CHAPTER VII

SEWAGE AND REFUSE DISPOSAL

SEWAGE

A highly complex unstable liquid like sewage, rapidly becoming in its decomposition very offensive and dangerous to health, is quite unfitted to be discharged into rivers and streams without treatment to render it innocuous.

It must be understood at the outset that treatment to be effective must accomplish more than simple clarification. It is possible by several methods so to treat sewage as to remove practically all the suspended solid matters, leaving a clear fluid which, in appearance, may differ only slightly from potable water; but this treatment alone will not render the sewage fit to be discharged into a stream, for it still contains in solution an immense amount of organic matter, which, as decomposition proceeds, will become turbid, and give rise to nuisance from deposit of putrefying solid matter on the bed of the stream. The process, to be complete, must go further than this: the soluble organic matter must undergo a change which so alters its nature as to convert noxious organic into harmless inorganic substances. At one time it was believed that the only really efficient means of accomplishing this was by submitting the sewage, after chemical precipitation in tanks, to land treatment, but recent experience has shown that equally good results may be obtained by artificial filtration, and still more lately it has been demonstrated that, in the case of ordinary domestic sewage at any rate, the preliminary precipitation process is not essential, and that the solid organic matter may, to a large extent, be liquefied and so prepared for further treatment (either by land or artificial filters) by much simpler and less expensive methods to be described presently.

Sewage when brought in contact with suitable land, or properly constructed artificial filters, is immediately attacked by living organisms (bacteria) universally present in the upper strata of the soil and in sewage, and which in time develop in the interstices of the land or filters; by these its organic matter is split up into simple constituents, which, with the assistance of the oxygen and carbonic acid gas present in the ground air or the air in the filter, unite with certain mineral bases in the soil and in the sewage itself, and thus are transformed from organic, unstable compounds, liable to putrefactive changes, into more fixed inorganic salts of an innocent nature.
The volume of sewage from any community bears a close relationship in dry weather to the amount of water used, but in wet weather it naturally varies with the amount of rainwater admitted to the sewers. This volume of sewage, the nature of the sewage (see p. 56) and the amount, character and situation of the land available for purification works, are all factors in determining the particular method of sewage treatment adopted in any community. Before the sewage passes on to purification, it is usual in most processes to screen it through fixed bar screens, with ½-inch intervals between the bars, to hold back gross floating solids. This is followed by grit settlement in a detritus tank, through which the sewage passes at a rate of not less than ½ or more than 1 foot per second to allow the grit to settle.

**Sedimentation of Sewage**

After this there follows a sedimentation of the sewage which in the continuous flow system is carried out in large tanks about 8 feet deep at the inlet, and 4 feet deep at the outlet, and sufficient in capacity to hold an 8-hour flow of sewage. Through these tanks the sewage flows slowly, and a sedimentation of solid matter as sludge takes place. This sludge is collected in a sludge well at the inlet end from which every few days it is drawn off through the sludge valve. The sedimentation may be aided by the addition of precipitants such as lime, aluminium or iron salts. This precipitation clarifies the sewage greatly, and where the sewage contains trade effluents it may be essential for sludge extraction. The outlet of the tanks is guarded by scum boards placed across it; baffle boards in the tank itself to impede the flow and aid the sedimentation are not necessary in well constructed tanks of sufficient size. Instead of a continuous flow, the sedimentation may be carried out by filling the tank and allowing the sludge to settle by quiescent sedimentation.

After sedimentation, with or without precipitation, the supernatant liquid passes on to further purification while the sludge may be pressed and disposed of as manure. Instead of pressing, it may be run into shallow troughs or lagoons and allowed to dry, and then dug out as manure. The sludge may contain as much as 90 per cent. of water. Such pressed or lagooned sludge contains a large amount of soap curd and is not a good land fertilizer. It usually presents considerable difficulty in its satisfactory disposal, and it may have to be burnt.

**The Septic Tank System**

The processes that go on in a sedimentation tank are not altogether simple physical or chemical ones. There is always some biological action in which low forms of life feed upon the organic matter in the
sewage, setting up and aiding its decomposition. To encourage this, 50 years ago, the septic tank system was introduced, in which the sewage was retained in a closed tank 16 to 24 hours. By this means a large measure of decomposition and liquefaction was set up and sludge formation obviated to a great extent. This process was found to take place in an open tank, an organic scum forming, so that closing in of the tank was no longer considered necessary. Much the same sort of change takes place in the Dortmund and Imhoff tanks, which are much in use in Germany and America. The Imhoff tank differs from the Dortmund (shown in Fig. 69) by the arrangements it possesses for baffling the gases arising from the sediment on the sloped floor. The Dortmund, as is seen in the diagram, has a series of radiating arms (B) through openings in which the sewage is admitted in such a fashion as to disturb the sludge as little as possible. The sewage remains in both these tanks about 3 hours. Having to a large extent liquefied and clarified the sewage by such preliminary processes, the sewage is submitted to further treatment which may be carried out either by land filtration or special biological filters. Land filtration may be done by either intermittent downward filtration or broad land irrigation.

