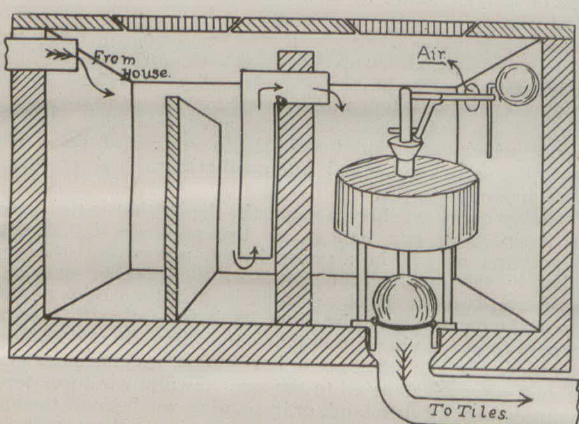
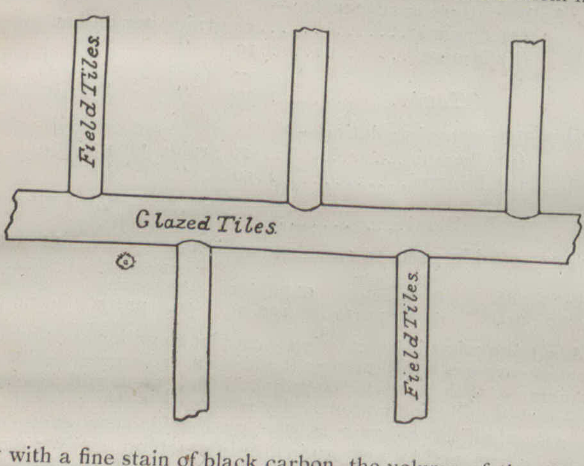
in solution as potash, lime and other salts, which will likewise be carried away in the water. It thus appears that some 100 grains of insoluble mineral matter will deposit in the tank daily with small amounts of carbon, or in 365 days for such a household not more than 10 lbs. of mineral matters will have accumulated. That such is true may readily be proved by anyone caring to make the experiment, as I have done, that such a tank at the end of a year has not had a total deposit of solid matter, greater than can be held by a half-bushel measure. If the balance then, after decomposition, is capable of being carried along with the 200 gallons of water daily, it is clear that nearly all of it is capable, like any other soluble material, of soaking away into the soil with the water, if the conditions are favorable.



I have had drawn up for your inspection the diagram of a tank, which is intended to deal with such materials in a way to give the organic matter an opportunity to decompose, the water carrying the soluble materials, being gradually removed from the decomposing tank, which we may call the septic tank—the word septic meaning putrid or decomposing—to a second tank, whence it may be discharged by a simple apparatus, at such intervals as may be found practical to produce the best results. The question then arises: In what manner can we dispose of this organic matter in solution, conveniently and in such a way as will not create a surface nuisance, or a pollution of ground water? Let us assume that by a series of sub-surface tiles, laid in a proper manner, we can distribute the 200 gallons over an equal number of feet of surface. It is plain that each square foot would receive 1 gallon of water daily. As soils vary in their capacity for water, from a coarse sand which will hold in its interstices not more than 25 per cent. of its volume of water, to a tenacious clay which holds 75 per cent. of its own volume of water, it is apparent that if one gallon of water were poured on the surface of a cubic foot of dry soil, there would not be any water leaking away from the bottom of even a coarse sand, since a cubic foot of water equals 6.25 gallons; so that it requires 1½ gallons to be poured on such foot of dry sand before it begins to drain away from the bottom. A dry clay would hold three times as much before it began to leak. In practice it will be seen that two four-inch tiles, laid side by side, would distribute such water fairly well over the surface of a cubic foot of earth; and also that the water contained in them soaking out of the open joints and pores of the tiles would rapidly dispose of the small amount of water received by each tile daily. In practice it is found that in any ordinary porous sandy soil or sandy loam, tiles filled twice daily will rapidly dispose of the charge of soluble sewage poured into them; and, lifting up tiles after several years' use, I have found them lined



only with a fine stain of black carbon, the volume of the tile not being materially lessened. I have further found that even heavy clay soils with an occasional underdrain have been quite adequate to dispose of the amount of sewage poured into them from an institution of 125 inmates.

