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New Construction Methods for Septic Tanks and Cisterns

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MARCH 1953

New **CONSTRUCTION METHODS**
for **SEPTIC TANKS**
AND CISTERNS

AGRICULTURAL ENGINEERING DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE ♦ BROOKINGS



New
**CONSTRUCTION
METHODS**
for
**SEPTIC TANKS
AND CISTERNS**

T. R. C. ROKEBY¹

When plumbing is installed in a farm home, the question as to what type of septic tank to choose must be settled. At present, the monolithic concrete type (poured) is most used, and has proved very satisfactory. To make an adequate monolithic tank requires clean, well graded aggregate (sand, gravel, or crushed stone) and, if a concrete mixer is not available, a lot of hand labor for mixing. In some areas good aggregates are difficult to get, and obtaining a mixer for such a small job may be expensive. If forms may be borrowed or rented, cost of the monolithic tank will not be too great, but if forms must be built especially for the job, the cost and labor will be considerable.

Frequently in such cases, some type of prefabricated tank has been used. Steel tanks are available, but many are inadequate in size, and

there is a danger that they will rust out within a comparatively short time. A survey by the Public Health Service indicated that the average life for such a tank is only seven years. Other tanks built of clay or concrete tile are usually too small. Precast concrete tanks are satisfactory, but may not be available in remote areas, or the cost of trucking may be excessive.

In an attempt to overcome some of these problems, two new methods of construction have been developed by the South Dakota Agricultural Experiment Station. The first was in the form of a vertical cylinder constructed of concrete silo staves. The second was rectangular in shape, built of standard concrete blocks. Both products are manufactured in South Dakota, and may be transported and handled easily.

Septic tank of concrete silo staves which are readily available. It has proved satisfactory during four years of operation.



¹Assistant Agricultural Engineer, South Dakota Agricultural Experiment Station. Acknowledgment is made to Nie's B. Anderson, former Assistant Engineer, for initiating this research.

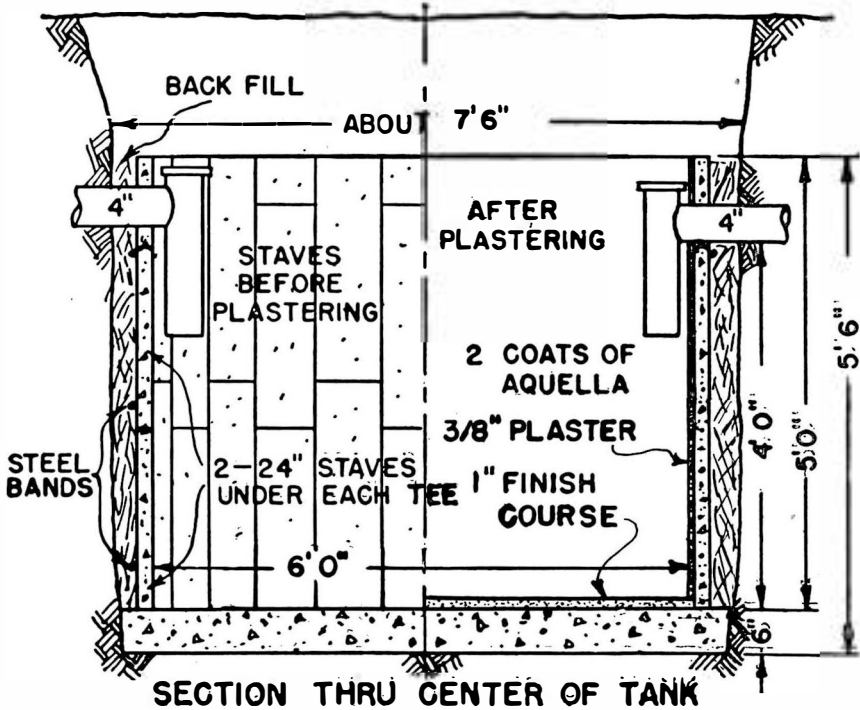


Fig. 1. Cross section of a septic tank built of concrete silo staves

Concrete Silo Stave Tank

This tank is in the form of a vertical cylinder, 6 feet in inside diameter and 5 feet in depth, with a capacity below the outlet of 850 gallons (Fig. 1). Thus it is suitable for a family of eight.