**Intermittent Downward Filtration**

Intermittent downward filtration is the term applied to that form of land treatment in which the effluent drains are laid 5 to 6 feet below the surface, and in which the sewage is turned on the land.
for 8 hours and the land rested for 16 hours during which time a free aeration of the soil takes place. The great object is to bring the sewage at regular intervals in contact with the soil, irrespective of any vegetation, but, by an arrangement of ridges and furrows, certain root crops may be cultivated, and in this way the process of purification may be assisted, while at the same time a small return is obtained from the sale of the produce. By such a system, properly attended to, and where the soil is particularly suitable, it is said that the sewage of from five hundred to one thousand inhabitants (if previously thoroughly clarified by precipitation) may be dealt with on 1 acre of land.

**Broad Land Irrigation**

A method very similar to the foregoing, with the difference that greater attention is paid to the cropping of the land, is called broad land irrigation. The area of land used is very much larger, and the sewage is discharged from surface carriers at such times and in such quantity as vegetation requires, or will admit of. The carriers are cut about 30 feet apart, along ridges, with a gentle slope on each side to admit of uniform distribution of the sewage. Constant attention is required to ensure that the sewage is thoroughly distributed and not allowed to discharge on to a small area, as this would cause waterlogging, and thus prevent the proper aeration of the soil. The land, in this case, is drained at a depth of from 3 to 4 feet, and the quantity of land required is said to be 1 acre for each hundred of the population, provided no previous treatment beyond straining is in use; with preliminary treatment, however, by precipitation or otherwise, the sewage of twice as many people, if not more, may be dealt with on 1 acre of suitable land. Irrigation with crude sewage, however, usually ends in failure.

Italian rye-grass is the most suitable crop for sewage-farm cultivation, as it grows very rapidly and absorbs a large quantity of moisture. As many as three or four excellent crops may be cut during the year, and it yields a fair return as a food for cattle. Root crops and cabbages may also be cultivated, but all crops which do not admit of the regular rotation of the sewage over the whole area at short intervals must be avoided.

**Subirrigation**

A third method of land treatment is by subirrigation, where the sewage is led into agricultural drain pipes within 1 foot of the surface. This is only suitable for very small communities with certain soils, and is extremely liable to go out of order, and although it may give good results for a time, it is not a system to be recommended.
Biological Filtration

In most large communities sufficient suitable land for land treatment is not available, or cannot be acquired, and biological filtration is usually preferred or may be the only method available. A contact bed is a filter bed filled and opened intermittently. It aerates while it is resting. It does not seem to matter very much what material is used for filters and contact beds provided certain essentials are complied with—namely, hardness, non-friability, stability—that is, freedom from liability to disintegration, either by chemical or mechanical action, and the absence of dust. Among the different materials used for the purpose may be mentioned coke; breeze, coal, clinker, broken gravel and shingle, granite, slag from iron works, broken saggers (a hard-burned clay refuse from potteries), ashes, and burned ballast. With the exception of the last two, all the materials mentioned answer the purpose well; but, as regards ashes and burned ballast, the former is frequently found to crumble and cause clogging, while it is difficult to ensure that the latter is sufficiently hardened by the burning process to prevent its caking and becoming useless. Filters act first merely as mechanical strainers, but in time they acquire the power of acting biologically on the organic matter through the agency of the bacterial life which grows in their interstices. The process is an oxidising one and dependent on a constant aeration of the filter beds. The particles in the filters should be as small as is compatible with a thorough aeration. The depth of the filter bed bears relationship to the size of the particles used, and in the case of particles over \(\frac{1}{4}\) inch, and in the case of contact beds, they should be 5 to 6 feet, while in the case of smaller particles in efficient slow sprinkling filtration, 3 to 4 feet is sufficient, but these filters must be properly constructed and carefully attended to. The distribution of the sewage over the whole surface of the filter bed is an important point to prevent clogging and to ensure an even action and aeration. There are several distributors on the market. The Fiddian distributor shown in Fig. 70 is an example. None is perfect, and all require careful attention even though their action is claimed to be automatic. When sufficient fall can be got between the tanks and the filters, it is not difficult to devise sprinkling arrangements, with or without revolving arms, which are quite efficient. Contact beds in general do not give such good results as slow filtration, and in use a double contact method, that is a duplication of the process, is necessary to get good results.

The Activated Sludge Method

Dealing with sewage by the activated sludge method differs materially from the methods so far described, in that the entire
process of purification is accomplished in tanks without subsequent filtration or land treatment. This method gives good results, and its use in large purification works has greatly extended in recent years. It involves no departure from the established principles of sewage disposal, but merely a change in their application, the necessary oxygen being provided by driving air into the sewage in the tanks in such a manner as to bring it into intimate contact with the crude sewage after fine screening only. By this process the growth of nitrifying organisms is encouraged, and, when activity is once established, the purifying process is a continuous one as long as sufficient tank capacity is available and the air pressure is adequately maintained. It has been established that ordinary domestic sewage

Fig. 70.—Fiddian Sewage Distributor.

may thus be purified in tanks of a capacity equal to six to ten hours' flow. On the other hand, twice these capacities may be necessary in the case of some sewages containing trade wastes.

