that the character of the shed in which it gathers guarantees its excellence. Mountains and hills of Laurentian gneiss receive the rain-fall, as we have already seen, in the beautiful valley of the Croton, and after being filtered by pure siliceous sands and gravel, the liquid is restored to the surface through numberless springs, feeding ponds, which serve as natural storage reservoirs, and creating rivers, down whose course it is borne to the great basin of Croton Lake. In some places it lingers over swamps, and at certain seasons of the year, as when snow melts in spring, it is discolored, but its purity is remarkable at all times, so thorough is the filtration it receives.

VILLAGE SANITARY WORK.

It is a recently recognized, but an old and universal, truth that human life involves the production of refuse matters which, unless proper safeguards are taken, are sure to become a source of disease and death. The danger is not confined alone, nor chiefly, to that element of household waste which is most manifestly offensive, but in almost equal degree to all manner of organic refuse. It is true that fecal matters are often accompanied by the inciting agent of the propagation of infectious diseases. For convenience, and as indicating the more probable means for disseminating infection, we may call this agent "germs." It has not yet been demonstrated with scientific completeness that a disease is spread by living germs whose growth in a new body produces a corresponding disorder; but all that is known of the circumstances of infection, and of the means for preventing it, may be fully explained by this theory. Typhoid fever, cholera, epidemic diarrhea, and some other prevalent diseases, are presumed to be chiefly, if not entirely, propagated by germs thrown off by a diseased body. So far as these ailments are concerned there is, therefore, a very serious element of danger added in the case of feces to the other evil effects which are produced by an improper disposal of any refuse organic matter. That any one or all of these diseases can originate from the decomposition, under certain circumstances, of fecal matters is not clearly determined. There is, however, good reason for believing that one common effect of the gases arising from improperly treated matters of this kind, is to debilitate the human system, and so to create a disposi-
tion to receive contagion, or to succumb to minor diseases which are not contagious.

The same debilitating effect and the same injurious influences, often result from the neglect of other organic wastes. The refuse of the kitchen sink is free from fecal matter, but it contains, in a greater or less degree, precisely the kind of organic material which has gone to make up the more offensive substance. If its final disposition is such as to contaminate the water that we drink or the air that we breathe with the products of their decay, the danger to life is hardly less than that from the decomposition of fecal accumulations.

It is proposed now to set forth, in the simplest way and without much discussion of principles (which may be studied elsewhere), the methods and processes by which village households and communities may be protected against the influences that come from an excess of soil moisture, from damp walls, and from imperfect removal or improper disposal of organic filth.

We will assume that a village has a water supply sufficient to admit of the use of water-closets in all houses, and to furnish a good flushing for kitchen sinks, etc. A necessary complement of this work—indeed it should properly precede it—is the establishment of a system of sewers by which all of this liquid outflow may be carried safely away. It would be out of the question in a small or scattered community, especially where roadways are unpaved, to establish any system which should include in its working the removal of surface water. The moment we undertake to make sewers of sufficient capacity to carry away the storm water of large districts, then we enormously increase the scale and cost of the work.

So far as the removal of house sewage alone is concerned, the work need by no means be very costly. If a tolerable inclination can be given to the line of sewers, say a fall of one in two hundred, a six-inch pipe will have a capacity quite up to the requirements of a village of 2,000 inhabitants using 100 gallons of water per day per head. It will, however, be safe to use a pipe of this size only when it is true in form and carefully laid, so that there shall be no retarding of the flow at the joints from the intrusion of mortar, or any other form of irregularity. Unless the joints are wiped quite smooth, the roughness remaining will serve as a nucleus for the accumulation of hair, shreds of cloth and other matters which will hold silt and grease, and form in time a serious obstruction. Nothing smaller than six-inch pipe should be adopted for a street sewer. Unless the work is to be most carefully done, for all but the branch lines, for a population of 5,000, or less according to the fall of the sewer, it will be safer to use eight-inch pipes. These pipes must be laid with great accuracy as to grade and direction. All corners should be turned with curves of large radius and regular sweep, and with an additional fall to compensate for the increased resistance of curves. The weight of the pipe should not be supported upon the sockets [see Fig. 1], partly as a question of strength, and partly because any irregularity of form or thickness of the socket would change the inclination of the sewer. The bottom of the trench being brought exactly to the required grade, let there be dug out a depression greater than the projection of the socket, the pipe resting upon its finished bottom for its whole length. [See Fig. 2] Too much care cannot be given to the thorough filling with cement of the space between the socket and the pipe inserted into it—the whole circle being well flushed and wiped, so that there may be no possibility of leakage.