Materials:

- 12 6-in. concrete silo staves
- 14 24-in. concrete silo staves
- 34 30-in. concrete silo staves
- 9 sacks cement
- 1 cu. yd. of sand
- 1 cu. yd. of gravel
- 3 pieces of 1/2-in. round steel rod,
- 13 ft. 8-in. long for hoops
- 3 pieces of 1/2-in. round steel rod,

- 10 ft. 8-in. long for hoops
- 6 steel silo lugs, 12 nuts
- 120 ft. (45 lbs.) of 3/8-in. knobbed reinforcing rod
- 10 lbs. or 1 gal. of waterproofing material, such as Aquella, Akona, or equivalent
- 2 sewer tile tees, 4-in. diameter

Excavation: The excavation should be 7½ feet in diameter, with a depth of about 7 feet, depending on the depth at which the sewer from the house will enter. Dig the sides vertical and level the floor before pouring concrete.

Floor: The floor is poured in two

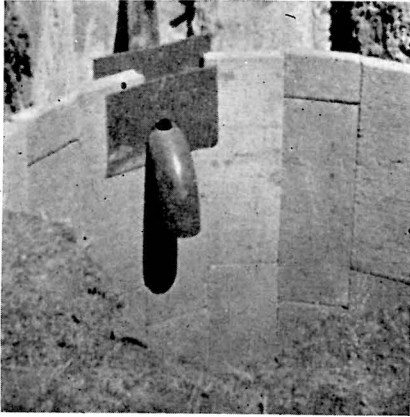


Fig. 2. Placing outlet or inlet fittings

courses. The first course, 4 inches thick, is of concrete mixed 1:2½:3½ (1 part cement, 2½ parts sand, 3½ parts gravel). The first course of the floor should cover the whole bottom of the excavation. The concrete should be well worked and carefully levelled to provide a firm, smooth base for placing the staves. Covering the floor with paper or a tarpaulin will make it easier to keep it clean while working on the walls. The pouring of the second course is postponed until the walls are fully constructed, so that the second layer ties floor and wall closely together.

Walls: The walls are made of concrete silo staves 2½ inches thick, 10 inches wide, in lengths of 30, 24, and 6 inches.

First mark a circle of 3-foot radius on the floor, to serve as a guide in placing the staves. The staves are set with the inner edge just touching this mark, with 24-inch and 30-inch staves alternating. When this first tier of staves has been completed, a hoop is placed around the out-

side, 6 inches above the floor, and tightened. A tier of 30-inch staves is now placed upon the top of the 24-inch staves except where the inlet and outlet are to be, where 24-inch staves should be used. A second hoop is placed 3 inches above the top of the 24-inch staves in the first tier, and partly tightened. Now place 30-inch staves to complete the second tier and tighten the second hoop. Fill in the remaining spaces with 6-inch staves, leaving openings 12 inches high for the inlet and outlet fittings. Place the top hoop just below these openings, and tighten.

Inlet and Outlet Fittings: Cut forms to fit around sewer tile tees and place in position in the openings (Fig. 2). The outlet tee should be placed at the bottom of the 12-inch opening left for it; the inlet tee 2 inches above the bottom of the opening. Fill in the spaces around the tees with a rather dry mortar, tamping it carefully to make a watertight joint around the tee.

Plastering the Walls: Apply a 3/8-inch coat of plaster of 1 part cement, 3 parts sand, and 1/4 part "Cem-mix," after thoroughly wetting the staves. Smooth the plaster as much as possible.

Finishing the Floor: Make sure the floor is perfectly clean, dampen it to obtain a good bond, and pour a finish course of 1:3 (1 part of cement to 3 parts of sand) mortar, 1 inch thick. Smooth and level this carefully, being sure to obtain a good joint with the plaster on the walls. Allow to cure for seven days or more.

