BULLETIN OF
KANSAS STATE AGRICULTURAL COLLEGE
Vol. 42 THE KANSAS INDUSTRIALIST No. 46
Entered at the post office, Manhattan, Kansas, as second class matter, under act of Congress July 16, 1894

SEWAGE DISPOSAL FOR COUNTRY HOMES

By F.F. FRAZIER

Bulletin No.5

ENGINEERING EXPERIMENT STATION

MANHATTAN, KANSAS
March, 1916

KANSAS STATE PRINTING PLANT.
W. R. SMITH, State Printer.
TOPEKA. 1916.
6-4207

ENGINEERING EXPERIMENT STATION.

The Engineering Experiment Station was established for the purpose of carrying on tests and research work of engineer-ing and manufacturing value to the state of Kansas, and of collecting, preparing and presenting technical information in a form readily available for the use of the various industries within the state. It is the intention to have all the work of this experiment station of direct importance to Kansas.

The station staff consists of the Director, who is Dean of the Division of Engineering, and of professors and instructors in the College from the various departments of the Division and from other scientific departments whose work is directly related to the work of this Division. The results of the investigations are published as bulletins and circulars of the Engineering 'Experiment Station, which are sent free to any citizen of the state upon request, and to others at the discretion of the director. Communications regarding bulletins, or inquiries regarding the work of the Station, should be addressed to the Director of the Engineering Experiment Station, Kansas State Agricultural College.

PRINCIPLES OF SEWAGE DISPOSAL.

Sewage disposal is a general term applied to the carrying away and. discharging of sewage, while sewage treatment is a specific term relating to some method of purification.

The essential duties of a sewer system are, first, to remove all the sewage to the place of disposal as soon as possible, and second, to dispose of it in such a way as to permanently rob it of its power for evil.

The character of sewage changes with its age and its opportunities to undergo bacterial action. Fresh sewage contains free atmospheric oxygen, derived from the water supply, and under bacterial influence its organic matter is oxidized until the dissolved oxygen is exhausted. This initial step in the decomposition of sewage is inoffensive and produces a product called stale sewage.

The following principles of sewage disposal should be noted:

1. Sewage begins to putrefy or decay in from 24 to 60 hours after it enters the sewer.
2. Sewage is decomposed by the processes of oxidation and reduction;
3. Sewage is truly purified only by oxidation.
4. Oxidation does not destroy the materials, but simply transforms them into harmless compounds.

The quality of sewage from country homes is somewhat different from that taken from the average city sewer, and, because of this fact, it can not be dealt with in exactly the same manner. Sewage from the average country home is weak in comparison with the strong effluent of the average city sewer. House sewage, such as would be discharged from the average farm home, would be composed of human excreta, soapy waters from the wash basins and the bath tubs, the wash waters used in the kitchen for cleaning vegetables, dishes, milk pans, cooking utensils, etc., and the water used in the laundry. This flow would contain large amounts of both organic and inorganic matter, and great numbers of bacteria, both beneficial and harmful.

Bearing on the question of quality, we must consider that some of the matter in sewage is dissolved and some is suspended. The latter forms the troublesome element. In ordinary farm sewage about one part in five hundred is solid matter. The chief purpose, therefore, of all preparation for a final purification of sewage is to remove as much of the suspended matter as practicable, because that which is dissolved can be oxidized with much less difficulty.

METHODS OF DISPOSING OF SEWAGE.

The methods of disposing of sewage may be grouped into three general classes: first, by the process of dilution; second, by allowing it to percolate through porous soils; and third, by reducing the suspended matter, either by sedimentation or by liquefaction due to bacterial processes, after which the liquid is disposed of either by dilution or by allowing it to percolate through a filtering medium where the process of oxidation may be carried to completion.

The Dilution Process. It is common knowledge that sewage discharged into a stream will disappear from sight and smell, provided there is enough water in the stream to dilute it sufficiently and that the oxygen content of the water is great enough to meet the oxygen requirements of the liquid discharged. This is the most inoffensive and the least expensive method of disposing of sewage and is practiced by cities whenever possible. The bacteria and the oxygen dissolved in the water act as the chief purifying factors. The oxidation is slow, and, as applied in practice, the dilution process is based on the mere endeavor to render the sewage inoffensive and not to immediately purify it. The practice of emptying large quantities of sewage into streams and lakes without first putting it through some purifying process will soon create a nuisance, and except by special permission is prohibited by law.

Broad Irrigation Process. The practice of irrigation with sewage is quite old and has been more or less successful, according to the climate, the character of the soil, the character of the sewage, and the kinds *of* plants cultivated on the land. The climate should be warm and comparatively dry. The soil considered by the best authorities to be most suitable is the light alluvium found in most river valleys. This soil, in spite of its extreme fineness, is sufficiently porous to let the sewage soak slowly through it, and as long as the amount put upon it is not so great as to cause water-logging, excellent results areobtained, owing to the very rapid oxidation of organic matter which takes place when the air in the soil becomes intimately mixed with the sewage passing through it. However, the tendency to water-logging is not always due to the large amount of sewage run onto the land, but may sometimes be caused by the absence of a sufficiently porous subsoil to carry off the purified *effluent* after its passage through the upper layers where most of the work of purification takes place. In cases of this kind the subsoil should be well drained, and Iit is usually necessary to drain it more thoroughly than is required for ordinary agricultural drainage. It has not been found advisable to place the tile more than 5 or 6 feet below the surface. The best land for surface irrigation, therefore, should consist of a fine alluvial layer overlying a subsoil of gravel, sand, or other porous material.

Where sewage is used for surface irrigation the conditions are usually favorable to the various kinds of root crops, such as beets, turnips, and the like, or any crop that will absorb large quantities of moisture. Crops like celery, lettuce, onions, radishes, and plants that are eaten without cooking, should not be grown on land irrigated with sewage, and especially is this true if it is possible for the sewage to come in direct contact with that portion of the plant which is to be eaten.

Reduction of Suspended Matter. As already stated, the suspended matter is the troublesome element in sewage disposal. The liquid portion is much more easily and safely disposed of. The suspended matter can be removed by reducing the flow to that of comparative rest, when this matter will settle and deposit. This action may be assisted by chemical precipitation, or the suspended matter may be partially removed by allowing liquefaction of the organic matter to take place. The latter action is accomplished by the bacterial process, which also improves the condition of the organic matter for subsequent filtration.

By the sedimentation and chemical precipitation processes, large amounts of sludge, or solid matter, will be deposited, and this must be disposed of. Because of this sludge problem these methods would not be practicable for sewage disposal on the farm except under special conditions. The liquefaction process of reducing the suspended matter is, therefore, most commonly employed.

SEPTIC TANK TREATMENT.

The process of liquefaction is more generally known as the septic tank treatment. It consists of the breaking down of the suspended organic matter by bacterial action. Bacteria are a vegetable growth of microorganisms which possess no green coloring matter. Some of these organisms require the presence of free oxygen to promote their growth and are called aerobic bacteria. Others do not require the presence of free oxygen and are called anaerobic bacteri~. The anaerobic bacteria are of two classes, the obligatory and the facultative.

The obligatory bacteria can not thrive in the presence of free oxygen, while the facultative bacteria possess the power of adapting themselves to live either in the presence or in the absence of free oxygen.

Each of these classes of bacteria has a duty to perform in the decomposition and the purification of sewage. Therefore, it is very important that the best possible opportunities be provided to promote their rapid growth and development. The efficiency of this method of disposing of sewage is dependent entirely upon the action of the anaerobic bacteria in decomposing the organic matter and of the aerobic bacteria in oxidizing it. Therefore, two things are necessary for the successful application of this method; first, the septic tank is required to produce decomposition and liquefaction of the suspended matter, and second, some method must be provided to furnish oxygen for the purifying action of the aerobic bacteria.