The objection to leakage is twofold: sewage matters escaping into the soil might contaminate wells and springs; and it would also rob the flow through the pipes of water needed to carry forward its more solid contents. The continued efficiency of these small drains for carrying away the solid or semi-solid outflow of the house, is dependent very largely upon the presence of sufficient water to create a scouring current. While eight-inch pipes are admissible as a safeguard against imperfect laying, they are liable to the grave objection that where the service to be performed is greatly less than their capacity, the stream flowing through them will not be sufficiently

Fig. 1. Pipes resting on their shoulders.

Fig. 2. Pipes resting on their full length.
concentrated to carry forward the more solid parts of the sewage. Up to the limit of their capacity, six-inch pipes, properly laid, are greatly to be preferred, as insuring a deeper stream which will more generally attain the velocity of three feet per second, needed to move the heavier constituents of the sewage. The difference in cost between six-inch and eight-inch pipes will be sufficient to cover any extra cost of the most careful workmanship. However much attention may be given to the cementing of the joints, it will be impossible to prevent the running into the pipes of a certain amount of mortar, and the workman should have a swab or a disk of India rubber of the exact size of the bore of the pipe, with a short handle attached to its middle, to draw forward as each joint is finished, and so scrape away any excess of mortar, before it hardens.

Wherever it is, or may probably become, necessary to attach a house-drain or land-drain, there should be used a length of pipe having a side branch, oblique to the direction of the flow, to receive such connection. The location of these branches should be accurately indicated on the plan, and they should be closed with a flat stone or a bit of slate, well cemented in place.

It will at times be necessary to use larger conduits than even an eight-inch pipe. Up to a diameter of fifteen inches, it is cheapest to use pipes, but for eighteen inches or more, brick-work is cheaper, and at that size—a considerable regular flow of water being insured—the slight roughness of brick-work offers no serious objection. The use of oval or egg-shaped sewers will rarely be necessary under the circumstances that we are considering, but there may be exceptional conditions where the covering in of a brook, or storm-water course, cannot be avoided, and in such cases the volume of water may vary so greatly that there will at times be a mere thread of a stream, and at times a torrent. Here the oval form is the best, as concentrating a small flow within a narrow and deep channel, and still giving the capacity needed for exceptionally large volumes. All bricks used for sewers, man-holes, etc., should be of the very hardest quality, and true in form. The general rule is to be kept in mind that the thickness of the wall of a brick sewer should not be less than one-ninth of the inner diameter, that is to say that up to a diameter of three feet the thickness of the wall should equal the width of a brick—four inches. This applies to circular sewers only; the oval form, being less strong, calls for a wall of a thickness equal to one-eighth of the largest diameter.

Connecting drains leading from houses to the sewer are to be made at private cost, but they should be made in accordance with plans furnished by the public authority, and by a workman acceptable to that authority.

The householder might be permitted to take the responsibility of the finishing of his drain but for the fact that the working of the public sewer calls for the largest amount of water in proportion to the amount of solid matters that it is possible to secure, and thus makes it imperative that this drain should be absolutely tight, so that the liquid parts of the house outflow shall not trickle away through its joints, only the more solid parts going into the public sewer.

Properly graded and smoothly jointed, a four-inch pipe will carry more water than even the largest boarding-house or country hotel is likely to discharge. There is, however, a tendency in all house-drains to become filled in the early part of their course by the accumulation of grease and solid matters caught in the grease. Where no form of grease-trap is used, there is a certain argument in favor of the use of six-inch pipes for the upper part of house-drains. The use of a grease-trap, however, should always be insisted upon, and with its aid these obstructing matters will be retained, and the outflow may be perfectly carried by a four-inch pipe.

So far as the public sewer is concerned, it makes little difference what is the size of the house connection drain through the greater part of its course, but the junction with the sewer should, under no circumstances where six-inch sewer-pipes are adopted, be more than four inches. I should even insist on four-inch connections with an eight-inch sewer. Through neglect, or by reason of improper management, many kinds of rubbish find their way into house-drains, and a four-inch opening will admit as many of these into the sewer as it will be able to carry away. If by reason of bad construction or neglect, an obstruction is to be caused at any point, it should be in the drain, which the person responsible for it must cleanse or repair.

The grease-trap referred to above may be any form of reservoir which will retain the flow from the kitchen sink until it has time to cool, when its grease will be solidified, and will float at the surface. The outlet from this trap should be at such a distance below the surface of the water that there will be no danger of its floating matter pass-
ing in with the discharge. A very simple device for this purpose is shown in Figure 3. From a trap of this sort the flow is constant whenever additions are made to its contents.