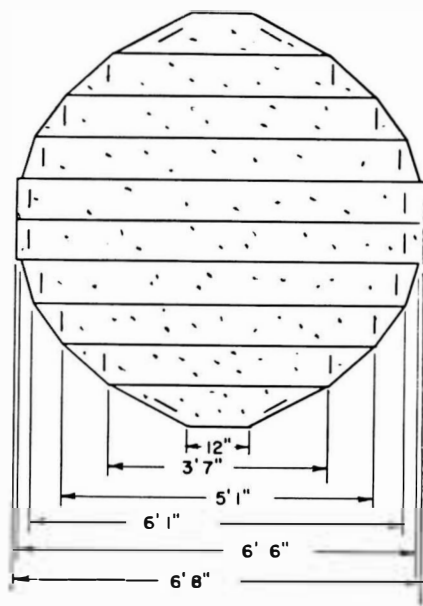


Fig. 3. Cover slab for septic tank

Waterproofing: Apply two coats of a waterproofing material such as Aquella or Akona according to instructions. Waterproofing is essen-

tial in order to prevent seepage through the porous staves.

Cover: The cover is made of reinforced concrete slabs, $4\frac{1}{2}$ inches thick and 8 inches wide, of varying lengths as shown in Fig. 3.

Mixture for Slabs: Mix 1 part cement, $2\frac{1}{2}$ parts of sand, and $3\frac{1}{2}$ parts of gravel or crushed stone to a smooth consistency in order to get a good bond between the concrete and the reinforcing rod. Each slab is reinforced with two $\frac{3}{8}$ -inch knobbed steel rods, spaced 1 inch from the bottom and $\frac{2}{2}$ inches from the sides. The rods should be formed into a hook at each end. Handles made from the rod should be placed at both ends of the slab.

These slabs may be made in forms of 2-inch by 6-inch lumber, placed on asphalt paper on any flat surface. Keep the slabs moist and allow to cure for at least three days before moving them.

Concrete Block Tank

This tank is rectangular in shape, 7 feet 4 inches long, 2 feet 8 inches wide, and 4 feet 8 inches deep (inside measurements), with a fluid capacity of 550 gallons (Figs. 4 and 5).

Materials:

- 119 standard concrete blocks (8 in. x 8 in. x 16 in.)
- 15 sacks of cement
- $1\frac{1}{2}$ cu. yds. of sand
- $1\frac{3}{4}$ cu. yds. of gravel
- 90 ft. of $\frac{3}{8}$ -in. reinforcing rod
- 2 4-in. sewer tile tees
- 10 lbs. or 1 gal. of waterproofing material (Aquella, Akona, etc.)

This size is recommended for a family of four or less.

Fig. 4. Block tank in use for four years



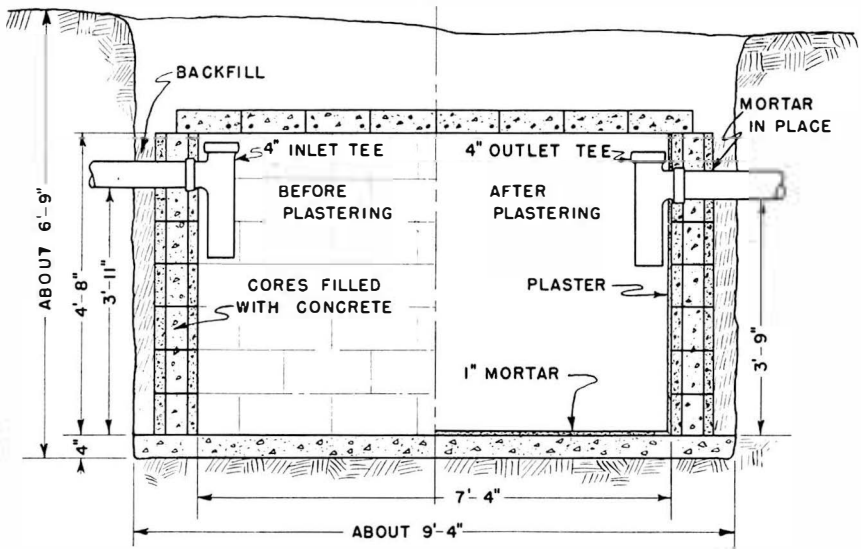


Fig. 5. Cross section of a septic tank built of concrete blocks

Excavation: The excavation should be made 9 feet 4 inches long, 4 feet 8 inches wide, and about 6 feet 9 inches deep, depending on the level at which the sewer will enter. Dig the sides vertical, and level the bottom before pouring.