The first stage of decomposition comes with the consumption of the oxygen present in the fresh sewage. When this supply of oxygen has been exhausted the reduction process begins and numerous gaseous compounds which produce foul odors are liberated. Ammonia, hydrogen sulfide, marsh gas, and free hydrogen are the principal gases given off. In the reducing decomposition of stale sewage, the anaerobic bacteria act upon the soluble organic matter and excrete complex organic compounds called enzymes, which sooner or later partially liquefy and gasify the suspended organic matter and yield a product called septic sewage. The next stage is the purification of the sewage by the action of the aerobic bacteria in oxidizing the decomposed compounds and making them more stable.

The septic process, when properly applied, effects a substantial clarification of the raw sewage, and especially brings about a liquefaction of a large portion, from 30 percent to 70 percent, of the suspended matter. The successful operation of a septic tank depends entirely upon the bacterial action in reducing the amount of sludge deposited, and, owing to the great uncertainty of this action, much difficulty is encountered unless the tank is properly designed as to size and shape. The efficiency of the action in a septic tank depends chiefly upon the time occupied by the sewage, in passing through it, and it is quite evident that the correct determination of its shape and capacity is of first importance.

With regard to shape, septic tanks are almost invariably built rectangular, both in plan and in cross-section, although other styles have been used. The rectangular style can usually be most economically constructed for a given capacity.

When the *effluent* from the tank is to be treated otherwise than by dilution, the septic tank for the disposal of sewage from the farm home should be of two chambers or apartments. The first chamber, or septic tank proper, should have a capacity to hold from two to three days' average flow. The fresh sewage should enter the tank beneath the surface of the old already present. This is to prevent any disturbance at the surface, which soon becomes covered over with a thick layer of scum which shuts out the air and thus aids in the promotion of the bacterial growth. The inlet may be a pipe bent downward so that the opening comes several inches below the surface of the sewage in the tank, or a straight pipe may be used and a baffle board inserted a few inches from the opening arid extended down to the necessary depth to prevent any disturbance at the surface. The sewage passes from the septic tank into the second apartment, or dosing chamber, through a pipe which extends beneath the surface of the sewage in the tank about one-third of its depth; or the sewage may run over a weir which is guarded by a baffle board that extends down about one-third the depth, to prevent any disturbance at the surface and to draw the sewage from that part of the tank where the liquefaction is most nearly complete.

The dosing chamber should have a capacity of about an average day's flow. As the fresh sewage flows into the septic chamber it forces an equal volume into the dosing chamber. The amount of sewage in the septic chamber, therefore, remains constant and the bacterial action is not disturbed. When the dosing chamber becomes full it is emptied by mechanically opening a gate, or by the operation of an automatic siphon, and the contents are carried to the place of disposal.

The liquid part of the sewage has not yet been purified when it leaves the dosing chamber, but contains numberless bacteria and some dissolved organic matter which must be oxidized. The septic sewage will also contain a considerable quantity of very finely divided matter in suspension, whose specific gravity differs very little from that of the liquid and which will not settle as sludge in the short time that the liquid is held in the tank. It may also contain some colloidal or jelly-like matter which would settle, if the sewage were allowed to stand, and would give rise to troublesome putrefaction. It should be remembered that the function of the septic tank is to reduce the ~~mount of suspended matter, and that the effluent must be further treated. In order to purify this effluent and rid it of these troublesome elements, it is necessary to provide some means by which they may be oxidized by the action of, the aerobic bacteria. This may be done either by dilution, by broad irrigation, by aeration and intermittent filtration, or by any combination of these methods. .

The aerobic bacteria of the soil are powerful in oxidizing nitrites into nitrates, and the process of subsurface irrigation affords a ready means by .which the liquid from a septic tank may be purified. The conditions necessary for the successful operation of a subsurface irrigation system are almost identical with those of broad irrigation, as to climate, character of the soil, and kinds of plants grown on the land. The sewage is distributed over the land by a system of open-joint drain tile laid a few inches beneath the surface of the ground. The sewage seeps out through the open joints of the tile into the soil, where it comes in direct contact with the air of the soil and the work of oxidation begins. Water-logging must be prevented the same as in broad irrigation, and the land should constantly be broken up and cultivated so that the soil may be properly aerated. Soil under sod, however, has proven to be very effective in destroying disease germs, and the roots of the grass will keep the soil loose and well aerated.

THE DESIGN OF A SEPTIC TANK DISPOSAL SYSTEM.

The Septic Tank Proper. To design a septic tank, first determine the average daily amount of sewage discharged by the household. For the farm home this amount will fluctuate considerably for different seasons of the year. It will be safe to assume, however, that each individual of the home will use from 20 to 40 gallons of water each day, a large part of which will find its way into the sewer. Therefore, an estimate of about 20 to 30 gallons per day for each person may be used. Since the septic chamber must be large enough to hold from two to three days' average flow, it is evident that the tank must have a capacity of about 75 gallons, or about 10 cubic feet, of sewage for each member of the home. A tank designed to accommodate six persons should have a septic chamber that will hold about 450 gallons, which is equivalent to about 60 cubic feet. It is not advisable to build a tank less than 30 inches wide, inside, and the depth of the sewage in the tank should be at least 40 inches. The length of the tank will be dependent upon the amount of sewage it should hold. It is consistent with past practice to have the length of the tank equal to about twice its width. However, no general rule can be given for proportioning the dimensions of a septic tank any more than a general prescription can be given for treating every person afflicted with a certain disease. Each sewage disposal plant will be an individual case, controlled by various factors, such as the character of the sewage, the topography of the place, the amount of room for installing it, and the method of final treatment to be used.

The flow of the sewage through the tank should be slow and as uniform as possible. The flow should be evenly distributed throughout the tank, and direct currents should be avoided. Baffle boards, properly placed, will break up direct currents and help to maintain a uniform flow by diverting it to all parts of the tank. The tank should be covered, and provision must be made for the escape of the gases formed in the decomposition of the organic matter. Explosions may occur unless the space above the sewage is properly vented. It is advisable to place the top of the tank about one foot beneath the surface of the ground to help prevent freezing. Manholes should be provided for entering the tank to adjust any difficulties and to do any repair work that may be necessary.

