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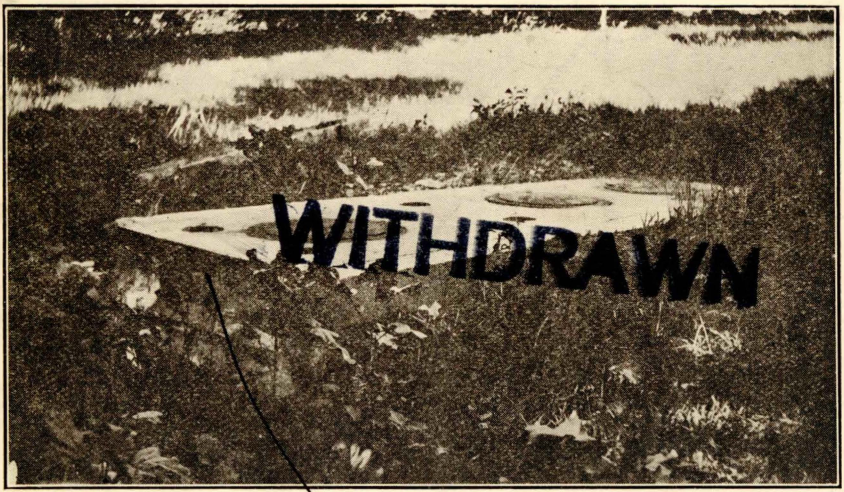
RESIDENTIAL SEWAGE TREATMENT PLANTS

By Lindon J. Murphy



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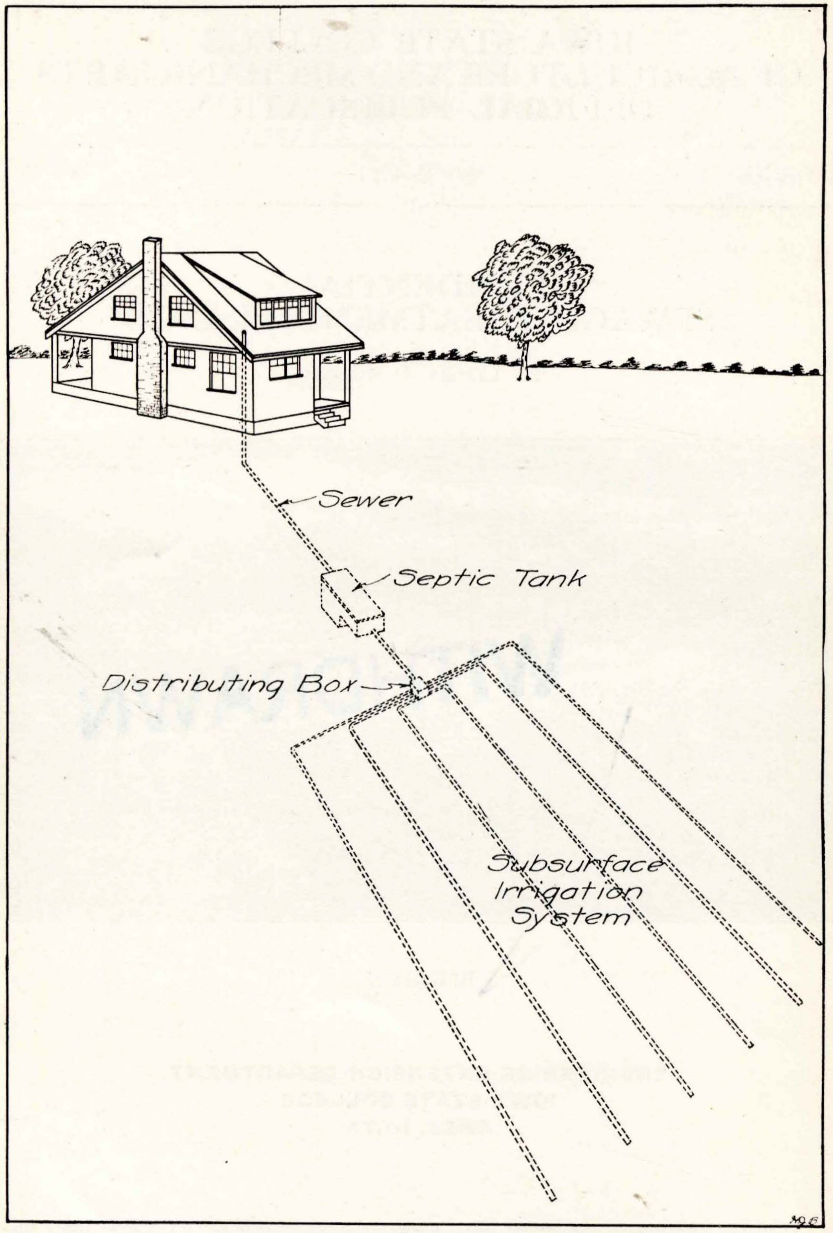

Typical Residential Sewage Treatment Plant.

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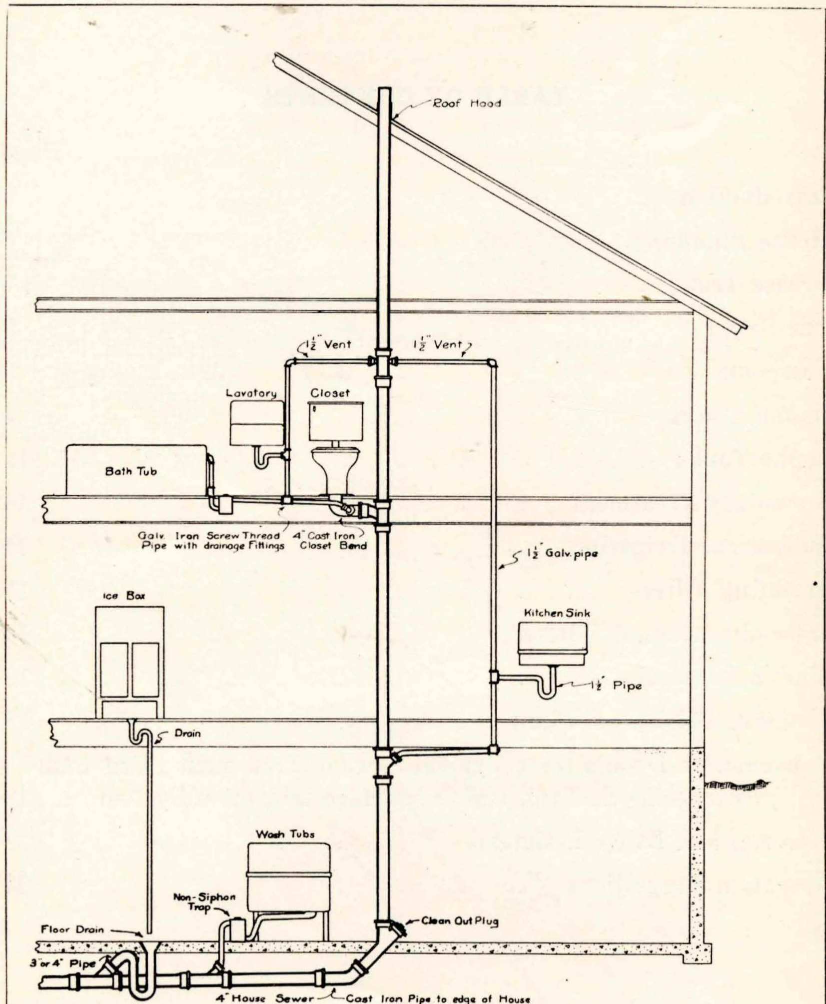