Floor: The floor is poured in the same way as for the silo stave tank.

Walls: The walls are built of standard concrete block laid up with mortar consisting of 1 part cement, 3 parts sand, and 1/4 part lime or "Cem-mix." The corners should be kept square and plumb by use of a straight edge or level.

To add strength to the walls, be sure the joints are staggered between adjacent courses, and fill the cores of the blocks with concrete (1:2½:4 mix). Cut openings in the block for inlet and outlet fittings.

Plastering and Waterproofing: Follow the instructions given for plastering and waterproofing the silo stave tank. Both silo staves and concrete blocks are of relatively porous concrete which will allow the passage of liquids and contaminating material. Proper waterproofing is essential to reduce the danger of ground water pollution.

Cover: Make precast slabs 4 feet long, 12 inches wide, and 4½ inches thick, using two 3/8-inch reinforcing rods. Follow the instructions given for the silo stave tank. Eight slabs will be required.

Size of Tanks: Both tanks may be made larger if required (Tables 1 and 2). Add more staves to the silo stave tank to increase the size. A larger excavation and longer rods will be required. The concrete block

tank may be enlarged by using one more block in each course at the ends, resulting in a width of 4 feet inside, and a capacity of 845 gallons. A tank of this size would be large enough for a family of eight, or a smaller family that has the additional load of a garbage disposal unit. The general methods of construction would be the same, but

more materials would be required, and the size of excavation, length of cover slabs, etc., would be increased.

Tanks should not be made smaller than described. In the case of the stave tank, little saving would result, whereas the 550 gallon concrete block tank is little larger than the recommended minimum of 500 gallons.

Table 1. Capacities, Dimensions and Materials for Septic Tanks Built of Concrete Silo Staves

Number of Persons	Liquid Capacity, Gallons	Diameter (Inside)	Liquid Depth	Total Depth (Inside)	Number of Staves Required			Rod Required
					6"	24"	30"	
8 or less	850	6' 0"	4'	5'	12	14	34	3-13' 8", 3-10' 8"
10	1050	6' 10"	4'	5'	13	15	37	3-13' 8", 3-12' 4"
14	1220	7' 5"	4'	5'	14	16	40	3-13' 8", 3-14' 0"

Table 2. Capacities, Dimensions and Materials for Septic Tanks Built of Concrete Block

Number of Persons	Liquid Capacity Gallons	Length (Inside)	Width (Inside)	Liquid Depth	Total Depth (Inside)	Blocks Required
4 or less	550	7' 4"	2' 8"	3' 9"	4' 8"	119
6	680	7' 4"	3' 4"	3' 9"	4' 8"	126
8	810	7' 4"	4' 0"	3' 9"	4' 8"	133
10	950	7' 4"	4' 0"	4' 5"	5' 4"	152
12	1150	8' 8"	4' 0"	4' 5"	5' 4"	168

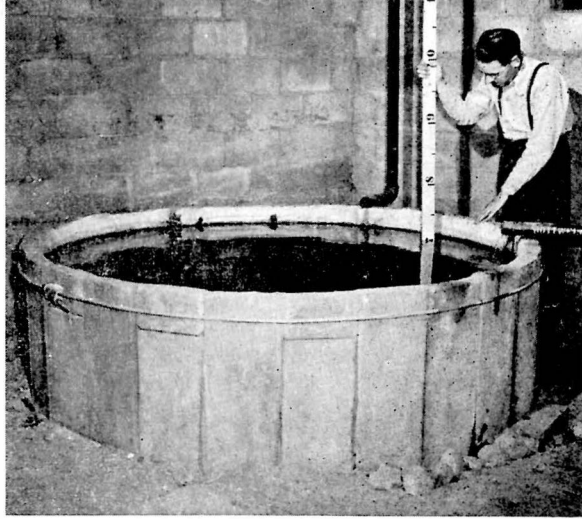
Note: A somewhat greater quantity of sand, cement, gravel and waterproofing material will be required for tanks larger than these described in the text.