It is necessary to note that activated sludge is quite different from the sludge deposited in a sedimentation tank. It is composed of flocculent particles which have separated themselves out from the screened sewage as a result of the continuous agitation with air. It is the same as the gelatinous film seen covering stones and the bank of a river which has been the subject of sewage pollution. Instead of driving air under pressure into the sewage, the agitation and aeration may be secured by paddle-wheel arrangements working in parallel channels about 4 feet wide. These channels are so connected as to make one long channel about three-quarters of a mile in length along which the series of paddle wheels drive, agitate and aerate the sewage. In still another system, the sewage is agitated in a vertical
direction and aerated at the top by being thrown out in a fine spray. The activated sludge has a biological action on the sewage whereby it is clarified and purified. After the aeration, the effluent is passed through deep sedimentation or humus tanks which separate the activated sludge, which is colloidal in character, difficult to dry, but of very considerable manurial value because of its high nitrogen content. The disposal or treatment of activated sludge is a matter not yet satisfactorily settled.

Rain water when admitted to sewers, largely increases the volume of the sewage during storms; up to three times the dry weather flow should be treated fully. Between three and six times sedimentation in standby tanks is sufficient, while over six times the dry weather flow may be discharged directly into the stream.

Design of Sewage Installations

The sanitary inspector is frequently required to design or comment upon small sewage purification installations, and a knowledge of the foregoing principles will enable him readily to do so. Briefly, he must see that a detritus chamber and screening are provided; that tankage capacity properly constructed and sufficient for one day's flow is arranged for, and a filter bed of a cubic capacity 3 or 4 times that of the tank exists. The filter must, of course, be sufficiently deep, filled with suitable filtering material, and have efficient arrangements for distributing the sewage on its surface. The final effluent should be taken from the bottom of the filter to some surface water drain.

Cesspools

In country districts where no system of sewers exists, cesspools are frequently met with. These must be a safe distance from the house itself and they should have a pump attached for the regular removal of the contents. Means of easy access must be provided to admit of occasional removal of the solid deposit. Cesspools constructed of porous brickwork, which allows of percolation through the bottom and sides, ought in all cases to be condemned. In cases in which cesspools are admissible—that is, when other and better means of dealing with sewage—such as by sub-irrigation—are not practicable, they must be constructed so as to be absolutely watertight. This may be accomplished by building the brickwork in cement, rendering it with cement, and surrounding it on all sides with puddled clay from 6 to 9 inches deep, for which, of course, it is necessary to allow in making the excavation. The puddled clay is first laid on the bed of the hole, and upon it the floor of the cesspool is built; the walls, one brick in thickness, are then carried up a
certain distance, and, having carefully removed all dirt from the surface of the clay-bed outside the walls, the interval between the outside of the brickwork and the soil is filled up with the clay, which must be thoroughly well rammed down; another few lines of bricks are then laid, and the interval similarly filled up, and so on until the whole is complete. To avoid disturbing the brickwork while the process of ramming the clay is going on, care must be taken to "stay" the walls across from side to side, and the "struts" should not be removed until the cement, to some extent, has set. An arched roof has next to be built, in which three openings must be left; one for the purpose of gaining access to the cesspool, in order to cleanse it periodically, the second for connecting a ventilating-pipe, and the third for fixing a pump. A properly constructed manhole-cover is best for the first purpose, although a movable stone slab will answer. For the purpose of emptying the cesspool a chain pump is most suitable, as the mechanism is simple and does not get out of order. A syphon intercepting trap must invariably be placed between the cesspool and the house, and near to the former. The size of the cesspool must be regulated in accordance with the size of the establishment for which it is intended, but the smaller it is the better.

DRY CONSERVANCY SYSTEMS

Excrement and Refuse Disposal

Where water closets are not available, some form of dry closet is used for the collection of excrement, and the system is known as the dry conservancy system. Dry closets appear in several forms as the privy, privy midden, pail closet, earth closet, chemical closet and earth latrines. All these conveniences are unsatisfactory sanitary structures as they retain in the neighbourhood of the dwellings, foul and often infected material, endangering health. They ought never to be permitted in any locality where facilities for water carriage are available. There are still, however, many places where such arrangements must be tolerated, and with the extension of camping and hiking amongst the population, it is necessary for the Inspector to be acquainted with the methods of dry conservancy. Under the Public Health Act, 1936, an earth closet as defined (p. 211) is the only form of dry convenience to be permitted in new buildings (p. 215).

Privies

Privies are constructed on different plans, according as it is intended they should receive the faces and urine only, or also the ashes and general refuse of a household.
The drawing (Fig. 71) represents the section of a privy built for a movable receptacle, and for excreta only. In this case, the seat of the privy is hinged so as to allow of the pail being removed from the inside, but if it is found desirable to remove it from the outside, a modification, in the shape of a door at the back or side, is quite admissible.