TYPICAL PLUMBING LAY-OUT FOR A SINGLE RESIDENCE

Engineering Extension Dept.
Iowa State College
1927

RESIDENTIAL SEWAGE TREATMENT PLANTS

By Lindon J. Murphy

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INTRODUCTION

No problem is more vital to the health, comfort and convenience of the family in the village or rural community than the proper disposal of sewage and other household wastes. The growing interest and appreciation of the importance of this problem is clearly shown by the almost constant call for definite information concerning the design and operation of single residence disposal plants.

Many families in village and rural homes are finding that it is possible to have the conveniences and sanitary safeguards which have long been the privilege of the city dweller. These homes are being equipped with running water, with a bathroom as complete as that in the city, and with laundry facilities adequate for our present standard of cleanliness. The majority are, however, still faced with the problem of satisfactorily disposing of the household waste.

In the small town or even the village the public sewerage system and disposal plant is in many cases undoubtedly the most satisfactory and economical solution to the problem. However, in the small village with widely scattered residences a common sewerage system and plant may be exceedingly expensive, and with the isolated or rural home no alternative is available, other than the individual residence disposal system.

The isolated outdoor closet has always been a nuisance, and it is now being recognized as a hazard to the health of the family through the possibility of disease being carried by flies, as well as the danger of polluting the water supply.

The cesspool was devised to eliminate the objectional outdoor closet, and it is in many ways a distinct improvement. However, with the resulting concentration of the sewage in one place, together with the increased use of water which has followed the adoption of modern plumbing and the water carriage system of sewerage, even greater danger of polluting the water supply has resulted. Numerous tests have shown that the purifying effects of the soil are limited almost entirely by their proximity to the surface. The nitrifying bacteria, with multitudinous other vegetable and animal organisms are effectively active only in the top foot or so of soil. Hence it is evident that a sewage effluent discharged from four to ten feet below the surface will receive very little purification and is a potential source of danger for the water supply. Porous gravel strata or fissured rock beds may carry the sewage directly to a nearby well.

It is apparent that a better, safer means of sewage disposal than this is necessary. Many years of tests and experimentation have resulted in the evolution of the modern sewage digestion tank, which is usually followed by filtration or some method of oxidation to secure an effluent meeting modern sanitary requirements.

Typical disposal plants meeting the needs presented by varying sanitary and economic conditions are explained in detail in the following pages.

HOUSE PLUMBING

Because of the fact that satisfactory sewage disposal in a modern treatment plant is dependent to a certain extent upon a well designed plumbing system, it may be advisable to list briefly the fundamental principles which should be followed in installing a plumbing system for the home. Mr. C. S. Nichols, Engineer, Division of Sewage Disposal, Dept. of Public Works, City of Miami, Florida, and formerly Professor of Sanitary Engineering, Iowa State College, has listed the following as essentials to a sanitary and satisfactory plumbing installation:

1. A thoroughly competent and reliable plumber should be employed.
2. Simplicity in the layout of piping and fixtures will materially aid in the elimination of plumbing troubles.
3. A main soil pipe, made of 4-inch cast iron pipe, with air-water-tight joints, should extend from a point 5 feet outside the cellar wall up through the house roof. The pipe should be straight from basement to roof.
4. All fixtures should discharge into the main soil pipe, and be provided with suitable traps thoroughly vented to prevent escape of sewer gases into the rooms.
5. A separate vent pipe should be carried from the outlet of every trap into a main, 2-inch, iron vent pipe, independent of the soil pipe. This pipe may be connected with the soil pipe above the highest and below the lowest discharge connections. Such venting is intended to prevent breakage of the water seal in the traps and the forcing of sewer gas into the house.
6. Plumbing materials and fixtures should be of good quality, simple in design, and should have all connections and joints made thoroughly and permanently air and water-tight. Such fixtures should be made of non-absorbent materials, such as porcelain or enameled iron.
7. All plumbing and fixtures should be accessible. The soil pipe should not be enclosed in a wall unless a removable wooden panel is placed over it. The fixtures should be located as near

the main drain as possible, first because the cost of plumbing will be less, and second, because this will facilitate the sanitary and perfect operation of the plumbing system. All fixtures, both for bathroom and for kitchen, should be placed in the open, to permit free access of air and light. Boxed-in sinks, bathtubs and other fixtures are insanitary; they allow the collection of dirt and moisture which are detrimental to health and life. Provide an abundance of light and air around all fixtures.

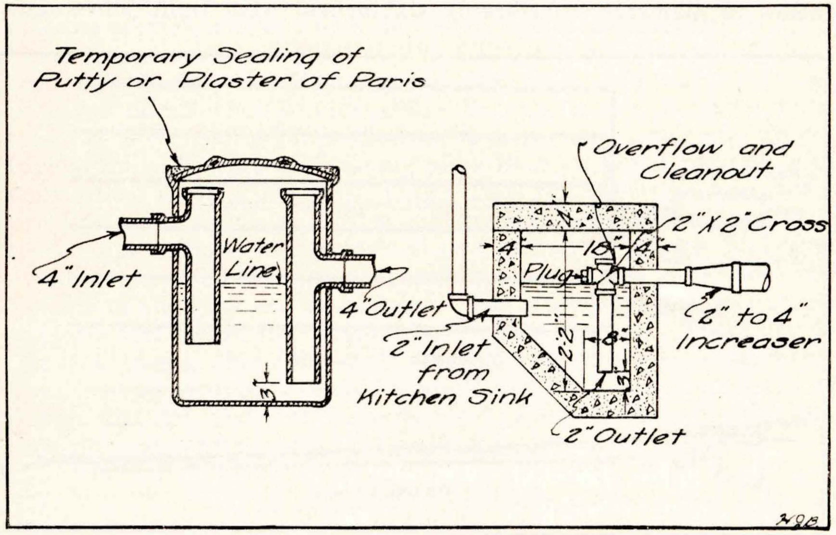

Fig. 3. Typical Grease Traps.

GREASE TRAPS

Sewage from a single residence may contain from 10 to 30 pounds of grease and fats per person per year. This grease, coming mainly from the kitchen sink, hinders septic action and clogs pipes, filters and soil. Where the quantity of greasy water or waste fats which may get into the sewer line is at all appreciable a grease trap is advisable.