A Concrete Silo Stave Cistern

A cistern has been built using the same method of construction advocated for the concrete silo stave septic tank (Fig. 6). It has now been in use for over five years.

This cistern is 7 feet 1½ inches in inside diameter, and 7 feet 6 inches deep. The water capacity is about 2000 gallons.

When the cistern was first filled, some leaks developed. These were apparently due to insufficient tightening of the hoops. The leaks were repaired with an asphalt compound and no subsequent leakage has taken place. Experience with this cistern indicates the need for thorough tightening of the hoops, and careful



application of the plaster and waterproofing coats.

Larger cisterns than the one described could be built, but construction of a satisfactory cover will be more of a problem if the diameter is made greater.

Fig. 6. This cistern was built of concrete silo staves and proved very satisfactory.

Summary

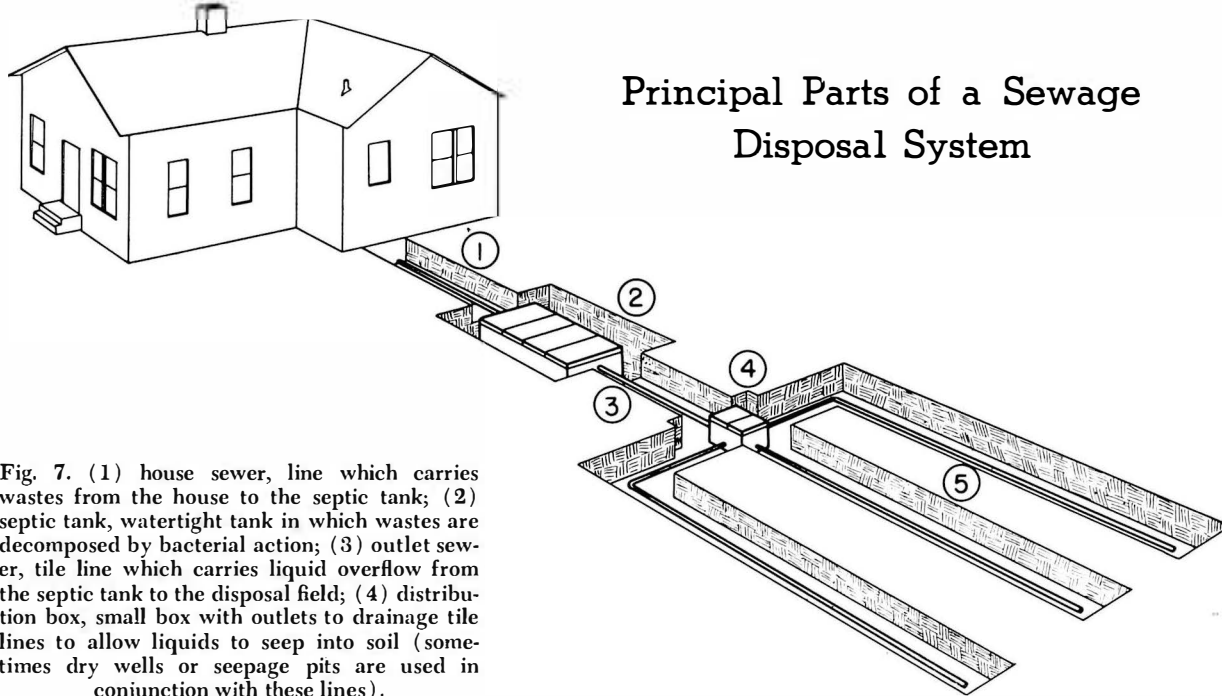
Two new construction methods for septic tanks have been developed by the Agricultural Engineering Department of the South Dakota State College Agricultural Experiment Station. The objective in perfecting these new construction methods was to overcome some of the shortcomings of prefabricated and monolithic tanks. Prefabricated tanks are often too small or, if made out of steel, rust easily. Precast concrete tanks, which are satisfactory, may not be available in remote areas. The monolithic tank requires well graded aggregate, and the task of mixing the concrete might prove difficult where no mixer is available.