In order to provide for ventilation, an opening, communicating directly with the external air, should be constructed as near to the top of the privy as possible.

The floor ought to be flagged, or paved with hard tiles, or other non-absorbent material; every part of it should be at least 6 inches above the level of the surface of the ground adjoining, and it should have a fall towards the door of the privy of half an inch to the foot.

![Fig. 71.—Privy with Movable Receptacle.](image)

Beneath the seat, the floor on which the receptacle rests must be at least 3 inches above the level of the surface of the ground, and it also should be flagged or asphalted; the sides of this chamber must be constructed of flagging, slate, or good brickwork, 9 inches thick rendered in cement. The receptacle itself should be limited to a capacity not exceeding 2 cubic feet.

In the case of a privy with a fixed receptacle for refuse, it is essential that the ashes and dry refuse should be regularly mingled with the excreta, consequently the capacity of the receptacle must be greater than 2 cubic feet. The limit of the capacity in this case is fixed at 8 cubic feet. In other respects the structure of the privy is practically the same as that just described. The great object in limiting the capacity of the receptacle, is to necessitate weekly removal of the contents. As this is hardly possible in rural districts, the above limit
of 8 cubic feet must there be exceeded. The following sketch (Fig. 72) represents a good arrangement for such districts. The student will note in this sketch (1) the higher seat with the step in front giving more room in the receptacle, (2) the ashes door at C, (3) the shoot arrangement at A directing the ashes on to the excreta, and (4) the emptying door at B. Such an arrangement might be used for as long as three months without emptying, but this, of course, would be very undesirable.

Privy Middens

A privy constructed as described, either with a fixed receptacle (commonly known as a privy) or with a movable receptacle (known as a pail closet), though providing a poor sanitary arrangement for dealing with excreta, has not the very grave faults of the privy midden, which is still found in many parts of the country. Here, the midden, where all the household refuse is placed, is situated at the back or between privies. It is often a large open structure, which becomes foul and offensive to a degree. Privy middens wherever situated, and however constructed, should unhesitatingly be condemned as dangerous nuisances. Ashes have little, or no, effect on excreta beyond keeping them dry, and so retarding decomposition.

Earth Closet

Dry soil, unlike ashes, gradually disintegrates the organic matter by a biological action so as to render the excreta innocuous—hence the earth closet, in which a sufficient quantity of soil is provided, from which a portion of soil is discharged over the excreta each time
a plug or handle is drawn. The following conditions are to be observed in this type of convenience: (1) the earth must be suitable, perfectly dry and fine sifted—a loamy soil is best, while sand, gravel or chalk is useless; (2) a pint and a half of earth should be distributed over the excreta each time the closet is used; (3) no rain-water or other moisture (e.g. domestic waste water) must find access to the earth closet. The excreta and earth after having been in contact for 6 weeks to 2 months, appear to have reverted back to earth alone, and may, after a time, be dried and used again in the closet. Earth closets must be fitted out of doors and are a moderately successful means of dry conservancy.

Chemical Closet

In the chemical closet, which is now included in the term “earth closet” (p. 211), the excreta are received into a liquid composed of caustic soda and carbolic acid and contained in a metal trough, where they are quickly dissolved. By reasons of the nature of the chemicals it is necessary that some arrangement should be made to prevent splashing upon persons using the closet, but this should be as simple as possible. Some aromatic oil usually floats on the surface of the liquid, which latter can be discharged at intervals by a plug to some place prepared beforehand. This is a good type of “dry” convenience, and is used in motor coaches, river and air craft and the like.

The last form of dry conservancy that need be mentioned is the earth or trench latrine, which is suitable only for temporary encampments. In principle such latrines are much the same as earth closets, but being temporary structures insufficiently protected from rain, they require frequent change of site. The depth to which latrines may be dug depends to a large extent on the nature of the soil, but in general this should not exceed 1 foot so as to get the full effect of the disintegrating action of the earth upon the excreta. The sites of such trenches must be carefully chosen so as to prevent any possibility of contamination of a water supply.

REFUSE

House Refuse

House refuse consists of all the solid waste materials which cannot be or ought not to be removed from the neighbourhood of the dwelling by water carriage. It is of very varied composition, consisting of such materials as ashes, dust, waste paper, waste food and vegetable garbage, rags, broken glass and crockery, old tins and iron, and, in places on dry conservancy, excreta. The last mentioned has now disappeared or is rapidly disappearing from the refuse of towns.
though it still occurs in the refuse of country districts. In rural
districts refuse containing excreta is usually removed by farmers at
their own convenience to manure their fields. This method of
disposal is a constant source of trouble to rural sanitary inspectors
and it may involve a contamination of water supplies; in urban
districts no methods short of burning such refuse can be considered
satisfactory for its ultimate disposal and even this does not obviate
the nuisance arising in emptying and cartage through streets. The
only proper solution in these districts is to abolish the dry conservancy
system altogether. Pail closet excreta have been dealt with in some
towns by the addition of sulphuric acid, or by reduction to a dry
powder by steam and the sale of the powder (poudrette) as manure;
in others the contents have merely been washed down the sewer;
but such processes were always offensive and are fortunately rapidly
becoming merely of historical interest.