Figure 4 shows the invention of an English engineer, Mr. Rogers Field, which has the effect of retaining all of the outflow from the kitchen sink until it is entirely filled,—say thirty gallons. When filled, any sudden addition of a few quarts of water, as from the emptying of a dish-pan, brings into action a siphon, whose entrance is near the bottom of the tank, and this siphon rapidly discharges all of the contents above its mouth in a flow having sufficient force to carry forward, not only any solid matters which it may contain, but also any ordinary obstructing accumulations in the drain below. The soil-pipe carrying the discharge of water-closets should not be delivered into the flush-tank, but at a point further down the drain, so that any solid matter it may deposit shall be swept forward by the next action of the flush-tank. The more often the flush-tank is filled, and the greater the proportion of its water to its impurities, the more efficient will be its action. Therefore, the slop closet waste leading from the upper story, and even the outlet pipes of bathing-tubs, may with advantage be delivered into it.

Although the flush-tank may receive no fecal matter, and even though the housemaid’s sink may not deliver into it, it will contain in the discharge from the kitchen alone an amount of organic matter which will produce offensive and dangerous gases by its decomposition. To provide for the safe removal of these gases a ventilating pipe should be carried up to some point not near to any window or chimney-top.

From the time the sewers are ready for service no accumulation of fecal matter or other organic household waste should be allowed to remain in the village. All old vaults and cess-pools should be filled with earth and disinfected by the admixture of lime with the upper layers of the filling. The use of water-closets in all houses should be made imperative, and the construction and arrangement of soil-pipes and of all outlets should be regulated by the health authorities.

It is not worth while here to discuss the details of the construction of water-closets and other interior plumbing work, except with reference to soil-pipes and such drains as may deliver the outflow of the soil-pipe to the public sewer. All soil-pipes should be of cast-iron, carefully jointed with lead, not less than four inches in diameter, and carried by the straightest course possible up through the roof and higher than the ridge-pole. Its open top must not be near any window, and if within ten feet of a chimney it should be at least two feet below the level of the top of that chimney. There should be no trap in the soil-pipe and no trap in a private drain between the outlet of the soil-pipe and the sewer. The reasons for this rule are twofold:

1. No matter what amount of water may be used for flushing out the soil-pipe, its sides will always be more or less coated with organic filth, and however slight this coating there will be a certain amount of decomposition. The decomposition of all such matters must be rapid and complete, not slow and partial. A necessary condition of complete destructive decomposition is an abundance of atmospheric air to supply the oxygen which complete decomposition demands. If the soil-pipe is closed at its top, or if it is obstructed by a trap in the lower part of its course, there can be no such circulation of air as safety requires.

If there is an opportunity for the free admission of air from the sewer to feed the
upward current almost constantly prevailing in a soil-pipe open at both ends, the gases resulting from the decomposition will be of a different and less injurious character than where the air is confined,—and by the mere volume of air passing through the pipe they will be so diluted that even were they originally poisonous their power for harm will be lessened. The gases formed by the decomposition of organic matter in the sewer itself, or in the soil-pipe, have a certain expansive force which is greatly increased by the elevation of temperature, caused, for example, by the discharge of hot water into the pipe or sewer. If the soil-pipe is open at its upper end this expansion will be at once relieved, but if the top of the pipe be closed there will always be danger of the forcing of the feeble barrier offered by the ordinary water-seal trap of a branch pipe leading from a wash-basin or sink. Then, too, the sealing water of the trap readily absorbs any foul gases presented at its outer end, toward the soil-pipe, and gives it off in an unchanged condition at the inner or house end. Such traps retard, but do not prevent, the entrance of sewer gases into the house. Water-seal traps which are unused for any considerable time are emptied by evaporation, and thus open a channel through which the air of the soil-pipe may find its way into the house.

It is usual in modern plumbing to relieve the pressure of gas in the soil-pipe by what is called a "stench-pipe." This is a pipe from one to two inches in diameter, leading from the highest point of the soil-pipe to the outside of the roof, where it is bent over to prevent the entrance of foreign matter, or is closed at the top and perforated with holes to allow the gas to escape. This small stench-pipe is inadequate for the necessary work. It is very important that there be the freest possible channel for the movement of air, and nothing will suffice for this save the continually of the pipe, at its full size, to its very outlet. Indeed, angles and bends in a pipe form a serious obstruction.

The arrangement of the soil-pipe here indicated, although excellent and efficient, is susceptible of further improvement by the use of a ventilating cowl or hood at the top of the soil-pipe. There are many forms of such cowls in use which are effective whenever there is a sufficient current of wind; but most of them require a certain force to bring them into action, and when this force is absent they usually retard the flow they are intended to increase. This is true of a recent invention known as "Banner's ventilating cowl," which so long as the wind blows is a most effective device. When the air is perfectly still, however, it offers by its curved air-way a certain resistance to the current, and in the case of baffling winds and flaws the air may blow directly into its opening.

