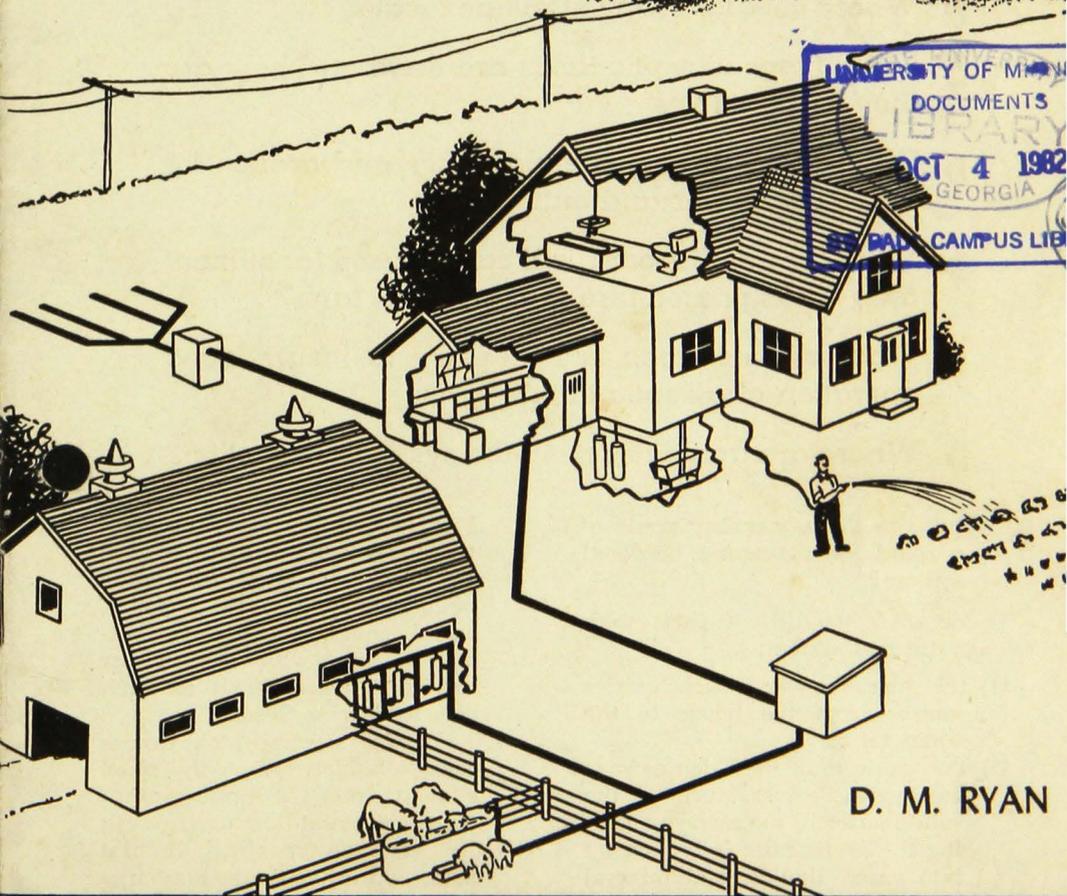


SEWAGE DISPOSAL AND WATER SYSTEMS ON THE FARM



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SEWAGE DISPOSAL ON THE FARM

DO YOU plan to install a sewage disposal system on your farm? Do you know what type of septic tank to install? Have you adequate grades to drain the basement? The following questions are discussed in this bulletin to give you some answers you may need:

1 ▶ **What are the necessary parts of a good farm sewage disposal system?**

2 ▶ **What size septic tank is needed?**

3 ▶ **Where should a septic tank be located?**

4 ▶ **What types of septic tanks are there and how are they installed?**

5 ▶ **What are the recommended sizes and grades for the house sewer and outlet sewer?**

6 ▶ **What type of disposal field can be used for effluent after it has passed through the septic tank?**

7 ▶ **What maintenance is necessary to insure good operation of a septic tank?**

8 ▶ **Where are trouble spots in the system's operation?**

▶ **What are the necessary parts of a good farm sewage disposal system?**

There are four distinct parts to a sewage disposal system:

- (1) the house sewer which carries wastes from the house to the septic tank;
- (2) the septic tank in which sewage treatment begins. Much of the solid matter in the sewage entering the septic tank is broken up into gases, liquids, and mineral particles through bacterial action.

In a well-built system the gases pass off readily without offense, liquids flow out of the septic tank, and the heavier solids, called "sludge," settle to the bottom. A scum which forms over the top of the sewage in the tank aids in decomposition;

- (3) the outlet sewer which carries sewage liquids, commonly called effluent, from the septic tank to the tile disposal lines or dry well;
- (4) the various types of disposal fields which handle the discharge from the septic tank.

2 What size septic tank is needed?

A large enough tank is the most important part of any sewage disposal system. A tank of 850-gallon capacity is the minimum size recommended, regardless of the size of the family. Any added cost in installing an extra-size tank will be repaid in the next 20 years.

The septic tank should hold all inflow for a period long enough to allow bacterial action to liquefy the sewage. If the bacterial action is complete, only clear liquid will flow through the outlet, and any adequate disposal system will handle this discharge for years without trouble. If a small "trick-size" tank is used, however, and sludge and raw sewage are forced through the outlet, there is no type of disposal field, even in coarse sand, that will work satisfactorily for a very long period.

The depth and length are the most important dimensions of a septic tank. These dimensions determine whether or not raw sewage and accumulated sludge will be carried out of the tank and deposited in the disposal field.

There are definite minimum dimensions necessary for successful operation of the tank, regardless of the capacity needed. In a large one-chamber tank a minimum depth of 6 feet is recommended. Only about 4 feet can be used to calculate capacity since about 1 foot is lost because the outlet is placed 1 foot below the cover and another foot is subtracted to allow for sludge accumulation in the bottom. This leaves the incoming sewage a distance of 4 feet from the accumulated sludge line. If the distance were less, the velocity of inflow would tend to scour the sludge in the bottom up into suspension, and carry part of it past the outlet.

A minimum length of 8 feet is suggested to allow suspended sludge to settle inside the tank instead of flowing out to choke the absorption field.

Let's analyze the need for a capacity of 850 gallons for a farm installation

of a septic tank. A septic tank is a receptacle that receives and holds the discharge from plumbing fixtures long enough to allow bacteria to "burn up" the raw sewage. To complete the reaction, a holding period of 72 hours (3 days) is recommended. Each member of the family requires a tank capacity of 40 gallons per day (24 hours). For a 72-hour period a tank capacity of 120 gallons (40 x 3) per member of the family is needed.

Every tank could be designed to the nearest pint if we could accurately determine the number of people who plan to use it. In analyzing tank failures it has been found that large numbers of guests during week ends made more use of the tank than the family did for the entire week. When estimating the number of persons who will use the system, therefore, be sure to allow for guests, relatives, and all hired help. A safe estimate for minimum numbers would be four for family, one for guests, and one for hired help, a total of six. Hence, 6 x 120 equals 720 gallons capacity needed to hold sewage for 72 hours. To this must be added the volume necessary to hold accumulated sludge, because when sludge builds up, it reduces the capacity of the tank. Adding volume for sludge to 720 gives a total of more than 850 gallons.

This total capacity must be below the outflow elevation because no sewage can be stored above the outlet. Rather than design each tank individually, we recommend a family-size tank (figure 1) though there are only two or three persons in the family. On the other hand, this size tank safely accommodates up to nine or ten persons.

3 Where should a septic tank be located?

The location of the septic tank depends upon the topography of the ground. If the ground is level it is best to locate the tank close to the house

to get the necessary minimum grades in both the house sewer and outlet sewer. The tank may be placed adjacent to the foundation wall but should not be a part of the wall.

If grades can be easily obtained, the tank is normally located not more than 25 feet from the house.

In heavy flat land, about one foot of dirt should be placed over the cover of the tank. The basement cannot be drained by gravity in heavy flat land. A sump pump can be installed in a pit in the basement to pump basement wastes into the house sewer line and out through the regular system.