The composition of house refuse from water carriage areas may
be conveniently considered under four heads, namely—combustible
carbonaceous matter, other organic matter, mineral matter and water.
The combustible carbonaceous matter consists mostly of paper, card-
board and wooden boxes, old wood, straw, cotton and linen rags,
and unconsumed coal such as "ashes" and coke. At one time the
amount of partly consumed coal in house refuse was considerable,
but with the increase in the price of coal, the improvement in fire
grates and the greater care and knowledge of the housewife, the
amount has become very small in most towns, except possibly those
in a coal area. So much is this the case that refuse formerly com-
bustible with comparative ease has required in some cases the addition
of coal or coke to make it burn. The other organic matter consists
of waste food, bones and offal, garbage, hair, rags, and discharges
and other matter attached to rags generally and a variety of other
organic particles got in household dust, etc. The organic matter
in house refuse is important as it attracts animal life, e.g. rats, birds,
insects, and under certain conditions it promotes the growth of low
forms of life, resulting in decomposition and putrefaction. The
mineral matter consists of old tins and iron and other metals, broken
glass and crockery, dust, grit and stones and spent ashes. Formerly
the only articles that were considered of value here were the metals
which in certain processes were sorted out for sale, but many other
articles, notably waste paper and bones, have in times of scarcity
considerable salvage value, so that during the war householders were
encouraged to sort such refuse before collection from their homes.
The amount of water in household refuse is relatively small and is
mainly from vegetables, fruit, tea leaves and the like, unless the
refuse is exposed to rain. The exclusion of water is of great importance
in refuse as its presence is a main factor in setting up quickly offensive decomposition. The relative amount of these different components varies in different communities according to the habits of the people and the industries carried on, for trade waste is frequently dealt with at a special charge to the owner along with the house refuse; the relative composition also varies with the season of the year and the residential or industrial character of the district. The total amount of refuse has been tending to increase in recent years; at present in large towns, including London, about 14½ cwts. are produced daily per 1,000 of population, in smaller towns about 13½ cwts. and in urban districts about 12 cwts. But the amount varies greatly, some large towns producing over 22 cwts. per 1,000 persons daily and others under 10 cwts., and the same is true for other districts. As a convenient figure 15 cwts. may be taken as the amount produced by 1,000 persons daily, so that if we divide the population by 1,000 and multiply by 3 we get the amount in tons with which the town will have to deal. About 30 cwts. of household refuse will occupy a space of 6 cubic yards in a collection cart, so that a cart of this capacity would take the daily refuse of a population of 2,000 in one journey. In the household ashbin, refuse occupies comparatively larger space, but the ordinary refuse bin of about 3½ cubic feet capacity will retain without overflowing over 60 pounds of refuse, which is sufficient for a family of five for ten days. Refuse may be reduced in bulk very considerably by pressure and it is important to note that by hand sorting and pressure in controlled tip building 30 cwts. of household refuse may be made to occupy a space of 3 cubic yards.

**Domestic Storage of Refuse**

The storage of house refuse in the home is done in middens, ashpits and ashbins. In no circumstances should middens be permitted, as they retain the refuse for too long in the neighbourhood of the dwellings, the refuse becomes wet and foul nuisances result. Where a weekly collection of refuse cannot be arranged for, then only should ashpits of a proper size and construction be allowed. The ashpit should not be situated nearer than 10 feet from the dwelling house, it should be made of brick lined inside with concrete, with a watertight flagged floor some 3 inches above the ground. It must be roofed and ventilated and have a proper means of access for cleansing. It should have no drain. It should be of such a size that its contents will not exceed 20 cubic feet. From the figures already given it will be seen that such an ashpit will contain rather more than 3 cwts. of refuse, and sufficient space for the refuse of one person for 200 days or a family of 5 for 40 days; the ashpit must therefore be cleansed at least every 6 weeks. In country districts it is often difficult
to secure this. In towns ashpits are rapidly giving way to an ashen system with a collection once or twice a week. The ashen is the only satisfactory means of refuse storage for the home. Many towns prescribe and approve of the type and construction of the ashen which are permitted to be used, and some actually supply and renew the bins for a small annual charge (see page 220). An ashen should be strongly constructed of galvanised sheet iron of at least 22 gauge and fitted with a closely fitting cover to exclude rain; it is usually cylindrical with a capacity as already stated of about 3½ cubic feet. Such a bin can usually be handled when moderately full by one man. Where towns prescribe or supply the bins it is possible to have special arrangements on the outside of the bins which fit on to a special dust collecting vehicle and the bin may then be emptied by tipping into the vehicle, the process being carried through without exposure of the refuse in the bin or vehicle, so that dust does not fly about. Another arrangement provides that the vehicle should set out with clean empty bins, which are left at the houses, and the full ones brought back in their place to the disposal works, but this method proves costly in practice because a large number of bins are only partly full.