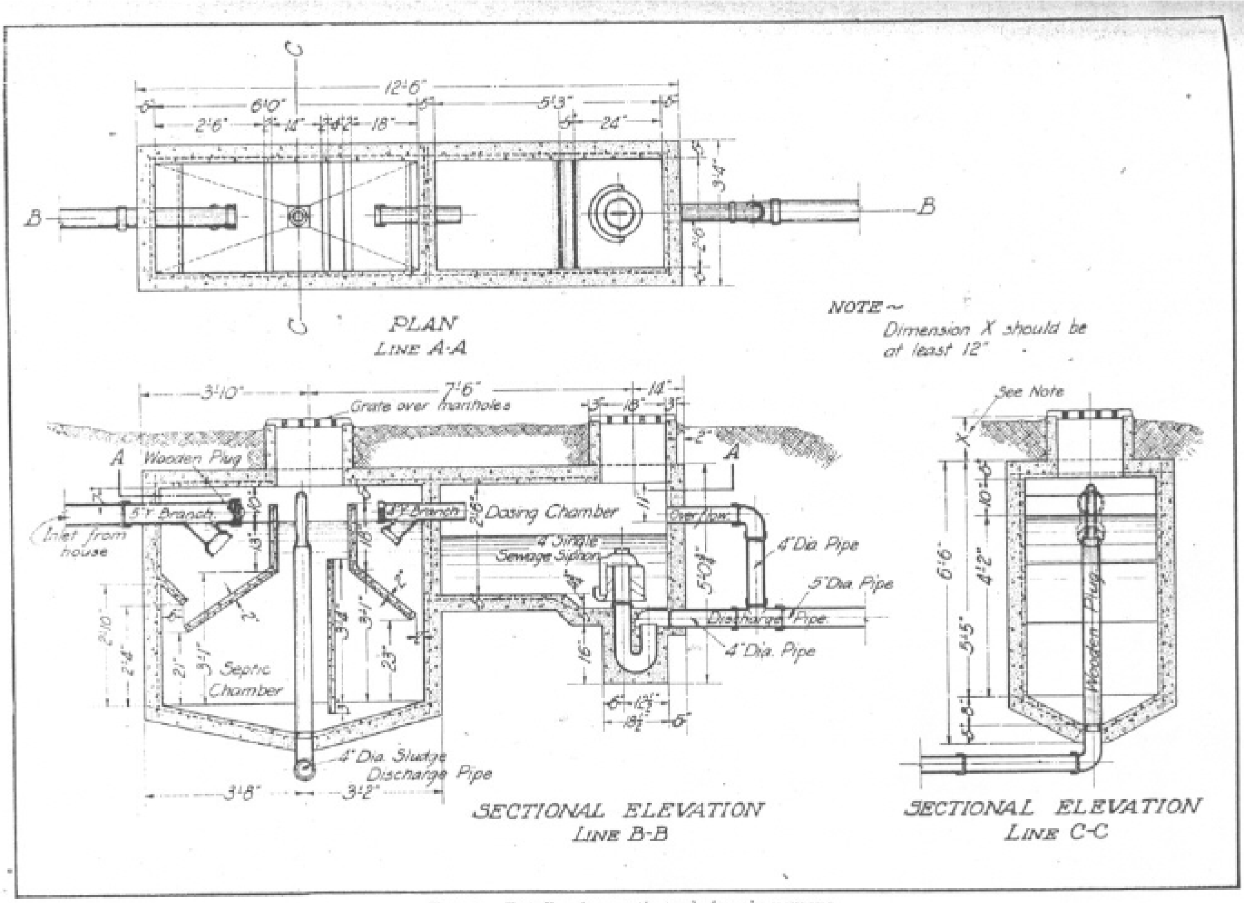


FIG. 1. Details of a septic tank for six persons.

Provision must be made for disposing of the sludge that will settle in the bottom of the tank. This will be composed of the inorganic matter and the heavier portions of the undissolved organic matter carried into the tank. From 40 percent to 50 percent of the suspended matter in the sewage will usually settle as sludge. It is very finely dived and can be mixed up in the water and pumped out of the tank or carried off in a sludge drain provided for that purpose. It is necessary, therefore, to provide a sump and slope the bottom of the tank so that the sludge will move toward the sump, to be pumped out or discharged through the sludge outlet. It will be necessary to remove the sludge from a successfully operated plant about once every two or three years.

Figure 1 shows a sketch illustrating the details of a septic tank. Figure 2 shows an isometric view of the left half of the same tank along its longitudinal section, and illustrates the position of the baffle walls, the inlet, the outlet, the siphon and the sludge drain.

The Dosing Chamber. In order to obtain the best results in the operation of the plant, sewage should not be retained in the dosing chamber longer than 24 hours. For a plant accommodating six persons and discharging once each day the dosing chamber should hold from 150 to 175 gallons. It is well, but not essential, for the dosing chamber to be made the same width as the septic chamber. The fall available for the outlet will often control the depth of the dosing chamber. The correct relation between the different dimensions is not so essential as in the case of the septic chamber. The chief purpose of the dosing chamber is to store the liquefied sewage, as it comes from the septic tank, until there is a sufficient quantity collected to distribute itself over the entire absorption system, and to allow a sufficient interval of time to lapse between discharges to permit the soil surrounding the tile of the absorption system to become aerated. If the sewage were allowed to flow from the septic chamber directly into the tile of the absorption system there would not be sufficient flow to distribute it over the entire area. The soil around the first few feet of the absorption tile would constantly be saturated with the sewage so that air could not enter it, and the aerobic bacterial growth which is so necessary for the purification of the effluent .would be destroyed. Such a plant would be nothing more than a water-tight cesspool with an outlet.

With the dosing chamber the purification efficiency of the plant is renewed after each discharge of the chamber. Unless provision is made 'for an intermittent discharge, it will be necessary to provide two or more systems of purifying tile, and it will also be necessary to pay close attention to alternating the flow from one system to another. Therefore, it is advisable to install an automatic siphon to control this intermittent discharge.

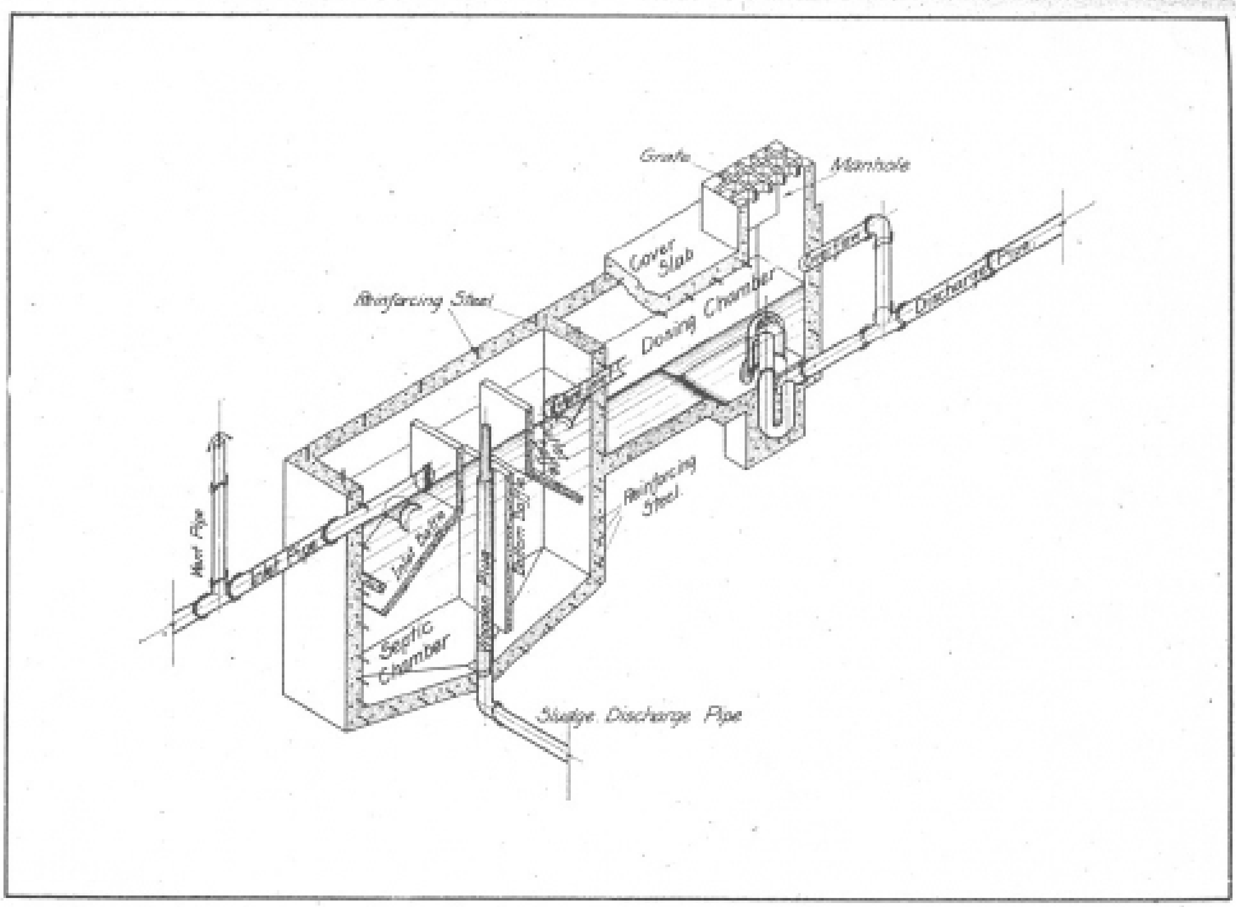


FIG. 2. Interior of the septic tank shown in figure 1.