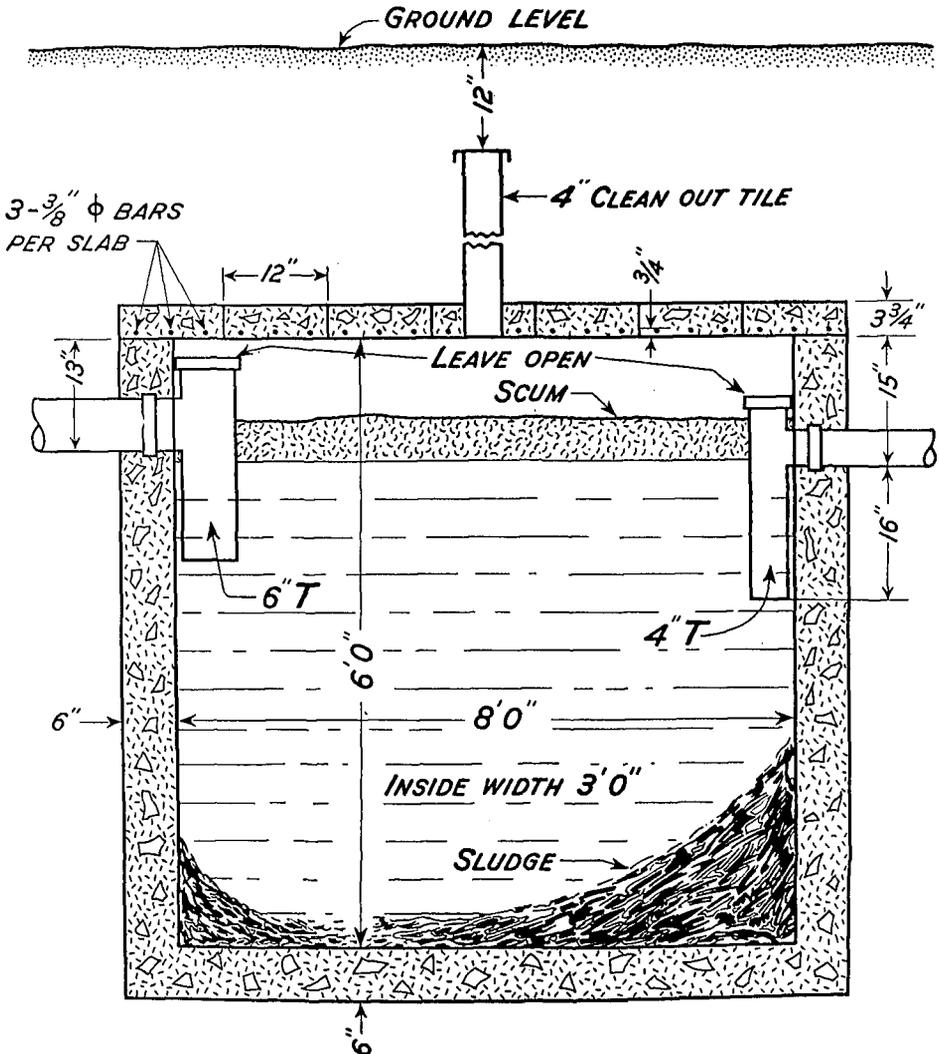


FIG. 1. Cross section of a constructed-in-place septic tank. Note: Cleanout tile is only used in deep installations.

4 What types of septic tanks are there and how are they installed?

There are various types of tanks that can be constructed or assembled. Neither the types of material used for construction nor the shape of the tank have a major bearing on the successful operation of the system. If the tank is of adequate size, with recommended minimum depth and length, made of durable material, and if it is provided with the necessary disposal field, it should function properly.

Constructed-in-Place Tanks

The constructed-in-place tank is best because:

- (1) the tank will be of adequate size;
- (2) proper type and placement of inlets and outlets for gas escape will be provided;
- (3) adequate pumping arrangement for cleaning is part of the construction;
- (4) through utilization of the farmer's own labor, the constructed-in-place tank of proper size is usually more economical;
- (5) with a large tank the interval between cleanouts is longer, cutting down the maintenance cost.

Constructed-in-place tanks may be built of poured concrete, clay tiles, concrete blocks, brick, or similar materials. Figure 1 illustrates the suggested size, 8 feet long by 6 feet deep by 3 feet wide. Since the width does not extensively help to control the sludge or raw sewage from scouring through the tank, it is not practical to construct the tank any broader than 3 feet. If the tank needs to be larger, increase either the length or depth.

Since more farm labor probably will be used in constructing a poured concrete tank than in other types of tank installation, some of the necessary details for building will be explained.

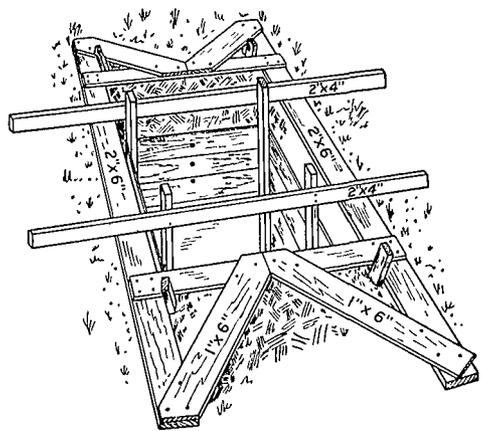


FIG. 2. Inside forms for septic tank braced into position for pouring of concrete.

After the site for the tank has been selected, it should be leveled for excavation. A plank frame (figure 2) should be laid out to serve as a guide for digging and to help prevent caving of the earth walls of the excavation. The walls usually serve as outside forms. A plumb bob or carpenter's level may be used to make sure that the side walls are kept vertical. The inside dimensions of the plank frame should be equal to the outside dimensions of the tank. For a family-size tank, the form should be 9 feet by 4 feet. The hole is excavated to the predetermined depth of the tank. This depends on whether the tank is placed close to the top of the ground or low enough to drain from below the basement. In either case the layout is the same.

The inside forms (figure 3) are constructed according to the inside dimensions of the tank.

These forms can be constructed of good material bolted together in sections so they can be used again. They also can be made of boards from the wood pile that are nailed together, but these forms will have to be torn apart with a wrecking bar. For a family-size tank the dimensions should be 8 feet by 3 feet. The inside forms should be sus-

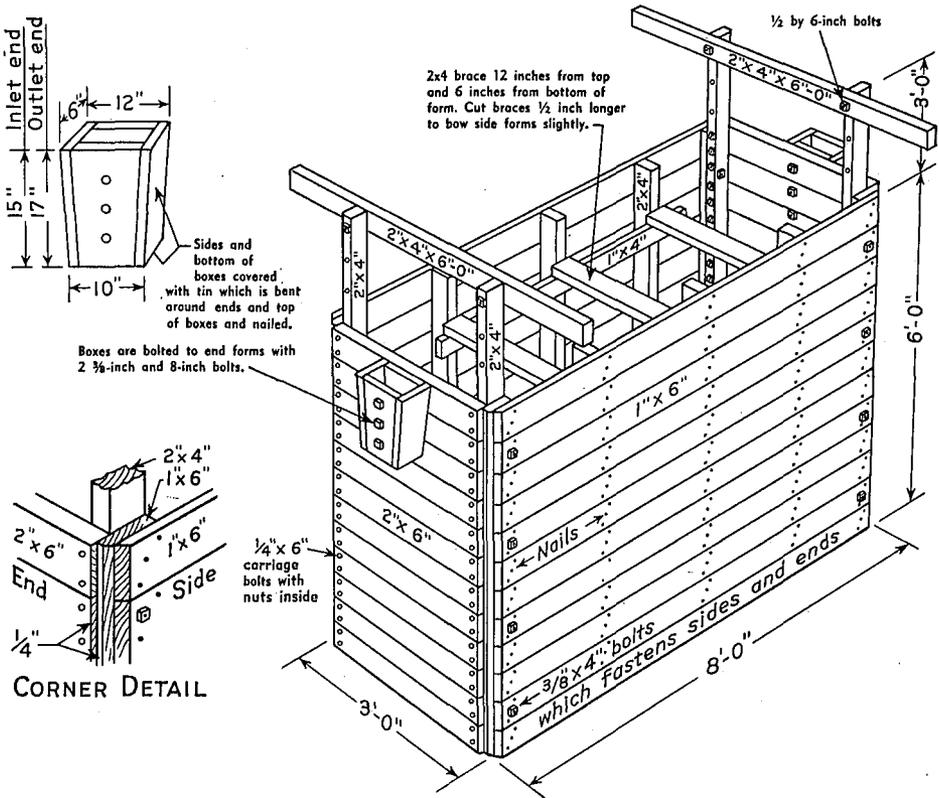


FIG. 3. Typical construction details for reusable septic tank form. Form consists of two end panels and two side panels fastened at each corner with four 3/8-by 4-inch machine bolts. The side panels are made of 1-inch thick boards, nailed to 1 x 6's. The ends of the side sections are beveled, leaving about 1/4 inch of the edge of the 1 x 6. The end panels are made of 2-inch thick boards bolted to 2 x 4's with 1/4-by 6-inch carriage bolts. The end panels are set out 1/4 inch from the edge of the 1 x 6 to facilitate removal. The surfaces of the corner pieces where they come together should be well covered with heavy grease before the form is assembled. Sides, ends, top, and bottom of end boxes are made of 1 x 6 boards to the approximate dimensions shown on side and end views.

pendent from the plank frame as shown in figure 2. The 2 x 4's on the end panels should extend about 3 feet above the boarded part of the panel. For deep installations auxiliary 2- x 4-handles about 6 feet long can be bolted to 2 x 4's on the end panel. Enough holes should be bored in both permanent and auxiliary handles to regulate the depth at which forms may be suspended. The bottom of the supporting crossbars

should be bolted about 1 1/2 feet above the boarded part of the panel for minimum depth installation. For installation to drain the basement, the distance between crossbar and panel should be about 6 feet depending on the depth the basement floor is below the outside ground line. When the inside form is within 6 inches of the bottom, it should be braced into position. The form is now within 6 inches of the dirt wall on sides,

ends, and bottom. This allows concrete to be poured in one continuous operation, and danger of leaky joints between sides and bottom is thus avoided.

Mortar can be placed into the notch at the end of the septic tank for the sewer pipe T at the entrance of the house sewer and for the outlet sewer as shown in figure 4. Tops of these outlet and inlet T's should not be plugged, but should remain open so that the entire system vents freely through the house sewer pipe and the roof vent. In fact, this procedure of allowing the gas to escape is recommended rather than venting the tank directly, because direct venting may drop the temperature too low within the tank.