This device should have a capacity several times that of the largest quantity of greasy water discharged into it at one time in order that the water may be well cooled and the grease congealed. As a dishpan of greasy water (2 1-2 to 3 gallons) is the largest quantity likely to be discharged into the sink at one time, the grease trap should have a capacity of at least 7 or 8 gallons. Several types of grease traps suitable for residential use are shown in Fig. 3. It will be noted that in each the outlet pipe has small clearance at the bottom. This with a V-shaped bottom helps to secure a scouring velocity, and thus prevent the accumulation of coffee grounds and solid matter in the bottom of the trap. The grease trap may be placed on the sink line either in the basement or just outside the building, located, however, where it will be accessible for inspections. These should be made every few months and the grease skimmed off.

THE SEWER

The house plumbing system should be connected to the treatment tank by a sewer line comprising vitrified sewer pipe at least four inches in diameter, (preferably six inches) with tight joints, and

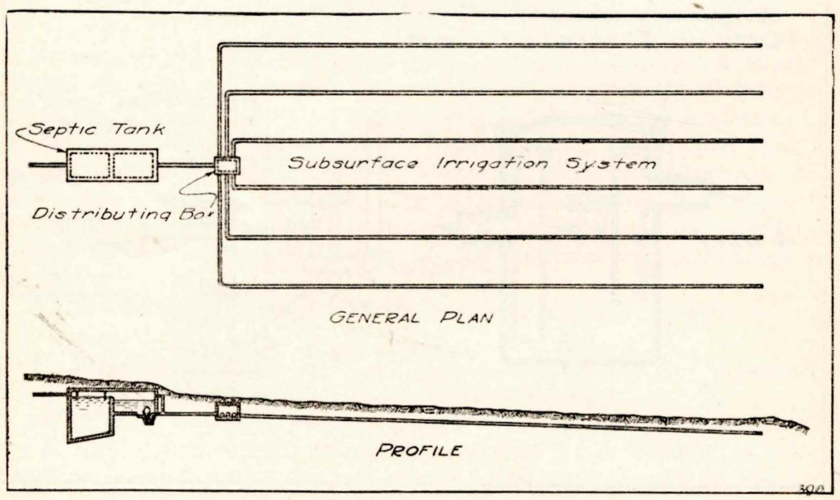

Fig. 4. Typical Layout for a Residential Sewage Treatment Plant.

laid on a true and uniform line and grade. The joints may be calked with jute or oakum and filled with cement mortar, or may be made tight with a poured or pre-cast asphaltic joint filler. Great care should be taken to lay the sewer in a straight line and on a uniform grade of not less than six inches per hundred feet.

PRINCIPLES OF SEWAGE DISPOSAL

Sewage disposal is ordinarily understood to mean the carrying away and treatment of sewage. Domestic sewage from the average home comprises anything from human excreta to dairy wastes and soapy water, thus containing much solid matter in suspension as well as that in complete solution, and having the property of changing character rapidly with age. It must therefore be treated carefully and promptly in a properly designed plant to prevent a nuisance.

In transforming sewage to a harmless and inoffensive state, two

distinct processes are found to take place. Reduction and oxidation. Reduction or the breaking down of the solid organic matter, is best accomplished in a digestion tank, several types of which will be mentioned later. The purification of the sewage effluent is largely accomplished by some form of oxidation, of which sub-surface irrigation and filtration are the most common.

CESSPOOLS

The cesspool, which was at one time popular as a means of sewage disposal is often confused with the septic tank because of their similarity of appearance and action. Two distinct types of cesspools have been constructed, the leaching and the tight. In the latter the processes taking place are identical with those going on in the septic tank. The cesspool is often thought of as being a larger and deeper type of tank. The processes taking place in it are frequently less controlled than those of the septic tank. Thus when the tight cesspool is provided with an outlet, baffles, and trapped overflows it becomes a septic tank. These improvements give greater efficiency, and with overflows provided the initial capacity becomes of less importance and the size of the tank can be reduced. The septic tank has all the advantages and few of the disadvantages of the cesspool. There are, in fact few places where the tight cesspool can be used economically. The leaching cesspool cannot be considered as a sanitary means of sewage disposal, and is to be particularly avoided where there is any possibility of contaminating the water supply.

IMHOFF TANKS

The Imhoff or two-story tank is a development and variation of the septic tank principle, which was worked out by Dr. Karl Imhoff of Germany in an attempt to eliminate some of the disadvantages of the septic tank. All of the material which will settle or float is separated from the rest of the sewage, and as this comprises most of the objectionable elements of the sewage, from the standpoint of nuisance its elimination is a distinct aid in the treatment of the sewage.

This separation is accomplished by dividing the tank into two compartments, one above and contained within the other. The sewage is allowed to flow slowly through the upper chamber, where the sludge settling out of the sewage, drops through a trapped slot into the lower or digestion chamber, and undergoes decomposition here in the absence of air. The sewage being undisturbed by the gases of decomposition and the particles of decomposing sludge carried up by these gases, leaves the tank in much fresher condition, is comparatively free from obnoxious odors, and is relatively easier to purify. The sludge is also much easier to treat and dispose of without creating a nuisance.