The Collection of Refuse

Dustbin clearance from blocks of flats presents considerable difficulty, especially when the flats are several storeys high. This is a difficulty which can more easily be overcome in the building of new tenements than in the conversion of existing property into flats. Probably the best method to be adopted in new tenements is the provision of dust-shoots readily available to all the houses. Such shoots should normally take a straight vertical course to the collection receptacle on the ground level. The entrances to the shoots should be so designed that the refuse can be emptied into the shoot without spilling, and they should be so closed that dust and odours do not escape therefrom. Any junction from the entrance to the main shoot should be very short and have an easy angle. The shoot should be 9 inches to 12 inches in diameter, of rounded cross section and be made of glazed stone-ware, so as to prevent the adhesion of dust and be easily cleansed. If this is thought out at the time of the erection of the tenements, such shoots would afford an excellent means of collection of refuse from the tenements.

There has been introduced into this country in recent years, a system called the "Garchey" system for the collection and transport of refuse from new tenements, in which the waste water from the sink is utilised to assist in the removal of house refuse. The sink is specially designed, having a 6-inch outlet supported upon a cast-iron container,
the outlet from which, as well as that from the sink, being closed by a specially designed plug. The outlet from the container is trapped and ventilated. The house refuse is deposited in the container, which also receives the sink water, and the sink water and refuse passes from this container to a collecting chamber. When the collecting chamber is full, the whole sink water and refuse is sucked from it into the disposal plant. The refuse is there dried by hydro-extraction and afterwards burned. This system is a Continental one, and although it appears to work satisfactorily in Leeds, it is still too early to express an opinion upon its general utility. In flats which have been adapted from old property, particular attention should be directed to the collection and disposal of refuse. No general system can be laid down for all cases, but the system adopted should be made as convenient as possible in every circumstance, as otherwise fouling of the surroundings will take place by the more thoughtless and careless of the tenants.

Transport of Refuse

The means of transport from the homes varies in its details in different districts. The size of the load depends greatly upon whether horse or motor traction is used and the distance from the central depot. Generally now motor traction is replacing horses and the differences in size in motor traction are contingent upon the gradients in the town and the distribution and density of the houses on the land. Motor freighters carry from 30 to 50 cwts. per load—that is, their internal capacity is from 6 to 10 cubic yards. The interior of the body ought to be so constructed as to be easily emptied and cleansed; the best material is sheet metal for the body, which should be provided with covers of similar material to prevent dust flying. Generally the loading line should be kept low so as to facilitate loading and tipping.

Disposal of Refuse

The ultimate disposal of the refuse may be undertaken in several ways; which system is adopted in any locality depends a good deal on local circumstances and a great deal on local caprice. The main test to apply to any system is to see how far it complies with the sanitary requirement of rendering a dangerous material, such as house refuse, innocuous, without creating in the process, or later on, dangerous nuisance. Next in importance is the question of relative net cost, and lastly the incidental values and faults of the system apart from sanitary considerations. If these tests are applied in this order it will be appreciated that the work of disposal can only be done by a local authority whose primary aim should be sanitary
efficiency, not low costs. The systems at present in use may be considered under three heads, (1) Incineration, (2) Sorting and pulverisation, and (3) Tipping.

Incineration

Incineration may be carried out in a high temperature destructor, working with forced draught at a temperature over 1500° F., or in a low temperature destructor working with natural draught. The high temperature destructor is apt to give rise to a grit nuisance from its chimney, while the low temperature destructor should be fitted with a special coke furnace to burn the fumes. The high temperature incinerator will consume about 10 cwt. of refuse per day per square foot of grate surface and the low temperature one about 5 cwt. per day per square foot. Before incineration a rough sorting may take place to keep back any metal or other material of commercial value. On the whole, incineration is a good system; it is not entirely free from nuisance; the situation of the destructor has to be most carefully chosen, the plant is costly and consequently few destructors are erected and transport costs are thereby increased. As has already been pointed out, house refuse is constantly decreasing in calorific value. The heat generated may be used to raise steam for some useful purpose and the clinker, which is hard, may be used for making concrete or for other purposes.

Sorting and Pulverisation

In sorting and pulverisation the refuse is first graded by revolving screens which separate dust to be used as manure and cinders to be used for steam raising; the refuse is then thrown on a moving pickerband and iron is extracted magnetically and paper, rags and other materials picked off by hand. The iron is compressed and sold as scrap iron, the paper and washed rags are sold to the paper manufacturer and bottles, earthenware jars, etc., may be washed and sold. Finally the remainder of the refuse is pulverised with mechanical hammers and sold as a dry, odourless powder of some manurial value. The whole process cannot be considered good from the point of view of sanitation. It is apt to give rise to nuisance, the conditions round the works and the conditions under which the workers are placed are bad, and the revenue from the salvage will seldom give a return in normal times, for the buildings, plant and spare land required.