Baffle plates may be used instead of the T's as an alternate method of construction. The inlet baffle should be placed about 12 inches from incoming sewage and extended downward a distance of 10 inches below the inlet pipe. The outlet baffle should be placed about 4 inches from the outlet end of the tank and extended downward about 16 inches below the outlet pipe.

Elbows are not recommended on inlets or outlets because the bottoms of elbows are below the liquid line and do not allow the gas to escape. To form the slot in which to place the baffle, nail a 2-inch by 1-inch piece of lumber on the outside of the inside form in the desired location.

A precast cover made of concrete is satisfactory. Two by four's set on edge may be laid out in a rectangular pattern on a smooth surface protected by tar paper. The form should be 4 feet wide and the length should be broken up into as many one-foot subdivisions as are needed. Each one-foot section should be reinforced by placing three pieces of $\frac{3}{8}$ -inch round reinforcing steel near the bottom of the slab as shown in figure 5. For convenience in moving the slabs, reinforcing steel may be bent and set in the fresh concrete for handles.

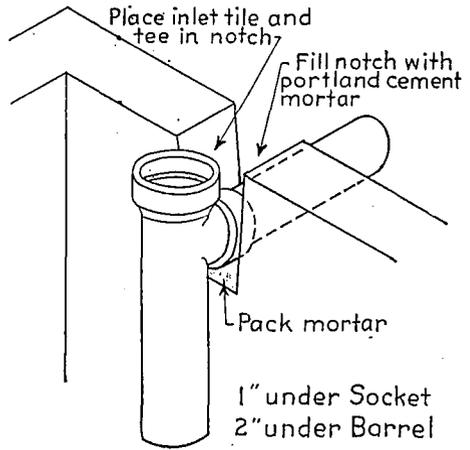


FIG. 4. Sketch showing how inlet and outlet tile are mortared into notch at end of septic tank.

Metal rings or old horseshoes also may be used.

When washed sand and gravel are used, a 1:2 $\frac{1}{4}$:3 concrete mix with not more than 5 gallons of water per sack of cement (two-thirds as much water as cement) is suggested for the septic tank. The family-size tank requires the following materials:

- 21 sacks of cement
- 2 cubic yards of sand
- 2 $\frac{1}{2}$ cubic yards of gravel
- 27 pieces of $\frac{3}{8}$ -inch round reinforcing bars, 4 feet long

When clean pit-run material is used, a 1:3 $\frac{1}{2}$ concrete mix is recommended. Based on the assumption that most Minnesota pits contain about 20 per

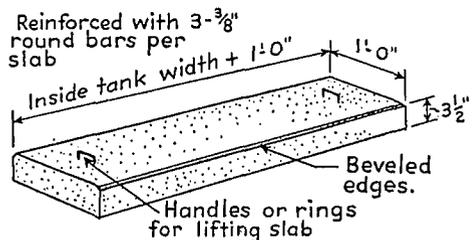


FIG. 5. Concrete cover slab.

cent gravel and 80 per cent sand, the family-size tank requires the following materials:

- 29 sacks of cement
- 4¼ cubic yards of pit-run material
- 27 pieces of ¾-inch round reinforcing bars, 4 feet long

Care should be taken to obtain a workable mix, and concrete should be spaded along form faces to help insure dense, watertight concrete.

Assembled-in-Place Tanks

Assembled tanks may be of steel, concrete pipe, clay pipe, or precast concrete stave materials. This type of tank will work fairly well if it has a large enough capacity. Seventy-five per cent of assembled tanks now installed are too small. In most cases it will take several units of assembled tanks to equal the capacity of one constructed tank. The precast stave material is flexible enough in use to allow any capacity desired in one unit construction.

5 What are the recommended sizes and grades for the house sewer and outlet sewer?

The house sewer to the septic tank should be a 6-inch diameter sewer pipe laid with tightly cemented joints and with the bell end up the slope. A 6-inch diameter for both house sewer and inlet T pipe is recommended because both pipes carry raw sewage. If they are too small, they may become plugged rather easily. If the septic tank is located far from the house, however, it would be better to lay a 4-inch house sewer to within one sewer pipe length of the tank and then expand to a 6-inch sewer pipe and T. Sewage floats better in a 4-inch pipe over long distances. A minimum of 2 per cent slope, or 1 inch in 4 feet, should be given the house sewer line, and it should be laid without bends to minimize danger of clogging. A 2-

inch drop between inlet and outlet of the septic tank should be allowed, as shown in figure 1.

The outlet sewer from the septic tank to the disposal field is usually built of ordinary 4-inch drain tile. If it passes within 75 feet of the water supply or near willow or elm trees, however, it is best to use sewer pipe with tightly cemented joints. If the septic tank is working efficiently, a 4-inch diameter for both outlet sewer and T pipe is sufficient because only clear liquid will flow through them. The outlet sewer should be laid on a slope of at least 1 inch in 25 feet.

6 What type of disposal field can be used for effluent after it has passed through the septic tank?

Final disposal of the liquid from the septic tank may be handled by discharging the effluent into:

- (1) tile lines laid close to the surface;
- (2) dry wells;
- (3) a field tile drainage system;
- (4) a filter that drains out onto the surface of the ground;
- (5) a filter that drains into a pit. The fluid in the pit is pumped to the top of the ground by an automatic sump pump.

Discharging Effluent into Tile Lines Laid Close to the Surface

This type of disposal field is used on flat land where the soil is fairly heavy but still has absorptive qualities. In practically all cases the septic tank should be set close to the surface with 1 foot of cover, which means the basement cannot be drained by gravity. The basement wastes can be pumped up to the house sewer by an automatic sump pump, as indicated in figure 6A. The layout of tile lines is illustrated by figure 6, A and B. The lines should be so arranged that extensions can be added. All tile lines should be approximately

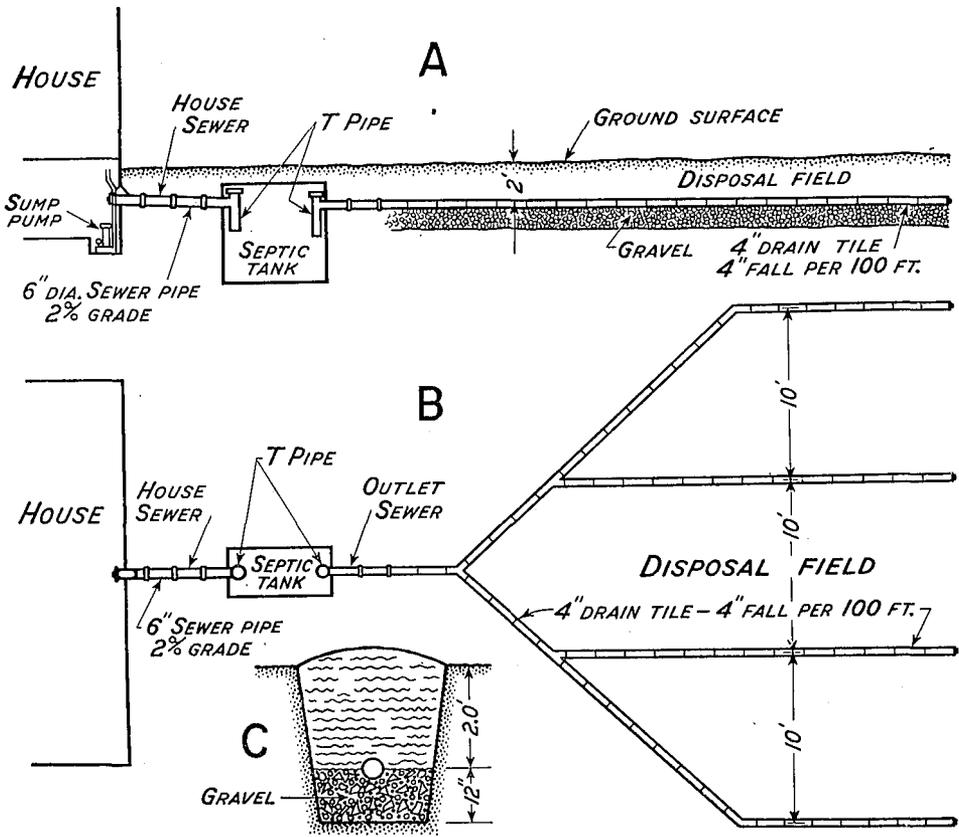


FIG. 6. Sewage system layout, using tile field. A. Sectional view. B. Plain view. C. Cross section of tile line.

75 feet from the water supply. Ordinary 4-inch field drain tiles are usually laid with $\frac{1}{8}$ -inch spacings that are covered with small strips of tar paper to prevent fine particles of soil from clogging the line. The disposal tile lines should have a fall of 4 inches in 100 feet and should be spaced about 10 feet apart.

