainwater is to a large extent excluded from the sewers by means of a separate system of drainage.

Construction of Drains and Sewers

Sewage is taken from the house in pipes called drains, which join other pipes called sewers, which latter carry the sewage from two or more houses (p. 211). Drains and sewers must be so constructed as to effect an immediate and perfect sewage removal. They should be water-tight, smooth in the interior, and small enough to be self-cleansing; they should, if possible, follow a straight course and have a sufficient fall, varying in accordance with the diameter, and, as far as possible, of the same uniform rate; where curves are unavoidable,
they should not be abrupt, and if possible, at such points where tributaries join, manholes should be provided. Ample provision should exist for ventilation, so that offensive gases may not stagnate but have free outlet into the open air.

Drains are very often needlessly large, and thus the flush is very much reduced. For example, given two drains of equal fall, carrying the same volume of sewage, the one 4 inches in diameter and the other 6 inches, the rate of travel, and therefore the flushing power, in the former case will be greater than in the latter, because the depth of fluid in the smaller pipe is greater than in the larger. The accompanying sketch (Fig. 20) shows the comparative difference in depth of the same volume of fluid in a 4-, 6-, or 9-inch pipe. As a rule, the diameter of house drains need not exceed 4 inches, except in the case of very large establishments. Too often, even now, a 6-inch pipe is used when a 4-inch would answer all requirements, and, in the case of old houses, one frequently finds that even the tributary drains are constructed of 9-inch pipes.

![Fig. 20.—Equal Quantities of Fluid in Different Sized Pipes.](image)

Whether drains are intended to convey the ordinary waste-water only, or in addition the excreta and urine of a household, they must be constructed with equal care and attention to detail.

Glazed stoneware or heavy cast-iron pipes are alone permissible for drains. Stoneware is a crude kind of porcelain made from coarser quality flint and sand nearly fused in the process of manufacture. It is opaque, often pale buff in colour, non-porous, hard and difficult to fracture, and gives a clear metallic ring when hit with a hammer. It has usually a shiny glaze obtained by throwing salt into the furnace, the sodium of the salt forming a kind of glass with the silica of the ware. Earthenware, which is unsuitable for drainage pipes, is made from clay, which is burnt at a lower temperature; it is softer and fractures with less sharp edges; even the best earthenware pipe does not give quite the clear metallic ring of the stoneware pipe. Earthenware is porous, and when glazed, the glaze is applied artificially. Earthenware pipes are most certainly distinguished from stoneware pipes by the amount of water the earthenware pipe will absorb when, after drying, it is immersed in water for 24 hours; the stoneware pipe similarly dealt with absorbs an insignificant amount.
All drain pipes should be perfectly circular and provided with a satisfactory spigot and faucet or socket, so as to give a jointing space of 2 to 2½ inches long internally and ⅜ to ½ inch wide all round in the case of stoneware pipes, and a jointing space of 3 to 4 inches long internally and ⅜ to ⅝ inch wide all round in the case of cast-iron pipes. The spigot enters the faucet in the direction of the flow as in A (see Fig. 21), not as in B.

Before proceeding to lay the pipes, each one should be carefully examined, and any that are imperfect should be rejected. In outline they should be perfectly round, otherwise the spigot will not fit accurately into the socket; the internal surface must be smooth and thoroughly well covered with glaze; and they must be entirely free from cracks or flaws of any description, otherwise the drain will not be water-tight.

![Diagram A](image)

![Diagram B](image)

Fig. 21.—Jointing in Pipes. (A) Correct (B) Incorrect.

Stoneware pipes are made in 2 feet to 3 feet lengths, the 4-inch pipe being usually 2 feet. The thickness of the stoneware should be ½ to ¾ inch. When a 4-inch pipe is spoken of, it is of 4 inches internal diameter. Cast-iron pipes are longer, usually from 6 to 9 feet long and the thickness of the metal from ⅜ to ⅜ of an inch. Cast-iron pipes are coated inside and out with Angus Smith's preservative, although sewage, because of the soap and grease it contains, does not appear to rust pipes. Cast-iron pipes are, of course, able to bear weight and strain much better than stoneware pipes. They require fewer joints because of their greater length; the jointing is more quickly and securely done, and they require less concrete support as they are stronger. On the other hand, custom and price confine their use to situations which will afterwards be mentioned.

Pipe Trenches

The trench in which the pipes are laid should be dug, not piece by piece, but in lengths, and it is important not to interfere with the solidity of the floor by excavating, in the first instance, to a greater depth than is necessary, as this necessitates the replacement of soil
and thus causes a risk of after subsidence. If it should happen, in
the process of digging, that more soil has been removed than is
necessary, in replacing it, so as to equalise the gradient, the replaced
soil must be firmly beaten down, otherwise subsidence will afterwards
occur which will interfere with the proper flow of sewage, and possibly
impair the integrity of the joints and cause leakage.