Among the various inventions of this sort nothing seems so free from objection as the old arrangement known as the "Emerson" ventilator, shown in Figure 5. This gives a vertical outlet, protected by a disk far enough above it not to prevent its delivery of air, and it becomes an effective suction cowl, with the least movement of the wind from any side or from above or below. No eddy caused by the angles of gable roofs can give it a backward draught, and if a pipe armed with it be held forward the strongest gale a puff of smoke blown into its other end will be instantly drawn through. As the patent for this invention has run out, it is competent for any tinsmith to make it, and it is a common article of manufacture.

II. What is said above concerning the ventilation of the soil-pipe from end to end relates to the interest of the private owner. The interest of the public gives an equally strong argument in its favor. The sewer should be as far as possible removed from the condition of an "elongated cess-pool." There must be no halting of its contents, and no deposit of filth or silt at any point. Within the shortest time possible, everything received into the sewer must be passed on and delivered at its outlet. Still, however perfectly this may be accomplished, there will always be a certain adhesion of slime to the walls of the sewer, and this slime must always be in a state of decomposition,—a constant source of offense and possible danger. The only way to avert this danger is to give the sewer such a thorough ventilation that the decomposition shall be rapid and safe, and that the resultant gases shall be at once diluted with fresh air.
This may be accomplished by the simple ventilation of the sewer itself, through open-topped man-holes; but such ventilation is less effective in the case of small sewers than of large ones. In the case of either large or small sewers it will be vastly increased if we compel every householder who makes a connection with the sewer, to carry a drain and soil-pipe, nowhere less than four inches in diameter, from the point of junction with the main line to the open air above the roof. Where houses are near enough to make the use of a public sewer advisable, the aggregate of these soil-pipes having, almost constantly, an upward current, will make such a draught upon the sewer, to be supplied by a downward current through the man-hole covers, as will maintain a perfect and continuous ventilation.

Important as it is to secure the proper arrangement and construction of sewers and house-drains, it is still more important to provide for the safe disposition of the sewage.

We must begin at the outset with the understanding that all sewage matters not only are of no value to the community, but that it will cost money to get rid of them.

There is hardly an instance, after all the efforts that have been made, of the profitable disposal of the outflow of public sewers. The theoretical value of the wastes of human life is very great, but the cost of any method for utilizing it seems at least equally great. The question of cost is so much more important (to the community) than the question of agricultural value, that the practical thing to do is to make such disposition as will cost the least, while fully meeting the best sanitary requirements.

So far as village sewage is concerned, there are three means open for its disposal: to discharge it into running water or into deep tide-water; to use it for the surface irrigation of land; or to distribute it through sub-irrigation pipes placed at little distance below the surface of the soil. Experiments are being made with more or less promise of success in the direction of the chemical treatment of this liquid so as to purify its effluent water, and retain in a solid form, and in combination with certain valuable added ingredients, all of its undissolved impurities. None of these processes can as yet claim consideration in regulating public works.

The cheapest way to get rid of sewage is to discharge it into a running stream or into tide-water. So far as the community itself is concerned, this is often the best way, but there will very often arise the objection that the community has no moral or legal right to foul a stream of which others make use in its further course. Where the amount of water constantly flowing is very large, and where the discharge is rapid,—any given part of the sewage reaching the open air within a few hours from the time of its entering the pipes,—and where it flows in moving water for a considerable distance before reaching others who may have occasion to use the stream, no practical danger is to be apprehended. But where the sewage is more foul, more sluggish, or exposed in the open current for a shorter time, the danger may be serious. The pouring of sewage into tide-water is always admissible where floats show that there is no danger of a return and deposit of solid filth; but the delivery, at all stages of the tide, in the immediate neighborhood of salt marshes and mud flats, and in land-locked harbors is to be avoided.

Where an unobjectionable natural outflow cannot be provided, the irrigation of agricultural lands affords the best relief. The action of vegetation, the oxidation which takes place in the upper and well aerated layers of soil, and the well-known, but not yet fully explained, disinfecting qualities of common earth, are effective in removing the dangerous and offensive impurities, and in converting them into a more or less important source of fertility. Precisely how far this system may be available during winter it is not easy to say. While the earth is locked with frost, there must be very little, if any, infiltration; but as an offset, the action of a low temperature upon the sewage matters will clearly be antiseptic, and it is only necessary to provide against an undue washing away of the surface of the ground during thaws, and against the flowing of the sewage beyond the proper limits.