It is advisable to lay out the field with about 2 feet of cover over the tile lines. Soil bacteria that act on sewage to render it harmless are present in sufficient numbers only in the upper layer of soil. The top layer of a heavy soil, which is well aerated, provides much better absorption than deep layers of

soil. The septic tank discharge will not be absorbed into frozen ground in winter, but because of a temperature of approximately 50° F. in the tank, the ground under the tile lines does not freeze if a few precautions are taken. Do not lay out a field under farmstead roads. Provide a good sod cover—the front yard where grass is maintained is a good location for the disposal field. If snow does not collect naturally over the tile lines it might be advisable to provide a snow fence, such as cornstalk bundles supported by a wire stretched between steel posts. If sod and snow cover is not provided, it would be

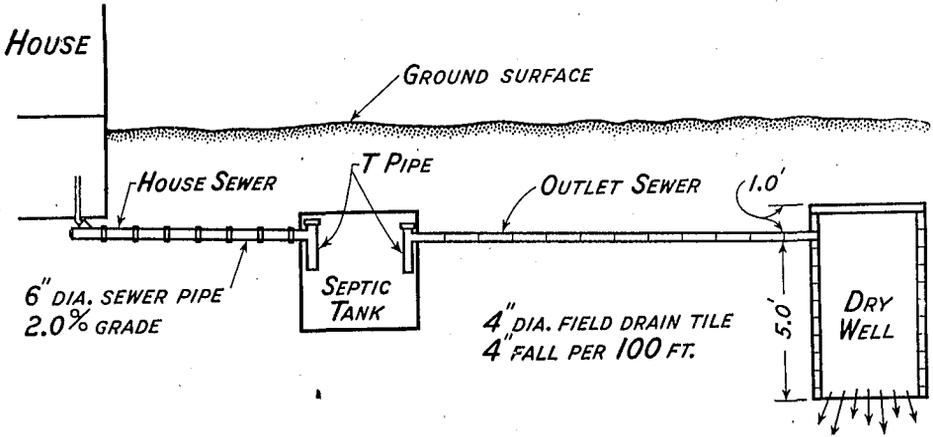


FIG. 7. Sewage system layout using dry well.

advisable to bank the lines with rotted straw bottom or hay.

Tile lines in tight soils should be cradled in gravel, cinders, or other coarse material to a depth of 12 inches below the center of the tile and the width of the trench, in order to hasten final disposal of liquid (figure 6C). Remember the effluent has to seep into heavy soil through small joints between tiles. If gravel is placed under the tiles, the liquid can immediately escape from the tiles into the gravel. Seepage rate

increases about five times with use of gravel.

To supply enough area for contact between disposal liquid and the ground, it is wise to lay out about 50 feet of tile line per person in the heavier soils.

Discharging Effluent into Dry Wells

This type of liquid disposal is recommended for use in gravel or coarse sand soils. The layout is illustrated by figure 7. A dry well is a hole in the ground

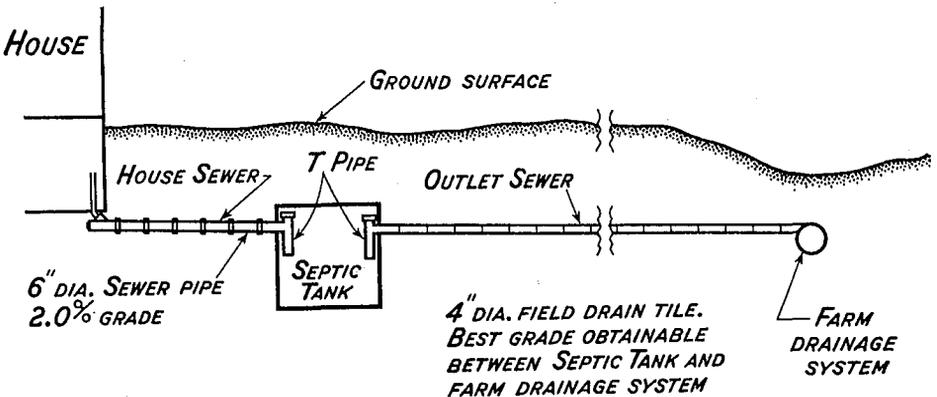


FIG. 8. Sewage system layout using farm drainage system.

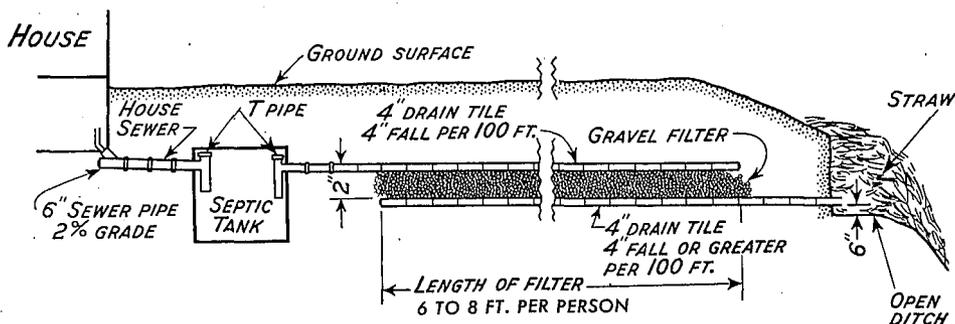


FIG. 9. Sewage system layout using filter where discharge drains out onto surface of ground.

with the sides walled up and the bottom left open in order that liquid may seep away into the ground strata. The side walls can be built out of blocks laid on their sides for the first 3 or 4 layers and the rest laid in the conventional manner. The openings in the blocks will allow liquid to seep into the ground for the first couple of feet if the bottom becomes plugged. The dry well also may be constructed of brick or blocks of any kind with open joints all the way up.

The cross-sectional area of the dry well should be about 25 square feet—such as 5 feet by 5 feet or 4 feet by 6 feet. If concrete blocks are used it would be practical to lay five blocks each way with alternate layers running out to the corner to break the joints. If brick or blocks are used without mortar, the dry well should be constructed round with about a 6-foot diameter. The brick or blocks will lock at corners. As dirt is tamped outside of the wall, the binding pressure will increase.

A minimum depth of 5 feet below the inflow is suggested to build up enough hydraulic pressure to force liquid into the ground more rapidly. Precast concrete slabs 1 foot wide, as described for the septic tank, may be used for the cover. The cover may be placed either 1 foot above the inflow or 1 foot below

the ground surface, provided the side walls are extended up that far, for ease in cleaning in case the dry well becomes plugged. The dry well should be at least 75 feet from the water supply.

Place 8 inches of gravel or crushed rock in the bottom of the dry well to act as a filter. Don't use open-stave dry wells in areas where fine sand is present. The sand may wash into the dry well and either reduce the capacity or slow infiltration.

Discharging Effluent into a Field Tile Drainage System

This system can be used wherever an adequate field tile drainage system can be tapped (figure 8). If the field tile drainage system does not provide enough dilution for the effluent, it might be advisable to install a filter between the tank and the drainage system as shown in figure 9.

Discharging Effluent into a Filter That Drains Out onto the Surface of the Ground

This type of disposal can be used in heavy soils where there is enough slope away from the house to install a filter and have the liquid drain out on the surface or into a ditch that is fairly well

removed from the house. The layout is illustrated in figure 9. The top tile has a flat grade to allow the liquid to seep through the joints and has the lower end plugged. The filter is 2 feet deep and the same width as the trench. Well-graded gravel is suggested for the filter. The bottom tile may have any grade that will drain the liquid quickly into the open. The upper end of the bottom tile is plugged. A minimum-length filter of 6 feet per person is recommended.

To prevent the outlet end of the tile from back freezing, it is advisable to have it empty into an open trench that can be covered with straw. There should be a 6-inch drop from the tile to the bottom of the trench, and the grade in the trench between the tile and the natural ground surface should be as steep as possible. Any part of the filter should be at least 75 feet from the water supply.

Discharging Effluent into a Filter That Drains into a Pit

This system will function where all others may fail. It can be used in any type of soil but is recommended for use in heavy clay soil that has a flat grade with a very high ground water level. Figure 10 illustrates this type of layout. It functions the same as the filter sys-

tem previously described, except for the method by which the liquid reaches the natural ground surface. In the first filter system the ground has enough slope at a reasonable distance from the house to allow the discharge from the filter to flow by gravity out onto the surface. Where a pit is used, the discharge from the filter flows into a pit where it is elevated to the natural ground surface by an automatic sump pump operated by a float valve.

It is suggested that the pipe from the sump pump to the ground surface have a weep hole to allow the liquid to drain back into the pit when the pump shuts off. If the liquid is allowed to stand in the pipe, it might freeze in cold weather. Surface water trouble can be held to a minimum if the filter is located on fairly high ground, or not in a hole.

What maintenance is necessary to insure good operation of a septic tank?

The septic tank requires very little attention if the disposal system is well built. A large septic tank requires much less maintenance than a small tank. All tanks should be inspected every 3 to 5 years, even though sludge removal might be required only once every 20 years. If the sludge becomes too deep

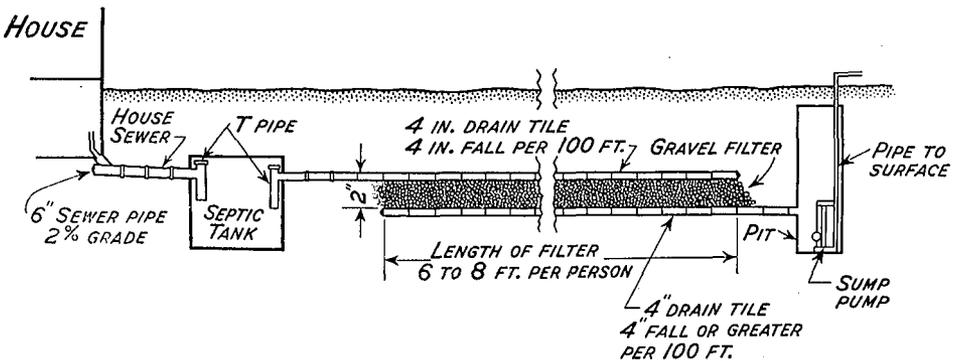


FIG. 10. Sewage system layout using filter where discharge drains into pit and is elevated to top of ground by automatic sump pump.

in the tank it will scour out into the tile lines and tend to clog them. It is advisable to clean the tank when sludge has accumulated to a depth of 1½ feet.