Unless the ground is naturally solid, all stoneware drains should
be laid on a bed of concrete 4 inches in depth, and, if it should be found
necessary to carry such a drain under a house, it should be entirely
embedded in concrete of at least the same thickness. The latter
precaution ought to be observed in all cases where it is necessary
that a drain should be laid in close proximity to a well, although,
if circumstances permit, it is better to select another route for the
drain or use iron pipes.

In laying the pipes on solid ground a point of the utmost importance
to remember is, that they should rest on their bodies on the bottom
of the trench, and not on their sockets, a portion of soil being removed
at points corresponding with each socket to allow of this. It is the
usual practice of inexperienced drain layers to disregard this pre-
cautiion, with the result that, when the trench is covered in, in place
of the weight of the soil being uniformly distributed along the entire
length of the pipe, the pressure is concentrated upon each joint, and,
in all probability, causes the recently introduced cement to be expelled
from the sockets. If the bodies of the pipe rest on an even place
at the bottom of the trench, and the sockets lie free in special excava-
tions, no difficulty is found in securing alignment at the joints. If
no excavation is made for the sockets, the joints will form a series
of downward angles, and impede the flow. To prevent this, various
patent joints are on the market, of which the best is possibly the
bevelled self-centring joint, which consists simply of a somewhat sharp
bevel at the end of the spigot, which fits into a similar bevel inside
the socket so as to fix the two evenly when jointing is done.

Joints in Pipes

Joints must be made with extreme care, the best Portland cement
being alone admissible for stoneware drains. Even now it is not an
uncommon practice to use clay for the purpose. An ignorant workman
may possibly be excused for following past custom in this respect,
but builders and architects are greatly to blame if they countenance
such a proceeding.

Having carefully cemented the joint, not only at the top but all
round, the workman before making the next joint should satisfy
himself, by raking the pipe out with a specially constructed wooden
implement, that none of the cement has been pushed into the interior,
otherwise it will interrupt the proper flow of the sewage and lead to obstruction.

Before replacing the soil the drain ought to be inspected by a responsible person, who should test the integrity of the joints by means of the hydraulic test to be afterwards described. The first portion of soil must be replaced with care, and should be packed well under and on either side of the pipes, so as to guard against after-displacement which is likely to cause fracture of the joints.

Fig. 22 illustrates a good method of making a stoneware drain joint. Teased-out hemp-spun yarn, free from tar, is first steeped in fluid cement (cement grout), and then well rammed into the joint, so as to fill it about half. The joint is then completed with stiff cement. Iron pipes require a caulked lead joint (see page 84).

![Diagram of a Good Joint for Stoneware Pipes.]

The fall of a drain should be such that a flow is obtained in the sewage at the rate of not less than \(2\frac{1}{2}\) feet per second, so that the drain may be self-cleansing. This is secured in a 4-inch drain by a fall of 1 in 40 and in a 6-inch drain of 1 in 60, and in a 9-inch drain of 1 in 90.

Reference has already been made to the need of a concrete foundation for a stoneware drain wherever the drain is laid through earth which is liable to be disturbed, or has recently been disturbed. If earthenware pipes are used, then in all circumstances they should be embedded in 6 inches of concrete all round.

**Pipe Junctions**

Junctions must always be made so that the two flows join in the form of a \(V\); no tributary drain should join another drain by making with it an angle greater than 45 degrees. It is important to remember, that unless tributary drains join main drains obliquely in this manner, so that the sewage enters in the direction of the flow, splashing will occur, and this, in time, is likely to lead to obstruction, owing to a
deposit being gradually formed from the drying of the sewage that has been driven against the sides of the pipe, above the water-line. It is needless to remark that it is a wrong proceeding to connect a tributary drain by knocking a hole in the main drain, although the practice is by no means an uncommon one. Special V-shaped junction pipes should always be used.

Bends

As far as possible, bends in drains should be avoided; when they are unavoidable, the curve ought to be an easy one. Pipes with easy bends are made, and should always be used when bends are necessary (Fig. 23, B), although it is a common practice to use straight pipes for the purpose. The effect of such a proceeding is shown by the accompanying sketch (Fig. 23, A). Not only are objectionable angles formed at the junctions of the pipes, which tend to interfere with the easy flow of sewage, but what is still more important, the impossibility of accurately adjusting the spigot end of one pipe into the socket of the next, in the case of straight pipes laid otherwise than in a straight line, necessitates an imperfect joint being made.