The action of the automatic siphon is simple. Figure 3 shows the condition of such a siphon after discharge has taken place. The trap at the bottom of the U-shaped pipe is filled with water, and air is entrapped in the left-hand leg by placing a bell over its top. As the sewage is discharged into the dosing chamber its level will rise above the bottom edge of the bell, and the sewage in the tank will be prevented from discharging by the weight of the sewage in the right-hand leg of the siphon. As the level of the sewage in the chamber rises it gradually forces the air downward in the left-hand leg until the pressure of the sewage in the tank is equal to the pressure head of the sewage in the right-hand leg of the siphon. When more sewage enters the tank the pressure heads will be unbalanced and a portion of the sewage in the right-hand leg will be forced out, and thereby a sufficient suction will be created to automatically bring the siphon into action and the chamber will be emptied. When the level of the sewage in the chamber gets below the mouth of the bell, air is admitted, the pressures are equalized, and the flow ceases. When more sewage enters the tank, its level will be raised over the mouth of the bell, the siphon will be sealed, and the chamber is again ready to be filled.

The space above the sewage in the dosing chamber should be vented, and an overflow pipe should be provided to carry off the sewage in case the siphon outlet should become clogged and cease to work properly. The overflow pipe is provided to meet an emergency, and should that emergency arise the cause should be removed as soon as possible.

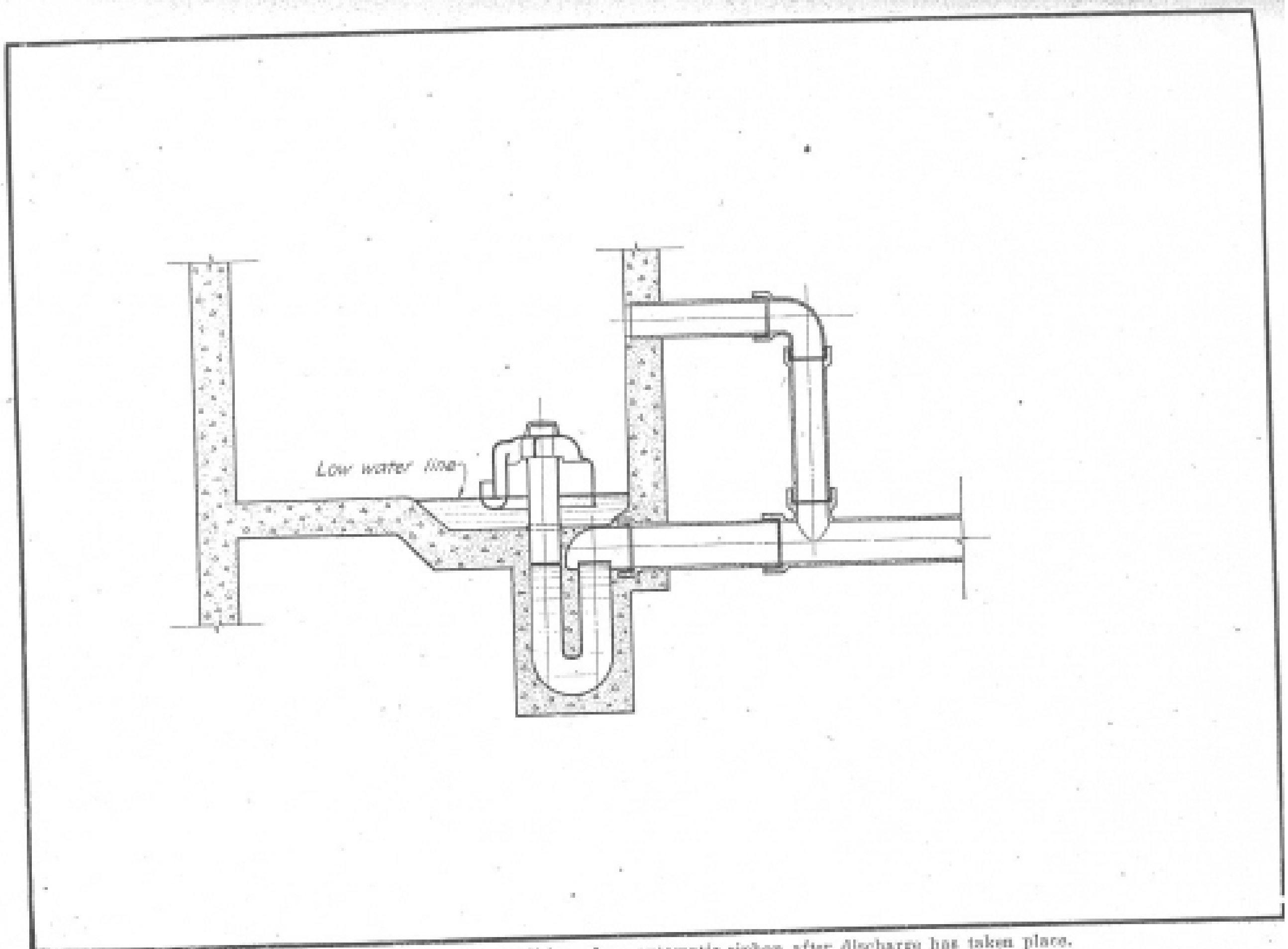


FIG. 3. Diagram showing the condition of an automatic siphon after discharge has taken place.

The Absorption System. The subsurface absorption method of purifying the effluent from the dosing chamber is the most desirable in the absence of a running stream with a sufficient flow the year round to avoid creating a nuisance. The location of the subsurface absorption system will depend upon local conditions. A light alluvial or sandy loam is to be preferred, although heavier soils can be used with proper precaution.

The drainage of the site should be away from the premises, and the system should be located so that the effluent must pass through 50 feet or more of soil or fine sand before it can reach any source of domestic' water supply. The outlet sewer from the dosing chamber to the distributing pipe should be 5- or 6-inch vitrified sewer pipe laid with cemented joints and with a fall of at least 1 foot in 60 feet. The distributing pipe should also be vitrified sewer pipe of the same size and laid level, with cemented joints. The tile lines of the absorption system are connected to the distributing pipe by T joints. (See system "C" in figure 5.)

The absorption system should be made of 4- or 5-inch first class farm drain tiles laid very carefully in line, with, open joints and on a uniform grade not greater than 2 inches per 100 feet. The top of the tile should be from 14 to 20 inches below the surface of the ground. Additional aid may be had in the working of the plant by placing about 4 inches of clean. gravel or cinders around the bottom and the sides of the tile. Tarred paper or other suitable material should be placed over the joints to keep out fine dirt.

The total length of the tiling necessary in the absorption system will depend upon the amount of sewage discharged at one time, the frequency of the discharges, and the character of the soil surrounding the tile. In general, the system should have a sufficient capacity, with, each pipe two-thirds full, to receive the entire contents of the dosing chamber.

The plan and the arrangement of the tile lines will be governed by the topography of the place and the amount of room available. Figures 4 and 5 show different plans of subsurface absorption systems. The following precautions should be observed in every case.

1. Arrange to have each tile line receive its full share of the sewage discharged.
2. Provide a ventilator at the end of each tile line in heavy soils.
3. Lay the lines not closer than 6 feet apart. Where considerable room is available 10 or 12 feet should be used: The character of the soil is the controlling factor.

Although the ground should absorb the entire flow during most of the year, proper drainage should be provided wherever necessary. If the subsoil is not porous enough to remove all the water settling from the upper, layers, a system of drain tile should be laid beneath the site of the absorption system.

It is best to avoid putting the, absorption system under, a garden or truck patch. It is better to place it under permanent sod in a field or pasture lot.