Tanks that have more than 1 foot of dirt over the cover should have a 4-inch tile placed in the cover at the time the cover is constructed. The tile should extend up to within 1 foot of the ground surface with a suitable cap to prevent dirt from entering. This placing of cleanout tile is indicated in figure 1.

When you are inspecting the tank, drop a measuring stick with a 2¾-inch-square foot through the tile opening to determine the amount of accumulated sludge. If the sludge is 1½ feet deep or over, a 2-inch pipe with a cistern pump installed on the top may be placed in the tank through the tile opening for cleaning. Cut the bottom of the pipe on an angle so that one side is about 1½ inches shorter than the other. This will allow sludge to enter when the pipe is placed on the bottom of the tank. A satisfactory job of removing sludge can be accomplished by alternately pumping and flushing with clear water with a pressure hose.

8 Where are trouble spots in the system's operation?

1. **May water containing detergents and grease be run through a septic tank?** Yes, if the tank is large enough (750 gallons) to hold ample liquid to dilute the wastes so that they will not hinder bacterial action.

2. **Should soapy and greasy water ever by-pass the tank and run directly into the disposal field?** No, the grease balls and soap curds will seal the pore space in the soil very tightly. If the tank is too small to handle soapy and

greasy water, it is best to make a separate disposal system.

3. **Is a grease trap necessary?** No, if your tank is large enough, it will serve as a grease trap. The grease and soap curds will either settle out in sludge in the bottom or rise to the top and be collected in the scum.

4. **When the water softener is regenerated, may the discharge be run into the septic tank?** If the tank has a capacity of 500 gallons or more, no harm will be done. In a smaller tank, the discharge may slow bacterial action considerably.

5. **Will yeast added to a septic tank increase the bacterial action?** No, the action of bacteria in yeast is the opposite of that of bacteria in the septic tank. Yeast is aerobic and bacteria anaerobic.

6. **Can anything be added to the dry well to increase infiltration if seepage has slowed?** Yes, add 5 gallons of sulfuric acid directly to the dry well. You may need to repeat the treatment in a few days if infiltration does not improve. Do not run acid through the septic tank. This will give only temporary relief. If sludge once plugs the bottom of the dry well, it will again.

7. **If the dry well has plugged, what can be done to repair it permanently?** The dry well plugs because sludge scours over from the septic tank. Undoubtedly, the tank is too small. The easiest way to increase the capacity for septic action is to dig a new dry well with a connection to the old dry well. The old dry well will then act as a booster tank to the original septic tank. This arrangement will work only where the soil at the bottom of the dry well is sand or gravel.

WATER SYSTEMS ON THE FARM

- 1 Where can you get the water?
- 2 How much water do you need?
- 3 What pump should you select?
- 4 What is important in planning the system?
- 5 Is size of pressure tank important?
- 6 Why does a tank waterlog?
- 7 How do you prevent freezing?

1 Where can you get the water?

Electrically operated water systems may pump water from (1) wells, (2) springs, and (3) cisterns. Regardless of the source, the water supply should be pure, dependable, and sufficient to provide water for all farm uses.

Wells are classified according to the method of construction. There are (1) drilled, (2) driven, (3) bored, and (4) dug wells. All surface and polluted water should be prevented from entering the well.

All wells should be located approximately 100 feet from any contaminating source.

this may lead to the purchase of a pump with insufficient capacity.

The water required on any farm can be estimated by using table 1. This information is necessary to determine the pump capacity needed.

TABLE 1. WATER REQUIREMENTS

	Gallons per day
Each member of family	40
Each dairy cow	25
Each steer	12
Each hog	3
Each sheep	1½
100 chickens	5
100 turkeys	8
	Gallons per hour
½-inch hose with nozzle	200
¾-inch hose with nozzle	275-300
Lawn sprinkler	200

2 How much water will you need?

The amount of water required per day depends on the number and kind of livestock, the number of persons in the family, and the number of modern conveniences on the farm that use large amounts of water.

Do not think in terms of the amount of water normally carried by hand, for

Example of Water Used Daily

	Gallons per day
4 persons at 40 gallons	160
10 cows at 25 gallons	250
60 hogs at 3 gallons	180
200 chickens at 5 gallons per 100 chickens	10
TOTAL daily requirement for farm and home	600

What pump should you select?

There are two general types of pumps, named according to the depth from which they are designed to lift water. They are known as (1) shallow well pumps and (2) deep well pumps.

Shallow well pumps are used when the suction lift is not more than 22 feet. Suction lift is the vertical distance from pump to water level, plus the friction loss in suction piping. The important water level is the "draw down" level, or the level maintained when the well is pumped at the desired rate. The figure "22 feet" is an arbitrary one, since various types of shallow well pumps vary in their practical suction lift from 15 to 28 feet. It is not recommended, however, that a shallow well pump be installed for a suction lift exceeding 22 feet. All shallow well pumps can be installed away from the well. Most of the common pump types are available as shallow well models, including the horizontal piston, centrifugal jet, and helical pumps. Often the centrifugal jet pump can be converted for use with either shallow or deep wells.

Deep well pumps are used where the suction lift exceeds 22 feet. Part of the pumping mechanism—cylinder, jet, or turbine impeller—should be located within 22 feet of the water. This part is usually immersed in the water. The jet type pump is the only deep well pump that can be installed away from the well. Other common types are vertical piston, helical, and turbine pumps.

How Pumps Operate

Piston Pump. This is the only pump that is belt driven and can be operated by other power sources if electricity fails. This pump operates on the same principle as the old hand pump. The capacity of the pump depends on the di-

ameter of the cylinder, length of stroke, and the number of strokes per minute. This pump will deliver a constant capacity at all normal discharge pressures. The discharge pressure is limited only by the power of the motor and the pump construction.

The deep well model is vertically mounted and will work at great depths as well as moderate depths. Figure 11 shows a horizontal double-acting shallow well model. Figure 12 shows the deep well model with the pumping head and motor located directly over the well. The cylinder is located down in the well below water level. It can be either single- or double-acting. The double-acting cylinder delivers water on both the up and downstroke while the single-acting delivers only on the upstroke. Obviously the capacity of the pump can be increased considerably by using a double-acting cylinder. The deep well model comes equipped with a differential cylinder in the pump head to level out the water surge and power requirements with a single-acting cylinder. The differential cylinder is replaced by a stuffing box when a double-acting cylinder is specified.

There are several types of cylinders (figure 13). The open type is used with

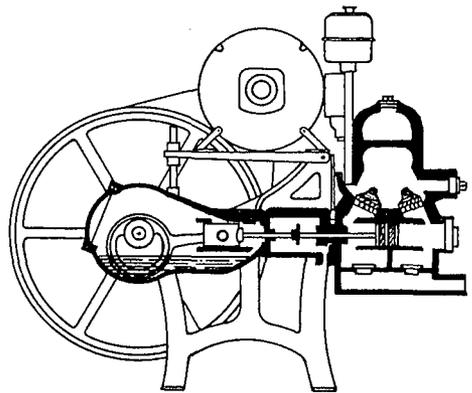


FIG. 11. Horizontal piston pump for shallow well operation.

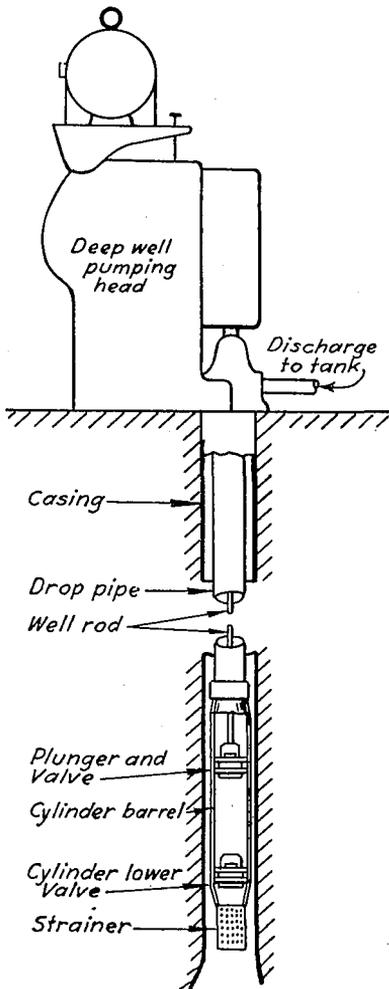


FIG. 12. Piston or plunger type pump for deep well operation.

electrically operated pumps, because the piston and valves can be pulled up through the drop pipe for repairs. With the closed top cylinder the entire assembly, including the drop pipe, must be pulled up. The tubular well cylinder is for small well casings. It has a rubber expander to seal the cylinder inside the casing which acts as the drop pipe. This cylinder is single acting.