It may be proper now to briefly describe the method of construction of such a system of tanks and sub-surface tiles. As in any system of house sewage, it is convenient to arrange all the fixtures so as to discharge into one soil pipe. These being brought out beneath the ground-floor through the foundation, or, if the house be on a hill-side, it may occasionally be possible to bring them out under the cellar floor so that the wash-tubs there may be discharged into them, if this unsanitary plan for the laundry be adopted, the soil-pipe will be led to the top of a tank made of brick and cement in a manner similar to that shown in the diagram. If most convenient, this tank may be built directly against the house to save iron pipe and to prevent its appearance on the lawn, since, as will be seen in a moment, it is necessary that the discharge pipe of the tank on level ground be not more than a foot beneath the surface. The capacity of this tank in the case we are discussing will be such as to hold in each compartment 100 gallons, to be discharged twice daily. It will be seen therefore, that a compartment 2 x 3 x 3 feet will nicely hold 100 gallons, or a tank of interior measurement 4 feet long by 3 wide and and 3 deep is adequate for two compartments each holding 100 gallons.

The arrangement of the interior of the tank is shown in the diagram. As in all sewage tanks, the plan is adopted of having several divisions, the sewage becoming less dense as it passes from one to the other, thereby aiding to make that discharged from the valve chamber as thoroughly liquid as possible.

It will be seen that from compartment No. 1 to No. 2 the fluids are drawn off by an overflow pipe from about midway beneath the surface since at the bottom will be found sediment, while the whole surface is covered with the decomposing matter, which appears to the eye a solid mass, but is really the organic material kept floating by the contained gases of decomposition. The liquids, which pass over of course contain a large amount of organic matter in solution, being composed especially of ammonia (NH_3) and carbonic acid (CO_2) combined as ammonium carbonate with the sulphur compounds as ammonium sulphide. These are held in the second compartment until 100 gallons have accumulated, at which moment the flush valve operates automatically and discharges in a minute or two the contents of the tank into the sub-surface tiles. It is apparent that the size of the tanks may be made such as to deal with 1,000 gallons quite as readily as with a 100.

The sewage thus discharged must, it is evident, be carried to tiles so laid that each tile will get its own share of sewage and no more. It is apparent that with a rapid discharge, the tiles laid on an exact level will each receive this amount, if together they hold exactly 100 gallons, provided the air which is in them be displaced. It is found in practice that in a loose soil the air from tiles laid near the surface readily gives place to the water, if discharged under the head in the tank. Where the soil is level, as of a lawn or garden, it is apparent that the matter is a simple one. If on a slope it is equally apparent that some careful detail work will be necessary in order that the tiles may, at the same time, be kept at the same depth beneath the surface and also receive each its own share of sewage. To complete the description of the tank it is apparent that as some gases, in excess of what are in solution, may be given off into the space over the sewage, it will be necessary to prevent them from accumulating and forcing themselves through the cover of the tank. This is obtained by making the cover of rough boards, and if thought proper, they may again be covered with earth and sod. The gases, if any pass outward, will be absorbed by the soil. In addition to this however, it is necessary to provide for the ventilation of the tank. This is done by a large goose-neck leading from the distal end of the tank, which admits cold fresh air and thus will displace the warm gases of decomposition which are carried up through the soil-pipe to be discharged above the roof as in ordinary house-plumbing in cities where the separate sewerage system is in operation. It may be asked, what ultimately becomes of the organic matter carried away in solution. In reply I would say that through the action of the microbes of the soil the ammonia salts are rapidly nitrified—that is, are changed into nitrates or nitric acid, which at once combines with the lime and potash salts of the soil and thus has become a neutral salt in a condition to act as plant food for the grass or vegetables growing above it.

The following table by W. D. Scott Moncreiff, from the Ashstead experiments, 1895, illustrates the change:—

Effluent from cultivation tank.

Chlorine	Free. NH_3	N.	Oxygen consumed	Nitric Nitrogen	Total Oxidized N	Total N of all kinds
9.0	12.5	10.3	9.843	0.12	0.12	12.46

From final filter tray after complete nitrification.

Chlorine	Free. NH_3	N.	Oxygen consumed	Nitric Nitrogen	Total Oxidized N	Total N of all kinds
7.5	0.25	0.2	0.58	9.0	9.0	0.6

As the tank arrangement from which these experiments are taken, was essentially a tank of this kind, except that, instead of the microbes of the earth to do the work Moncreiff had arranged a series of artificial filters or pieces of coke over wnich the sewage from the septic tank flowed, by which means the liquids for analysis could be obtained, there is nothing different in principle to the system we are discussing.

Little more need be said, I think,, to make it clear that in these results of the study of biological processes, which convert organic matter back to its original constituents, we have not only a practical lesson of how to apply science to our every day needs and convenience, but we may also see how economical is Nature and how wholly wise in her operations if she does not have man attempting in his ignorance to violate some of her primary laws. To me it daily seems more true, the more that I try to comprehend the meaning of the processes of Nature in this fine old world of ours.

"That nothing walks with aimless feet,
That not one life shall be destroyed,
Or cast as rubbish to the void
When God hath made the pile complete."