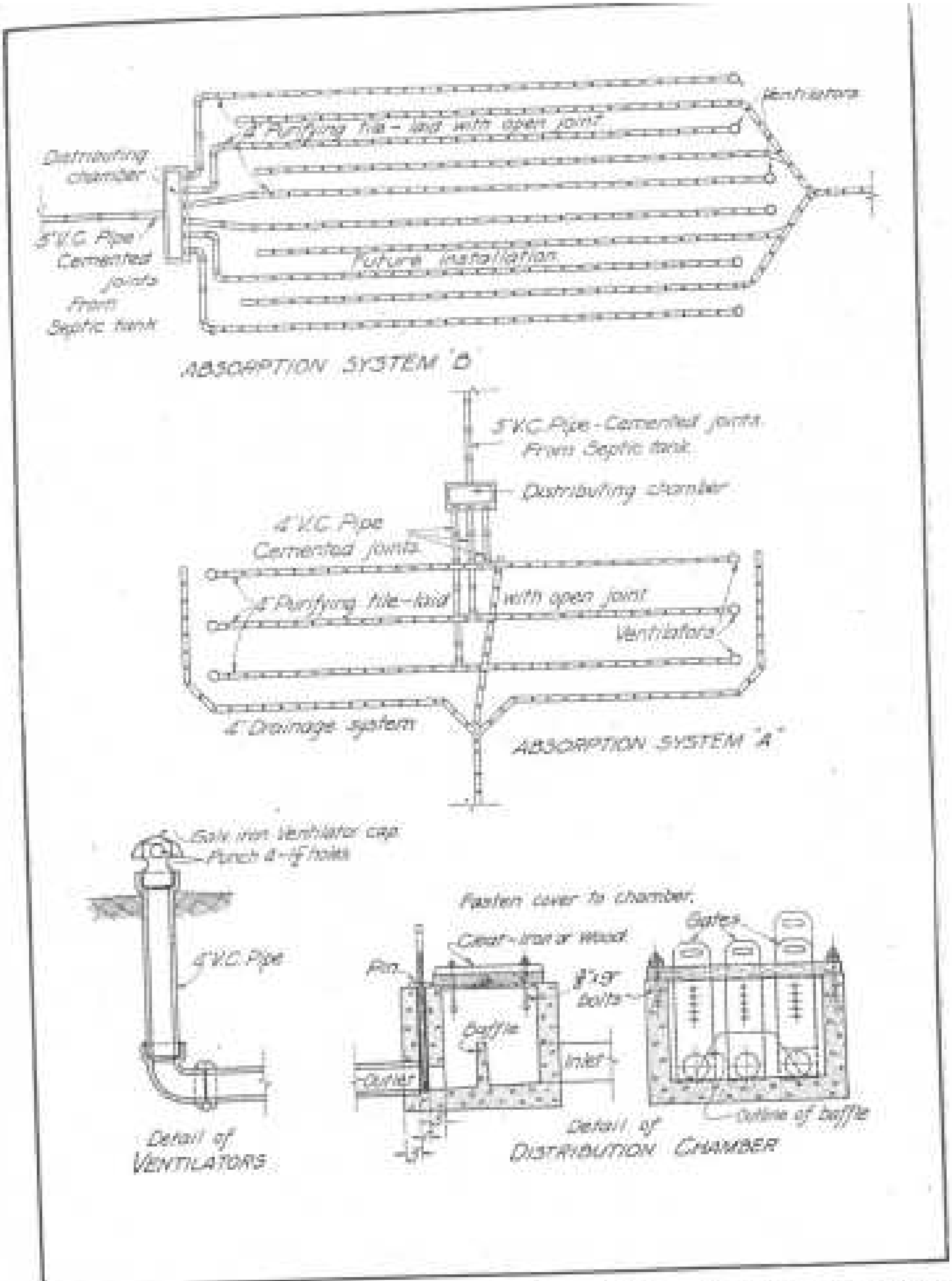


FIG. 4. Plans for absorption systems: System A, suitable for hillside; system B, suitable for flat land.
NOTE.—It is not important that the different tile lines run parallel with each other.

Drain from the House to the Septic Tank. The sewer from the house to the septic chamber should be no smaller than 5-inch vitrified sewer pipe, carefully laid with a uniform fall of not less than 1 foot in 80 feet and not greater than 1 foot in 50 feet. This pipe should be laid with cemented joints, and should be trapped near the point where it leaves the building and properly vented by a fresh-air inlet pipe just inside the trap. The sewer should also be vented just before it reaches the septic tank. Figure 5 shows a diagram of the .sewer connecting the house to the septic tank and the tank to the absorption system. The soil pipe should extend at least 5 feet beyond the foundation of the house, and its junction with the sewer pipe should be made securely water-tight. The inside plumbing should be done by a reliable and experienced plumber.

Location of the Septic Tank. Having determined the size and dimensions of the tank that will be required, the next problem is to decide where it can be placed to *get* the most satisfactory results at the least expense. The tank should be placed at least 100 feet from the house whenever possible. Neither the tank nor the sewer line running to or from it should be closer than 25 feet to any well or spring, and they should be so placed that any leakage must drain from rather than toward the source of the domestic water supply.

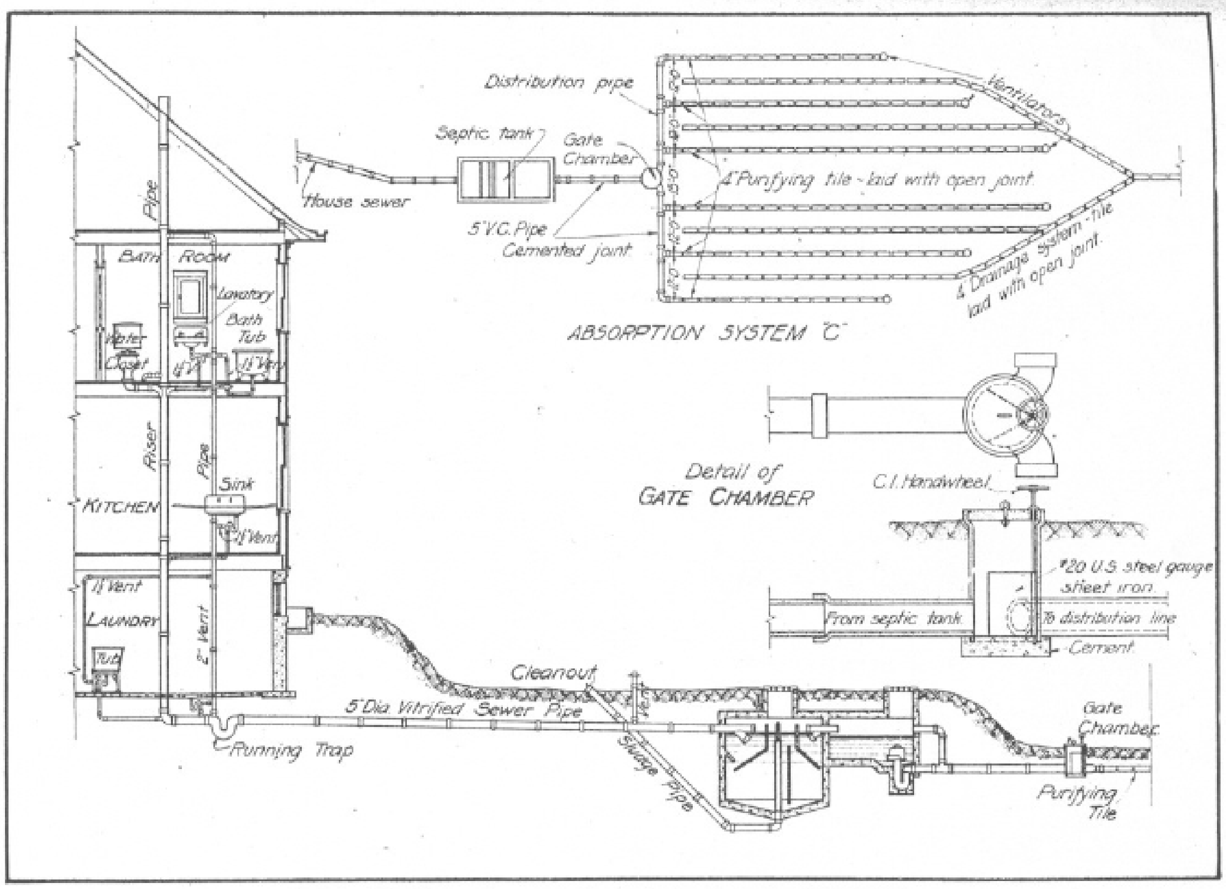


FIG. 5. Plumbing system, sewer lines and plan of an absorption system.