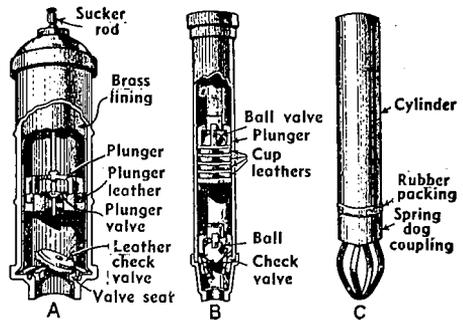


FIG. 13. A. Closed type cylinder, commonly used on hand pumps. B. Open type cylinder, popular in many sections on power pumps. C. Tubular well cylinder.

Centrifugal Pump. The pump unit is compact with a high speed electric motor (usually 3450 RPM) and an impeller on a common or coupled shaft. The impeller is a disc with curved blades and it revolves in a close housing. Figure 14 shows the principal impeller designs. The enclosed type is used with water pumps. The open and semi-open types are more suitable for stiff liquids, such as oil or screened wastes. In operation, liquid enters at the center and is whirled out the edge of the impeller into a circular channel or passage. The movement of liquid away from the center reduces pressure and creates suction. Discharge pressure depends on the diameter and speed of the impeller. Capacity depends on the size of the water passages through the impeller and the impeller's speed. This pump is quiet in operation and delivers a steady output.

The centrifugal pump normally loses capacity rapidly as the section lift or discharge pressure increases. It is available with one or more impellers (single stage or multistage). The single stage pump is a low-lift, low-pressure pump. Multistage pumps, with each impeller boosting the water pressure, maintain capacity against higher pressures.

Jet Pump. The centrifugal jet is the most common ejector or jet pump. The

jet is an auxiliary unit which modifies the normal performance of the centrifugal pump. The jet helps stabilize capacity between the normal pressure system settings (20 to 40 pounds per square inch) by reducing the large low pressure capacity and extending the upper pressure limit against which the pump will deliver water. The jet also improves suction lift. The centrifugal-jet pump is available for either shallow or deep wells in single stage and multi-stage units. The deep well model is most suitable for medium depths between 22 and 60 feet. Efficiency drops rapidly as lift is increased up to 60 feet or over.

The action of the jet draws water from the well and boosts it up the pipe toward the impeller. Thus the jet pushes and the impeller pulls the water up from the well.

Jets are designed for low, medium, and high lift. The low-lift jet is most efficient; about 1.3 gallons of water recirculate to the jet for each gallon delivered to the pressure tank. The high-lift jet requires that 2.5 gallons be recirculated for each gallon delivered to the tank. Installations can be made with either one pipe or two pipes leading to the jet. When two pipes are used, one of the pipes is a pressure return pipe (figure 15). When one pipe is used, the space between this pipe and the casing is the pressure return. The casing must be airtight, therefore, if this installation is to work (figure 16). The two-pipe jet is best where casing size will permit its use. The single pipe jet is especially suitable for small well casings of 2 or 2½ inches.

Helical Pump. This pump has the combined characteristics of the centrifugal and piston pumps. The pumping element is composed of a stator and a rotor. The stator is of general cylindrical shape with a double wormlike thread on the inside. The rotor revolves inside the stator and has a single corresponding thread. In action, it rolls

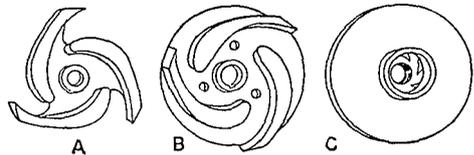


FIG. 14. Principal impeller designs. A. Open type. B. Semi-open. C. Enclosed.

on the inner surface of the stator producing a squeezing effect which forces the water ahead of the rolling action with very little turbulence. This pump will deliver comparatively large capacities from small diameter wells. It will pump from great depths or against high discharge pressures (figure 17).

Submersible Pump. This is a self-priming deep-well pump installed below water level. Pump and motor unit are installed under water in the well. The unit will fit into a 4-inch or larger well casing. It has a water-cooled pump and motor. You don't need a pump house or pit. The casing may be cut below frost level to permit installation of an underground horizontal service line to a tank located in a nearby building or basement. The unit for farm installations will deliver about 1,500 gallons of water per minute where depth to water level is 60 feet, but only about 375 gallons per minute where the depth to the water level is 400 feet.

In wells where trouble from sand or other abrasive materials cannot be eliminated, it may not be advisable to install the submersible pump.

4 What is important in planning the system?

Capacity. The flow of the well fixes the maximum continuous capacity of the water system. It is, therefore, an important factor to know, especially if it might limit the size of the pump. The flow can be measured during a continuous period of test pumping. Both the well and the pump should have sufficient capacity to furnish the total amount of water needed each day in two hours of pumping time. In the example on page 14, the daily needs were

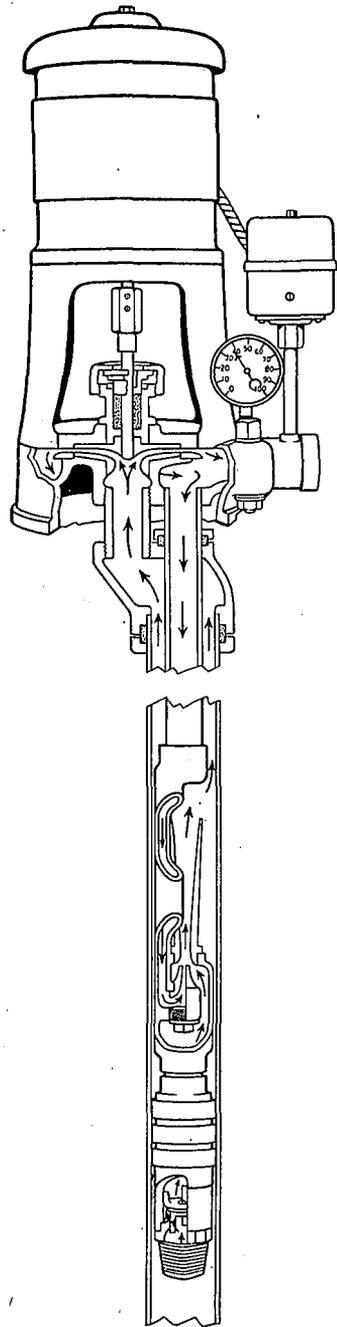
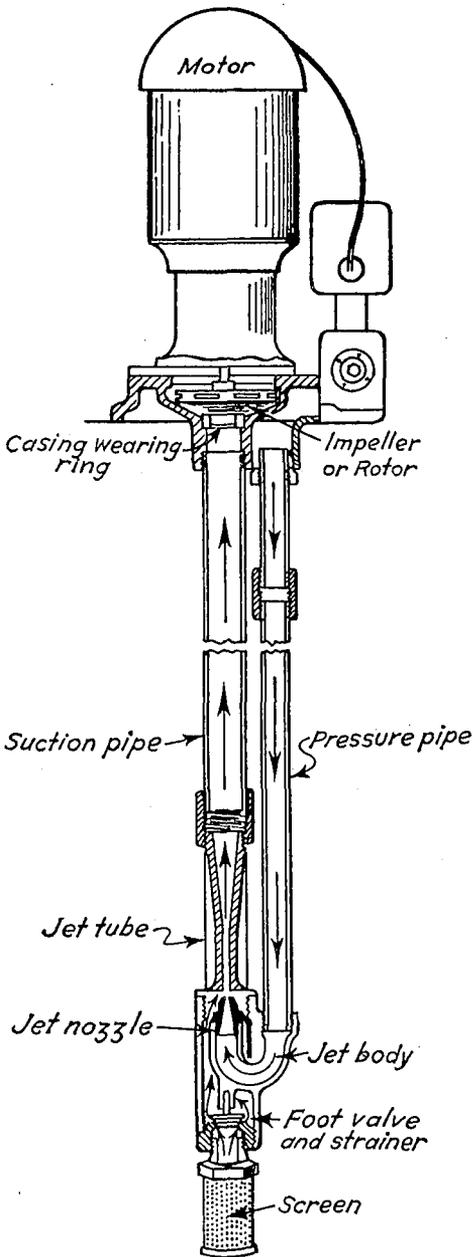


FIG. 15. (Above) Deep well centrifugal two-pipe jet and FIG. 16. (Right) Deep well centrifugal single-pipe jet pump.

600 gallons. This figure divided by two is 300 gallons. If the water source is adequate, a pump with a capacity of 300 gallons per hour would be practical.

In the state there are some drilled wells which have 2-inch casings. The capacity of these wells is limited by the size of the cylinder or jet body that will go into a small casing. There are also some slow flowing artesian wells. If the well is inadequate, the problem can be solved by (1) improving the old well, (2) putting down a new well, or (3) installing a pump which has the same or less capacity than the old well and providing extra water storage to supply the farm with water during those periods when water is used faster than it is pumped. The additional storage can be an extra large pressure tank, an elevated gravity tank, or an underground cistern. With slow-flowing wells, a belt connected pump jack, operating at reduced speed, is commonly used. The underground cistern or reservoir is frequently supplied from a windmill pump. The electric system pumps from the cistern to supply the farm with water under pressure.