Generally, in the neighborhood of villages it will be easy to find lands over which the delivery may be carried on throughout the year without objection. The sewer, or some form of covered channel, should lead far enough from any public road to avoid offense. From this point it may be led by open gutters to the land over which it is to be spread,—or rather through such a system of surface gutters as will enable us to deliver it at different parts of the field, according to the requirements of the crops, and so as to use fresh land at frequent intervals, leaving that which has been saturated to the purifying processes of vegetation and atmospheric action.
The gutters having been made, it is easy, by the use of portable dams,—of thin boiler-iron, like broad shovels,—which may be set in the course of the flow, to divert the current into any branch channel or to stop it at any desired part of this channel. All the gutters having sufficient descent to lead the sewage rapidly forward, it is usual to set a dam near the far end of the gutter and allow the sewage to overflow and run down over the surface until it has reached as far as the formation of the ground and the quantity of the liquid will allow it to spread. This portion having received its due amount of the liquid, the dam is moved to a higher point and the overflow is allowed to spread over a second area. In this way, step by step, we irrigate all that may be reached by a single gutter. Then the moving of the dam in the main line turns the water into another gutter, and this is proceeded with in like manner. In practice it is found best to begin the overflow at the farthest end of the lowest-lying gutter, working step by step until the higher parts of the field are reached. It would be better that there should be land enough to require the irrigation of any given area not oftener than once in one or two weeks. The amount required for a given population cannot be determined by any fixed rule,—so much depending on the amount of water used per capita, and on the absorptive character of the irrigated soil. In the case of villages, one acre to each five hundred of the population would generally be found ample. There are several instances of the successful use of a much smaller area than is here indicated, by the use of intermittent downward filtration. The most noted instance of success in this direction is that at Merthyr-Tydvil in Wales, a large mining town, where the allowance is only one acre to each two thousand of the population. There are two filter-beds of light loam over a gravelly subsoil thoroughly underdrained with tiles at a depth of six feet. One of these beds is cultivated with some crop, like Italian rye-grass, which bears copious irrigation, and the other by some crop, like wheat, which, in the absence of irrigation, will thrive on the fertility left over from the previous season. The volume of sewage is very great, but the action of the six feet of earth in removing its impurities seems to be complete,—the water flowing out from the drains having been proved by analysis really to be far purer than the standard fixed by the Rivers Pollution Commission.

It is an important condition of this system that the sewage, where its quantity is small, shall be stored in tanks until a large volume has accumulated, and that it then be rapidly discharged over the soil. There is no objection to an actual saturation of the ground provided the soil is not of such a retentive character as to be liable to become puddled and so made impervious. The tanks being emptied, the flow ceases until they are again filled. During the interval the liquid settles away in the soil, by which its impurities are removed. Its descent is followed by the entrance of fresh air, and the oxidizing action of this, accompanied during the growing season by the purifying effect of the growing crop, leads to an entire decomposition or destruction of all organic matters.

The third system,—the distribution of sewage through irrigation pipes laid at a depth of ten or twelve inches below the surface of the ground has its efficiency attested by numerous instances in private grounds. I have with confidence adopted it for disposing of the sewage of the village of Lenox, Massachusetts, where there was no other means available short of cutting an outlet at great expense through a considerable elevation. This system is an extremely simple one, and is available in every instance where even a small area of land lying slightly below the level of the outlet is to be commanded. The arrangement of the sub-irrigation pipes is simple. Suppose that in land having an inclination of about one in two hundred, occupied by grass or other growth, a trench be dug twelve inches deep, that there be laid upon the bottom of this trench a narrow strip of plank to insure a uniform grade, and that upon this plank is laid a line of common agricultural land-drain tiles,—say two inches in diameter. However carefully these tiles may be placed, there will be at their joints a sufficient space for the leaking out of any liquid they may contain,—the tiles being laid either with collars around the joints or with bits of paper laid over them to prevent the rattling in of loose earth during the filling. The excavated earth is to be returned to its place, well compacted, and covered with its sod. Suppose this drain to have a cross section equal to three square inches, and a length of one hundred feet, its capacity will equal about sixteen and a half gallons or a half barrel. If this amount of liquid be rapidly discharged into the drain, the inclination being slight, it will
at once be filled or nearly filled for its whole length, and the liquid will leak away in tolerably uniform proportion at every joint along the line and will saturate the surrounding earth. The plan adopted at Lenox and recommended for all small villages which cannot secure a better outlet, is simply a multiplication of these drains to a sufficient extent.

A description of the manner in which the Lenox work is arranged will illustrate the adaptation of the system to its circumstances. As circumstances vary, the adaptation must be modified. [See Fig. 6.]