The Imhoff tank has for these reasons become very popular in

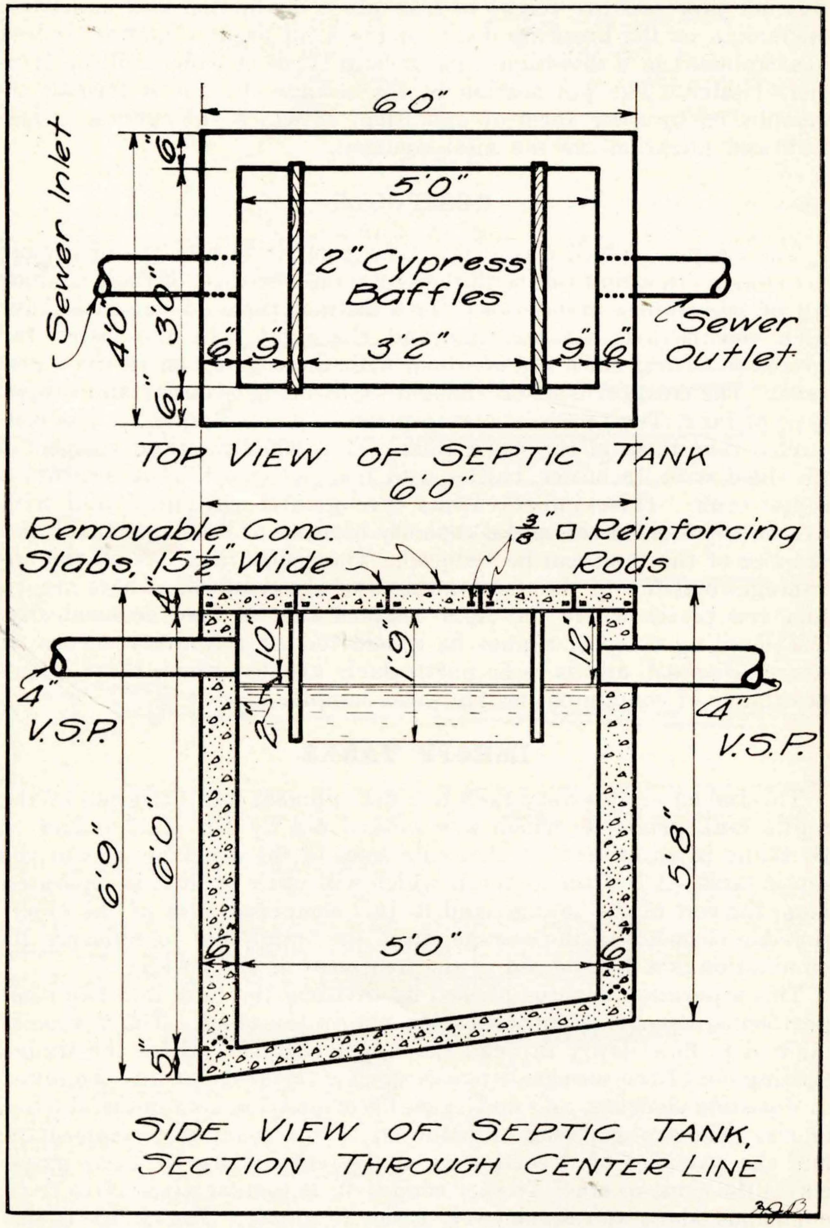

Fig. 5. Single Chamber Residential Sept'c Tank.

municipal installations. The difference in results over those obtained in the septic tank become much less marked in the smaller plants, and with residential installations the results are very comparable. The cost of the Imhoff tank is almost always higher. It requires a great deal more operating attention for satisfactory results than does the septic tank. Hence for installations serving less than twenty people it is seldom recommended either from the standpoint of economy or operation.

SEPTIC TANKS

Principle of Operation. The primary function of the septic tank is to settle out and break down the solid material in the sewage. Its action constitutes only the preliminary part of sewage purification, and no plant consisting solely of a septic tank can be expected to give an effluent free from contamination, or those elements dangerous to health.

The theory of operation of the septic tank is simple. Much of the organic matter carried in suspension in sewage is heavier than water, and under favorable conditions will settle out by gravity. The septic tank is designed so that the sewage may be retained practically quiet for a sufficient length to allow the heavier organic material to settle out, and the lighter constituents to rise to the surface as scum, yet not long enough to cause the sewage to become objectionably septic.

As the solid matter settles in a septic tank it is attacked by billions of "anaerobic" and facultative anaerobic bacteria (those which live and thrive in the absence of light and air), which break the organic matter into more stable compounds, part of which are liquid and part gaseous. In rising through the liquid the gases of decomposition carry some of the lighter materials to the surface, where together with other materials lighter than water, it forms a scum. This mat need not be disturbed except when the tank is cleaned or when its depth becomes excessive.

Capacity. A residential septic tank is ordinarily designed to serve a family of 5 or 6 people. Under village and rural conditions the daily water consumption averages 20 to 30 gallons per capita. While the daily sewage flow is approximately equal to the water consumption, it is advisable to provide a larger per capita capacity in the settling tank to take care of the difference in character and varied flow of the sewage. An estimated flow of 50 gallons per capita per day has been found suitable in determining the size of the septic tank.

A retention period of 24 hours is recommended for a tank of this capacity. Rectangular tanks are usually the simplest to construct. A report presented at the Conference of State Sanitary Engineers, June 1926, recommends that the tank be not less than 4 feet deep, not less than three feet wide, and from 4.5 to 6 feet long. The

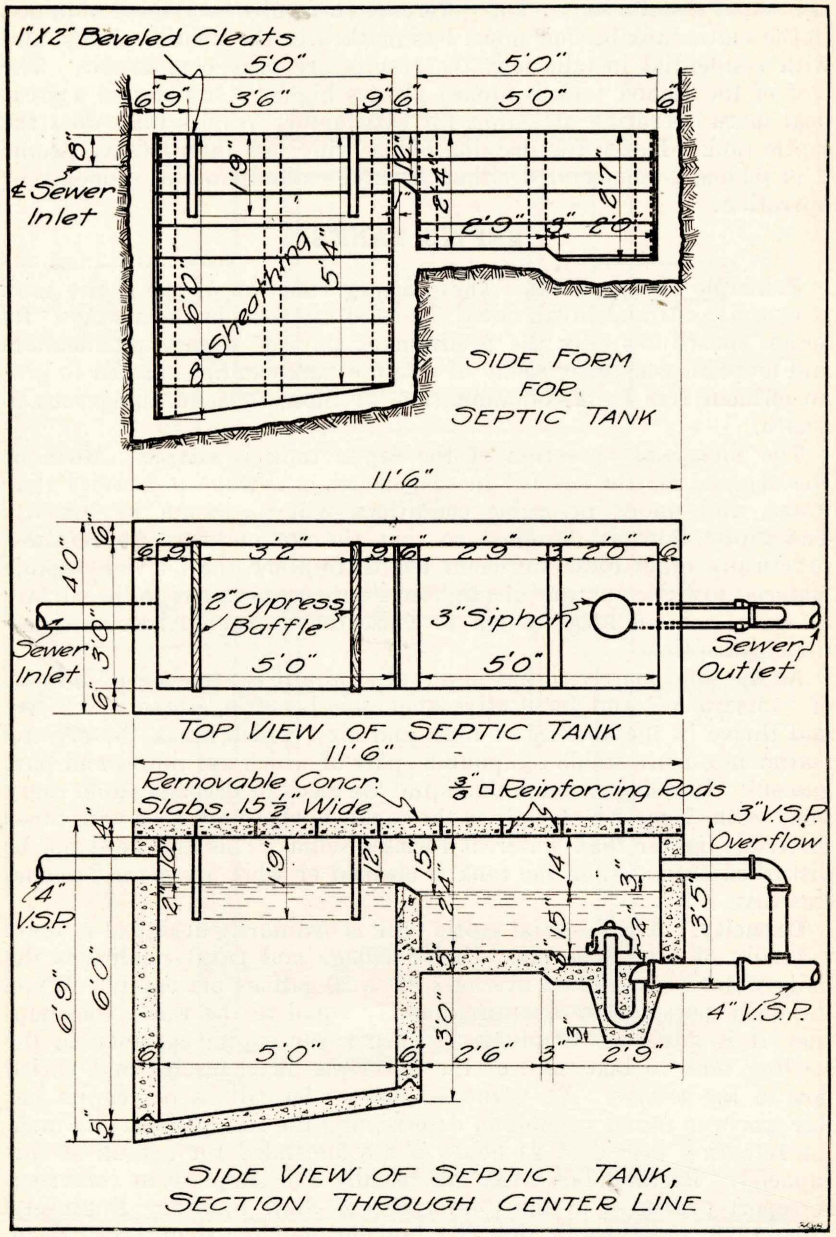

Fig. 6. Residential Septic Tank and Dosing Chamber.

capacity of the tank is made large enough so that a sludge space of from 2 to 4 cu. feet per capita will be provided in addition to that required by the detention period.