The location of the tank will often be controlled by the amount of outlet fall available. The tank must be so placed as to secure the proper grade for the sewer line from the house to the tank and from the tank to the place of final disposal.

Sewage Disposal Plant at Fort Hays Branch Experiment Station. A plant similar to the one just described was built at the Fort Hays Branch Experiment Station, Hays, Kan., in 1909, under the direction of the Department of Civil Engineering of the Kansas State Agricultural College.

This plant has now been in successful operation more than six years, and no serious trouble has manifested itself during that time. The work of the plant has proved to be efficient and entirely satisfactory.

THE CONSTRUCTION OF A SEPTIC TANK.

The tank may be built either of brick or of concrete and should be made as nearly water-tight as possible. If brick is used it should be laid in cement mortar and plastered on the inside with mortar of one part cement to two parts of clean sand. If concrete is used a mixture of one part cement two parts sand, and four parts crushed rock or coarse gravel should be used. For concrete, the bottom of the tank should be made first. If the excavation is in firm earth its sides and ends can take the place of the outside forms for the concrete. These sides and ends should be made smooth and the dimensions carefully made to correspond to the respective outside dimensions of the tank. In case the earth is not compact enough to stand without caving and falling into the concrete while the latter is being placed, the excavation must be made large enough to insert outside forms. Care should be taken to see that the bottom of the tank is placed at the proper elevation.

After the floor has been built and allowed to harden the inside form work for the walls and partitions can be set in position on this foundation. These forms should be built tight and firmly braced so that the weight of the concrete will not make them bulge out of shape. In figure 6 is shown a sketch illustrating one method of constructing the inside form for the tank shown in figures 1 and 2. The reinforcing steel should be put in position in the forms and securely fastened in place before starting to place the concrete. The cleats on the sides of the form shown in 'figure 6 should be properly located, and if the baffle walls are to be constructed in place, provision must be made to securely fasten the metal lath of the baffle walls with the reinforcing steel of the side walls. This may be accomplished in the following manner: Fasten pieces of No.12 gauge tie wire to the reinforcing steel of the side walls and brjng them directly to the face of the cleat; then bend the wires and extend them along: the face of the cleat for 8 or 10 inches and fasten down with a couple of staples. The wires should meet the face of the cleat at intervals of about 10 or 12 inches, and two wires should be used at each point. When the forms are removed these wires will extend along the bottoms of the slots and can be used to fasten the reinforcing metal of the baffle walls in position. This metal should be some form of woven fabric that will hold the cement mortar well, and it should be rigidly supported while the plaster is being applied. The following mixture makes a very satisfactory plaster: One part Portland cement, three parts clean sand, and a small amount of hair. Enough hydrated lime should be added to make the mortar work well under the trowel.

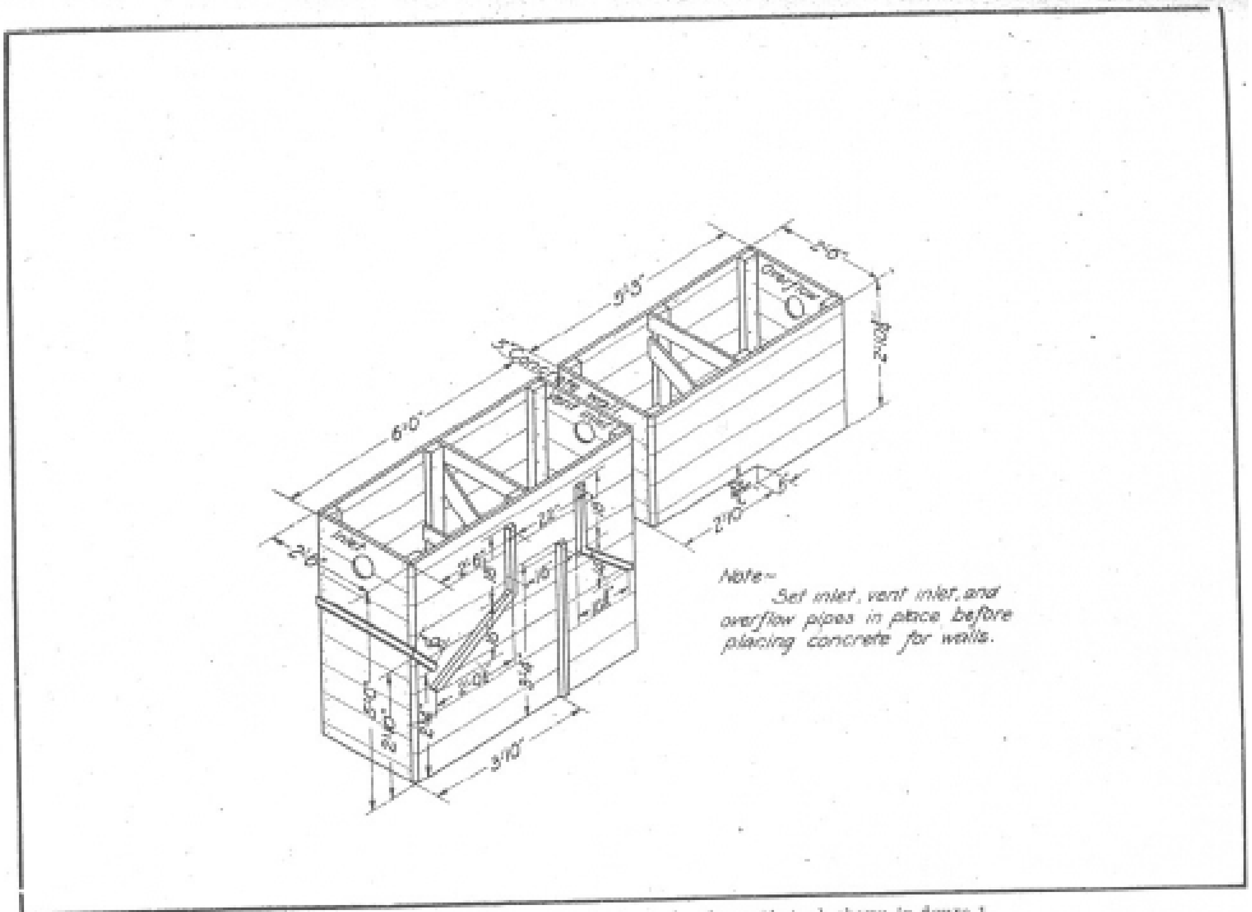
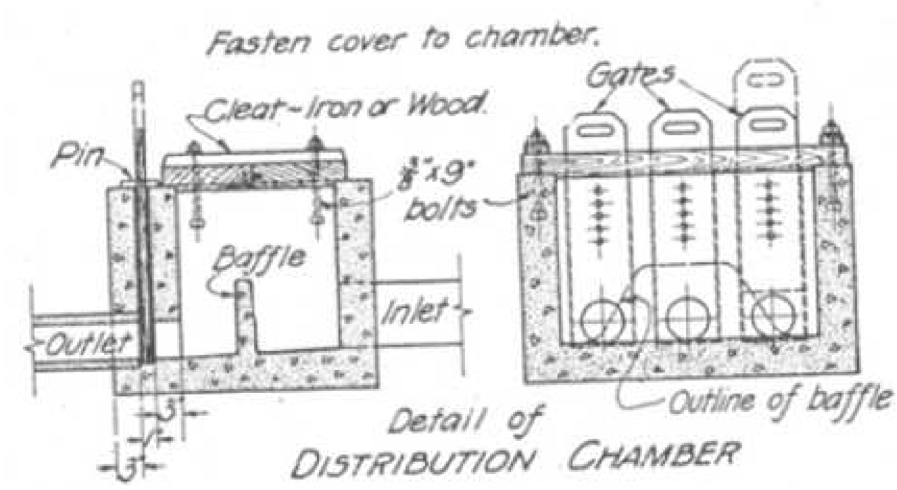


FIG. 6. One method of constructing the forms for the septic tank shown in figure 1.