The main outlet sewer delivers at a distance of about one-half mile from the last junction with a branch sewer. It is a six-inch pipe five feet below the surface of the ground, and it delivers into a flush-tank like that shown in Figure 4, but having a capacity of about five hundred cubic feet. This tank stands at the upper side of a field having an inclination of seven in one hundred. There is a branch from the main sewer, above the tank, supplied with a stop-cock, by which, in case of need, the sewage may be carried on down the hill without going into the tank. The outlet from the chamber below the siphon leads off in another direction down the hill, and has a stop-cock and a branch which will allow its flow to be diverted. The discharge through the branch of the main above the tank, both deliver into a horizontal surface gutter, to be well grassed, and lying at the top of the land to be irrigated. By this arrangement, should repairs become necessary in the tank, the flow may be turned into the gutter; or, should it be desired for any reason to use the outflow of the tank for surface irrigation, the second branch outlet will deliver it into the same gutter, where, the overflow being uniform along the whole length of five hundred feet, the stream will pass in a thin sheet off on to the descending ground. The hill-side, immediately below the gutter, is brought to a true grade and covered with grass. As its inclination is much greater than would be admissible for sub-irrigation drains, these are laid obliquely in parallel lines at intervals of six feet from one end to the other over the whole graded slope. These drains are connected at their upper ends with the direct outlet pipe leading from the siphon chamber. They have an aggregate length of about ten thousand feet. The method of operation is as follows:

The capacity of the tank is supposed to equal about two days' discharge, or about thirty-five hundred gallons, and the whole capacity of the drains is about half that of the tank, so that the rapid emptying of the whole volume into them will insure their being pretty thoroughly filled from end to
end. This arrangement will provide for the saturation of the soil about once in two days, and will leave a sufficient interval between the periods of saturation for the thorough dispersal and aeration of the filth.

The extent to which this system will be interfered with by frost it is impossible to say. This will probably be less than would be supposed, for the reason that the ground would often be covered with snow, and that the sewage will have sufficient warmth to exert considerable thawing influence. Whenever the discharge of the liquid through irrigation pipes is shown to have become obstructed by freezing, it will only be necessary to divert the flow and turn it into the surface gutter to be distributed over the ground.

It is possible that in this case, as in the one which has been under my observation for six years past, there will be no interruption of the working because of cold, but should the interruption become serious, I shall propose the planting of evergreen trees in parallel rows midway between the drains. The protection that would thus be afforded, both by the trees and by the drifting snow which they would gather, would probably keep the ground free throughout the winter. Incidentally to the chief advantage of this system, there will be, so long as the land is in grass, quite an addition to its product.

These works were nearly completed in the autumn of 1876, but will not be entirely ready for use until the coming summer, so that I am unable to point to their successful working in support of my argument. They constitute, however, only an extension of a process which, here and in England, has been in successful operation for ten years.

There are hundreds of villages, with and without a water supply, where the houses are too scattering and the street lengths too great to make it advisable that the heavy cost of any form of public sewerage should be assumed. In all such villages, the public authority or the active influence of the Village Improvement Association should be exerted to secure a regular and systematic adoption of some more perfect system for the private disposal of household drainage than is usual. Fortunately, the best system is the cheapest.

No form of cess-pool, no leaching vault, and no cemented tank should be allowed under any circumstances. Neither should there be permitted any form of the old-fashioned out-of-door privy with a vault. Every household should be supplied with water-closets, or well-arranged earth-closets, to which reference will be made below.

The foul water discharge of kitchen sinks, or of whatever form of slop-sink is used for the water of bedrooms, should discharge into a flush-tank, and should be led from this by a tightly cemented four-inch drain to a tight settling basin in the ground beyond. If water-closets are used, the soil-pipe should deliver into the drain between the flush-tank and the settling basin. The settling basin should be constructed as shown in Figure 7, and this, as well as the flush-tank, the soil-pipe, and the connecting drains, should be amply ventilated. The outlet from the settling basin should be carried by well-cemented, vitrified pipes (four-inch) to the connection with the subsoil irrigation pipes. The flush-tank discharging at each operation of its siphon about thirty gallons of liquid, two hundred feet of drain, unless the soil is very compact, will dispose of the whole discharge with sufficient rapidity. The tank being emptied, the flow ceases, and within a very short time the drain becomes empty of its contents, which are absorbed by the sponge-like action of the earth, and are subjected to the combined influence of the roots of plants, and of the concentrated oxygen contained among the particles of the soil. They will soon have their character entirely changed, so that the earth will become purified, and will be ready to receive the next discharge from the tank. In the case of my own drains, after five years of unremitting use, the gradual accumulation of bits of grease and more solid matters obstructed the drains, and there appeared undue moisture about their upper ends. All that was then necessary was to re-open the

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FIG. 7. SETTLING BASIN.
trenches, and remove, wash, and replace the tiles. This operation cost for a length of two hundred feet less than three dollars.