The new construction methods use readily available building materials. One method employs concrete silo staves, and the tank is built in form of a vertical cylinder. This same method was followed to build a cistern. The other uses

standard concrete blocks for a rectangular tank. Both type tanks have been in operation four to six years and have proved satisfactory. Observations will continue in order to make an estimate of the probable life of the tanks.

The cost of the tanks was somewhat more (exclusive of labor) than that of a similar size monolithic tank, if forms could be rented. If forms had to be built for a single use, the new type tanks can be expected to bring about a saving in labor and material.

The construction of both type tanks is simple and sizes can be adjusted to the needs of the family. One step in the building process has to be kept in mind as important. Both silo staves and concrete blocks are of relatively porous concrete, therefore the danger of ground water pollution is present unless careful waterproofing is provided.



Principal Parts of a Sewage Disposal System

Fig. 7. (1) house sewer, line which carries wastes from the house to the septic tank; (2) septic tank, watertight tank in which wastes are decomposed by bacterial action; (3) outlet sewer, tile line which carries liquid overflow from the septic tank to the disposal field; (4) distribution box, small box with outlets to drainage tile lines to allow liquids to seep into soil (sometimes dry wells or seepage pits are used in conjunction with these lines).

Reprinted and adapted from

"Water and Sewage Systems for the Farm"

By GEORGE MCPHEE and LOUIS LUBINUS
Extension Circular 446 (Revised)
June 1952

How the Disposal System Works

Raw sewage and wastes from the house flow into the septic tank. There the bacteria, that live in the absence of air, decompose the solids into liquids, gases, and mineral residue. Most of the residue settles to the bottom of the tank as sludge; some is carried to the liquid surface by gas bubbles to form a scum. The scum seals the liquid surface from entrance of air. The gases under pressure escape through the house sewer and out of the house sewer vent or out the tile disposal line. The liquids pass off into the outlet sewer to the disposal field. Here the liquids seep out the tile joints into the soil and are purified by air-breathing bacteria which live only in the upper layers of the soil where air exists. The discharge from the septic tank may look clear but it contains disease germs and impurities which are converted to harmless matter by the soil bacteria.

Wastes discharged over 3 feet below the ground surface may seep to ground water levels before purification takes place and cause pollution.

A good disposal system will handle the normal kitchen greases, soaps, drain solvents and milk cleaning agents ordinarily used and found in waste. However, do not use or add disinfectants to the waste in quantity because this will harm the bacterial action in the tank. If the family is large or if there are unusual conditions whereby there is a large amount of grease or soap in the waste, a grease trap may be provided. This is a small box that receives waste from the kitchen sink through an individual sewer line and discharges into the house sewer. Grease traps are not recommended for the average farm because they clog easily and require frequent cleaning.

Sewer Sizes and Grades

The sewer line inside the house, and extending 4 to 5 feet through the foundation, should be cast iron soil pipe. From this point to the septic tank, vitrified clay sewer tile with bell joints usually is used. Cement

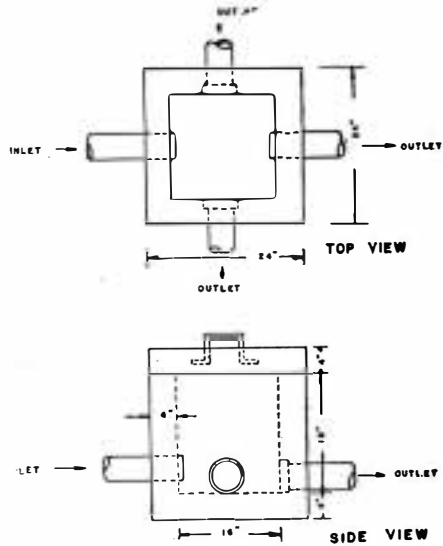
fiber pipe, of a type especially designed for house sewers, also has proved satisfactory. Six-inch tile is recommended; 4-inch is the minimum. The proper grade or slope is 1 inch every 4 feet or 2 feet per 100

feet. This grade should be established carefully to assure a uniform line and to avoid pockets where solids could lodge. The bell end should be toward the house or up the slope and the joints tightly cemented with cement mortar. The house sewer should be laid without bends to avoid clogging.