In connecting a branch drain with a main drain easy bends should be used (Fig. 24), but, when it is necessary to depart from the straight line in the case of the drain itself, or in the case of sewers, by far the best proceeding is to construct a manhole at the point where the curve occurs, in a manner to be presently described. Indeed, whenever practicable, all tributary drains and sewers should join the main drain or sewer, as the case may be, at a manhole, so as to facilitate inspection and cleansing.

Inspection Pipes

Various kinds of inspection pipes are made, and ought to be introduced at the top end of all branch drains, particularly when they are laid in concrete. The necessity for breaking into a drain, should it become obstructed, is thus avoided, as the clearing rod may be introduced at the opening provided.
Perhaps the simplest method, and one which does not entail any disturbance of the surface, is to introduce what would correspond to a V-shaped straight junction with the opening directed upwards (Fig. 25), to which a pipe, leading from the surface of the ground is connected, and along which a rod may be passed. The top end of this pipe must be sealed, either by a special cap or by a piece of slate fastened with clay, a small movable stone slab with ring attached being placed so as to mark the situation and allow of easy access to the opening.

Another method of inspection (Fig. 26), is by means of a pipe divided longitudinally into two segments, the upper of which may be removed by means of a chisel.

A still more convenient arrangement than any of these is now available in the shape of various kinds of access gully-traps. These can be obtained from most makers and may be used with advantage in all new drainage work.

The Construction of Sewers

Sewers are constructed of pipes or of bricks according to their size. In the former case the same rules have to be observed as have been described in the case of drains.

The proper size and fall for a sewer is a question for engineers, and both are dependent upon the amount of the sewage flow.

In sewers over 24 inches in diameter, the velocity of the flow should not be less than 2 feet per second; in sewers under this diameter 2.5 feet per second is required.

A sewer 10 feet in diameter having a fall of 2 feet per mile, a sewer of 5 feet in diameter having a fall of 4 feet per mile, a sewer of 2 feet in diameter having a fall of 10 feet per mile, and a sewer 1 foot in diameter with a fall of 20 feet per mile, will all have the same velocity of flow, but the volume of sewage in the 10-foot sewer must be 100 times, in the 5-foot sewer 25 times, and in the 2-foot sewer 4 times the volume of sewage in the 1-foot sewer.

Circular stoneware pipes should be used for all sewers up to 18 inches in diameter, but sewers of larger capacity should be egg-shaped, with the small end of the egg downwards, and constructed of good impervious bricks laid in the best Portland cement (see p. 131). The
advantage of an egg-shaped sewer is its greater ability for self-cleansing where the amount of effluent discharged through it is subject to considerable fluctuations.

Manholes

Manholes ought to be introduced at intervals of not less than 100 yards, and the convenient sites for these are where tributary sewers join, but, as already stated, it is essential to construct one at each point where the sewer has to alter its straight course. The same holds good in the case of the drains of all well-drained establishments; the satisfaction of being able to look through, and to pass a rod through from one end to the other of the drains and their tributaries, amply repays the extra outlay.

A manhole chamber (Fig. 27) is built of brickwork set in cement, and the drain or sewer is continued along the floor of the chamber by means of open half-channel pipes set in a bed of concrete.
surface of the concrete should be raised some inches above the edges of the half-channel pipes to prevent the sewage from overflowing on to the floor of the chamber, and it should be floated with cement all over so as to present a smooth and impervious surface. At points along the main channel tributary drains are connected by means of curved half-channels similarly laid in concrete, the junctions being formed by special half-channel junctions being introduced in the course of the main channel at these points. All street manholes should be fitted with a perforated iron lid to allow of the free circulation of air in the sewers (see Fig. 27), a bucket or tray being suspended under the perforations to catch any dirt that may enter from the road. In the case of private drains, the manhole lids in the course of the drains should be air-tight.

In the case of drains discharging into cesspools an intercepting trap is essential.

So much for the points that have to be attended to in connection with the laying of drains and sewers. A description of the various forms of traps has purposely been omitted at this stage, as they may more fitly be described when sanitary appliances come to be considered.

Supervision of Drain Laying

As regards the supervision of the work of drain laying, it is impossible to exaggerate the importance of keeping a watchful eye upon the workmen to ensure that every detail is attended to. Unless faults are discovered during the progress of the work, they are exceedingly likely to be overlooked altogether, until, sooner or later, serious consequences result. The fact is, men are frequently employed as drain layers who are entirely ignorant of the principles to be observed and the risks to be guarded against, and until it becomes the custom to require such men to be registered, a requirement which is happily becoming general in the case of plumbers, we cannot look for much progress in this department of sanitary work.