For any ordinary household of six or eight persons, where the water-closet is not used, two hundred feet of drain of this sort will be sufficient. If there are water-closets, it may be well to duplicate the length; and, to provide for the necessary connections to lead the liquid to the drains, we may assume that in all five hundred feet of length will be required. The cost of two-inch tiles, at the works, in small lots and where collars are furnished, is about three cents per foot, and we will suppose that transportation will increase the cost to five cents per foot, making the cost of this item twenty-five dollars. The strips of board (three inches wide) will cost, at a very liberal estimate, five dollars more, and the cost of digging and laying not more than another five dollars, so that the establishment of this method of disposal, under the most liberal allowance of prices, will not exceed thirty-five dollars. Ordinarily, especially where neighbors combine to buy their material in larger quantities, it will hardly exceed one half of this amount. This, be it understood, is for a complete and permanent substitute for the expensive and nasty cess-pool now so generally depended upon in the country.

A piece of ground fifty feet square, having ten rows of tile five feet apart and fifty feet long, will suffice for even a large household with an abundant water supply. For the better illustration of the arrangement of this system, I give in Figure 8 a plan for the work in the case of a lot fifty feet wide, with a depth of open ground behind the house of somewhat more than fifty feet. The leaching-drains may safely begin at a distance of even ten feet from the back of the house—requiring for the whole a clear area of only fifty feet by sixty feet. With small households the length of drain may be very much shortened. In my own case, where water-closets are not used, the total length of irrigation drain is only two hundred feet.

The Earth-Closet was invented by the Rev. Henry Moule, Vicar of Frodingham in England, more than ten years ago. Its progress in England has been considerable, and its introduction there has resulted in a profit to the company undertaking it. In this country it has met with less general favor; two companies, with large capital, after expending all their resources, have been obliged to abandon their attempts to build up a profitable business. Having been actively interested in the enterprise from its inception, and having given constant attention to the merits of the system, I am to-day more than ever convinced that the solution of one of the most difficult problems connected with country and village life is to be sought in its general adoption. The public reports of sanitary officers in England, who have investigated the subject to its foundation, fully confirm every thing that has been claimed by the advocates of the earth-closet, unless, perhaps, in connection with the incidental question of the value of the product as a manure. The only thing which now deters the authorities of some of the larger manufacturing towns of the north of England from adopting the dry-earth system as a means of relief, under the sharp exaction of 'the law that prohibits

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**FIG. 8.**
ing the chief purpose of deodorization, fails to add to it a sufficient amount of fertilizing matter to make it an available commercial manure. Extended experience in small villages and public institutions seems to confirm his view that if the earth-closet is to be adopted by towns, they cannot depend either on farmers buying the manure, or undertaking the labor of supplying and removing it. It is estimated that for a population of one hundred thousand persons, there would be required seventy-five tons of earth per day, to say nothing of heavy refuse matters which would be thrown into the closets, and would increase the amount to be removed. Even the quantity required for a village of a few hundred inhabitants, if it were to be brought in and carried out, would entail a considerable cost for handling.

I have recently concluded an experiment of six years' duration, the result of which seems to show that this objection to the adoption of the earth-closet system may be set aside or at least reduced to such proportions as to make it unimportant. In the autumn of 1870 I had brought to my house, where only earth-closets are used, two small cart-loads of garden earth, dried and sifted. This was used repeatedly in the closets, and when an increased quantity was required additions were made of sifted anthracite ashes. I estimate that the amount of material now on hand is about two tons. We long since stopped adding to the quantity, finding that the amount was ample to furnish a supply of dry and decomposed material whenever it becomes necessary to fill the reservoirs of the closets.

The accumulation under the seats is discharged through simply arranged valves into bricked vaults in the cellar. When these vaults become filled,—about three times in a year,—their contents, which are all thoroughly decomposed, are piled up in a dry and ventilated place with a slight covering of fresh earth to keep down any odor that might arise. After a sufficient interval these heaps are ready for further use, there being no trace, in any portion, of foreign matter or any appearance or odor differing from that of an unused fresh mixture of earth and ashes. In this way the material has been used over and over again, at least ten times, and there is no indication to the senses of any change in its condition.

A sample of this material has recently been analyzed by Professor Atwater, at the Connecticut Agricultural Station, at Middletown. The analysis shows that it contains no more organic matter than Professor Voelcker found in fresh earth prepared for use in the closet,—say about two hundred pounds,—nearly all of which organic matter it undoubtedly contained when first made ready for use. In my case, there was an addition at a moderate calculation of at least 800 lbs. of solid dry matter during the six year's use by an average of four adult persons. Professor Voelcker's analysis showed that the unused earth contained about twelve pounds of nitrogen. Professor Atwater's analysis shows that my two tons contained only about eleven pounds of nitrogen. By calculation, the 800 pounds of solid dry materials added in the use of my material contained 230 pounds of nitrogen.