Pipe Friction. There is resistance to the flow of water in all pipes, caused by

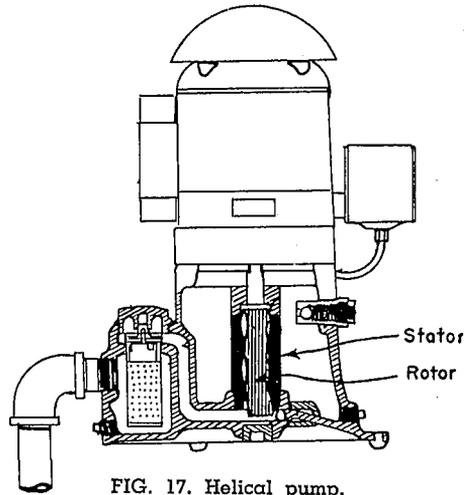


FIG. 17. Helical pump.

friction against the inside surface of the pipe. The effect of pipe friction is to increase the vertical height or "head" against which the pump must work and to reduce the pressure and flow at the faucets. The actual resistance of a pipe line depends on the size of the pipe, length of the pipe, rate of water flow, inside pipe smoothness, and number of bends.

Table 2 shows, in feet of head and pounds pressure, the loss due to pipe

Table 2. Pipe Friction per 100 Feet of Ordinary Iron Pipe Expressed as Feet and as Pounds for Various Rates of Flow

Flow gal- lon per minute	Size of pipe												
	1/2 inch		3/4 inch		1 inch		1 1/4 inch		1 1/2 inch		2 inch		
	ft.	lbs.	ft.	lbs.	ft.	lbs.	ft.	lbs.	ft.	lbs.	ft.	lbs.	
2	7.4	3.2	1.9	.82									
3	15.8	6.85	4.1	1.78	1.26	.55							
4	27.0	11.7	7.0	3.04	2.14	.93	.57	.25	.26	.11			
5	41.0	17.8	10.5	4.56	3.25	1.41	.84	.36	.40	.17			
6			14.7	6.36	4.55	1.97	1.20	.52	.56	.24	.20	.086	
8			25.0	10.8	7.8	3.38	2.03	.88	.95	.41	.33	.143	
10			38.0	16.4	11.7	5.07	3.05	1.32	1.43	.62	.50	.216	
12					16.4	7.10	4.3	1.86	2.01	.87	.70	.303	
14					22.0	9.52	5.7	2.46	2.68	1.16	.94	.406	
16					28.0	12.10	7.3	3.16	3.41	1.47	1.20	.520	
18							9.1	3.94	4.24	1.83	1.49	.645	
Feet of pipe equivalent to a 90-degree elbow	5		6		6		8		8		8		

NOTE: 1 pound pressure = 2.31 feet water column. 1 foot water column = .43 pound pressure. It is necessary to elevate a gravity tank 92.4 feet to supply the same pressure at an outlet as can be supplied by a pressure tank when the pressure is at 40 pounds per square inch.

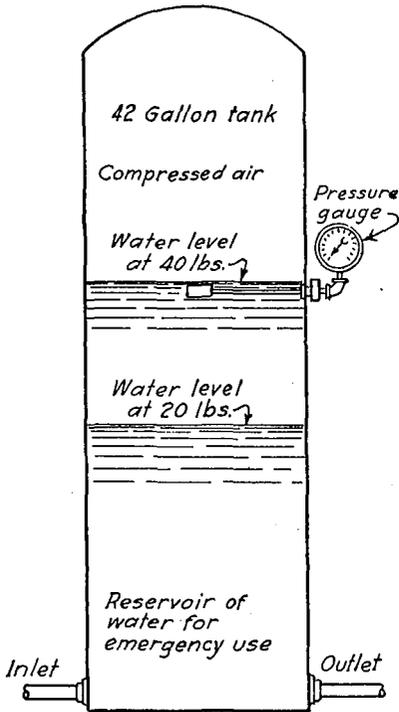


FIG. 18. Hydropneumatic or pressure tank.

friction in 100 feet of ordinary iron pipe of various sizes when given quantities of water are flowing. A good rule of thumb is: Use a 1¼-inch, galvanized wrought-iron pipe; a 1-inch copper tubing; or a 1-inch plastic pipe (soft roll) for underground installations.

Example: What pressure, in pounds or feet of head, will be required to overcome friction if the flow is 5 gallons per minute through a 1¼-inch pipe, 300 feet long, having three 90-degree elbows?

From table 2, friction loss in three 90-degree elbows is equal to 24 feet of 1¼-inch pipe (3 x 8) and friction loss in 100 feet of 1¼-inch pipe (5 gallons per minute flow) is .84 feet of head or .36 pounds pressure. The friction loss for 300 feet of pipe and three 90-degree elbows would be:

$$\frac{324 \times .84}{100} = 2.72 \text{ feet of head}$$

$$\frac{324 \times .36}{100} = 1.17 \text{ pounds pressure}$$

Pump Location. The location and depth of the well determine to a large extent the most practical arrangement of the water system. Shallow well pumps need not necessarily be installed directly over the well. Of the deep well pumps only the jet pump can be installed away from the well. When the well is near the house it is often practical to install the pump and pressure tank in the basement, safe from freezing and readily accessible. In this installation the horizontal suction line should slope from the well upward toward the pump to prevent an air trap. The distance the pump may be installed away from the well is limited by the pipe friction in the suction line from the pump to the water and by the distance the water is below the pump.

5 Is size of pressure tank important?

The pressure tank performs two functions: (1) It provides water storage so the pump does not have to operate each time a faucet is opened momentarily. This prevents much "start and stop" wear on the motor. (2) The tank also provides the air cushion for the entire water system. The tank is about two-thirds filled with water and one-third with air at a pressure of 40 pounds per square inch. About one-fifth of the total capacity of the tank can be used before the pressure drops to 20 pounds per square inch.

A 42-gallon pressure tank is the standard size supplied for farm water systems. It is a compromise between a larger tank where water may get warm or stale in summer and a smaller tank which requires that the pump go on and off more often. This size provides an active water supply of about eight gallons. Larger tanks are sometimes needed where water demands exceed the flow of the well or the output of the pump, and additional carry-over storage is necessary.

The pressure switch controls the electric motor. It normally cuts the

pump in when the pressure drops to 20 pounds per square inch and shuts the pump off when 40 pounds per square inch is reached. Usually the upper setting can be changed within reasonable limits. Increasing the upper pressure setting might overload the electric motor.

6 Why does a tank waterlog?

The compressed air in the pressure tank is gradually absorbed by the water, making it necessary to add air frequently. Otherwise the tank becomes waterlogged, and the pump will operate whenever a faucet is opened. The air volume control, mounted on the tank, is a device to regulate the amount of compressed air in the tank.

The tank can also accumulate too much air and become air-bound. When this happens the water spurts at the faucets.

There are three common air volume controls. Deep well piston pumps have a small plunger air pump which supplies air to the water entering the tank. A float-controlled air escape valve allows excess air to escape (figure 19B).

Shallow well piston pumps have a float-controlled air valve which is connected to the suction side of the pump by a small copper tube. When the air supply gets low the float rises with the water and opens the air valve to the copper tube. This allows the pump to suck in air, along with the water, through a snifter valve. When enough air has been furnished, the float lowers with the water and shuts the valve so

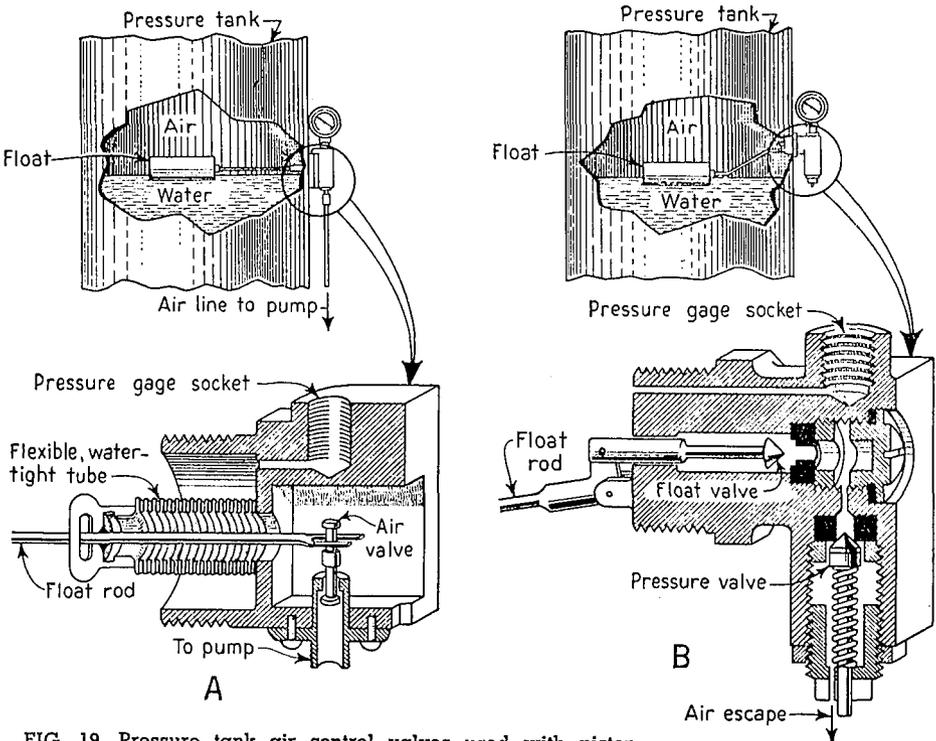


FIG. 19. Pressure tank air control valves used with piston pumps. A. Shallow well type. B. Deep well type.