The residential septic tank is, in the majority of cases, built with a flat bottom due to the greater ease of construction. The cleaning out of sludge is however greatly facilitated by the construction of a hopper

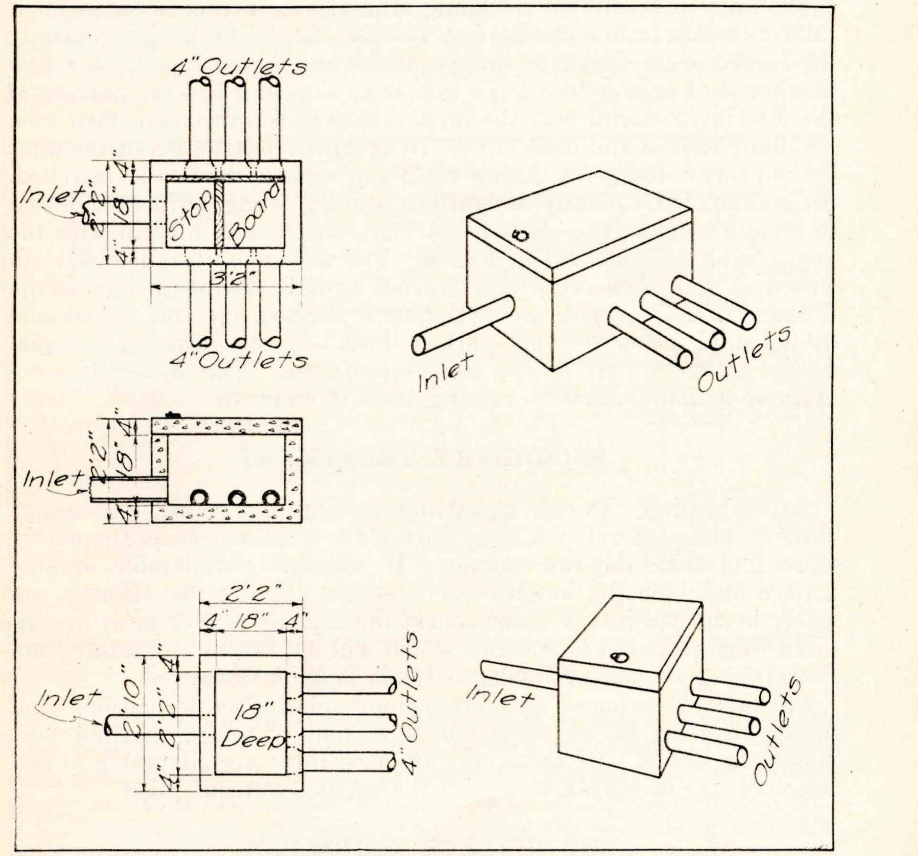

Fig. 7. Distributing Boxes.

bottom. On the more expensive tanks, sludge removal pipes are provided so that by the turning of a valve the ripened sludge will be discharged by hydrostatic pressure.

Covers for small plants are usually made of reinforced concrete slabs, cast in small sections, so as to be easily removable for inspection and cleaning. Planks have been used for this purpose though they are not to be recommended because of their lack of durability. In some large installations the tops have been poured in place with small manholes left for access to the tank. This method is not advisable because of the difficulty of removing the scum and sludge.

The attached sketches show several types of septic tanks which have given satisfactory results.

Dosing Apparatus. A dosing tank is a device designed to collect the sewage effluent from a settling tank and to discharge the effluent intermittently into a purification system. Septic tanks, particularily the larger ones, discharge sewage almost continuously. If this flow is allowed to dribble into a tile line or onto a sand bed the portion of the filtering material near the inlet is sure to be overdosed, thus soon becoming choked and ineffective. To avoid the destruction of the filter by improper dosage, a dosing tank and siphon should be installed. Such a tank is frequently designed to hold the sewage effluent collected in from 8 to 24 hours. It is frequently constructed integral with the septic tank as indicated in Fig. 6. The siphon is installed and adjusted so that when the sewage reaches a predetermined height in the dosing tank, the entire accumulation is flushed out and distributed by the sudden flow to every part of the filter, thus insuring an equal dosage to every part of the distribution area. The siphon is automatic in action and has no moving parts to wear out.

SECONDARY TREATMENT

After passing through a settling or digestion tank, the sewage effluent, although rid of a large part of the solid matter, is frequently more foul than the raw sewage. It contains considerable organic matter and immense numbers of bacteria. Before the effluent can safely be turned into a water course the organic matter must be oxidized to more stable compounds which will not create a nuisance, and the harmful, disease producing bacteria must be destroyed.

Secondary treatment methods include sub-surface irrigation, sand filters, trickling filters, contact beds, secondary tanks, leaching cesspools, and others. Of these only the first three are adaptable to satisfactory use in conjunction with the small treatment plant.

SUB-SURFACE IRRIGATION

As the name suggests, sub-surface irrigation consists in discharging the effluent from the primary treatment tank into the earth below the ground surface. This is usually accomplished through a line or series of lines of farm tile laid with open joints. These are frequently four-inch tile laid in rows 6 to 10 feet apart and 12 to 20 inches under the ground surface. The upper layers of the soil contain innumerable nitrifying bacteria which attack the organic material and reduce it to

more stable compounds. In sections of the state where there may be danger of freezing the distribution lines, it will often be advisable to place the lines deeper than 20 inches at the sacrifice of the greatest efficiency in purification. The gravel filled distribution trenches shown in Fig. 8 will then often give the most satisfactory results, with the distribution tile carried at a depth sufficient to preclude severe freezing.

This method of treatment is particularly adapted to use in the smaller disposal plant. It is one of the few methods whose first cost is low and which, if properly constructed, will function successfully year after year with practically no attention. Probably more than

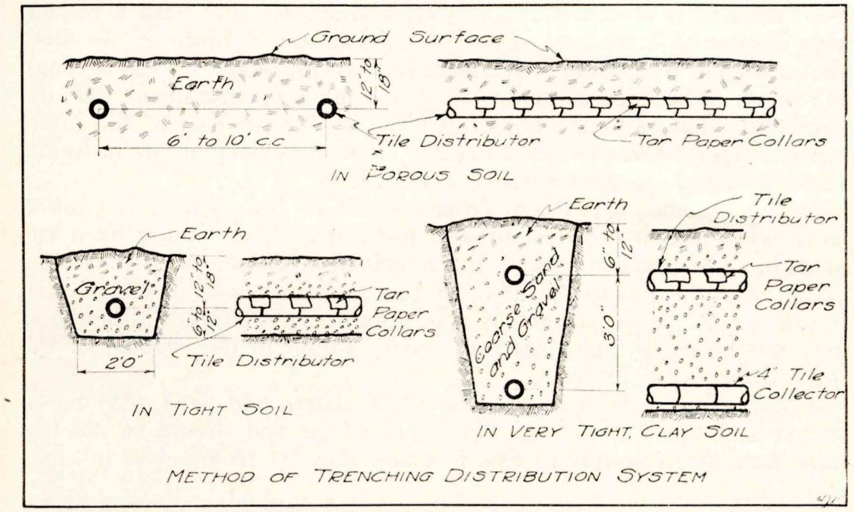

Fig. 8. Details in Sub-surface Irrigation.

three-fourths of the small septic tanks are equipped with sub-surface irrigation systems. This method may be used where there is no danger from ground water pollution. A sandy or gravelly soil presents, of course, the most favorable conditions, though with proper precautions, it may be used in tight soils. The tighter the soil, the greater the amount of tile needed, and the more care needed in constructing the system. Recommendations for the total length of distribution lines vary from 20 to 60 feet per capita depending upon soil conditions. No one line should be over 100 feet in length. The fall required in each lateral is small, ranging from 3 to 4 inches per hundred feet.