Tipping

Tipping is met with in three forms, (1) tipping in the sea, (2) crude tipping on land, and (3) controlled tipping. Disposal by tipping into
the sea can only be carried out in certain localities, the refuse must be taken well out to open water and the discharge must be timed to suit tides and local currents. Despite all care the floating refuse may be blown back on the shore and this method of disposal even in favourable situations has little to recommend it. Crude tipping has nothing to be said in its favour, for even its cheapness is more apparent than real. Rats and flies are attracted to the loosely tipped masses and infest them. The lighter materials in the tips are scattered by the wind and the constituents of the tip are disturbed by rats and birds and human agencies. Fire may start in the tip, giving rise to large volumes of smoke and may go on for months, while, on the other hand, objectionable decomposition may be set up. Mass or crude tipping must in all circumstances be unhesitatingly condemned.

Controlled Tipping

Controlled tipping is a method of tipping designed to obviate the serious objections to mass or crude tipping. In many localities it has been conducted with remarkable success from every point of view and it has come to be recognised as free from objection and of the widest application. Controlled tipping is a carefully planned and executed operation whereby household refuse is placed in a favourable position for undergoing a rapid and complete disintegration, or rotting, without causing nuisance. This is attained by a method akin to shallow burying in which, by natural forces, complex nitrogenous and carbonaceous matters are broken up and subsequently oxidised to those simpler and more stable compounds found in the upper layers of the soil. There are four main points to be considered in planning the operations:—the site, the method of tip building, the covering material, and the nature of the refuse.

If the work is well done, the site is the least important of these considerations, as, with proper precautions, almost any site can be made satisfactory. Good controlled tipping has been done in the immediate neighbourhood of dwelling houses, schools and public places without nuisance and with little or no complaint. The system is well adapted for land reclamation, the filling in of old quarries and the levelling up of areas of land laid waste by underground workings or other industrial processes, and the land reclaimed can be laid out in parks, gardens, playing fields and the like. Though depressions in land are admirably suited for this system, sides of hills can be made equally suitable, the tipping smoothing out and altering the contour of the land. Controlled tipping from one point of view is a building operation in which the refuse is submitted to a moderate degree of pressure, and for this purpose there must be a fixed plane from which the tipping starts, and two other fixed planes
set at an angle to the first and to each other, along which the tipping proceeds. For this reason, tipping on a hillside must be begun at the foot of the hill and the tip built upwards in terraces running along the front of the hill, and for this reason again, mound tipping, or the making of artificial hills on flat ground is impossible, unless adequate concrete retaining walls are first built. A moderately well drained site is better than a damp one, but dampness is no bar, and even the collection of casual water at the foot of a quarry is not a difficulty that cannot be surmounted. Having regard to the cost of transport to the tip, a site near at hand to the population to be served is to be preferred.

The method of tip building is the most important of all considerations. The floor of the site, or, at any rate, that portion to be used at once, must be surveyed and made flat and firm. This latter can be done with the refuse itself, provided that after compression an average of not more than six feet of refuse is required for the purpose. If more than this is required, a level floor may be made with the refuse in layers, as subsequently described. When water tends to collect in the hollows, the level floor is better made with clean hard ashes. If the firm floor has been made with the refuse, a nine inch layer of covering material is placed over it and the major operations can be commenced. The area of the floor must be set out and marked in lines parallel to the line of the proposed tipping, the exact distance between these parallel lines depending for the most part upon the width and kind of waggon that carries the refuse to the tip, as the waggons will travel between these lines and may have to turn. As this determines the width of the face of the tip, it is an advantage to keep the lines as close as possible and 30 feet is usually sufficient. Along these lines, at intervals of about 30 feet, narrow wooden posts are erected which project exactly 6 feet above the floor level. The top of the post can be daubed with red paint, or capped with a tin can, to distinguish it. The whole of the floor having now been divided up in parallel alleys, tipping is begun on the alley formed between the floor and the other fixed plane, that is, the side of the hill, if such is the site. Loads of refuse are brought to this alley and tipped over the starting place, which should be a firm embankment, 6 feet high, with a convenient road leading to it. The tip is formed by the sorting and compression of the refuse, so that, as far as possible, no air spaces are left between the component parts. Bottles or earthenware have to be broken with a hammer, tin and metal containers compressed or filled with rubbish, bundles of rags and old mattresses and carpets spread out, the whole being pressed down as firmly as can reasonably be attained by manual labour by the men working on the face. In this fashion, the refuse is reduced
in bulk to about one-half of the loose freighter refuse. The face of the tip must move evenly forward, perpendicular to the sides of the alley. In vertical height it is 6 feet, extending, therefore, up to the top of the guide posts, and the face slopes down at an angle of about 45 degrees. The open side of the alley slopes down at the same angle. The face, sides, and top of the tip are sealed at the end of
each day's working with a layer of 9 inches of earth or other suitable material, so as to exclude air as far as possible. The face of the tip with each day's working gradually moves along the alley to its end, and tipping can then be begun in the contiguous alley at the end where the tipping in the first alley commenced. With the hand compression exercised when the tipping was done, and with the vehicles continuously moving over the surface, the refuse in the first alley has been subjected to considerable pressure, and the side of this alley, in its turn, provides the second fixed surface necessary for tipping and compression along the second alley. So the tipping proceeds along each alley in turn, until the whole floor is covered with refuse 6 feet deep, surmounted by a 9-inch layer of earth or other covering. It is usual to sow grass seed on each alley after completion of the tipping, and by the time the floor is covered, the greater part of the area of operation is covered with grass. Having so covered the floor, with tipped material and earth, a new floor has been made on which the same series of operations can be repeated.