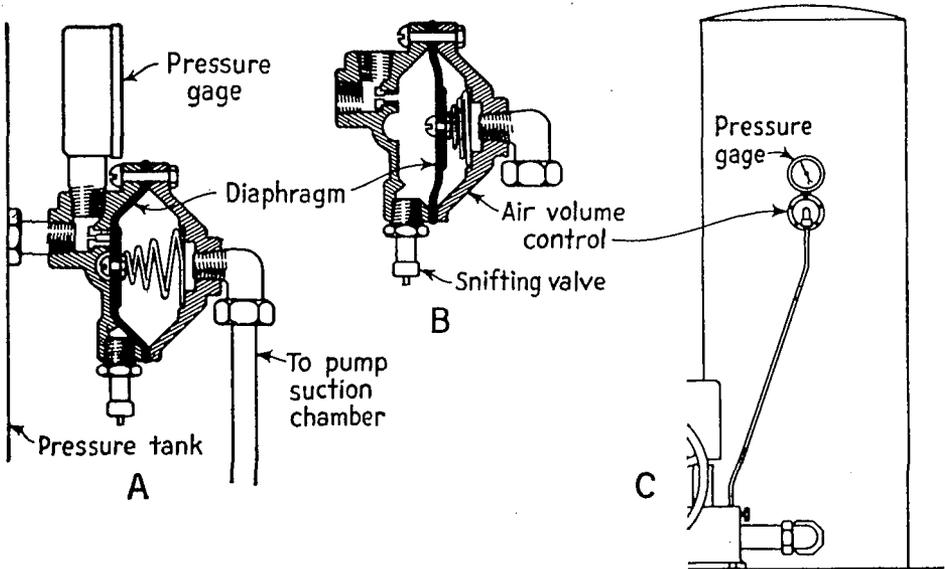


FIG. 20. Diaphragm type air volume control. A. Diaphragm position when pump is not operating. B. Diaphragm position during operation. C. Mounting on pressure tank.

that the pump cannot draw air (figure 19A).

Centrifugal and centrifugal-jet pumps use a small air diaphragm which is attached to the tank at the proper water level. The diaphragm is connected to the pump suction by a copper line. Each time the pump starts, the suction displaces the diaphragm and it takes in a small charge of air. When the pump stops, it releases the diaphragm to normal position and air is displaced into the tank. If the water level is high, air is added; if it is low, air just transfers between the diaphragm and the tank and no air is added (figure 20).

If the tank is air-bound.

- (1) The float or needle valve is stuck on the air volume control.
- (2) There is a leak in the suction line or through a gasket or some part of the suction system.
- (3) The suction line may not extend into the water far enough.

If the tank is waterlogged.

- (1) The float is waterlogged, preventing proper operation of the air volume control.

- (2) The air valve may not be functioning properly due to weak suction. This occurs when water flows to the pump or when there is very short suction lift. There should be a valve in the suction line which can be closed until there is enough suction.
- (3) Either the air valve or air line is clogged. Find the source of trouble to eliminate waterlogging permanently. As a temporary measure, drain the tank or add air with an air pump.

7 How do you prevent freezing?

In Minnesota, six to nine feet is the range of depth water system pipes should be placed to prevent freezing. Check the experience of the nearest city water department. The primary requirement for a sanitary well is that the casing extend above ground. Above-ground installation of the pump equipment is preferred because (1) it is more sanitary, (2) drainage is easily pro-

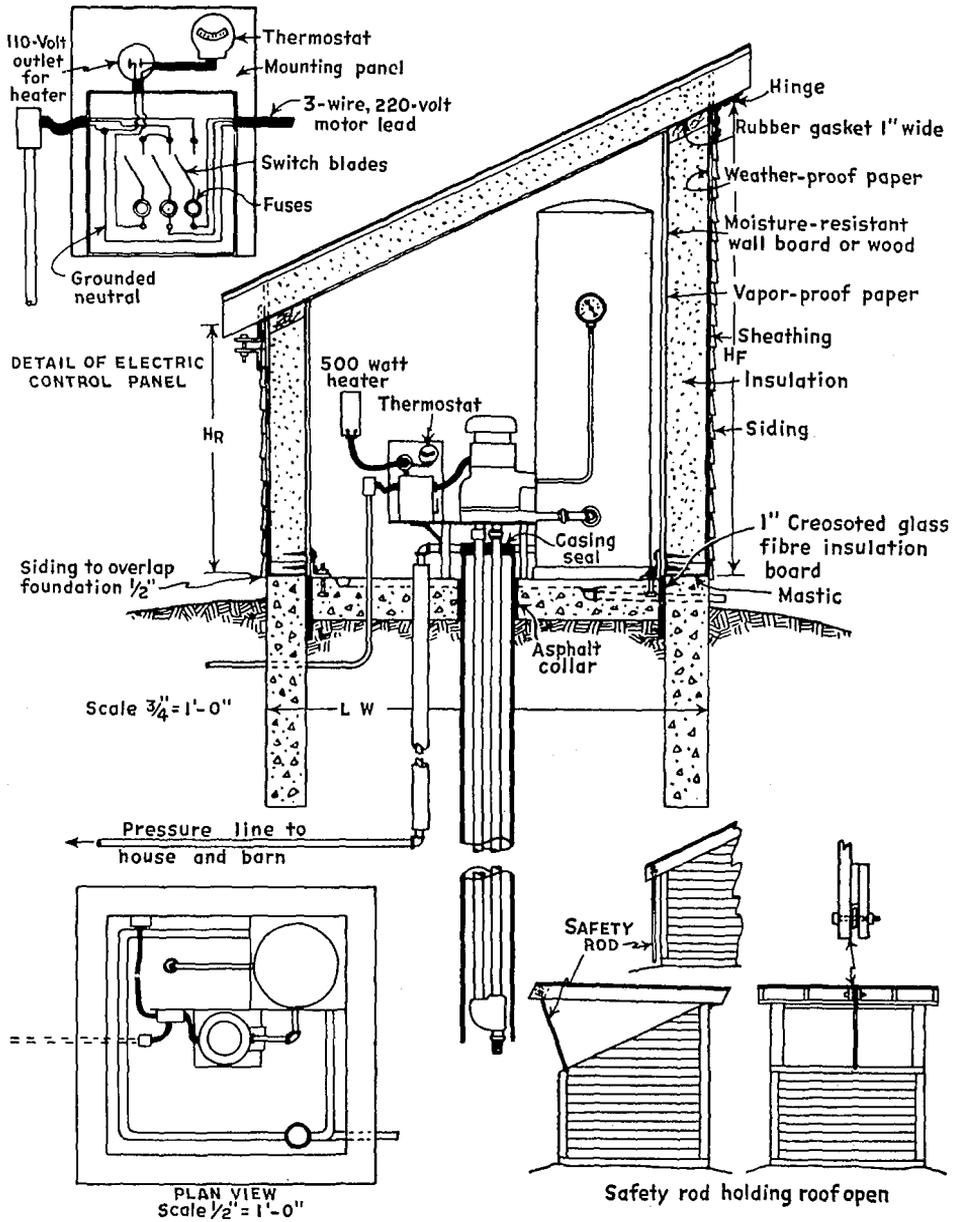


FIG. 21. Insulated above-ground pump house.

vided, and (3) the equipment is readily accessible for repairs and maintenance. These are important considerations for all farmers installing new water systems and especially so for dairy farmers in expanding Grade A whole milk areas. Farmers should investigate local and Minnesota State Board of Health regulations to make sure they comply with ordinances governing the sale of milk and other products.

Figure 21 shows the insulated pump house which will provide very reliable freezing protection for equipment. This plan is designed for minimum space inside. Access is through a hinged roof. The hinges may have removable pins to allow the cover to be lifted off. The low side permits ready access to pump and equipment but the house is removable for major pump repairs. All equipment is independent of the walls so that the house may be moved easily.

The floor of the house is drained to prevent flooding if a serious water leak occurs. Where the natural ground line slopes away from the well, the floor drain should lead to the surface where it will empty into a shallow trench filled with straw to prevent back freezing. If a surface drain is impossible, a gravel

sump below frost penetration level should be provided at least 30 feet from the well to take seepage. Under no circumstances should the drain be connected to a field tile that has (1) sewage emptying into it, (2) a drain from the milk house connected to it, or (3) surface drains.

The roof of the house clamps shut tightly with a gasket or felt seal to prevent cold from entering. The construction is frame with 2 x 6 studs to give light weight so that the house can be moved easily. The use of 2 x 6 studs permits 5½ inches of insulation to be placed throughout the wall and ceiling. There should be vapor-proof paper on the inside of the studdings over the insulation. The inside wall-finish material should be water-resistant. Hardboard, plywood, or wood sheathing are very good materials. The pressure water line is insulated through the floor to below frost level by a 4-inch tile filled with insulation. This tile should be sealed at top and bottom with 2 inches of concrete. The roof should not be shingled unless the slope is 1 to 2 or greater. The outside wall is composed of sheathing and siding with building paper between.

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