The 1926 Conference of State Sanitary Engineers recommended that the main distributor should be of vitrified sewer tile with cemented joints, that the laterals should be of 3 or 4-inch farm tile laid in a two foot trench containing from 6 inches to one foot of cinders, gravel or crushed rock below the tile. This porous material aids greatly in the diffusion and absorption of the liquid. The tile should be as near the surface as is consistent with its adequate protection. In sandy soil it may be necessary to merely dig a trench twelve inches wide and twelve to eighteen inches deep, in which the tile is laid carefully to grade. After the joints are protected with tar paper or broken tile to prevent infiltration of sand and mud, the tile may then be covered with the sandy soil previously excavated.

TRICKLING FILTERS

Trickling filters provide a means of secondary treatment by which a good effluent is obtained at a moderate first cost, and with a reasonable degree of attention. Local conditions must, however, be such that a head of 6 to 8 feet is available for passage of the sewage through the filter. The care given to the plant must be intelligent and dependable. The cost of a trickling filter is, like the cost of the intermittent sand filter, somewhat greater than the owner of the ordinary small sewage treatment plant can afford.

In this method the effluent from a septic or Imhoff tank is allowed to trickle through a bed of broken stone, gravel, cinders, broken tile or lath. The greater part of the purification is secured through the action of aerobic bacteria upon the sewage as it passes down through the filter. A stable effluent of good quality is produced, although it does not have the high degree of purity found in the effluent of the intermittent sand filter.

The filtering material should be clean, sharp, and hard, varying in size from 1 to 3 1-2 inches. The depth of the bed should be not less than four and one-half to five feet and may be from seven to eight feet.

It is necessary that the sewage be applied uniformly to all parts of the bed, and that it be applied intermittently. For best operation the dosing cycle can be comparatively short as contrasted to that necessary with the intermittent sand filter, frequently being set between fifteen and thirty minutes. Uniform dosage is secured by several methods whose elaborateness commonly depends upon the size of the plant. The larger filters are in nearly every case equipped with spray nozzles; in the small beds splash plates and tipping trays may be used.

The size of filter depends upon the number of persons served and the quantity of sewage flow. The American Public Health Association has recommended that not over thirty-six gallons be applied per square foot of filter daily and that the volume of bed be not less than eight cubic feet per capita.

Trickling filters may be used wherever the requisite amount of attention for satisfactory operation can be given, and where sufficient

head is available. They must be recommended with caution for use in built up sections because of the possibility of noticeable odors and filter flies under certain conditions.

INTERMITTENT SAND FILTERS

A method of secondary treatment which is very popular for large residential and institutional plants where the volume of sewage is too great for economical sub-surface disposal, is that of intermittent sand filtration. Its popularity is undoubtedly due to the excellent purification secured.

Sand filters are also used in those localities where, because of adverse conditions, sub-surface irrigation is not practicable, and yet where a high degree of purification is desired.

This type of plant has, however, certain limitations which may prevent its use. From 36 to 54 inches of head must be available to make possible the satisfactory operation of the plant; considerable land area is required for the sand filters; in a built-up district such a plant may become a nuisance; sand filters are not ordinarily economically advisable for installations serving less than 25 people.

A distinct draw-back to the utilization of the intermittent sand filter for small residential installations, is the fact that it requires careful operating attention to insure satisfactory results. Inspections of the bed should be made every few days, and where several beds are available the flow of sewage alternated weekly between beds. At intervals of about a month the beds should be raked and scraped. In the winter additional attention is necessary in mounding the beds. It is evident, therefore, that sand filters should not be constructed unless proper operating attention is assured.

Sand beds are contained either within concrete walls or earthen embankments. The bottom is usually shaped from the earth to meet the needs of the underdrainage system designed for the bed.

The filtering material should be a good quality of sand, clean and sharp, and for best results should have an effective size of 0.30 to 0.50 mm. The depth of the sand bed is dependent largely upon the head available, but it should never be less than twenty-four inches. A depth of thirty inches is desirable.

The bottom of each bed should be sloped to drains, which frequently consist of 4 to 6 inch tile placed in parallel rows 6 to 10 feet center to center, and leading to a main outfall sewer. The underdrains should be laid with open joints, and should be covered with broken stone or gravel to a depth of 6 or 8 inches. The gravel around the underdrain may vary between 1-4 inch and one inch in size; above this should be placed a two-inch layer of pea gravel to prevent the sand washing down into the underdrains. The capacity of the small residential filter is usually placed less per acre than that of the large city plant because of the greater percentage of sediment carried onto the bed and the liklihood that it will receive less careful operating attention. A rate of 100,000 gallons per acre per day is frequently used, with a liberal allowance of approximately 100 gallons per capita per day. Recommended bed sizes vary from 43 to 55 square feet per person or 750 to 1000 people per acre. At least 40 feet of sand filter area is advisable to insure satisfactory results.

SLUDGE DISPOSAL

Sludge may be defined as the settled solids which collect in the bottom of digestion tanks. While anaerobic action breaks down a portion of the heavier sewage matter, a considerable portion remains in the tank, and unless removed the sludge will in time fill the tank so that it is worthless so far as sewage treatment is concerned. The capacity of sludge hoppers vary, of course, in different designs. If, however, the black ripened sludge in the bottom of the tank is removed and buried perhaps once a year, the most favorable conditions for efficient sewage treatment are maintained.

LOCATION OF DISPOSAL PLANT

The proper location of a residential sewage disposal plant depends largely upon local conditions. It is sometimes permissable to place a properly constructed septic tank quite near the house. It must be kept in mind however that a leaky tank may seriously pollute a nearby well or water supply, as well as being a possible nuisance from odors during certain seasons of the year.

There can be no definite limit set as to the distance which impurities may be carried through the soil as the natural drainage to or away from the water supply will vary widely in different cases. To guard against the danger of contamination the septic tank and absorption bed should be located as far from a well or other supply as possible, never closer than fifty feet. The septic tank and filtration system should also be placed on the down-hill side of both the surface and sub-surface drainage from the water supply. All sewer lines from the house to the tank and from tank to the absorption bed should be of vitrified sewer pipe with thoroughly cemented joints.