Great care should be taken in selecting the materials for the concrete. The cement should be a Portland cement of an approved brand, and the sand should be clean and coarse, or a mixture of fine and coarse partic1es with the coarse grains predominating. It should be free from all

Distribution Box Detail



vegetable matter and should contain no loam or clay. The crushed rock should be a hard and durable stone, free from dust and fine screenings. If gravel is used it should also be clean and free from loam or clay, and it should be screened over a 1,4-inchmesh screen and then remixed in the proper proportions. Clean, clear water should be used.

Concrete may be mixed in anyone of a number of different ways and good results obtained. The important point is to be certain that the correct proportions of materials are used and that the various ingredients are thoroughly and evenly mixed.

ESTIMATE OF MATERIALS AND COST.

The following is an estimate of materials and cost of the sewage disposal plant, the tank of which is shown in Figure 1. The tank in question contains approximately 3½ cubic yards of 1 :2 :4 concrete, each yard of which would require 6.28 bags of cement, 0.44 cubic yards of sand, and 0.88 cubic yards of stone or gravel.

MATERIALS REQUIRED FOR A SEPTIC TANK SYSTEM FOR SIX PERSONS.

Cement, 25 sacks at 40 cts	$10.00
Sand, 2 cubic yards at 75 cts	1.50
Gravel, 3 cubic yards at 50 cts	1.50
Form lumber:	
200 bd. ft. 1-in. sheeting at $20 per M	4.00
45 bd. ft. 2 in. x 4 in	1.00
Steel, 60 lbs. reinforcing, at 3 cts	1.80
Sewer pipe:	
150 ft. of 5-in. vitrified clay, at 11 cts	16.50
15 ft. of 4-in. vitrified clay, at 8 cts	1.20
Drain tile, 350 ft. 4'in. at 3 cts	10.50
Siphon, 1 automatic 4-in. sewer siphon	18.00
Incidentals	5.00
	$71. 00

Several of the items in the above list can often be purchased at a less cost than that given. Good sand and gravel can often be obtained for the hauling or for a small charge of from 10 cents to 25 cents a load. The form lumber can often be selected from a supply of lumber on hand, for little or no charge. A mixture of 1 :2½ :5 concrete might be used by choosing first class materials and exercising special care in mixing and placing it. A small saving in first cost might be made by using 4-inch vitrified sewer pipe in place of 5- or 6-inch pipe, but, this is not recommended. A 4-inch pipe is very likely to stop up, and the trouble and expense of taking it up and cleaning it out will be many times the extra cost of a larger pipe. It is best to have the size of the outlet pipe about one inch larger than the diameter of the siphon. A 4-inch siphon would, therefore, operate best with a 5- or 6-inch discharge pipe. Sewage siphons as small as 3 inches in diameter have been used, but the extra satisfaction given by the larger siphon is more than worth the small difference in price. It may be possible to get along with a shorter length of pipe in the absorption system. This will depend upon the location and the character of the soil. It is best to plan the absorption system so that its length can be increased in case it is necessary to do so. These are all points worthy of consideration for each individual plant, but caution should be taken to avoid any false economy. The cost of such a plant can rarely be reduced to less than $50, not including labor. The cost of labor for constructing the plant may be estimated at approximately two-fifths the cost of materials.

OTHER METHODS OF DISPOSING OF HOUSEHOLD WASTE.

For dwellings that do not have water piped into the house, or other modern plumbing conveniences, some means must be provided for disposing of the water used in the home. It is not an uncommon practice in such houses to throw the wash waters upon the ground from the back porch, or door-step, or place it in a pail and carry it away when the pail is full. Both of these methods are inconvenient and the results are often very unsightly and unsanitary, and they should be avoided whenever possible.

The House Drain. One way to overcome this evil is to place a sink in the kitchen and connect it to a sewer line that will carry the used water from the house to some place for disposal. The sink should be provided with a strainer to prevent solid matter from entering the sewer, and it should be properly trapped to prevent the gases of the sewer from entering the house. (See Figure 5.)

This sewer should be made of 4-inch vitrified clay pipe, laid with cemented joints, and it should extend 50 feet or more from the house and well, to a point where it may be emptied into an open-joint drain pipe without danger of polluting or contaminating the domestic water supply. This open-joint drain pipe will serve as a purifying tile line during dry weather, and it will carry the wash water away, sufficiently diluted, when there is enough rain to make it carry surface water. If the amount of water discharged from the kitchen exceeds 30 or 40 gallons per day it is better to provide a slop-water basin that will hold two or three days' flow and discharge it intermittently into a small system of absorption tile similar to the one already described under the septic tank sewage disposal system, and shown in Figures 4 and 5.

Whenever the water is likely to contain: a considerable amount of grease a grease-trap should be installed a short distance from the house to prevent the grease from entering the drain tile and causing it to stop up.

The Cesspool. In some cases it may be possible to direct the slop-water from the house into a leaching cesspool without creating a nuisance or endangering the health of the community. The cesspool may sometimes be used successfully to dispose of all the sewage discharged from a home equipped, with a complete plumbing system. This method of disposing of sewage has been severely criticized, but when properly designed and located the cesspool still holds a place on the list of methods of sewage disposal for isolated country homes.

The installation of a system of this kind requires several important considerations. The first and most important precaution to be taken, in every case, is to protect the water supply from pollution and contamination. The cesspool should be located so that all the surface water, and also the underflow water, from the immediate vicinity will drain in a direction contrary to any well or spring or whatever source of supply is used for domestic or drinking purposes. All the water that leaches from a cesspool should be required to filter through 50 feet or more of soil or very fine sand before it can reach the source of any water supply. In localities where the bed-rock is only a few feet below the surface of the ground the water from a cesspool may often find its way into faults, or cracks, or into open passageways in the rock and flow unfiltered into a well or spring and thereby cause pollution. A cesspool should never be installed where such conditions are likely to exist. There is always danger unless the water has been perfectly filtered.

The extent to which the water from a cesspool' will be purified depends largely upon the character of the filtering medium and upon the time required to pass through it. As the water moves through the ground the amount of organic matter which it carries gradually diminishes and its bacterial content is greatly reduced. The process of purification will begin to be most effective after the point of complete saturation has been passed, and contamination is not likely to exist far beyond that point. The distance of safety will, therefore, depend largely upon the porosity of the earth surrounding the tank and upon the absence of possible chances for the liquid to find a passage to the source of water supply without complete filtration. A light and porous soil will absorb water more rapidly than clay, and the point of complete saturation will be located farther from the source of pollution in the former than in the latter. The distance of safety will, therefore, be less in clay than in a light and more porous soil.