The best covering material is earth and road sweepings. The poorest covering material is ashes, because the latter do not seal the tip efficiently. The decomposition occurring in a well-made controlled tip is always complete in less than two years' time, when the material which has been built into the tip will be found to be very similar in constitution to earth, and this may justifiably be used as covering material afterwards. Considerable difference of opinion exists as to whether so much as 9 inches of sealing or covering material is required. It is becoming clear that in a well-built and compressed tip, 6 inches, or less, is sufficient for ordinary household refuse, but when the refuse contains in large part, fish, offal, animal or other organic materials, the refuse must be covered forthwith by a layer of covering material at least 2 feet in depth.

The changes that go on in the refuse in a controlled tip are not at the moment capable of a clear scientific explanation. The nitrogenous matter and the carbonaceous matter undergo chemical changes, dependent apparently upon some low form of life. These changes are influenced to the largest extent by the prevention of the free circulation of air, and if this is not effectively done, the changes will occur much more slowly. As has been already indicated, the building and compression of the material are the main factors in preventing such free circulation, aided by a reasonable amount of sealing. The changes are accompanied by the generation of heat. This is thought to be due to bacteria, whereby the oxygen in the air of the tip is used up and the roting of the refuse is encouraged. At the present time this is largely theoretical, but what is important to remember is that the changes that are taking place in a controlled
tip are due to a variety of living organisms, each of which requires for its growth, certain optimum conditions. As the conditions change, each variety in turn has an opportunity of playing its part, until the decomposition is complete. So far as temperature is concerned, there appears to be a limit (well under boiling point) beyond which organisms will not function, so that at this limiting point, the changes depending on the functioning of the organisms cease, and temperature falls, so that we get a sort of living thermostatic control, preventing any risk of spontaneous combustion.

In the tipped refuse, a thermometer sunk 3½ feet and observed daily, shows a fairly rapid rise, so that in a week or a fortnight's time, a temperature of as much as 170° F. may be reached. Thereafter the temperature will be steady for a day or two, then fall slightly. The temperature will remain at this lower level for some months, and then slowly fall to a fixed normal temperature. When this is attained, decomposition is complete. The exact temperatures recorded at these various stages seem to vary somewhat in the few places in which such observations have been made, probably due to slight differences in the method of working and in the composition of the refuse. It is to be noted, however, that the changes are not affected by the external temperature, and it is clear that at the time when the materials in the tip are of most value to rats as a food supply, the increased temperature of the tip prevents its invasion and infestation by these animals. In any case it may be taken as a fact that, when properly built, these tips do not fire and they are not rat-infested.

Cockroach infestation seldom gives much trouble in tips where the work of building is properly done. Crickets may be found wherever a sufficient degree of compression has not been maintained, for example, alongside quarry walls where the dust wagons do not pass. Crickets are almost regularly found in bakehouse refuse and thereby find their way to tips, and care is necessary to build so as to give them the minimum chance of shelter. If found to be infesting any part of the tip, they can be exterminated by the application of some crude disinfectant, usually some cresol compound, to the part affected, and it may be necessary to dig up the surface before applying the cresol. They are usually easy to deal with and form the only infestation found in controlled tips.

It cannot be too strongly stressed that sanitary success in controlled tipping is dependent almost entirely on the careful supervision and management, and on the intelligence and care which the foremen and workmen exercise in carrying out the work. There are two quite simple tests to check how the work is being carried out. First, the refuse should be compressed, in the first instance, to at least half
the bulk it occupied in the dust carts, and second the newly-made surface of the tip should show an even fall, not exceeding 10 per cent. of the depth of the layer of refuse after 12 months. There always is a fall from the changed constitution of the refuse during this time, but if it is excessive, the suspicion arises that a detailed and careful compression has not been carried out in the tip building. The drop in the surface can easily be detected by reference to the tops of the guide posts forming the alleys, and if the tops reappear out of the 9-inch soil covering them, the drop in the surface has been too great, and requires investigation. The Ministry of Health have issued certain suggested precautions upon controlled tipping, most of which have been referred to above. By this means of tipping, it will be observed that only a very small area of refuse stands exposed during the operations, and that each evening the tip is left covered in a tidy condition. In areas where controlled tipping is taken up, initial complaints may be made, but experience shows that they invariably cease, as the public appreciate the freedom from nuisance, the tidiness of the method, and the good results attained.
Fig. 74.—Controlled Tipping forming Playing Fields.