Doubtless the constitution of Professor Voelcker's sample was somewhat different from the original constitution of my own; but, practically, except perhaps for the addition of a trifling amount of residual carbon remaining after the decomposition, they were about the same, and after being used ten times over, the whole of the 800 pounds of organic matter added, including 230 pounds of nitrogen, seem to have entirely disappeared.

It becomes interesting and important to know what has become of this added matter. That it was absorbed into the particles of the earth is a matter of course, and the result proves that after such absorption it was subjected to such a chemical action of the concentrated oxygen always existing in porous dry material as led to its entire destruction. Porous substances condense gases—air, oxygen, etc.—in proportion to the extent of their interior surface. The well-known disinfecting action of charcoal—the surface of the interior particles of which equal from fifty to one hundred square feet to each cubic inch of material, and all of which surface is active in condensing oxygen—is due not simply to an absorption of foul-smelling odors, but to an actual destruction of them by slow combustion, so that the same mass of charcoal, if kept dry and porous, will continue almost indefinitely its undiminished disinfecting action.

The earth used in the closet is a porous material, sufficiently dry for the free admission of air or of oxygen. The foulest materials when covered with dry earth at once lose their odor, and are in time as effectively destroyed by combustion (oxygenized) as though they had been burned in a furnace. The process is more slow but none the less sure; and it is clear that in the case of my dirt-heap the
THE SOUL'S IMMORTALITY.

foul matters added have thus been destroyed. The practical bearings of this fact are of the utmost importance. Earth is not to be regarded as a vehicle for the inoffensive removal beyond the limits of the town of what has hitherto been its most troublesome product, but as a medium for bringing together the offensive ingredients of this product, and the world's great scavenger, oxygen. My experiment seems to demonstrate the fact that there is no occasion to carry away the product from the place where it has been produced, as, after a reasonable time, it has ceased to exist, and there remains only a mass of earth which is in all respects as effective as any fresh supply that could be substituted.

The quantity necessary to provide can be determined only by extended experiment; my experiment proves that the amount needed does not exceed one thousand pounds for each member of the household, and that this amount once provided will remain permanently effective to accomplish its purpose.

With a suitable public supply of water for the purpose, and with a suitable means of disposal, nothing can be better and nothing is more easily kept in good condition than well regulated and properly ventilated water-closets. Where these are available, with enough water for their flushing, their use is to be recommended. Where there is not sufficient water, there a well-regulated system of earth-closets seems to be imperatively demanded. By one process or the other we must prevent the fouling of the lower soil, and the consequent tainting of wells and springs, and the ground under houses and adjoining their cellars. With a system of sub-irrigation pipes which deliver foul matters into earth that is subject to the active operation of oxidizing influences, we need fear no contamination of the deep and un aerated soil. It would be better, however, where this system is used, for the disposal of the outflow of soil-pipes, to avoid the use of wells. As a general rule, it is safer not to use for drinking purposes the water of any well near a house or a stable,—practically, it is better not to use wells at all as a source of water for domestic supply. Filtered cistern water is greatly to be preferred.*

* For further discussion of this topic by the same writer, see the "Home and Society" department of the present number.—ED.

THE SOUL'S IMMORTALITY.

AN ATTEMPT AT A SOCRATIC DIALOGUE.

Socrates. Wherein, Alciphron, does a living tree differ from a dead tree?

Alciphron. A living tree adds to its bulk. A dead tree loses from its bulk.

Soc. And wherein besides this?

Al. A living tree produces fruit, and seed also, by which its kind is propagated. A dead tree does neither of these things.

Soc. And besides these?

Al. A living tree prefers light, and also a soil suited to its demands, as possessing richness and moisture. A dead tree is indifferent to such things.

Soc. And once more?

Al. A living tree chooses such elements from the soil as make for its own prosperity, and enable it to yield what it was intended for; and it rejects what do not belong to it. A dead tree makes no choice.

Soc. And yet once more?

Al. A living tree is always seen making an effort to repair any injury that happens to it. If its bark or covering, for instance, is bruised, it sets itself to work at once to heal the wound. A dead tree does nothing of the kind.

Soc. And the more thriving, and prosperous, and happy, the living tree is, the more certain it is to do these things. Is that not so?

Al. I think that is also true.

Soc. And is there any stage in the life of a tree or plant, when it first begins to do these things, having up to that time failed to do them?

Al. I think there is no such stage in the life of a tree or plant. They do these things from the beginning.

Soc. A tree then never is guilty, as a child is sometimes, of things hurtful to itself, so that we say of it, "when it is old enough, it will know better?"

Al. I think not.

Soc. And whether do you regard a living tree or a dead tree with the most pleasure?

Al. Certainly the living tree.

Soc. And why the living tree?

Al. For many reasons. It is much more beautiful and pleasing to the eye, as a living object is always more agreeable to look at than a dead object.