CONSTRUCTION DETAILS FOR A TYPICAL SEWAGE TREATMENT PLANT COMPRISING A SEPTIC TANK AND SUB-SURFACE IRRIGATION SYSTEM

Septic Tank. After completing the construction of the house sewer to the tank site, excavation for the septic tank may be started. If the soil is of a character that does not cave in readily, it is common practice to use the earthen walls of the pit for outside forms. In this case the excavation should be made carefully so that the walls when poured may have a uniform thickness. Extra care will be

necessary to make the sides smooth and vertical, and the corners square.

The methods of constructing the inside forms, for both the single chamber tank and the tank with dosing chamber attached, are shown in figures 6, 9 and 10. All pipe openings should be accurately placed and cut. To prevent the adhesion of forms to the concrete and to make removal easy, the faces of all forms should be well greased. Crankcase oil, crude oil or soft soap may be used for this purpose It can be applied with a swab or brush.

In order to insure watertightness in the tank a mixture of 1 part

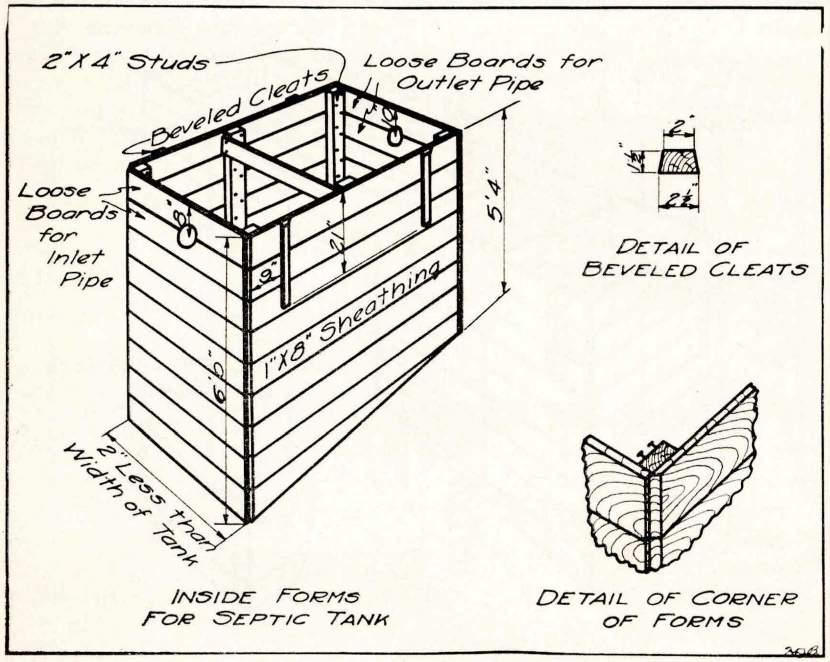

Fig. 9. Form Details for Plant No. I Comprising a Single Chamber Septic Tank.

portland cement, 2 parts sand, and 4 parts gravel or broken stone should be used. The materials should be clean and hard, and must be thoroughly mixed. A sloppy mixture is to be avoided. The concrete should be poured promptly and worked thoroughly with a spade to make the face smooth and eliminate voids and pockets. The settling tank floor, being the lower, should be poured first. The wall forms for the settling tank should then be set on the green concrete floor, the outlet pipe placed, and the concrete work continued, carrying the walls up uniformly on all sides. When the settling chamber walls have reached the bottom of the excavation for the siphon chamber, the siphon trap with its connections should be set to line and grade and blocked into position. The floor of the siphon chamber should now be poured, and the wall forms set thereon. Pouring of all the walls should then be continued, setting the inlet at its proper position. The whole should be completed without an appreciable stop, making the entire structure monolithic. The top slabs may be formed and poured separately, as shown in Fig. 6. A small amount of steel is placed in the bottom of these cover slabs to stiffen them and prevent possible cracking. Two 3-8 inch bars or a strip of heavy stock fencing may be used in each slab for this purpose.

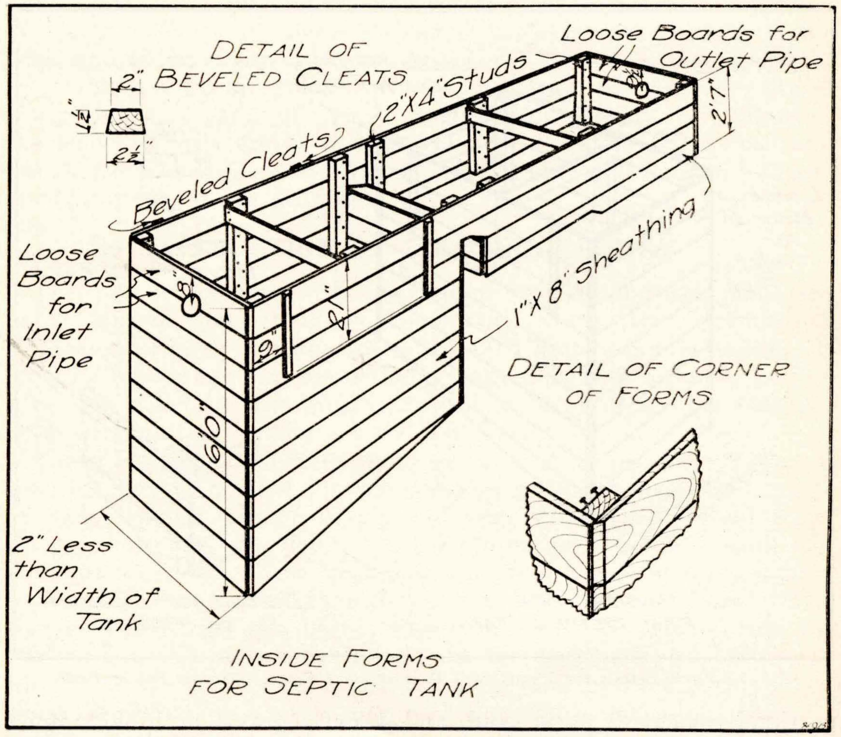

Fig. 10. Form Details for Plant No. II Comprising a Septic Tank and Dosing Chamber.

Sub-Surface Irrigation System. The success of this method of final disposal is largely dependent upon the wise selection of the field which is to serve as a sewage filter, and the skill with which the distribution system is laid out. Most farm land is too fine and fertile for ideal filtering media; it admits insufficient quantities of air, holds water too long, and tends to clog readily. Hence the distribution field should be of ample size—allowing 400 to 1000 sq. ft. per person, this area depending, of course, on the texture of the soil. It should be

well drained, dry and porous. The field should be devoid of trees and shrubbery, giving air and sunlight free access. It should be located at least 300 feet down-hill from the domestic water supply. A gentle slope to the field is preferable although a steep slope may be used with a properly laid out system.