The time element is also of importance. The rate at which water filters through the ground is very slow. In clay it will only move a few inches each day, and in fine sandy loam the rate of filtration is not likely to be more than 2 or 3 feet each day. The pathogenic bacteria, or disease germs, that may be present in the sewage will probably die during the time that is required for the water to filter through 50 feet or more of fine soil. It can not be stated, however, that the filtration will be disease proof. Holes or passages may be present in the soil that will destroy the chances for complete filtration. There is always more or less doubt as to the conditions that exist underground, since they can not be thoroughly investigated. The proper protection of the water supply is, therefore, rather uncertain, and the utmost care must be taken in choosing the location for a cesspool.

Another important consideration is to avoid the presence of bad odors near the house. Fumes and gases are given off in the decomposition of the sewage in the cesspool and offensive odors are produced. The cesspool should be placed at least 100 feet from the house whenever possible, and it is advisable to locate it where the odors will be least like]y to give annoyance.

The size of a leaching cesspool will depend upon the amount of sewage discharged daily and upon the character of the ground surrounding the tank. In genera], there should be a capacity of about 20 cubic feet for each person. In a light, porous soil it may not require this much, while in a soil of clay that is more impervious to water, the capacity may need to be greater.

The following table suggests dimensions for cesspools of different sizes:

Table 1. DIMENSIONS OF CESSPOOLS.

Number of persons	Inside diameter, ft	Depth, ft	Approximate total capacity, cu ft
2 to 3	4.0	6.0	75
4 to 5	5.0	7.0	135
6 to 7	5.5	8.0	190
8 to 10	6.0	9.0	250

The tank for the cesspool may be built either circular or rectangular in plan. It should be constructed of brick or stone, laid up without the use of cement or mortar. The tank should be covered, but a manhole should be left so that it can be we]] inspected. The top of the tank may be arched over and a plank or concrete cover placed over the opening similar to the manner commonly used in covering cisterns.

The sewer line from the house to the cesspool should be made of vitrified clay sewer pipe at least 5 inches in diameter, and laid in the manner described under the septic-tank system on page 18 and illustrated in Figure 5.

The inlet sewer should enter the tank and bend downward so that the fresh sewage will be admitted below the surface of the sewage already in the tank. An outlet, or overflow, pipe should be inserted a few inches below the level of the inlet pipe and on the opposite side of the tank. This outlet pipe should also bend downward in the tank so that the outward flow will be drawn from beneath the surface. The outlet pipe may be made of 4- or 5-inch farm drain tile, and it should run to a place where the overflow water can be discharged onto an artificial filter bed or onto the surface of the ground where it can be absorbed by the soil.

In order to insure the proper working of a leaching cesspool, the soil around the tank should absorb all, or at least the major portion, of the water. The same bacterial action takes place in the cesspool as takes place in the septic tank, although it may not be nearly so complete. It will, therefore, have to be cleaned out more often. About once a year, or perhaps more often, it will be necessary to pump the sewage out of the tank and clean it out. A cesspool should never be allowed to become clogged and back up in the sewer and overflow on the surface. This is likely to occur unless the overflow pipe is kept open.

The Ordinary Privy Vault. In cases where water closets are not installed in the dwellings or outhouses, some other means must be provided for disposing of the human refuse. The ordinary privy vault is' generally more dangerous than the strongly condemned cess:pool.' During the summer months the refuse in these vaults is usually exposed to flies, and it affords excellent breeding places for these pests. The fly has proven itself to be one of the principal agents in the transportation of disease. Other insects and animals also often have access to the contents of these chambers, and they, too, are distributors of disease. During the rainy season these vaults often become filled with water, which leaches away into the soil just the same as in the case of the much condemned cesspool.

The danger of these conditions can not be emphasized too strongly, and they should be avoided whenever possible.

The Dry-earth Closet. In the absence of a water-service system for disposing of the human refuse, the dry-earth closet is, perhaps, the best means available for accomplishing the desired results.. In this type of closet the refuse is received in a box or chamber directly beneath the seat. Each time the closet is used a small amount of dry earth of a light and loamy nature is added to absorb the moisture and promote the oxidation of the organic matter. Lime is also very effective in deodorizing and converting this waste matter into harmless material. It is usually best to mix a small amount of lime with the earth that is used. The earth should be well pulverized and kept in a handy place in the closet. The chamber should be well ventilated and its contents protected from flies.

The receptacle should be located entirely above the ground and arranged so that it can be easily removed and loaded onto a sled or wagon by one man and hauled to a field where it can be emptied and the contents worked into the soil. The success of this method of disposing of human waste is dependent upon the faithful effort of those using the closet. No unnecessary waste matter should be emptied or thrown into the chamber. Enough dry earth and lime should be used to absorb the moisture and subdue offensive odors. When strong odors arise it is evidence of carelessness on the part of someone, and the receptacle should be emptied and a new effort made to properly care for the place.

Every method of sewage disposal will require some attention. Municipalities employ trained and experienced men to operate their sewage disposal plants, and usually the results obtained by their methods of dfsposal depend as much upon the proper operation of the plant as upon the method of treatment.

It is, therefore, very important for the rural citizen to give some of his attention to the proper disposal of the household waste. It should be remembered that the purpose of sewage disposal is to protect health, and for convenience. Health is the most valuable asset to human life, and should be guarded whenever possible. No person can afford to be careless with those things which concern his health, or the health of others.

THE KANSAS STATE AGRICULTURAL COLLEGE OFFERS

College Courses in Agriculture; General Science; Home Economics; Veterinary Medicine; Architecture; Civil, Electrical and Mechanical Engineering; and Industrial Journalism.

These are four-year courses leading to degrees. Students are accepted who can offer for entrance fifteen units of high-school work or its equivalent.

The School of Agriculture offers courses in Agriculture, Home Economics, and Mechanic Arts. These are three-year courses leading to a diploma. Students are accepted from grade and from rural schools.

Short Courses are offered as follows: Creamery Course, ten weeks, beginning in January; Farmers' Short Course, ten weeks, beginning in January; and Housekeepers' Course in Home Economics, twenty-five weeks, beginning in September.

A Summer School of six weeks, beginning in June, offers courses in Agriculture, General Science, Horne Economics, Mechanic Arts, and related subjects. These courses are particularly adapted for teachers; others, also, may attend.

For full information, write to: PRESIDENT H. J. WATERS,
Manhattan, Kan.

Kansas State Agricultural College, Engineering. Experiment Station

Station Staff

H. J. WATERS, President

A. A. POTTER, Director

Applied Mechanics and Machine Design
- R. A. SEATON, In Charge
- P. J. FREEMAN, Strength of Materials
- M. R. BOWERMAN, Machine Design
- I. I. TAYLOR, General Investigations

Architecture
- J. D. WALTERS, In Charge
- W. A. ETHERTON, Rural Architecture
- F. C. HARRIS, Assistant
- STANLEYA. SMITH, Assistant

Chemistry
- J. T. WILLARD, In Charge
- H. H. KING, General Investigations

Civil Engineering
- L. E. CONRAD, In Charge
- F. F. FRAZIER, General Investigations

Electrical Engineering
- C. E. REID, In Charge
- R. G. KLOEFFLER, General Investigations
- C. A. BJORKMAN, Fellow

Farm Machinery
- F. A. WIRT, In Charge
- R. E. WISEMAN, Assistant

Highway and Irrigation Engineering
- W. S. GEARHARTI, Highway Engineering
- H. B. WALKER, Irrigation and Drainage

Physics
- J. O. HAMILTON, In Charge
- G. E. RABURN, General Investigations

Shop 'Practice
- W. W. CARLSON, In Charge
- R. L. SWENSON, General Investigations

Steam and Gas Engineering
- A. A. POTTER, In Charge
- S. L. SIMMERING, General Investigations
- W. H. SANDERS, Farm Motors
- E. V. COLLINS, Farm Motors
- W. A. BUCK, Assistant
- W. G. KNICKERBOCKER, Assistant
- L. S. HOBBS, Fellow