In many installations the outlet sewer from the septic tank to the disposal field can be drain tile which acts as part of the disposal field. Bell joint tile with cemented joints should be used for the outlet sewer to (1) extend the sewer away from the house 50 feet or more where the septic tank is located close to the house, (2) carry the sewer 75 feet beyond the well where the line runs past the well, (3) take any part of the outlet sewer or disposal lines through trees or vegetation which might grow into the open joints of ordinary drain tile. If a distribution box is used with the system, the outlet sewer between this and the tank should be bell joint

tile installed with the same care as the house sewer. The slope of the outlet sewer can be less than the house sewer; 2 to 4 inches per 100 feet is sufficient. A 4-inch drop in the first 8 or 10 feet is recommended to help the overflow liquid clear the tank outlet rapidly. See Fig. 8.

Fig. 8. Distribution box



The Disposal Field

The disposal field is a closed system of underground drainage tile which provides a large soil area into which the septic tank overflow can seep. The overflow liquid contains many undissolved particles, invisible to the eye, as well as germs and dissolved organic matter. For final disposal this material must be acted upon by soil bacteria which change it into a form suitable for plant food. The shallow tile system carries this liquid through the upper layers of

soil where soil bacteria exist. Raw sewage or septic tank overflow should never be discharged directly into a stream or other body of water. Neither should it be discharged on the ground or into old wells.

Disposal lines require only a slight slope or grade so that the liquid will move slowly. A slope of 2 inches per 100 feet is recommended. In sandy or loamy soils, 40 feet of tile for each person in the family is recommended. In tight soils, up to

85 feet per person is needed. No system should have less than 300 feet of disposal line. Sufficient tile is very important to proper operation of the system. Excessive slope or insufficient tile forces the overflow to the end of the line instead of allowing it to seep out along the line.

A single long disposal line is satisfactory for some installations; however a multiple branch line disposal field is usually preferable. The system should be planned so additional branches can be added if necessary. The tile is put down 24 to 36 inches; branch lines should be spaced at least 10 feet apart. In tight soils a 6-inch layer of gravel or cinders under the tile is recommended. See Fig. 9. The tile is laid with a 1/8- to 1/4-inch space at the joint. The top of the joints should be covered with strips of tar paper to keep dirt from clogging the joints when the trench is refilled.

In extremely tight soils, seepage pits can be used in conjunction with

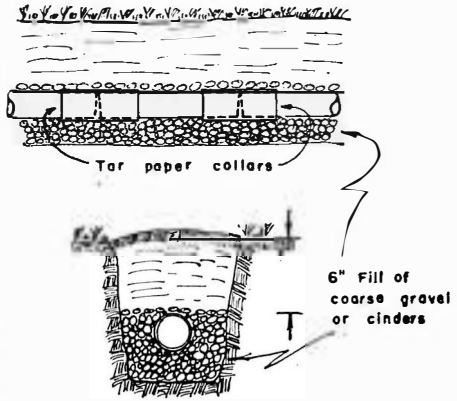


Fig. 9. Placing drain tile in disposal field

the tile lines. Post holes dug in the tile trench every 10 feet and filled with coarse gravel serve this purpose. Another method is to dig a deep trench and fill it with coarse material or dig a dry well at the end of the tile line. A dry well has open construction with unmortared blocks or masonry units and no floor. Seepage pits should only be located where they will not contaminate water sources.

Maintaining the System

A map should be made of the system when it is installed so the location of lines and tank is a permanent record. Some people plant shrubs around the tank to establish its location. A one-chamber tank requires cleaning more frequently than a two-chamber tank. The tank should be inspected every two years. When the tank is half filled with sludge cleaning is advisable. As sludge accumulates the effective capacity of the tank is reduced and eventually sludge scours out into the disposal

lines. A diaphragm pump is very good for this purpose. The sludge should be buried in trenches. Ordinarily, cleaning is only necessary once every 5 to 10 years.

In this climate many people fear the recommended shallow sewer and disposal lines will freeze. The danger of freezing is slight, especially if there is a cover of snow, because the lines never run full and the flow is intermittent. The shallow lines can be covered with straw as added protection.