Distribution systems A and B shown in Fig. 11 are adapted to use in level or gently sloping fields. Layout C shown in Fig. 11 is suitable for use on a steeply sloping hillside. The size and length of distribution tile, as previously mentioned, varies widely with different soils.

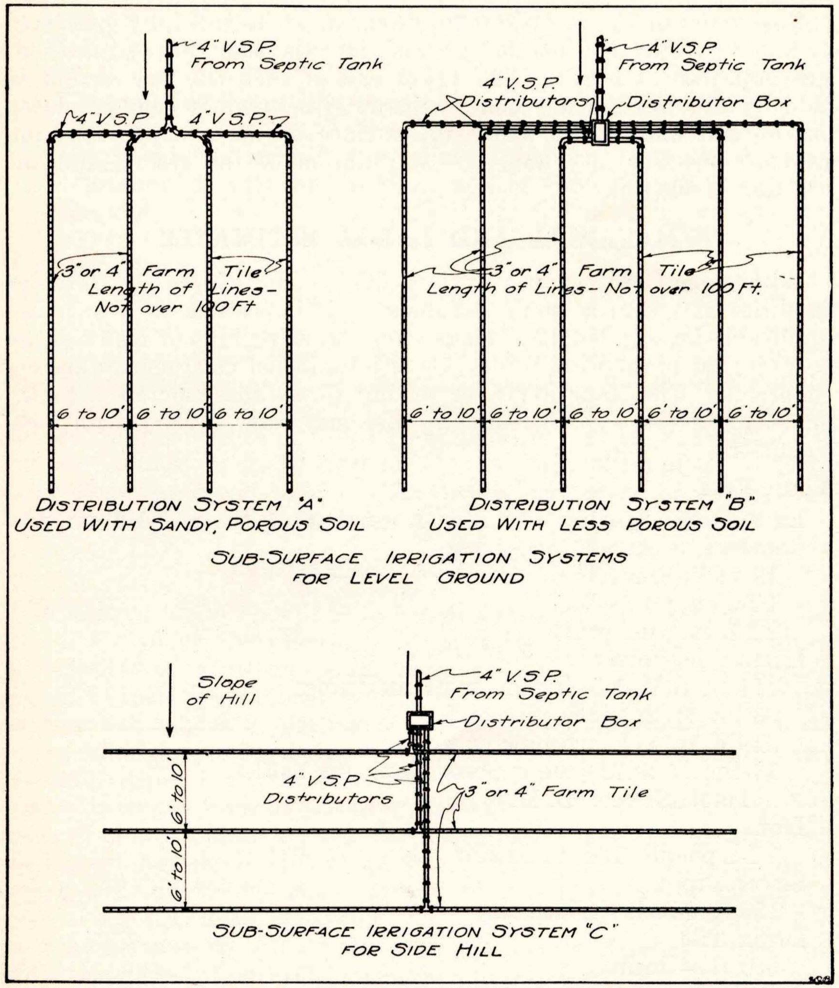

Fig. 11. Types of Sub-surface Irrigation System.

With sandy, porous soils, water sinks rapidly and the tile lines may be larger in size (usually 4 inches), and shorter (as low as 20 feet per capita in gravelly soil). In tight, clay soils 3 inch tile are frequently used, as they give a more even dosage over the entire line; the lineal feet of tile necessary will run as high as 60 feet per person with tight soil. The tile are usually placed in parallel lines from 6 to 10 feet apart, laid 12 to 18 inches deep, and on a slope of 3 to 4 inches per hundred feet. The last twenty feet of each tile line should preferably be laid level or given a slight upward slope, thus preventing undue flow of sewage to the low ends of the system.

The joints of the distribution system must be carefully protected so that loose dirt will not fall or wash into the tile. Several methods are indicated in Fig. 8. The lower end of each tile line should be closed with a brick or flat stone, or better still, an elbow may be placed on the end and vented above the surface of the ground, thus improving the flow of sewage, the ventilation of the system and the aeration of the soil.

MATERIAL AND LABOR ESTIMATES

With labor and material prices fluctuating widely in different localities and with seasonal demands, it is impossible to give prices applicable for any length of time. The following bills of material are accurate for normal conditions where no unusual emergencies are encountered. The labor items for setting forms and concrete are estimates for average conditions only and may vary greatly with local conditions.

Plant No. I

Excavation, figuring two feet of earth over cover, 7 1-2 cu. yds.
Concrete, 3 cu. yds. requiring,
  18 sacks cement
  1 1-3 cu. yds. sand
  2 2-3 cu. yds. gravel
Lumber for forms
  114 ft. B.M. 1-inch pine or fir sheathing.
  60 lin. ft. 2x4 inch pine or fir.
  24 lin. ft. 1x4 inch pine or fir.
  13 lin. ft. 2x12 inch cypress plank for baffles.
    Total 188 feet, B. M.
Iron
  1 1-2 pounds 10d wire nails
Sewer Pipe
  150 ft. 4 inch vitrified clay
Drain Tile
  300 ft. 4 inch
Labor, placing forms and concreting
  40 hours

Plant No. II

Excavation, figuring two feet of earth over cover, 12 cu. yds.
Concrete, 4 1-2 cu. yds. requiring,
  27 sacks cement
  2 cu. yds. sand
  4 cu. yds. gravel
Lumber for forms
  210 ft. B.M. 1-inch pine or fir sheathing.
  110 lin. ft. 2x4 pine or fir.
  54 lin. ft. 1x4 S-4-S pine or fir.
  13 lin. ft. 2x12 cypress plank for baffles.
    Total, 328 feet B.M.
Iron
  2 pounds 10d wire nails.
Sewer pipe
  150 ft. 4-inch vitrified clay (may be more or less depending on location of tank and distribution field from the house).
Drain tile
  300 ft. 4-inch (may be more or less depending on soil conditions).
1 Automatic sewer siphon 3-inch.
Labor, placing forms and concreting
  50 hours.

In all bills of material and labor it has been assumed that the soil in which the excavation for the plant is to be made will be firm enough to dig the pit true to dimensions, and thus serve for outside forms. Where the excavation is in sandy or loose soil which will not stand straight so that it may be used for outside forms the amount of form lumber necessary will be more than double that shown above, and the total excavation may be from two to seven times the amount given.

OPERATION SUGGESTIONS

Occasional attention will be necessary to insure the successful operation of any plant. No offensive odor should be perceptible with proper operation of the treatment plant, hence any unusual or excess foulness should be investigated. No chemicals should be used in the septic tank as they will inhibit or destroy the bacterial action which is essential to the satisfactory operation of the tank. If scum forms to any considerable depth it should be removed and buried. The well-ripened sludge in the bottom of the tank should be pumped out yearly. If allowed to accumulate beyond the storing capacity of the tank, a great deal of solid material will be carried over into the distribution system which will rapidly become clogged. It will be necessary in such a case to dig up, clean and relay the tile, preferably in new trenches midway between the former lines. A plant properly constructed and with the distribution system laid in fairly porous soil should, with reasonable attention, operate satisfactorily for many years.

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